Jan. 25, 1966 J. GREENHUT 3,231,695

SPEED RESPONSIVE SAFETY CONTROL

Filed April 4, 1962 3 Sheets-Sheet 1

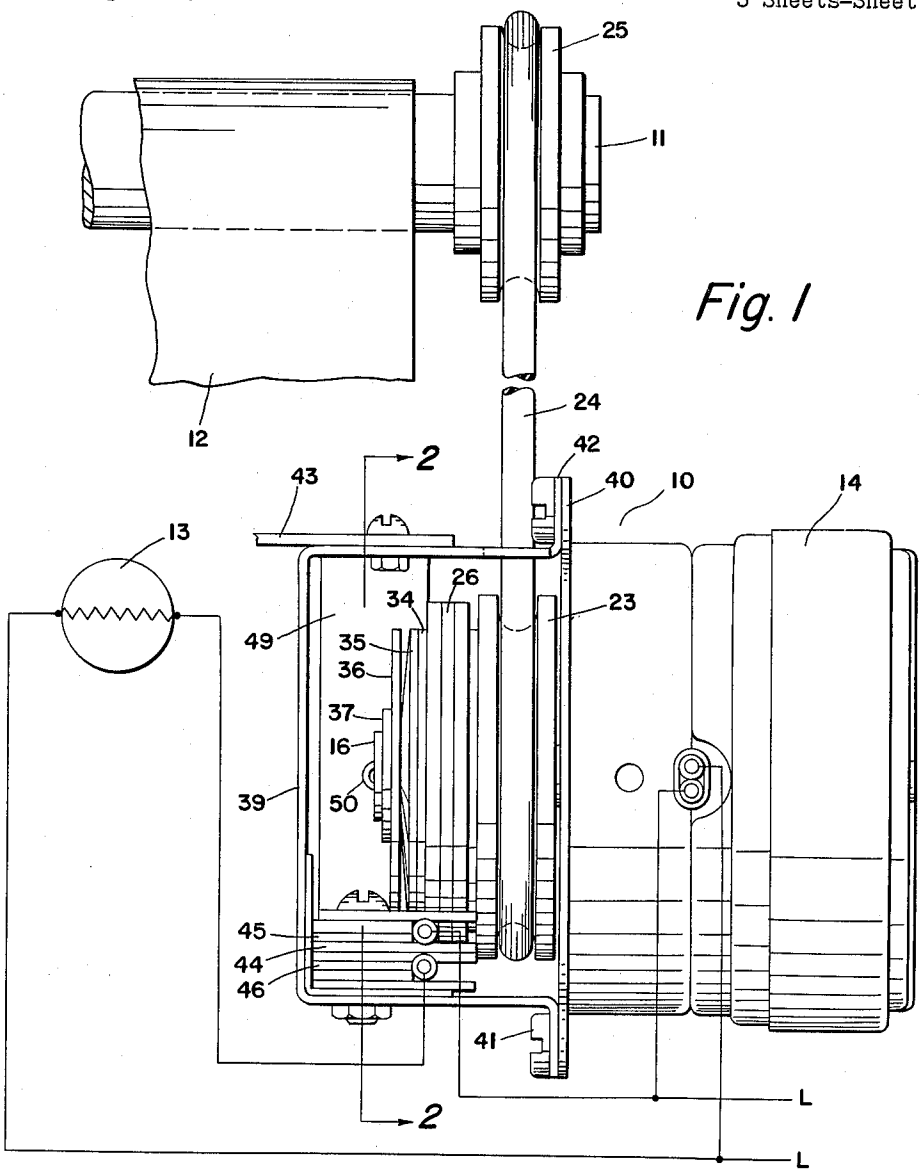


Fig. 1

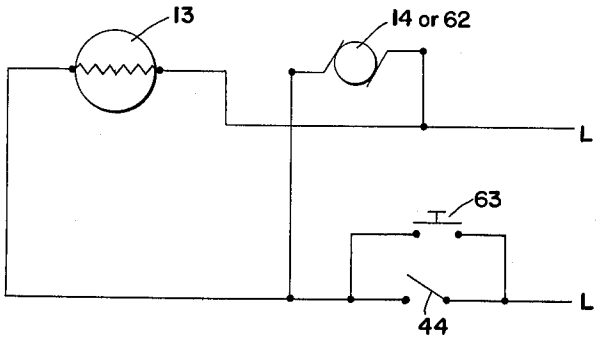


Fig. 7

INVENTOR.
JOSEPH GREENHUT
BY Isler & Silverstein
ATTORNEYS

Jan. 25, 1966 J. GREENHUT 3,231,695

SPEED RESPONSIVE SAFETY CONTROL

Filed April 4, 1962 3 Sheets-Sheet 2

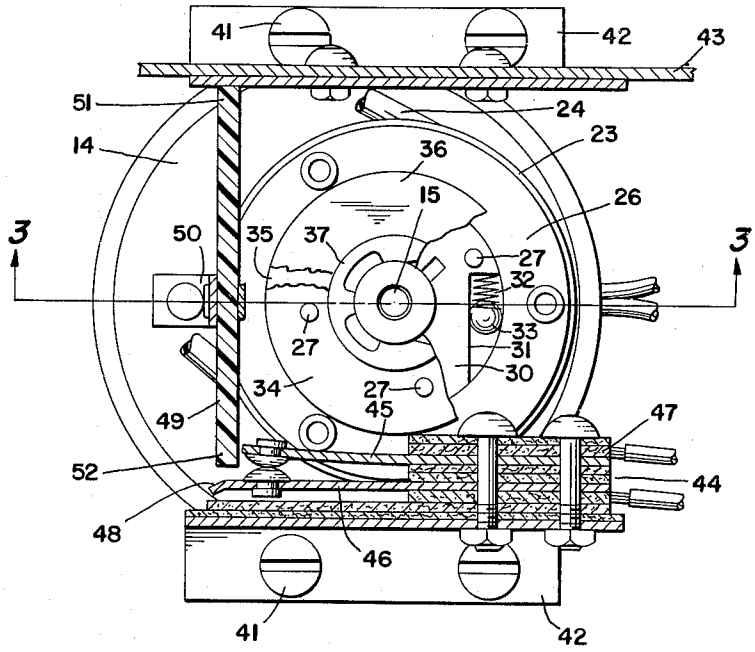


Fig. 2

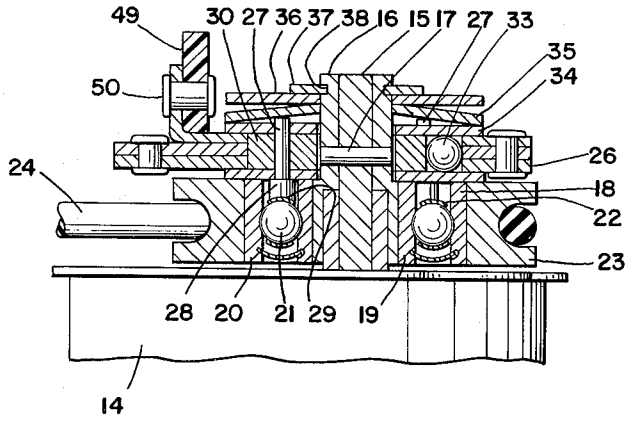


Fig. 3

INVENTOR.
JOSEPH GREENHUT
BY Isler & Ornstein
ATTORNEYS

Jan. 25, 1966 J. GREENHUT 3,231,695

SPEED RESPONSIVE SAFETY CONTROL

Filed April 4, 1962 3 Sheets-Sheet 3

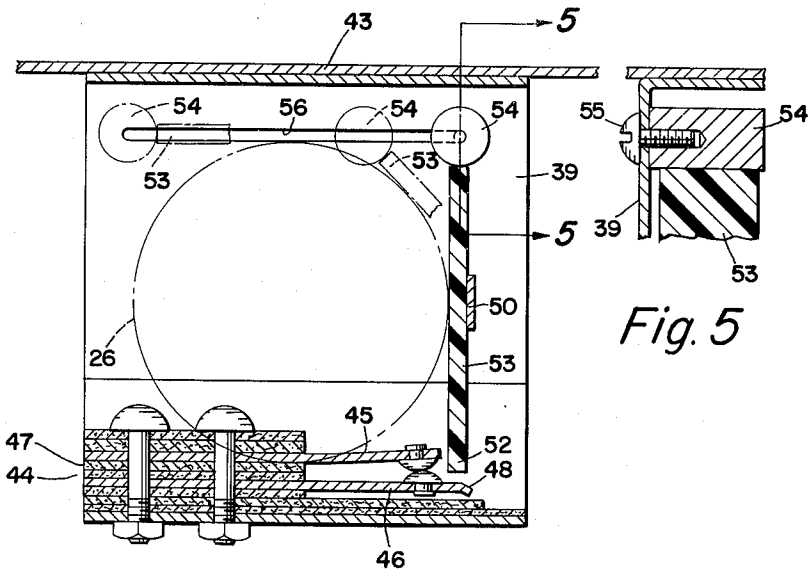


Fig. 5

Fig. 4

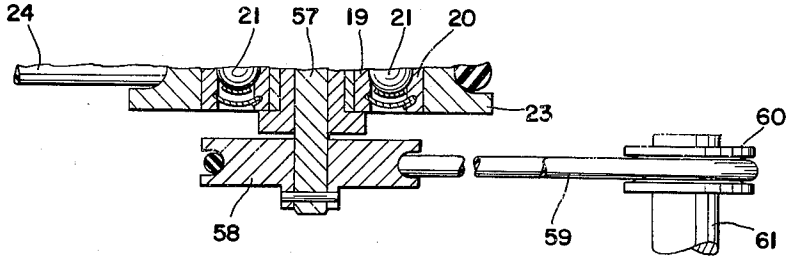


Fig. 6

INVENTOR.
JOSEPH GREENHUT
BY
Isler & Silverstein
ATTORNEYS

United States Patent Office 3,231,695 Patented Jan. 25, 1966

3,231,695

SPEED RESPONSIVE SAFETY CONTROL

Joseph Greenhut, 2564 Saybrook Road, University Heights, Ohio

Filed Apr. 4, 1962, Ser. No. 185,120
