

[54] HARDNESS TESTING MACHINE

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[52] U.S. Cl. 209/74, 73/79, 209/74

[51] Int. Cl. B07c 5/00

[58] Field of Search 73/79; 209/79, 73, 74

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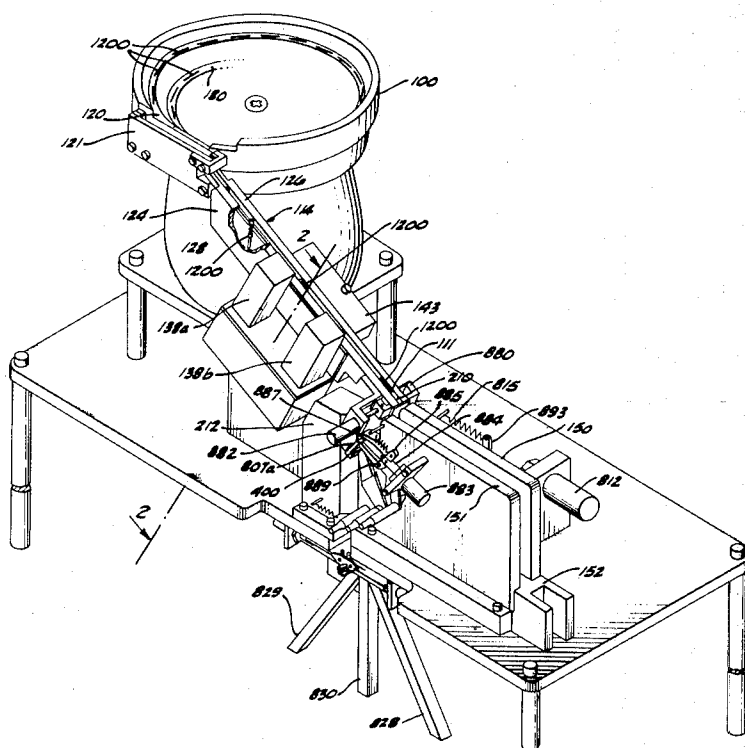
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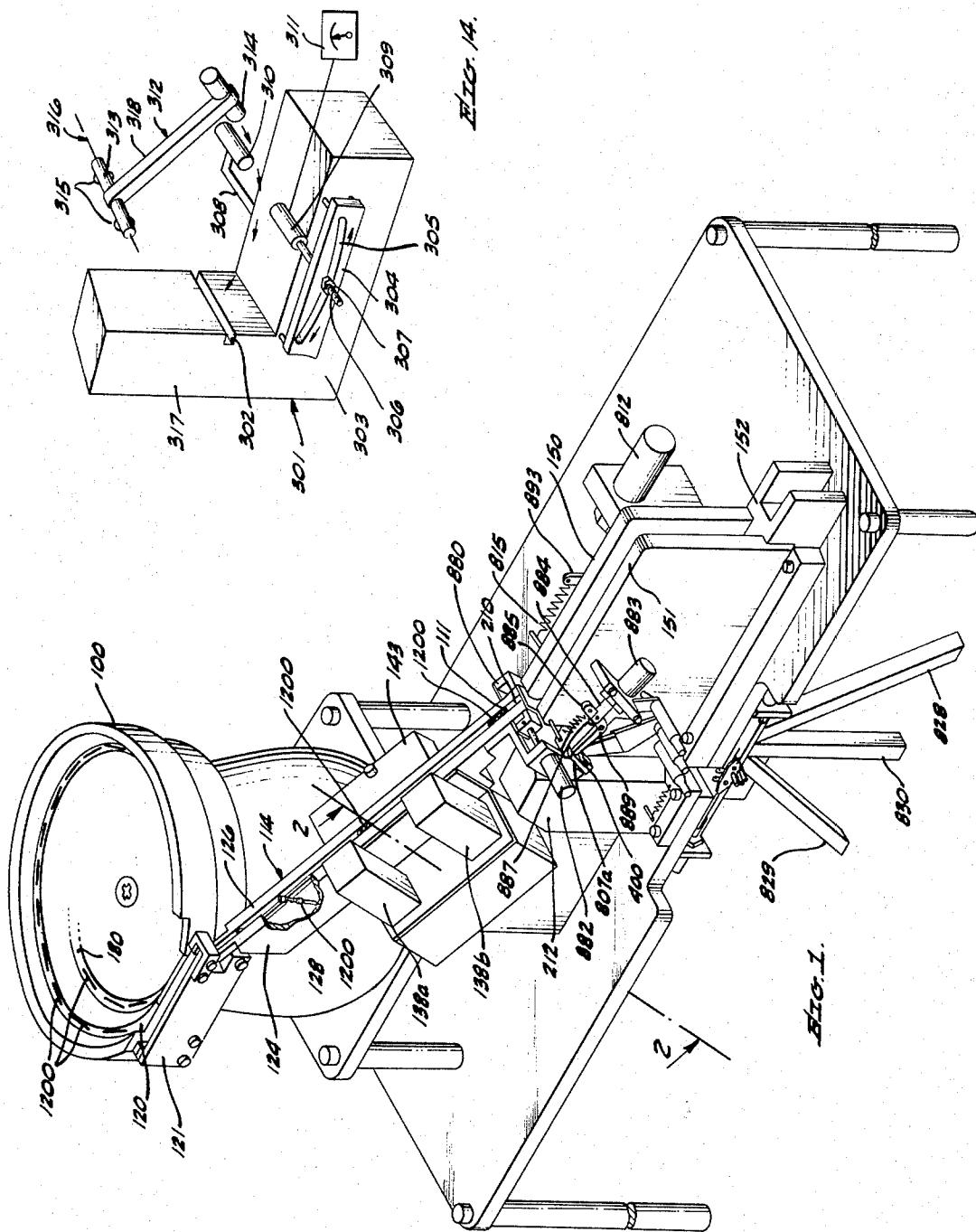
[57] ABSTRACT

