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**Franks et al.**

[11] **3,885,165**

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## [54] PRESS CONTROL SWITCH


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[52] **U.S. Cl.** ..... **307/115**; 200/11 R; 318/162; 200/25

[51] **Int. Cl.** ..... **H01h 19/14**

[58] **Field of Search** ..... 307/141.4, 123, 115; 318/162, 461; 200/11 R, 11 AD, 25; 317/249 R



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[57] **ABSTRACT**

A press control switch comprises a rotatable tuning shaft assembly rotatably driven in positive synchronism with a machine, such as a stamping press and associated infeed and/or outfeed equipment, for processing the workpiece therethrough. A plurality of proximity pickup units are fixedly mounted adjacent the shaft assembly in radially spaced relation therefrom and are axially spaced therealong. A plurality of disk pairs are axially spaced along the shaft in radial opposition to the corresponding ones of the proximity pickups and are provided, on their oppositely and outwardly facing radial surfaces, with circumferentially extending conductive segments adjacent the disk periphery. Means are provided for circumferentially adjusting the disks of each pair relative to each other for determining the angle of shaft rotation through which each disk pair will actuate its associated proximity sensor. The shaft assembly includes one end portion bearing at least one such disk pair which is rotatably adjustable with respect to the rest of the shaft assembly and which may be positively circumferentially locked with respect thereto. The shaft assembly further includes a motion detector disk having a plurality of circumferentially spaced conductive segments thereon which coact with a further proximity sensor to monitor shaft rotation and synchronism thereof with the machine to be controlled. Triac circuitry driven by respective proximity sensors actuates corresponding control functions of the machine by which the shaft assembly is rotatably driven.


**12 Claims, 9 Drawing Figures**

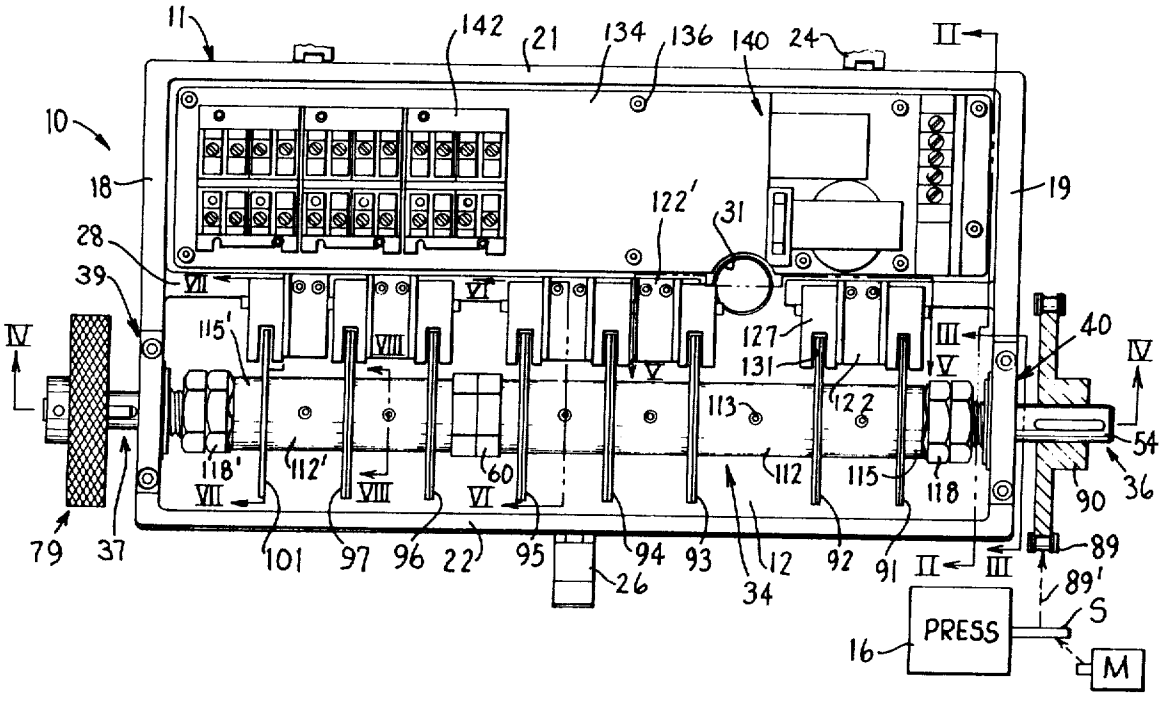
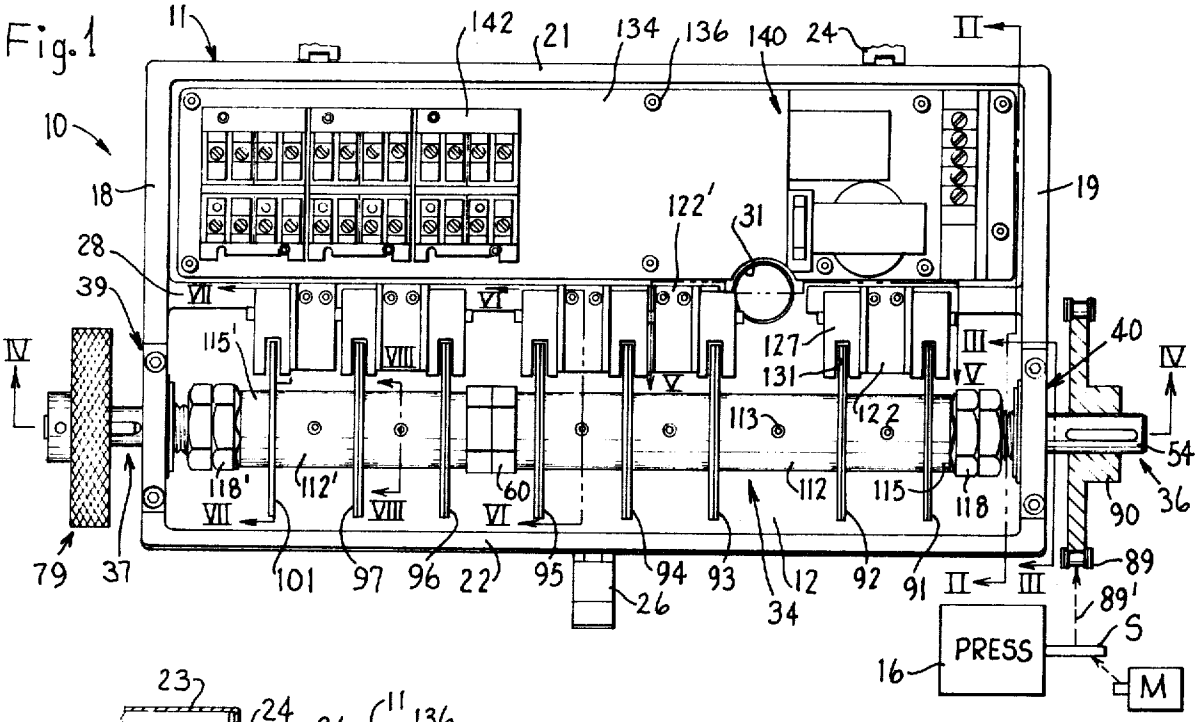