3 Claims. (Cl. 200—61.39)

The present invention relates to a safety control device adapted to be utilized with other apparatus to safeguard such apparatus, or the material being processed thereby, from injury due to a malfunction in the apparatus, which is reflected in an abnormal variation in the speed of a rotating member. The control device may actuate a visual or audible signal or alarm or some form of record keeping device, or it may de-energize the malfunctioning apparatus or a portion thereof, or it may exercise all or a combination of such functions in safeguarding the apparatus or the material processed thereby.

Thermo-sensitive reproduction equipment for the reproduction of paper copies is illustrative of the type of apparatus to which my invention is applicable. In such equipment, the original sheet (which is to be reproduced) is maintained in contact with a sheet of heat sensitive copy paper and conveyed by a web or feed belt past a heat lamp or other suitable source of heat. The speed of the belt determines the intensity of the reproduction, as it establishes the length of time that the thermo-sensitive copy paper is exposed to the heat. Customarily, regulating means are provided for adjusting the speed of the belt within limits so that the user can select the desired speed within the available range. The feed belt is driven by an electrical motor through a suitable combination of drive shaft and idler rolls. One of the problems encountered in such reproduction equipment, is slippage of the feed belt with respect to its drive shaft. This condition may arise from various causes, but most often occurs after a considerable period of use during which the belt and the drive shaft have become dirty or covered with a thin film of oil. When such slippage occurs, it may expose the papers, as well as the belt itself, to the heat source for an unduly long period of time, thus creating the possibility of injury to the papers or the belt or both, and the attendant danger of fire.