A machine and method for non-destructive testing of the

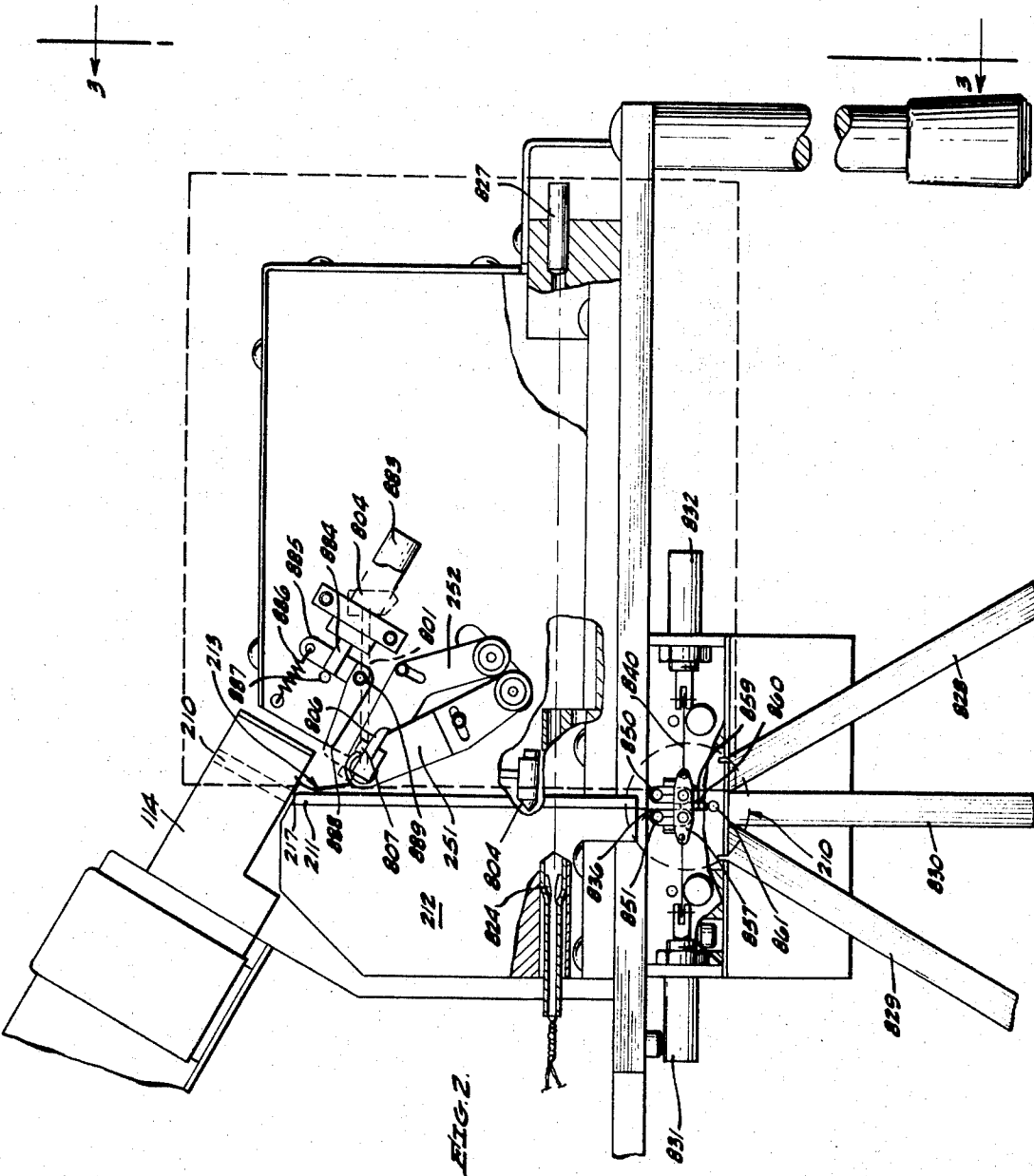
crimp portions of substantially all electrical contacts in a production run and sorting accordingly of the contacts into chutes. From a hopper contacts are fed by gravity along a sloping track, and dropped one by one down a chute. A fall interrupt bracket, clamping, and pendulum cocking and releasing mechanism stops and clamps the contact. The pendulum, from which a hammer is suspended, is released to strike and rebound from the contact crimp portion. Photodiode sensing means determine the distance of rebound and accordingly a chute directing plate assembly is set to later direct the contact into the appropriate soft, too hard, or contact not tested chute. The contact fall interrupt bracket is rotated away from the contact fall path and the contact falls further and is diverted by the chute directing plates into the appropriate chute. Diversion into the non-tested chute is caused by malfunctions of the machine, e.g., failure to clamp the contact when the pendulum hammer strikes the contact. In a second embodiment there is provided an anvil having a groove to retain a specimen. A pendulum suspending a hammer portion is released and the hammer rotates around an axis to strike the specimen and rebound in a return arc path. The return path length is in accordance with hardness. On an adjustably settable swinging frame are mounted an axially aligned photosensitive element and a light source. The frame, anvil and pendulum elements are relatively positioned such that the aligned element and source are along the hammer return path so as to enable the specimen hardness to be measured.