Fig.1



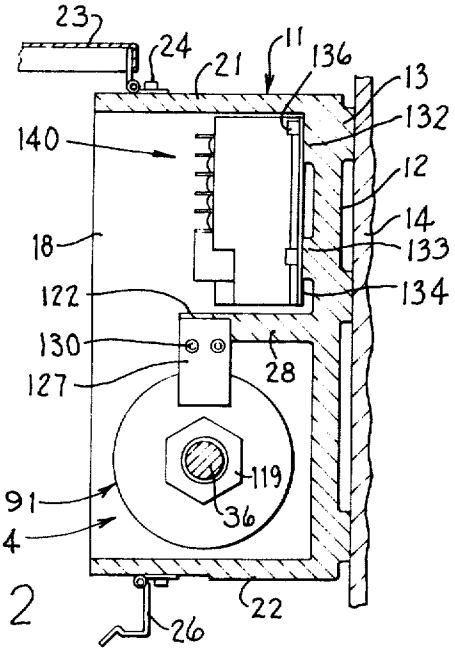




Fig.2

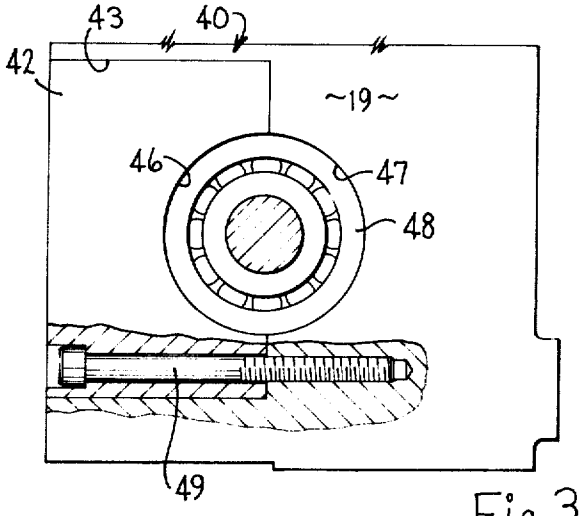



Fig.3

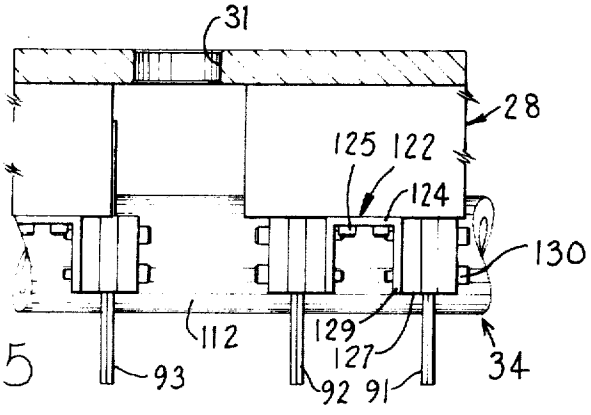



Fig.5

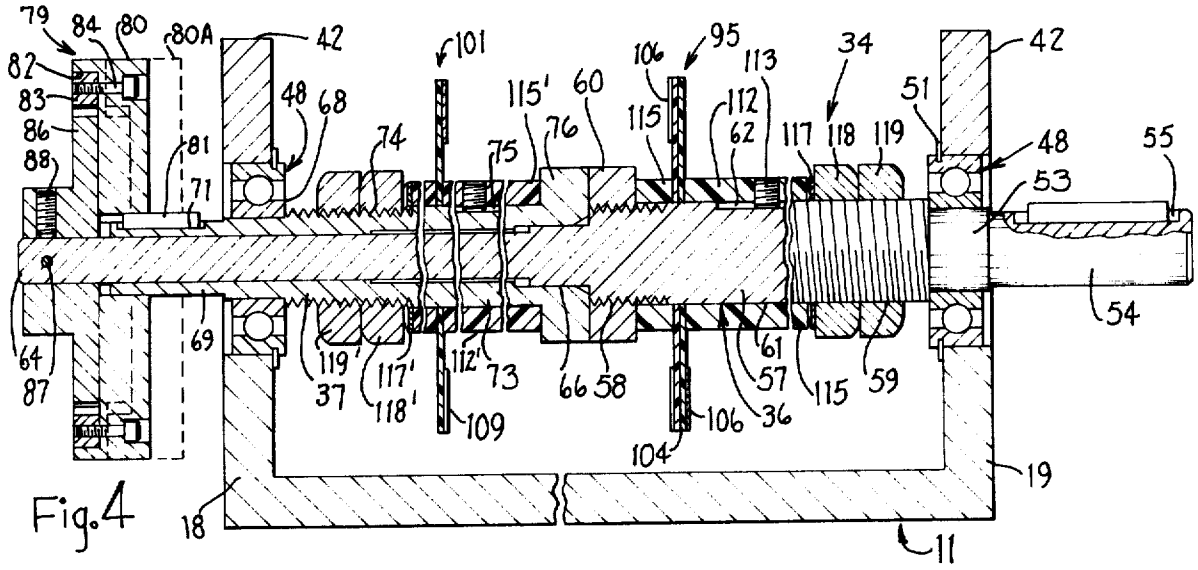



Fig. 4

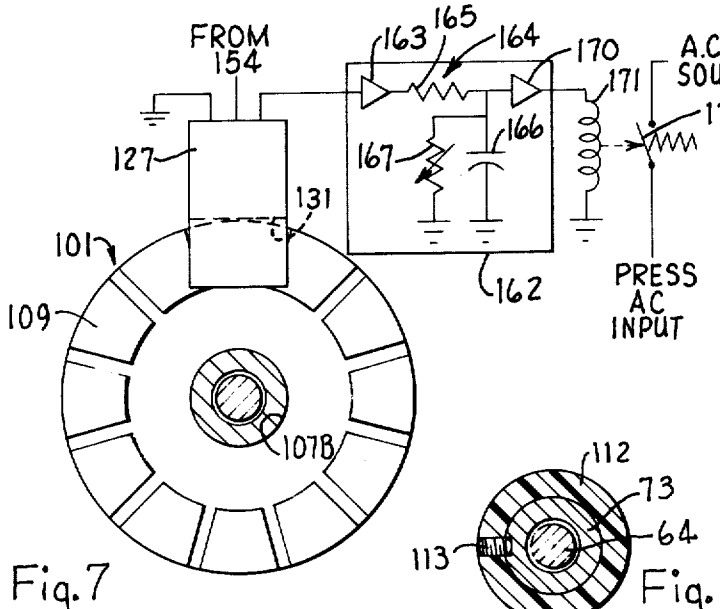



Fig. 7




Fig. 8

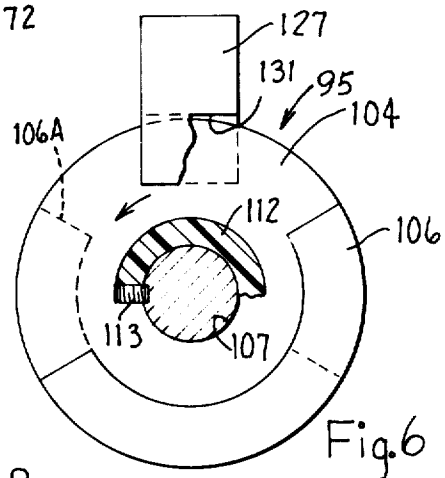



Fig. 6

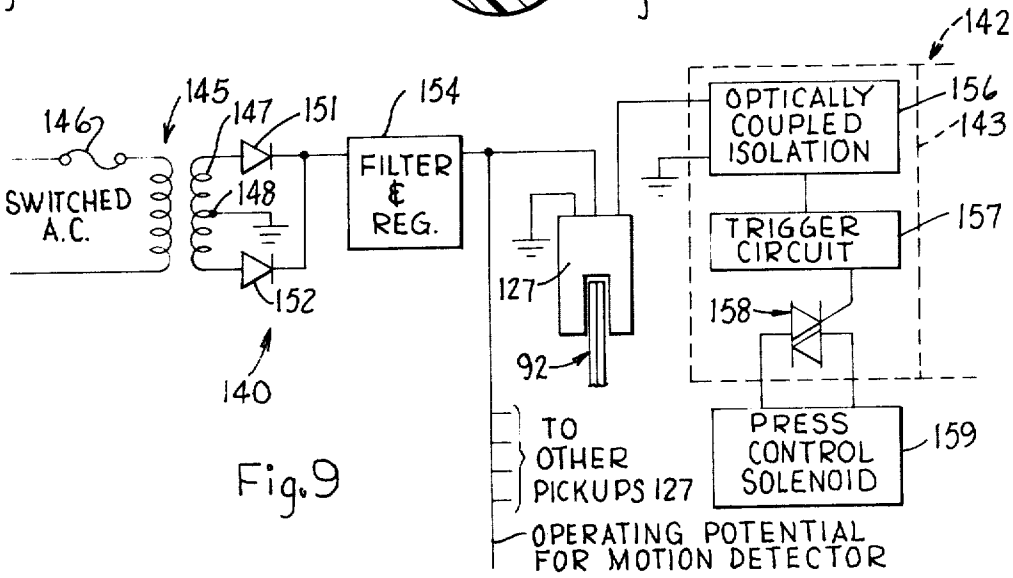



Fig. 9

# PRESS CONTROL SWITCH

## FIELD OF THE INVENTION

This invention relates to a multifunction machine control switch and more particularly relates to a multifunction switch apparatus employing a rotatable shaft assembly synchronously driven by a machine, such as a stamping press, to be controlled.

## BACKGROUND OF THE INVENTION

The present invention was developed for control of a stamping press and, for convenient reference, will be discussed in such context. However, use of the present invention in other multifunction control applications is contemplated, particularly in multifunction machine control.

Control of multifunction production machinery, such as stamping presses, has long posed a problem in the art.

Stamping presses, for example, require accurate timed control and synchronism of plural functions such as workpiece infeed, location of the top of the press ram stroke, amount of press ram overshoot, workpiece strip length cut off and removal of scrap from the die. One or more of these functions may require its timing to be varied with respect to other functions, in relation to increases or decreases in the set operating speed of the press. The timing of various of these functions may require variation when dies or workpiece material are changed, as when the press is converted from production of one product to production of another.

In addition, such multifunction controls face a difficult operating environment, being subjected to significant and repetitive mechanical shock in operation of the machine e.g. stamping press, controlled thereby as well to contamination and damage by grease, dirt, metal particles and so forth. Such controls should provide precise timing of machine functions, despite substantial variations in the operating speed of the machine and should be capable of rapid, simple adjustment particularly where frequent variation of relative timing between the functions is required, as well as where the time duration of given functions relative to the machine power input shaft speed is required.

One prior control for stamping presses included conductive drums on a shaft rotatable with the press input shaft and engageable with conductive brushes. One disadvantage of such arrangement is that environmental residues, dirt and the like accumulate on the brushes and/or drums within a short time, making the apparatus unreliable and requiring frequent and careful cleaning.