It is a primary object of my invention to provide a safety control for sensing the above-described malfunction in such apparatus.

Another object of my invention, is to provide a safety control of the character described, which will cause the heat source to become inoperative when the hazardous condition occurs.

A further object of my invention is to provide a safety device of the character described, in which the rapidity of its response to the malfunction is determined by the degree of severity of the malfunction.

Another object of my invention is to provide a safety device of the character described, in which means are provided for selectively varying the lag period or response time of the device.

Other objects and advantages of my invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification, and in which like numerals are employed to designate like parts throughout the same,

FIG. 1 is a plan-view of a safety control device embodying the features of my invention, associated with a portion of the apparatus which is to be monitored by the safety control device;

FIG. 2 is a cross-sectional view taken as indicated on line 2—2 of FIG. 1, portions thereof being broken away to show certain details;

FIG. 3 is a cross-sectional view taken as indicated on line 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view, taken in a direction opposite to that of FIG. 2, and showing a modified form of the invention;

FIG. 5 is a fragmentary sectional view taken as indicated on line 5—5 of FIG. 4;

FIG. 6 is a fragmentary sectional view similar to FIG. 3, but showing a further modified form of the invention, and

FIG. 7 is a view showing a modified form of circuit diagram.

Referring more particularly to FIGS. 1–3 of the drawings, I have shown a safety control device **10**, embodying the features of my invention, associated with the idler roll **11** of a motor-driven feed belt **12**, which is part of a reproduction apparatus of the general character previously described. An electrically energized source of heat, such as the heat lamp **13** indicated schematically in FIG. 1, is disposed in proximity to the feed belt **12**, so that papers carried by the feed belt will be exposed to the heat source.

The device **10** includes a synchronous motor **14** which, through its low speed shaft **15**, provides a constant reference speed for the operation of the control device. The motor shaft, in turn, is affixed to a hub **16** by a pin **17** which extends through the hub and the shaft. Mounted on the hub **16** is a planetary reduction assembly **18**, which, as here shown, consists of a conventional ball bearing having an inner race **19**, which is fixedly secured to the hub, and an outer race **20**, and a plurality of balls **21**, carried in a ball cage **22**. A pulley **23** is fixedly secured to the outer ball race **20** for rotation therewith. By means of a belt **24**, the pulley **23** is connected to a pulley **25** on the idler shaft **11**, thus interconnecting the two pulleys for simultaneous rotation. It will be understood that other suitable means could be employed for physically interconnecting the pulley **23** for rotation with the idler shaft **11**.

An actuating member, here shown as an angular disc or ring **26**, is journalled on the hub **16** for relative rotation thereto. The actuating member **26** is mechanically coupled to the ball cage **22** by means of a inter-engaging pins **27** whose head portions **28** are accommodated in the recesses or sockets **29** which are conventionally provided in the ball cage **22** in the spaces between the balls. For economy of manufacture, the actuating ring **26** is illustrated as being made of laminated stampings. However, this is merely a preferred form, and it is to be understood that the ring **26** may be provided by any suitable manufacturing process.

In some applications of the safety control device, the pins **27** are affixed directly to the actuating ring **26**. However, in the present embodiment, I have shown the clutching arrangement interposed between the carrier for the pins and the ring itself. To provide this clutching action, the pins **27** are mounted to a carrier disc **30** which is rotatably mounted within the ring member **26**. A peripheral portion of the disc **30** is cut away to provide a recess **31** which accommodates a spring **32** and a ball **33**, thus providing a unidirectional ball clutch assembly of the type well known in the art. By means of the ball clutch the actuating ring **26** is coupled for rotation with the carrier disc **30** when the carrier disc rotates in one direction. However, in response to rotation of the carrier disc in the opposite direction, the actuating ring is free to slip with respect thereto. A dust shield **34** is mounted adjacent to the carrier disc and actuating ring.