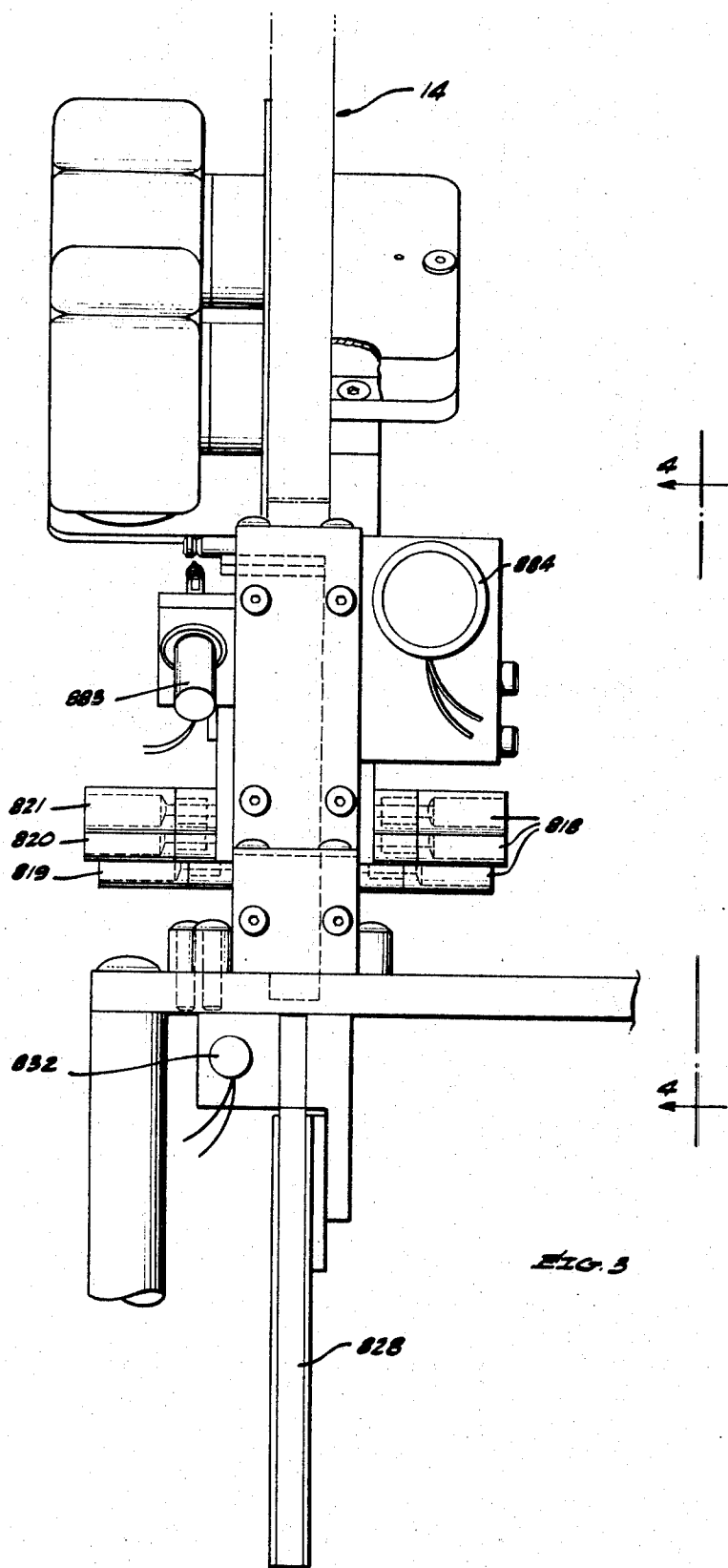
14 Claims, 14 Drawing Figures

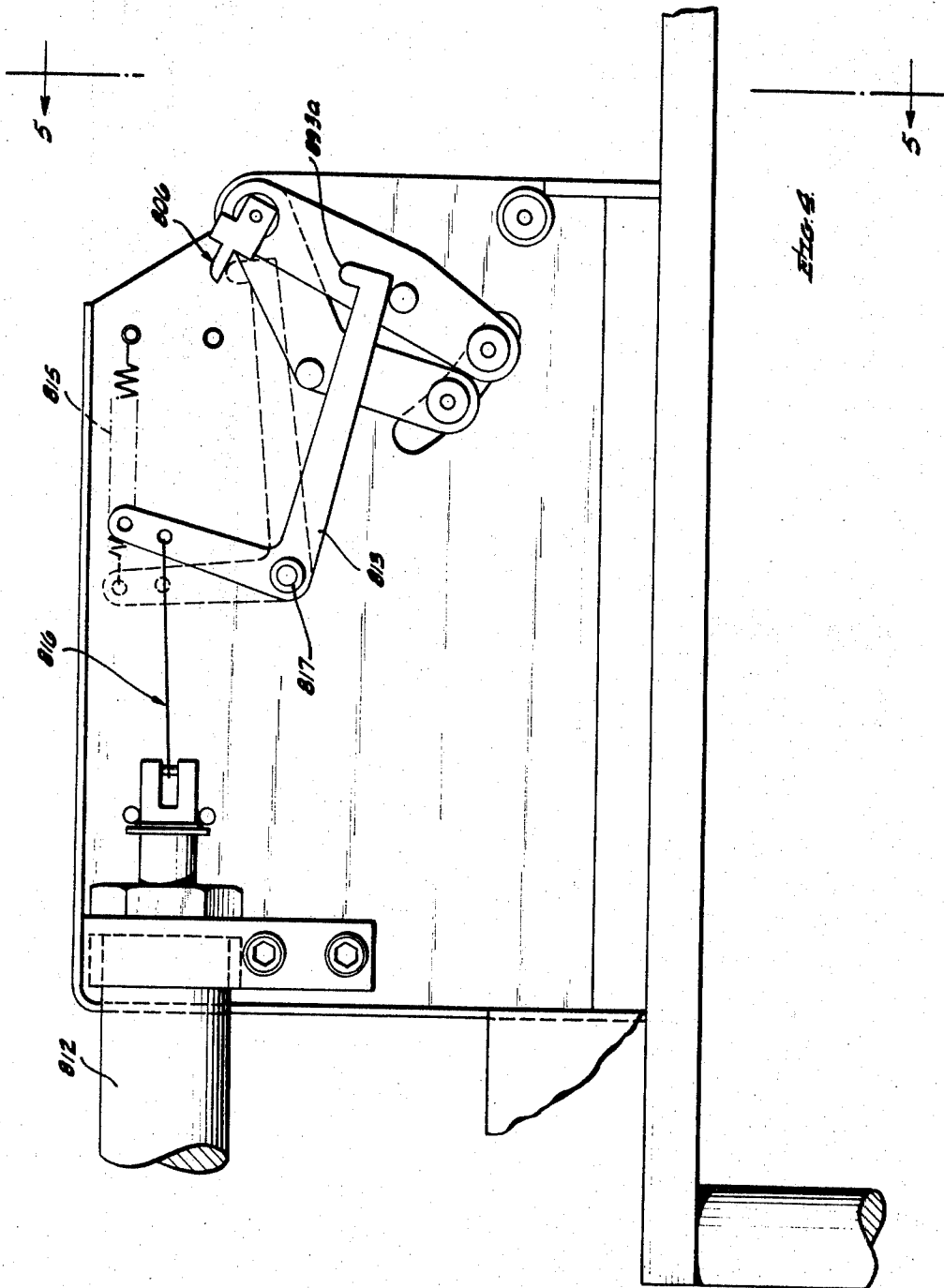