Another prior press control used cams on a shaft rotatable with the press drive shaft, wherein the cams actuate mechanical switches. Disadvantages of such prior arrangement include the accumulation of dirt and other environmental residues on the contacts and/or cams and switches. In addition, the switch contacts, and when used, intervening rocker arms between the switches and cams tend to float particularly at higher press speeds.

Thus, such prior devices have been less than satisfactory for use as press controls.

Accordingly, the objects of this invention include provision of:

1. A multifunction machine control switch apparatus capable of controlling, and maintaining synchronism between, a plurality of operative portions of a production machine, particularly of a stamping press, and capable of maintaining synchronism between such portions and the input drive shaft of such machine.
2. Apparatus, as aforesaid, capable of maintaining proper machine operation over a wide range of operating speeds thereof.
3. Apparatus, as aforesaid, wherein the duration and start and stop times relative to machine input drive shaft rotation, of a plurality of functions can be rapidly and simply adjusted.
4. Apparatus, as aforesaid, wherein provision is made for rapid and simple adjustment of one group of control devices with respect to a remaining group of control devices in an independent manner.
5. Apparatus, as aforesaid, which provides reliable and accurate electrical control of machine operation over long periods of use in a hostile atmosphere and environment and which is relatively uneffected by accumulation of dirt, grease, and other contaminants on operating parts thereof.
6. Apparatus, as aforesaid, which is free of moving mechanical switching contacts and is not subject to mechanical float or bounce of switch elements, particularly at higher press speeds.
7. Apparatus, as aforesaid, which includes means for monitoring the rotational speed of such elements and of the rotatable press input shaft driving same.
8. Apparatus, as aforesaid, readily usable with new or existing machines.
9. Apparatus, as aforesaid, which is relatively simple in construction and manufacturable at relatively low cost, which is capable of a relatively long and troublefree operating life under adverse conditions with little or no maintenance, and which is readily maintainable.
10. Apparatus, as aforesaid, which provides for substantial interchangability and standardization of parts therein, so as to minimize maintenance and inventory size.