The entire assembly is held in place by means of a spring or bellville washer **35**, a flat washer **36** and a retaining clip **37** which is received in an angular groove **38** provided adjacent to the end of the hub **16**.

A U-shaped cover **39** is provided for the assembly and is atached to a mounting plate **40** on the motor **14** by means of screws **41** extending through the flanged portions **42**. The cover **39** may also serve as a bracket for the purpose of mounting a safety device **10** to a support portion **43** of the apparatus. Mounted within the cover **39**, is an electrical switch assembly **44**, which includes two contact carrying arms **45** and **46** which are suitably insulated from each other by an insulation pack **47**. The contact arm **46**, which is disposed most closely adjacent to the wall of the cover **39**, has an extending portion **48** which projects beyond the length of the contact arm **45**. The contact arm **46** is made of spring material so as to maintain the contacts in normally closed position.

The projection **48** on the contact arm **46** is disposed in the path of movement of an actuating arm **49** which is affixed to the actuating ring **26**, as at **50**, for concurrent movement therewith. The range of movement of the actuating arm **49** is limited by its abutment with the wall of the cover **39** at one end and by its abutment with the projection **48** at its other end. By predetermining the length of the actuating arm **49**, the maximum range of arcuate movement of the actuating arm can be maintained to a desired degree.

The normally closed switch assembly **44** is disposed in the circuit to the heat lamp **13**, as schematically indicated in FIG. 1. It will be apparent that the opening of the switch assembly, will cause the circuit to the heat lamp to be interrupted or opened.

In the operation of the safety control device, the synchronous motor **14** maintains a constant speed, for example, 30 r.p.m. at the motor shaft. This rotation of the motor shaft **15** is transmitted through the hub **16** to the inner race **19** of the planetary assembly **18**. For purposes of example, it may be assumed that the reproduction equipment, which is to be controlled, has a variable speed range which is reflected in the rotation of the idler shaft **11** at 20–30 r.p.m. If, for any reason, the movement of the feed belt **12** should be decreased to a speed which is significantly less than the established operating range of the equipment, a hazardous condition can exist. As previously mentioned, when the feed belt **12** travels too slowly, it is exposed for too long a period of time to the intense heat of the heat source **13**. This can cause injury to the belt itself, as well to the papers carried by the feed belt. Under some conditions, the speed of the belt may be reduced sufficiently to create a definite fire hazard.

In order to detect this type of malfunction in such reproduction equipment and to obviate the hazardous condition which may result therefrom, the safety control device **10** is designed to open the circuit to the heat lamp when the speed of the idler roll **11** drops significantly below 20 r.p.m., for example when it reaches 17 r.p.m. If the shaft **15** of the synchronous motor is rotating in a counter-clockwise direction and the pulley **23** is maintained stationary, it is characteristic of the planetary ball bearing assembly **18** that the balls **21** and the ball cage **22** will tend to move in a counter-clockwise orbit. However, if pulley **23** and the outer race **20** of the assembly are rotated in a clockwise direction, the orbital movement of the ball cage in the counter-clockwise direction is diminished and, at sufficiently high speeds of rotation of the pulley **23**, is completely off-set and may even result in orbital rotation of the ball cage **22** in a clockwise direction. In the illustration given, the ratio between the pulleys **23** and **25** is so established that, when the pulley **25** on idler roll **11** is rotating at just above 17 r.p.m., the transmitted rotative speed of the pulley **23** is just sufficient to overcome the counter-clockwise orbital movement of the ball cage **22** and thus maintain the balls and the ball cage in a position where no orbital rotation thereof occurs. This rotative speed of the pulleys **23** and **25** may be termed a critical speed or equilibrium speed because of the rotative forces impressed upon the balls and the ball cage by the inner race **19** and the outer race **20** of the planetary assembly are such that the ball cage assembly is maintained in a condition of orbital equilibrium.