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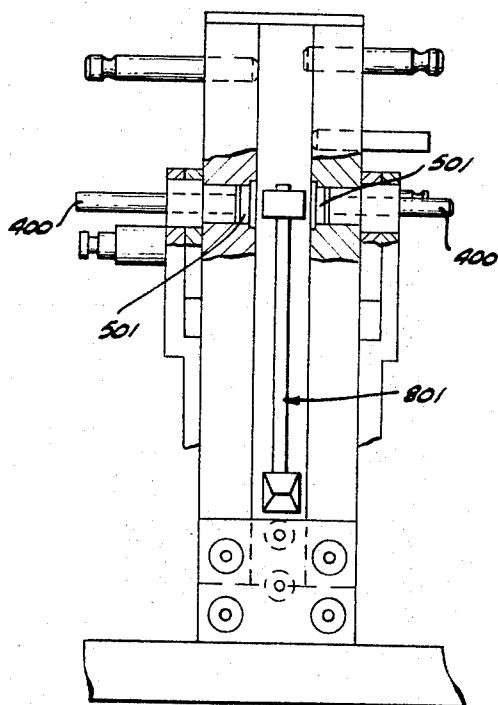


FIG. 5.

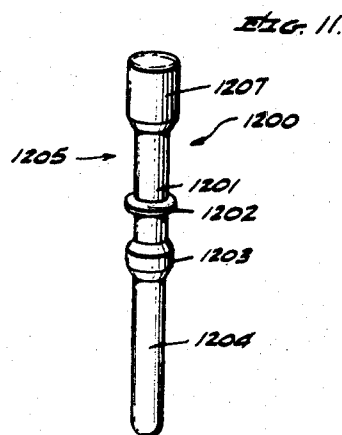


FIG. 11.