Other objects and purposes of this invention will be apparent to persons acquainted with apparatus of this general type upon reading the following specification and inspecting the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational view of apparatus embodying the present invention, partially in diagrammatic form and, for clarity, omitting wiring between electrical components.

FIG. 2 is a fragmentary sectional view substantially taken on the line II—II of FIG. 1.

FIG. 3 is an enlarged, partially broken sectional view substantially taken on the line III—III of FIG. 1.

FIG. 4 is an enlarged fragmentary sectional view substantially taken on line IV—IV of FIG. 1.

FIG. 5 is an enlarged sectional view substantially taken on the line V—V of FIG. 1.

FIG. 6 is an enlarged sectional view substantially taken on the line VI—VI of FIG. 1.

FIG. 7 is an enlarged sectional view substantially taken on the line VII—VII of FIG. 1 and additionally disclosing, in schematic form, circuitry associated with a speed detection portion of the apparatus.

FIG. 8 is an enlarged sectional view substantially taken on the line VIII—VIII of FIG. 1.

FIG. 9 is a diagrammatic view disclosing a typical portion of the electrical circuitry associated with the apparatus of FIG. 1.

Certain terminology will be used in the following description for convenience in reference only and will not be limiting. The words, "up", "down", "right" and "left" will designate directions in the drawings to which reference is made. The words "front" and "rear" will refer to the leftward and rightward portions of the apparatus as shown in FIG. 2. The words "in" and "out" will refer to directions toward and away from, respectively, the geometric center of the device and designated parts thereof. Such terminology will include derivatives and words of similar import.

## SUMMARY OF THE INVENTION

The objects and purposes of the invention are met by providing a press control switch which comprises a rotatable tuning shaft assembly rotatably driven in positive synchronism with a machine, such as a stamping press and associated infeed and/or outfeed equipment, for processing the workpiece therethrough. A plurality of proximity pickup units are fixedly mounted adjacent the shaft assembly in radially spaced relation therefrom and are axially spaced therealong. A plurality of disk pairs are axially spaced along the shaft in radial opposition to the corresponding ones of the proximity pickups and are provided, on their oppositely and outwardly facing radial surfaces, with circumferentially extending conductive segments adjacent the disk periphery. Means are provided for circumferentially adjusting the disks of each pair relative to each other for determining the angle shaft rotation through which each disk pair will actuate its associated proximity sensor. The shaft assembly includes one end portion bearing at least one such disk pair which is rotatably adjustable with respect to the rest of the shaft assembly and which may be positively circumferentially locked with respect thereto. The shaft assembly further includes a motion detector disk having a plurality of curcumferentially spaced conductive segments thereon which coact with a further proximity sensor to monitor shaft rotation and synchronism thereof with the machine to be controlled. Triac circuitry driven by respective proximity sensors actuates corresponding control functions of the machine by which the shaft assembly is rotatably driven.

## DETAILED DESCRIPTION

The apparatus **10** (FIG. 1) embodying the invention includes a generally rectangular housing **11.** The housing backwall **12** here carries mounting bosses **13** (FIG. 2) for bearing against a wall **14** of a multifunction machine, such as a press, to be controlled. The housing backwall **12** is normally fixed to the press wall **14** by any convenient means, such as machine screws not shown. In FIG. 1, for convenience, the press **16** is diagrammatically disclosed in substantially reduced size, block form. The housing **12** further includes end walls **18** and **19** and top and bottom walls **21** and **22** which project forwardly from backwall **12.** A cover **23** (FIG. 2) is hinged at **24** on the top wall **21.** A catch **26** on the bottom wall **22** holds the cover closed over the open forward (leftward in FIG. 2) face of the housing **11.**

The housing **11** may be of any convenient construction but is preferrably a metal casting, such as of aluminum. A horizontal shelf **28** extends forwardly from the backwall **12** part way to the front face of the housing and is located substantially centrally between the top and bottom housing walls. The shelf **28** is interrupted intermediate its ends, as shown in FIG. **1,** to allow wired connections to portions of the press not shown, as well as to allow entry of electric power supply lines into the housing **11.**

A rotatable timing shaft assembly **34** (FIGS. **1** and **4**) extends horizontally across the housing **11** between the shelf **28** and bottom wall **22** and through end walls **18** and **19.** The shaft assembly **34** includes a main shaft **36,** which extends the full length of the shaft assembly, and a hollow adjustable shaft **37** (FIG. **4**) telescoped over the leftward end portion of the main shaft **36** as hereafter described.

The main shaft **36** is preferably of cold rolled steel and the hollow adjustable shaft **37** is preferably of bearing bronze.

Bearing units **39** and **40** (FIG. **1**) support the ends of the shaft assembly **34** and, more particularly, opposite end portions of the adjustable shaft **37** and main shaft **36,** respectively. The bearing units **39** and **40** are preferably mirror images of each other and a description of bearing unit **40** (FIG. **3**) will suffice for both. Bearing unit **40** includes a substantially platelike, rectangular retainer **42** snugly received in a forwardly opening, substantially rectangular notch **43** in the forward edge of corresponding housing end wall **19.** Opposed hemicircular depressions **46** and **47** in the opposed ends of the retainer **42** and notch **43** snugly receive a bearing **48,** here a ball bearing. A pair of cap screws **49** secure the retainer **42** in notch **43** to fixedly mount the bearing in the corresponding housing end wall. Thrust rings **51** (FIG. **4**) on the bearings **48** positively prevent axial outward movement of the bearings with respect to the housing walls **18** and **19.**

The main shaft **36** (FIG. **4**) comprises a series of portions distributed axially therealong as follows. The main shaft **36** includes, near the rightward end thereof, a cylindrical journal **53** snugly supported for rotation within the bearing **48.** A reduced diameter driven portion **54** extends rightwardly out of the housing **11** and has a keyway **55.** Immediately inboard of the journal **53** is an enlarged diameter support portion **57** including threaded end parts **58** and **59** and an elongate intermediate part **61** having a keyway, or slot, **62** extending axially therealong. The remaining, leftward portion of main shaft **36** comprises an elongate minimum diameter portion **64** which integrally couples to the support portion **57** through a short, intermediate diameter journal **66.** A nut **60** is secured on the threaded portion **58** of the main shaft and preferably prevented against movement with respect thereto, as by silver soldering or the like. Alternatively, the nut **60** may be integral with the main shaft.