If the speed of the idler roll **11** should gradually and slowly drop below the critical or equilibrium speed, the ball cage assembly will slowly and gradually commence to have orbital rotation in a counter-clockwise direction. If the speed of the idler shaft **11** should drop suddenly, then the ball cage assembly will rotate much more rapidly in a counter-clockwise orbital movement. If, on the other hand, the speed of the idler shaft **11** is greater than the critical speed, then the ball cage assembly will be caused to rotate in a clockwise orbital movement. The speed of such orbital movement will be proportional to the speed of the idler roll **11**, as translated to the pulley **23**.

By means of the pins **27**, any orbital movement of the ball cage **22** is transmitted into concurrent rotative movement of the carrier disc **30**. By reason of the ball clutch assembly, such rotation of the carrier disc in a counter-clockwise direction will be immediately transmitted to the actuating ring **26**. However, if the rotation of the carrier disc **30** is in the opposite, clockwise direction, the actuating ring **26** can be maintained against corresponding rotative movement.

The operation of the device will now be described. If the feed belt **12** is travelling at a speed within the expected and established range, the idler roll **11** and its associated pulley **25** will be rotating at a speed between 20 and 30 r.p.m. This rotation will be transmitted through the belt **24** to the pulley **23** on the safety control device and will result, in the manner previously described, in the orbital rotation of the ball cage **22** and the carrier disc **30** in a clockwise direction of movement. During this rotation, the actuating ring **26** will be urged in a like direction of rotation, but will be restrained against further rotation in such direction as soon as the upper end **51** of the actuating arm **49** abuts the adjacent wall of the cover **39**. When the actuating arm is in this position, its lower end **52** is not in contact with the contact arm **46**, but is disposed closely adjacent to the projection **48** on that contact arm. The contact arms **45** and **46** are in their normally closed position of engagement and the switch assembly **44** completes the circuit to the heat lamp **13**. However, if for any reason, the speed of the feed belt **12** should be impeded or its movement should be momentarily arrested completely, so that the rotation of the idler roll **11** drops below the critical or equilibrium speed, this will be immediately reflected in counter-clockwise rotation of the actuating ring **26** which will cause the end **52** of the actuating arm **49** to move into engagement with the projection **48** which is disposed in the path of counter-clockwise movement of the actuating arm. This engagement will cause the contact arms **45** and **46** to become separated and thereby open the electrical circuit to the heat lamp **13**. The movement of the actuating ring and its actuating arm **49** will be arrested as soon as the movement of the contact arm **46** is arrested by abutment adjacent to the cover **39**. When the range of arcuate movement of the switch actuating element **49** is extremely limited, as illustrated in the present instance, then the switch operating response of the safety control device **10** to the malfunction or under-speed condition is substantially instantaneous. The restraint on further movement of the actuating ring and the actuating arm creates an overload condition on the synchronous reference motor **14** which causes it to stall. In this particular application of the safety control device, it is desirable that the operation of the drive motor of the reproduction apparatus not be interrupted, as continued movement of the feed belt **12**, even at subnormal speed, can prevent injury resulting from the residual heat which is still existent even after the heat lamp is shut off.

The operator of the reproduction apparatus will immediately observe that the heat lamp has been extinguished, and will have to take appropriate steps to remedy the malfunction which resulted in the underspeed condition of the feed belt **12**. As soon as the malfunction has been remedied, the feed belt **12** will be operating at its established speed. Thereby the actuating ring **26** and the arm **49** will be relieved of the counter-clockwise rotative force and will be urged by the spring pressure of the contact arm **46**, as well as by the slight frictional force of the rotating carrier disc **30**, which should be rotating in a counter-clockwise direction, to its position where the upper end **51** of the actuating arm again abuts the cover **39**. The switch assembly **44** will again assume its normally closed position and the circuit to the heat lamp **13** will again be completed, permitting normal operation of the apparatus.