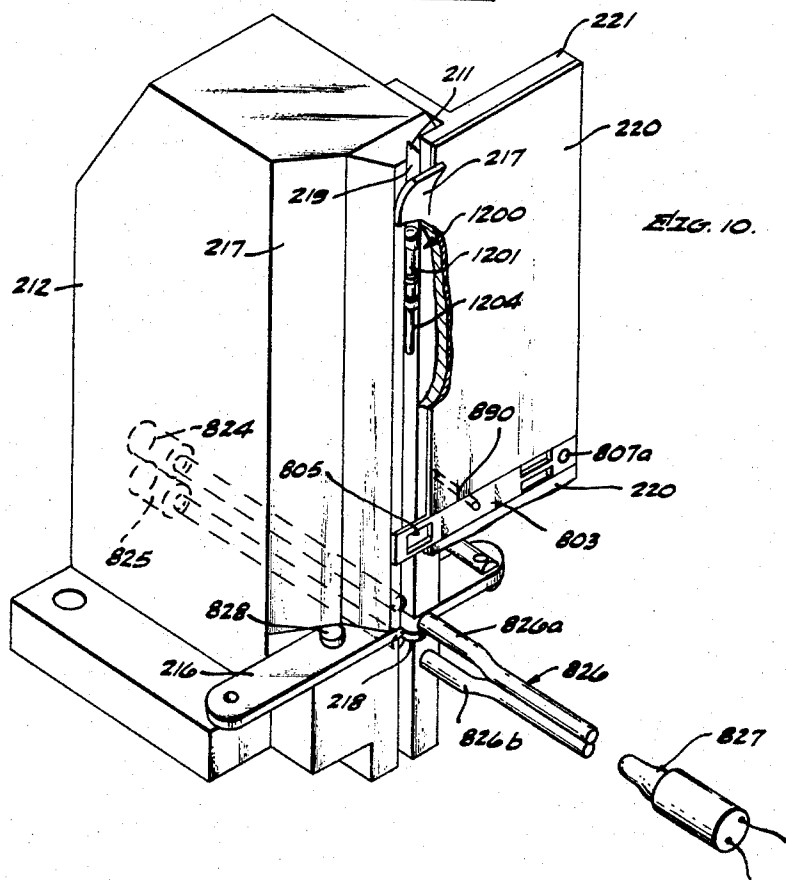


FIG. 10.