The hollow adjustable shaft **37** is telescoped over the portion **64** and journal **66** of the main shaft and is internally stepped to snugly but rotatably bear on the journal **66** and an intermediate part of the minimum diameter end portion **64** of the main shaft. The hollow adjustable shaft **37** is journalled at **68** in the bearing **48** in radial opposition to the leftward radial bearing contact between the main and hollow shaft. The hollow shaft **37** has a reduced diameter, clutch support end portion **69** extending outboard of the bearing **48,** which has a keyway **71.** The hollow shaft **37** further includes an enlarged diameter support portion **73** which is threaded at **74** adjacent the bearing **48.** A keyway, or slot, **75** in-

termediate the ends of support portion **73** terminates at the rightward end of the hollow shaft **37** in a radially extending, nut-like head **76.** The head **76** axially abuts the leftward end of main shaft support portion **57** and/or the opposed radial face of nut **60.** Such abutment and radial abutment of the threaded portions **59** and **74** with the adjacent bearings **48** holds the shafts **36** and **37** in axially assembled condition.

A releasable, positive clutch unit **79** (FIG. **4**) normally provides a driving connection between the leftward ends of shafts **36** and **37.** The clutch unit **79** includes an adjustment knob **80** axially slideable on the leftward end **69** of main shaft **37** and keyed thereto at **81.** The leftward, outboard face of knob **80** is recessed at **82** for housing an internally toothed ring gear **83,** secured to the knob **80** by axial screws **84.** An externally toothed spur gear **86** is received in recess **82** normally drivingly engages the teeth of ring gear **83.** The spur gear **86** is fixed to the extended leftward end **64** of main shaft **36,** as by a roll pin **87** and/or set screw **88.**

The adjustment knob **80** is normally retained in engaged position, shown in solid lines in FIG. **4,** shown by frictional engagement with the hollow shaft **37,** key means **81** and spur gear **86.** However, if desired, resilient biasing means of any convenient kind can be employed to resiliently urge the adjustment knob **80** leftwardly. The adjustment knob **80** is shiftable rightwardly to the dotted line position **80A** for disengaging spur gear **86** and thereby allowing relative rotational adjustment between hollow shaft **37** and main shaft **36.**

A positive drive connection is established between the main press drive shaft S (FIG. **1**) and the rightward end **54** of main shaft **36,** as by conventional chain drive, schematically indicated at **89,** to a sprocket **90** keyed to the shaft end **54.** The press drive shaft in turn is conventionally driven from a suitable motive power source M, conveniently an AC powered electric motor.

The shaft assembly further includes a plurality of disk units **91** through **97** and **101.** The disk units **91** through **97** are preferably identical and a description of one will suffice for all. Thus, the disk unit **95,** for example, comprises a face-to-face abutting pair of relatively rotatably adjustaable disks **104.** The disks **104** are preferably identical. The disks are of insulative material, here of fiberglass impregnated with a synthetic resin material. Each disk **104** includes a semicircular (here of 180° extent) printed conductive layer **106** spaced from center of such disk and extending to the periphery thereof. The conductive layer **106** is preferably applied by printed circuit board construction techniques. A central opening **107** in each disk enables snug but relatively rotatable reception of the portion **57** of main shaft **36,** or portion **73** of hollow shaft **37,** therethrough. The disks **104** of each pair are normally arranged in back-to-back abutting relation with the conductive portions **106** thereof facing axially outwardly of the pair.

The disks are of each pair are relatively rotatably adjustable to maximize or minimize the circumferential overlap of the conductive portions **106** thereof. Thus, as seen in FIG. **6,** the conductive portion **106** of a disk **104** can be overlapped with the corresponding conductive portion **106A** of its mate. Such overlap can range from a full overlap to a non-overlapped condition, to provide, in the preferred embodiment shown, conductive material in 180° to 360° of the circumference of the disk pair.

The motion detector disk **101** (FIG. **7**) differs from disk units **91** through **97** in that it comprises only a single disk and is provided with a plurality of circumferentially short, spaced conductive layer portions **109.** The motion detection disk **101** is otherwise similar to the disks **104.**

Several disk units, here for example disk units **91** through **95,** are spaced along the support portion **57** of main shaft **36** by intervening hollow cylindrical spacers **112** (FIGS. **1** and **4**). The axial lengths of the spacers **112** is selected to maintain the desired spacing between adjacent disk units. The spacers **112** snugly, but axially slideably, surround the shaft portion **57.** Means (here set screws **113**), secured to each of the spacers **112,** engage in the slot **62** to prevent rotation of the spacer **112** on the shaft, while allowing free axial movement of the spacer on the shaft. Shorter spacer rings **115,** similar to the spacers **112** but without the set screws **113,** are located axially outboard of the end disk pairs **91** and **95.** The spacers **112** and spacer rings **115** are preferably of nylon. A resilient wave washer **117,** a nut **118** and lock nut **119** (FIG. **4**) are provided on the threaded portion **59** of main shaft **36** in that sequence. The wave washer **117** bears against the adjacent spacer ring **115,** the latter preferably overlapping somewhat the threaded shaft part **59.** Upon tightening of nuts **118** and **119,** the resultant assembly of disk units **91** through **95,** spacers **112** and spacer rings **115** is snugly axially pressed together between the wave washed **117** and the nut **60** fixed to the main shaft **36.** Such accurately axially locates the disk pairs on the shaft **36.** Also, frictional engagement between disks of each pair and between the disk pairs and adjacent abutting spacers and/or spacer rings circumferentially fixes the disks of each pair with respect to each other, with respect to the other disk pairs on the main shaft and with respect to the main shaft itself.

The remaining disk pairs **96** and **97** and the motion detector disk **101** are located on the hollow shaft **37** in a similar manner by further and corresponding spacers **112'**, spacer rings **115'**, wave washer **117'**, nut **118'** and lock nut **119'**. Thus, the disk pairs **96** and **97** and motion detector disk **101,** with their corresponding spacers **112'** and rings **115'**, are disposed on the portion **73** of hollow shaft **37** and are snugly sandwiched thereon between the head **76** and the locking assembly comprising washer **117'** and nuts **118'** and **119'**, the nuts threadedly engaging the threaded portion **74** of the hollow shaft. If desired, the motion detector disk **101** may be disposed instead on the main shaft in addition to or in replacement of one of the disk pairs **91** through **95.**

Distributed along the forward edge of the shelf are a plurality of channel or U-shaped pickup mounting brackets, preferably aluminum extrusions, one thereof being indicated at **122** (FIGS. **1, 2** and **5**). The mounting bracket **122** includes a bight wall **124** secured by cap screws **125** to the forward edge of the shelf **28.** The brackets **122** depend from the front shelf edge substantially over the axis of the shaft assembly **34** and in axially centered relation between an adjacent pair of disk units, here disk units **91** and **92.**

A generally U-shaped proximity pickup **127** is carried on the outboard face of each of the forwardly extending legs **129** of the bracket **122** and is secured thereto, for example by screws **130** threadedly engaging the correspopnding leg **129.** The pickups **127** are each centered over a corresponding disk pair and are

provided with a downwardly opening slot **131** (FIG. 1) extending transversely therethrough for loosely and freely rotatably receiving the conductive peripheral portions **106** of the corresponding disk pair in overlapping relation. In the particular embodiment shown, the proximity pickups are the type manufactured by Electronic Counters and Controls, Inc. of Mundelein, Illinois and are arranged to sense the presence or absence of metal in the slot **131** thereof.