It is to be noted that the utilization of the ball clutch assembly **32–33** permits the safety control device to be responsive only to the underspeed condition of malfunction. It will be apparent however, that under the same conditions of rotation that have been described, the safety control device **10** can be made responsive to an overspeed condition only by reversing the direction of engagement of the ball clutch and disposing the switch assembly **44** so that it is engaged by the upper end **51** of the actuating arm **49** instead of the lower end **52** thereof. In other words, the principal of the operation of the safety control device is applicable to either underspeed or overspeed response.

If the malfunction or underspeed condition is of a momentary character only, which is cured without any required attention from the operator of the apparatus, then the switch assembly **44** will automatically reset itself and restore the heat lamp circuit as soon as the idler shaft **11** has been restored to normal operating speed. There may even be applications of the safety control device, where it is not desirable that the operation of the apparatus be interrupted if the malfunction is only momentary. By shortening the length of the actuating arm **49** or otherwise enlarging the arcuate range of movement of the switch actuating element **49**, the response of the safety control device **10** can be delayed so that momentary malfunction conditions will not induce sufficient movement of the switch actuating element **49** to cause it to engage and open the switch assembly **44**. However, if the malfunction is more than momentary, the switch actuating member **49** will persist in its switch opening movement and thus interrupt the electrical circuit in the manner previously described. However, the extent of movement of the actuating element **49** is only one factor in determining the speed of response of the safety control device **10**. Another factor is the rate or speed at which the actuating element is moved. This factor is determined by the severity of the malfunction rather than by its duration. Thus, even if the actuating element **49** has a sufficient extent of movement so as to create a two second time lag in the response of the safety control device when the speed of the idler roll **11** is reduced ten percent below the critical speed, the response of the safety control device may, nevertheless, be substantially instantaneous when the speed of the idler roll is suddenly reduced to, for example, 60% of the critical speed. The safety control device is therefore characterized by the capability of having a very rapid, substantially instantaneous, response to a severe condition of malfunction, while providing a predetermined time lag or time delay to a minimal or less aggravated condition of malfunction.

Although the rapidity of response of the safety control device can be established in the design of the device, under some circumstances it may be desirable to have an adjustable time delay or response arrangement. In FIGS. 4 and 5 of the drawings, I have shown a modified form of the safety control device in which such

adjustability of the response is provided. In the modified form, the actuating arm **53** is made somewhat shorter than the previously actuating arm **49**. A cylindrical abutment **54** is secured to the cover **39** by means of a screw **55** which extends through a slot **56** provided in the cover. When the screw is released, the cylindrical abutment **54** can be moved along the slot to various selected positions and then secured in the selected position. The variation in the location of the cylindrical abutment will determine the permissible range of arcuate movement of the actuating arm **53**. If the cylindrical abutment is in the solid line position shown in FIG. 4, the degree of movement of the actuating arm **53** will be severely limited and the response of the safety control device will be substantially instantaneous, as it was in the form shown in FIG. 1. If, however, the abutment **54** is relocated by moving it along the slot **56** to one of the positions shown in phantom outline in FIG. 4, then the actuating arm **53** will have a greater degree of movement thus creating a time lag in the response of the safety control device to an underspeed condition. By using this modified form of the safety control device, the desired time lag or response period of the device need not be predetermined, but can be established at the point of application of the safety control device and can be determined empirically.