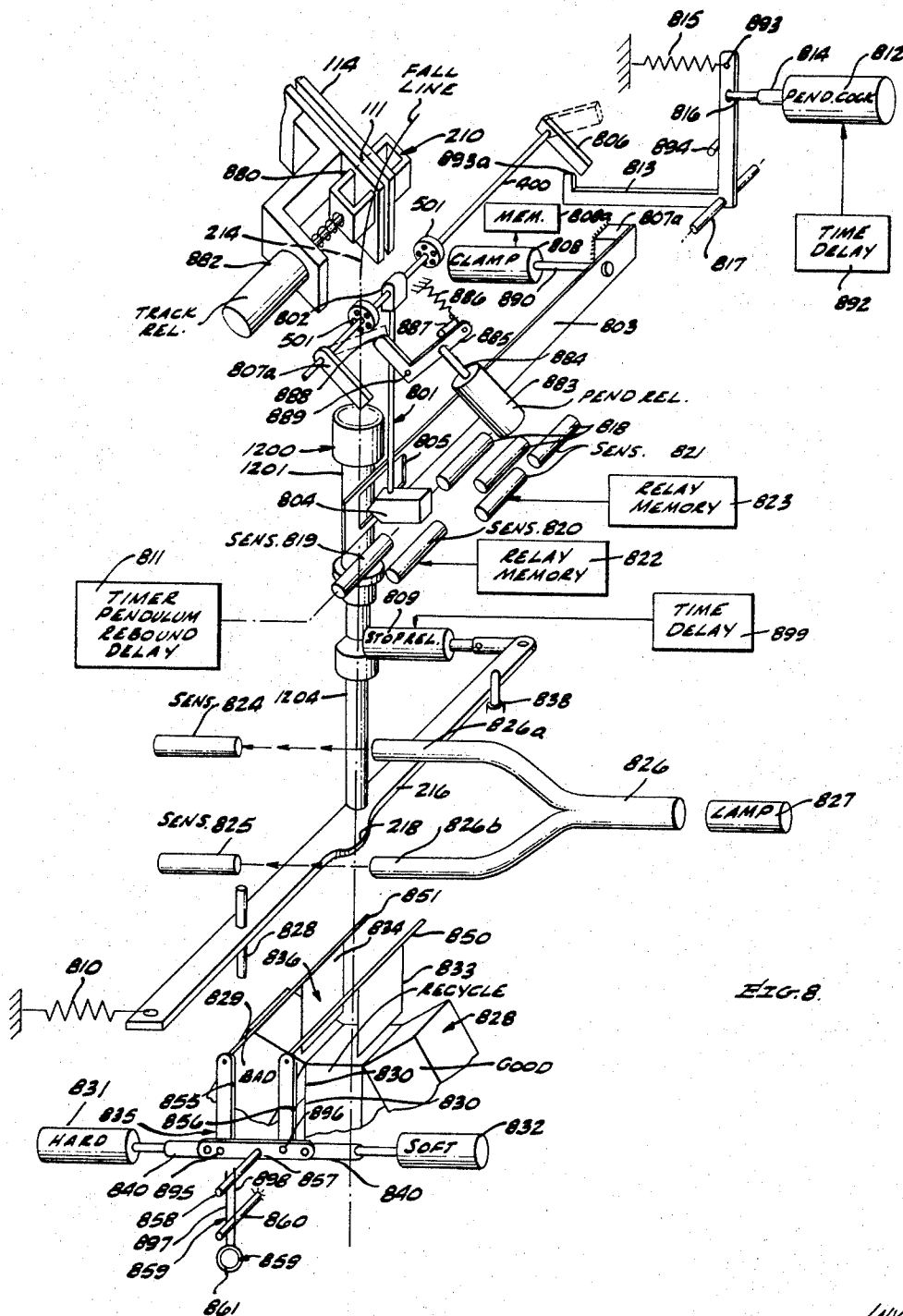


FIG. 8.