When an odd number (three or more) of disk units are provided in close spaced relation (for example disk units **93, 94** and **95,** in FIG. 1) the pickup mounting bracket for the odd disk unit (for example disk unit **93**) may be modified, if desired, to eliminate the unnecessary mounting bracket leg, as for example at **122'**.

The housing **11** includes a pair of longitudinally extending bosses **132** and **133** (FIG. 2) above the shelf **28.** A circuitry mounting plate **134** extends substantially the width of the housing above the shelf **28** and is fixed to the bosses **132** and **133** as by screws **136** (FIGS. 1 and 2). The mounting plate **134** carries a regulated DC power supply **140** at its rightward end and a plurality of paired triac units **142** at its leftward end. In the prefered embodiment shown, the triac units **142** are preferably of the type manufactured by Texas Instruments, Inc. of Dallas, Texas, each unit providing a pair of optically coupled triac circuits as schematically indicated in FIG. **9,** there being one such track circuit **143** for each operating disk pair. In the particular embodiment shown, three paired units **142** provide six triac circuits **143** and such are connected by cabling not shown in the proximity pickups of the disk pairs **92** through **97.** Disk pair **91** is here provided as a spare should additional machine functions require control in any particular instance. Sufficient space is provided on the mounting plate for additional triac units.

The interconnection of the pickups **127,** triac circuits and the power supply **140** is schematically illustrated with respect to one such pickup unit in FIG. **9,** the connections for the remaining pickup units being similar.

The power supply **140** includes a step down transformer **145** driven from the switchable AC source, shown, through a fuse **146.** The secondary winding **147** of the transformer has a grounded center tap **148.** A pair of rectifying diodes **151** and **152** couple the ends of secondary **147** to a conventional filter and regulator circuit **150.** The output of the filter and rectifier circuit **154** is applied to an input of each of the pickups **127.** The DC output of filter-regulator unit **154** may also be used as indicated to provide DC operating potentials for circuitry (FIG. 7) associated with the motion sensing pickup. The output of each pickup **127** is applied to the corresponding triac circuit, here through a conventional optically coupled isolation device **156** and trigger circuit **157,** to the gate of a triac **158.** Each triac, in turn, controls current flow through a corresponding one of plurality of conventional press control solenoids **159,** each associated with a preselected and conventional press, press infeed or press outfeed operating device not shown.

In the embodiment shown, disk pair **92** controls a conventional air blow-off device for blowing scrap workpiece material out of the press dies, disk pair **93** operates a press cut off device controlling outgoing workpiece strip cut off (and hence the length of the completed workpiece) and is also useable to control the height of a stack of finished workpieces. Disk pairs **94** and **95** correspondingly control workpiece infeed.

On the other hand, disk pairs **96** and **97** mounted on the adjustable shaft **37** respectively control the timing of the top stop of the press (stopping of the press with the die open) and the overshoot of the press ram. Both such parameters are variable with speed of operation of the press, as a result of differences in ram momentum at different speeds and in view of the response time for hydraulic valves utilized to provide operating fluid for driving the ram. Reference may be made to U.S. Pat. No. 3 410 130, assigned to the assignee of the present invention for discussion of a press and workpiece feeding means with which the present invention can be used.

As schematically indicated in FIG. **7,** output from the proximity sensors **127** of the motion detection disk **101** is applied to circuitry **162.** Circuitry **162** includes, in series, an amplifier **163** driving an RC threshold network **164.** The output of the latter is applied through a further amplifier **170** to the operating coil **171** of a relay having a contact **172** in the main AC power supply for the press. Threshold circuit **164** includes a resistance **165** coupling amplifiers **163** and **170,** and a parallel capacitor **166** and variable resistor **167** coupling the input of amplifier **170** to power supply ground. Operating potential is supplied the amplifiers **163** and **170** from the filtered and regulated output **154** of supply **140** of FIG. **9,** in any conventional manner not shown. Opening of contact **172** turns off the press when the rotational speed of the shaft assembly **34** falls below a preselected minimum speed, indicating a failure in the positive drive connection between shaft assembly **34** and the press drive shaft.

Basically then, if the shaft assembly **34,** and therewith motion detector disk **101,** are rotatably driven, the corresponding proximity pickup **127** provides a pulsed output, corresponding to passage of the conductive segments **109** thereof through pickup slot **131,** to amplifier **163,** and thence through resistor **165** to charge capacitor **166.** Adjustable resistor **167** provides a constant resistance discharge path for capacitor **166** and, depending on the adjustment thereof, limits the input voltage supplied by capacitor **166** to amplifier **170.** When the speed of shaft assembly **34** is above the threshold established by resistor **167** (e.g. corresponding to a press drive shaft speed minimum between for example **20** to **50** rpm), amplifier **170** drives the relay coil **171** and maintains closed the switch **172** between the AC source and the press AC input, maintaining the press in operation. On the other hand, when the pulse rate from pickup **127** falls below such threshold, the charge on capacitor **166** falls, as does the corresponding output of amplifier **170,** whereupon relay coil **171** is provided insufficient holding current and switch **172** opens, deenergizing the press.

## OPERATION

Considering the assembly of the apparatus **10,** precise adjustment of the length of the shaft assembly, with respect to the width of the housing **11,** can be established by placing the telescoped shafts **36** and **37,** with the bearings **48** in place on the journals **53** and **68,** in the depressions **47** and retaining same therein with the retainers **42** and screws **49.** Thereupon, the jam nut **60** can be threadedly adjusted on the main shaft **36** to provide the desired axial clearance, by contact with the

head **76**, between the shaft portions **59** and **74** and their adjacent bearings **48**. Once the desired end clearance is obtained the shaft assembly can be removed from the housing and the jam nut **60** may be silver soldered in place on main shaft **36**.