In FIG. 6, I have shown another modified form of the safety control device in which the reference speed synchronous motor **14** has been eliminated and, in lieu thereof, the constant speed shaft **57** of the safety control device is connected through pulley **58**, belt **59** and pulley **60**, to the shaft **61** of the electric motor (not shown) which drives the reproduction apparatus. The drive motor itself thus serves as the reference speed for the safety control device. It will be understood, that by selecting a proper ratio between the pulley **58** and the pulley **60**, the desired speed at the shaft **57** can be obtained. In other respects, the safety control device operates in the manner previously described. However, inasmuch as the drive motor for the apparatus may be considerably more powerful than the synchronous motor **14** which has been previously described, it may not be feasible to stall the drive motor when the safety control device operates to open the switch assembly **44**. Therefore, as shown in the schematic wearing diagram of FIG. 7, the circuit may be so arranged that the opening of the switch **44** will open the circuit to both the heat lamp **13** and the drive motor **62**. Such a circuit will prevent any stalling or overloading of the motor **62**. Such a circuit may likewise be used when the synchronous motor **14** is employed. This circuit does not automatically reset itself as is the case in the circuit shown in FIG. 1. After the malfunction has been remedied, the circuit is reestablished by means of the reset switch **63** which establishes a shut circuit until such time as the switch **44** closes.

Although the safety control device has been described as opening a normally closed switch, it will be readily apparent that the principle of operation of the device can be applied equally to a normally open switch by simply reversing the positions of the contact arms **45** and **46**. It will also be understood that I have described a simple form of single pole single throw switch **44**, but that my invention is not limited to the use of such a switch but contemplates also the use of multiple pole multiple throw switch arrangements where such switches are considered necessary or desirable.

Although I have referred to the shaft **61** as being the motor drive shaft, it will be understood that such shaft could be any shaft directly associated with the drive motor **62**.

It is to be understood that the forms of my invention, herewith shown and described, are to be taken as preferred examples of the same, and that various changes may be made in the shape, size and arrangement of the parts thereof, without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. A speed-responsive safety control comprising: a driven rotary element whose speed variation is to be sensed, a rotary reference speed element correlated to the desired speed range of the driven rotary element, a planetary reduction mechanism interconnecting said elements in speed sensing relationship, a constant speed synchronous electrical motor, independent of said driven element, driving said reference speed element, said motor being characterized by the ability to be stalled under overload without injury to said motor or to said elements and mechanism, a clutch mechanism responsive solely to rotation in one direction, a switch-actuating element operatively connected to said planetary mechanism through said clutch mechanism for positive rotary actuating movement in said one direction responsive to a differential speed relationship between said driven element and said reference speed element, and means disposed in the path of said movement of said switch-actuating element for overloading said motor and arresting differential-speed responsive movement of said actuating element after said actuating element has traversed a selected angularity of rotary movement to a switch-actuating position.

2. A speed-responsive safety control as defined in claim 1, including spring means yieldably opposing said movement of said actuating element into switch-actuating position.

3. In a speed-responsive safety control the combination of a driven rotary element whose speed variation is to be sensed, a rotary reference speed element correlated to the desired speed range of the driven rotary element, a planetary reduction mechanism interconnecting said elements in speed sensing relationship, a switch-actuating element operatively connected to said planetary mechanism for arcuate switch-actuating movement responsive to a differential speed relationship between said driven element and said reference speed element, a pair of spaced abutments disposed in the path of movement of said switch-actuating element and limiting the arcuate travel thereof, means mounting at least one of said abutments for selective movement relatively to the other of said abutments to adjustably vary the limits of arcuate movement of said switch-actuating element.

References Cited by the Examiner

UNITED STATES PATENTS

2,046,283	6/1936	Berlyn	192—150
2,723,686	11/1955	Durash	139—336
2,753,969	7/1956	Chung	192—150
2,782,902	2/1957	Sloane	198—203
2,843,691	7/1958	Champion et al.	200—61.46
2,901,076	8/1959	Dean	192—150

KATHLEEN H. CLAFFY, *Primary Examiner.*

ORIS L. RADER, ROBERT K. SCHAEFER, *Examiners.*