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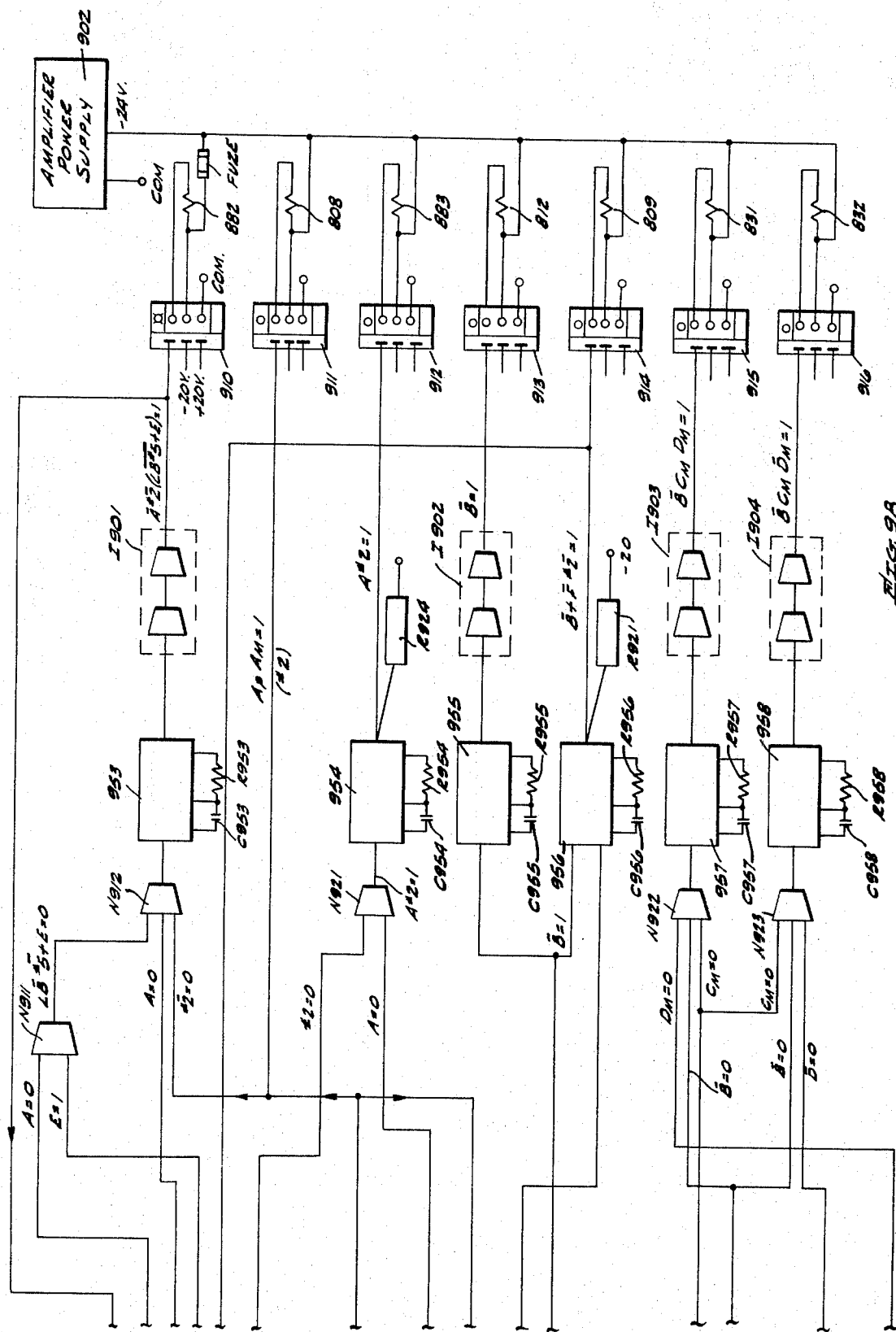