Assuming proper prior location and securement of the jam nut **60** on main shaft **36**, assembly of the shaft assembly **34** may proceed as follows. With the hollow shaft **37** telescoped over the leftward, or small diameter end, of the main shaft **36**, with the head **76** abutting the jam nut **60**, the rings **115**, disk pairs **91** through **95** and spacers **112** are assembled on the main shaft **36** in the order shown in FIG. **1**. The set screws **113** are adjusted radially into the slot **62** sufficiently to overlap the sidewall thereof, but not to engage the bottom wall thereof, whereby the spacers **112** are capable of axial but not circumferential movement with respect to the main shaft. Thereafter, the wave washer **117**, nut **118** and lock nut **119** are threaded onto the main shaft portion **59**. The nut **118** is threadedly adjusted to partially compress wave washer **117** and thereby establish a resilient compressive force on the rings, disk pairs and spacers sufficient to hold same circumferentially in place during normal operation. The positioning of nut **118** is locked by lock nut **119**.

In a similar way, rings **115'**, disk pairs **96** and **97**, motion detector disk **101** and spacers **112'** are applied to the hollow shaft **37** and resiliently held against circumferential movement thereon by wave washer **117'** and nut **118'** and **119'**. The bearings **48** are applied to the journals **53** and **68** and the resultant shaft assembly is then conveniently placed in the housing with bearings **48** entering the housing end wall depressions **47** and being retained by the retainers **42** and screws **49**.

At this point, or immediately proceeding the previous step, the clutch unit **79** and drive sprocket **90** may be assembled on the end portions of the shaft assembly. The adjustment knob **80** of the clutch **79** is urged rightwardly (FIG. **4**) over the key **81** on the exposed end of the hollow shaft **37** to its position shown. Thereafter, the spur gear **86** is placed on the extended end **64** of main shaft **36**, with the external teeth thereof meshed with the internal ring gear **83** of the adjustment knob **80**. Set screw **88** and pin **87** are placed to circumferentially and axially lock the spur gear on the shaft end **64**. The drive sprocket **90** is placed on the rightward main shaft end **54**. Preferably, a set screw not shown on the sprocket hub is tightened in engagement with the key on the shaft end **54** to secure the drive sprocket thereto.

The plate **134**, with the triac units **142** and power supply **140** thereon, is secured to the housing by the screws **136**. The pickup brackets **122** and **122'**, with the pickups **127** thereon, are secured to the shelf **28** by the screws **125**, to locate the pickup slots **131** with the disk peripheries substantially centered therein. The resultant assembly can then be mounted by any convenient means, such as screws not shown, on the machine **16** to be controlled.

Triac units **142** and power supply **140** on the plate **134** are preferably prewired to each other and if desired may be prewired to the pickups **127**. Electrical connections to the above components, as seen in FIG. **9**, is lead through the housing opening **31** to the AC supply and to the solenoids **159** mounted in a conventional mannar other locations on the press. Access may be had to the parts shown in FIG. **1** at any time by opening the cover **23**. The cover **23** is normally losed to lessen entry to foreign material into the housing.

In operation, the shaft assembly **34** is positively rotatably driven through the positive chain and sprocket connection **89**, **89'** and **90** from the main press drive shaft S in turn driven by motor M in any conventional manner. A one-to-one drive ratio is preferably maintained between shaft assembly **34** and press main shaft S.

The shaft assembly **34** thus rotates in positive synchronism with the press drive shaft S. As indicated, the press **16** may for example be a punch press of the type disclosed in aforementioned U.S. Pat. No. 3 410 130 and wherein the press drive shaft S controls the operation of a moveable press ram, providing for opening and closing of a motion of opposed punching dies, as well as associated workpiece feed and cut off devices. Indeed, the present invention may be considered an improvement on the aforementioned patent, providing timing control of, for example, step feedin of a workpiece blank to the punch press and cut-off of the punched workpiece.

The particular functions to which the disk pairs **91** through **97** and motion detector disk **101** may be employed, in the context of such a punch presses, has been discussed above and does not require repetition herewith.

One rotation of the shaft assembly **34** will normally correspond, as above indicated, to one complete cycle of the punch press ram. The shaft assembly **34** can be set up to cause performance of a set of press functions in a desired sequence and with desired function duration by appropriate rotational adjustment of the disks on shafts **36** and **37**. More particularly, the amount of circumferential overlap of the conductive portions **106** and **106*a*** (FIG. **6**) of each disk pair determines the duration of a given associated function of the press **16**. Once the duration of a given function has been set by relative rotation of the disks of a corresponding disk pair, rotation of the entire disk pair on the corresponding shaft **36**, **37** determines the time at which the function will start and stop in a given cycle of press operation and relative to other press functions controlled.

Such duration and start-stop time adjustments are carried out by loosening of the nuts **118**, **119** and **118'** and **119'** to lessen the axial pressure, and friction, which normally maintains a given rotational setting of each of the disks with respect to the shaft assembly. The disks and disk pairs are then individually rotatably adjusted. Thereafter, such nuts are again tightened to restore proper frictional engagement.

It is contemplated that, in certain instances, it may be desirable to provide wave washers **117**, **117'** which upon selected tightening of such nuts will maintain circumferential positioning of the disks on the shafts **36** and **37** during normal operation of the apparatus, but wherein such frictional engagement is sufficiently low as to allow a hand circumferential adjustment of the disks and disk pairs on the shafts **36** and **37**, without necessity for loosening nuts **118**, **118'**.

Circumferential adjustment on a disk or disk pair on the shaft does not disturb the existing circumferential location of adjacent disk pairs, because the intervening spacers **112** are prevented from circumferential movement by engagement of the set screws **113** with corresponding slots in the shafts **36** and **37**.

In some instances variation of operating conditions of the machine being controlled will require adjustment of timing of one set of functions with respect to timing of another set of functions. Thus, in the apparatus shown, a change of press speed will vary the press ram conditions controllable by disk pairs **96** and **97**, with respect to workpiece handling functions controlled by other disk pairs. Thus, upon such a change of speed on the press, the operator can, be rightward movement of the adjustment knob **80** to disengage the clutch **79**, effect rotational adjustment of hollow shaft **37** with respect to main shaft **36**, and thereby effect simultaneous circumferential adjustment of disk pairs **96** and **97** with respect to the remaining disk pairs mounted on main shaft **36**. With the required adjustment made, the adjustment knob **80** is returned leftwardly to engage the spur gear, and lock in the adjustment.

The operation of the circuitry of FIGS. **7** and **9** has been discussed above and does not require repetition at this point.

Although a preferred embodiment of the invention has been disclosed in detail for illustrative purposes, it will be recognized that variations and modifications of the disclosed apparatus, including the rearrangement of parts, lie within the scope of the present invention.

The embodiments of the invention in which an exclusive property or privilige is claimed are defined as follows:

**1.** Control switch apparatus for a multifunction machine, comprising in combination:

means defining a housing mountable on the machine to be controlled;

rotatably driveable shaft means rotatably supported on said housing;

disk means including a plurality of disk pairs on said shaft means, said disk pairs each including similar relatively circumferentially adjustable first and second slim waferlike disks of insulative material, each said disk having a coaxial flat semicircular layer of electrically conducting material on one radial face thereof and adjacent and within the periphery thereof, the total circumferential extent of such layers corresponding to their electrically effective extent and being variable by relative rotation of said disks;

proximity pickup means axially and noncontactingly adjacent the rotational path of said layers of a disk pair for sensing the total circumferential extent of said disk pair occupied by both overlapping and non-overlapping portions of said layers opposed to said pickup means;

spacer means on said shaft means and disposed between said disk pairs for determining the axial location of said disk pairs on said shaft means and frictionally preventing unintended circumferential displacement of said disks with respect to said shaft means.

**2.** The apparatus of claim **1** in which said pickup means comprises a plurality of proximity pickups supported on said housing in aligned relation with said shaft means, each of said pickups having a slotted sensing portion actuable by electrically conductive material and through which the peripheral portion of the adjacent disk pair is freely but closely rotatable, said first and second disks having opposed radial friction faces in face-to-face contact out to the disk-pair periphery, one said flat semicircular layer being provided on the outer radial face of each said disk of said pair, said layers being of similar circumferential extent and arranged in non-interfering relation with said friction contact faces of said disks.

**3.** The apparatus of claim **2** in which the disks are of resin impregnated fiberglass and the conductive layer is a printed circuit-type layer.

**4.** The apparatus of claim **1** in which said shaft means includes a main shaft and a hollow shaft telescoped on a portion of said main shaft and clutchable thereto, bearings spaced on said housing and engaged by spaced journals on said main and hollow shafts respectively, abutting radially extending members respectively located on the interior end of said hollow shaft and intermediate the ends of said main shaft, axially adjustable compression means on each of said main and hollow shafts adjacent respective ones of said bearings, said spacer means comprising a plurality of spacers disposed in alternating fashion with the disk pairs of said first and second sets of said main and hollow shafts, and axially pressed between the corresponding radially extending means and axially adjustable means on said shafts.

**5.** The apparatus of claim **4** in which said housing includes a shelf extending transversely thereacross in parallel relation with said shaft means and radially spaced therefrom, a plurality of brackets dependently mounted from a longitudinal edge of said shelf and in substantially radial planes of the shaft, pickup means on said brackets, each such pickup means being adapted to straddle one of said disk pairs for sensing orbiting of an electrically conductive portion of said disk pair therepast.

**6.** The apparatus of claim **5** in which said brackets include a bight wall extending along said shelf edge toward the axis of said shaft means and a leg extending from said shelf edge over the axis of said shaft means, said pickup being removably mounted on said leg and having a sensing slot for receiving the correspondding disk pair periphery looseley therein.

**7.** The apparatus of claim **1** in which said spacer means and disks are axially movable on said shaft means and including axially spaced abutment means at least fixable on said shaft means with a set of disk pairs and spacer means disposed in series therebetween, and resilient axial bias means on said shaft means axially inboard of said abutment means for applying a resilient axial compressive force on said disk pairs and spacer means of magnitude preventing unintended disk rotation with respect to said shaft while permitting manual circumferential adjustment of individual disks or disk pairs on said shaft without loosening said abutment means.

**8.** The apparatus of claim **7** in which said shaft means comprises at least one shaft member having an axial slot and said spacer means comprises a hollow spacer between and frictionally interengageable with adjacent flanking disk pairs, said spacer including inwardly extending means circumferentially locked but axially movable in said slot of said shaft member for preventing unintended rotation of one said disk upon circumferential adjustment of a disk of the adjacent disk pair.

**9.** The apparatus of claim **7** in which said resilient bias means comprises an axially compressible spring and at least one said abutment means comprises a nut axially threadedly adjustable on said shaft means for

setting the precompression of said spring and means actuable for locking said nut on said shaft means.

**10.** The apparatus of claim **1** in which said shaft means comprises a first shaft extending the length of said shaft means and an adjustable hollow shaft snugly telescoped on one end portion of said first shaft and including bearings spaced on said housing for engaging a respective journal on each of said first and hollow shafts, axially abutting means on said first and hollow shafts for positively limiting further inward axial movement of said hollow shaft on said first shaft and incorporating a nut axially threadedly adjustable on one said shaft and axially engageable means fixed on the other shaft for precisely adjusting the spacing of said journals to conform to the bearing spacing.

**11.** Control switch apparatus for a multifunction machine, comprising in combination:

means defining a housing mountable on the machine to be controlled;

rotatably driveable shaft means rotatably supported on said housing;

disk means including a plurality of disk pairs on said shaft means, said disk pairs each including similar first and second waferlike disks of insulative material, each said disk having a coaxial semicircular layer of electrically conducting material on one radial face thereof and adjacent the periphery thereof;

spacer means on said shaft means and disposed between said disk pairs for determining the axial location of said disk pairs on said shaft means and frictionally preventing circumferential displacement of said disks with respect to said shaft means;

said spacer means comprising hollow cylindrical spacers snugly received on and slideable axially on said shaft means, and including means preventing circumferential movement of at least selected ones of said spacers on said shaft means and further including axially adjustable compression means for releasably sandwiching together an alternating series of disk pairs and spacers on said shaft means with sufficient force as to prevent unintended relative rotation of said disks and shaft means, and preventing unintended circumferential shifting of adjacent disks, but allowing circumferential adjustment of said disks with respect to each other, with respect to adjacent disk pairs and with respect to said shaft means.

**12.** Control switch apparatus for a multifunction machine, comprising in combination:

means defining a housing mountable on the machine to be controlled;

rotatably driveable shaft means rotatably supported on said housing;

disk means including a plurality of disk pairs on said shaft means, said disk pairs each including similar first and second waferlike disks of insulative material, each said disk having a coaxial semicircular layer of electrically conducting material on one radial face thereof and adjacent the periphery thereof;

spacer means on said shaft means and disposed between said disk pairs for determining the axial location of said disk pairs on said shaft means and frictionally preventing circumferential displacement of said disks with respect to said shaft means;

said disk means further including a detection disk having a plurality of uniform and uniformly spaced conductive segments on a radial face thereof and adjacent the periphery thereof, said detection disk being carried by said shaft means for rotation therewith, pickup means fixedly mounted on the housing in overlapped close relation with the orbit of said conductive segments and responsive to rotation of said segments therepast for producing a pulsed output corresponding to the actual speed of the shaft means, means determining an adjustable speed threshold and means responsive to said pulsed output and threshold for dicontinuing energization of said machine when the rotational speed of said shaft means falls below the expected minimum speed of said machine, represented by the threshold.

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