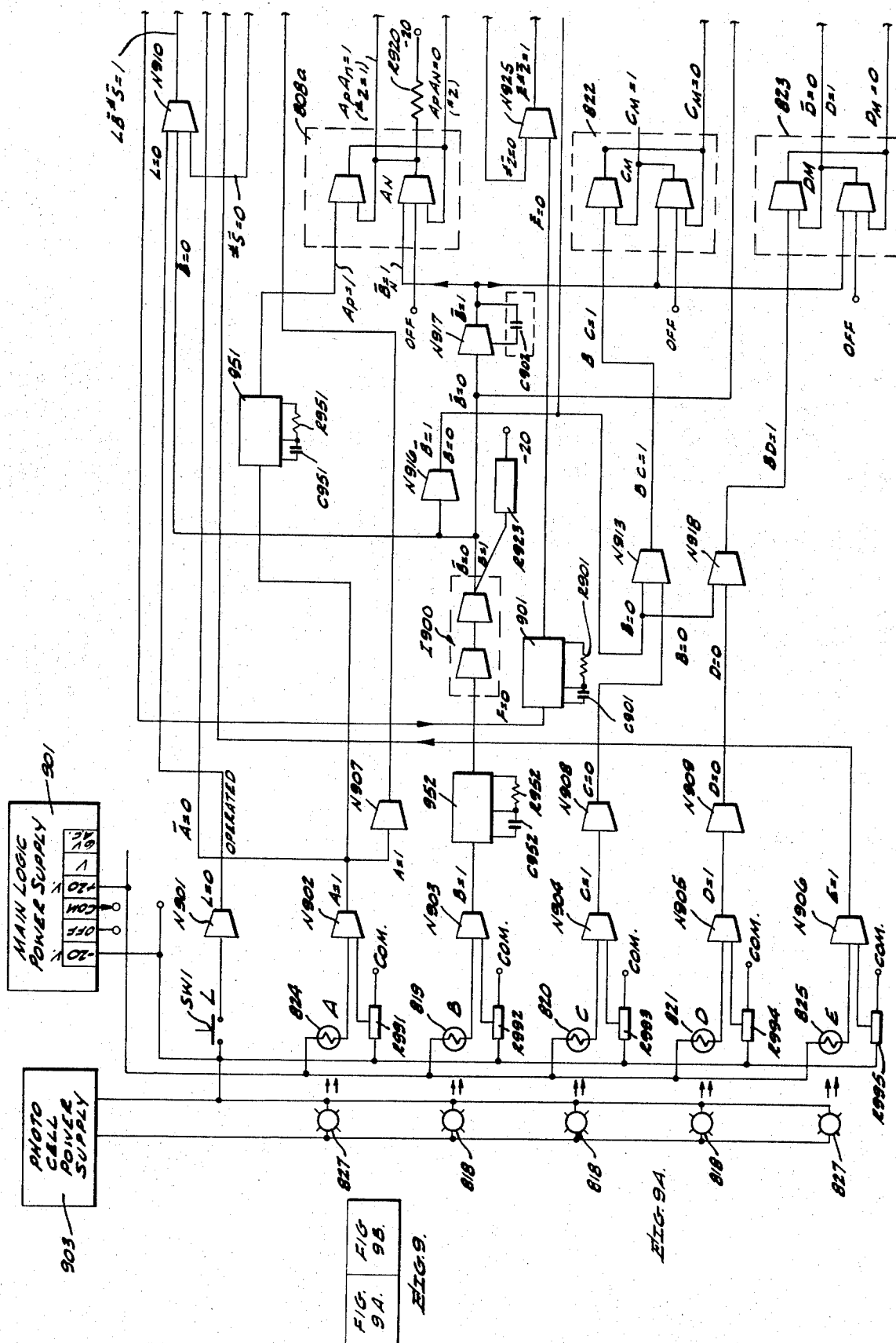


FIG. 9B.



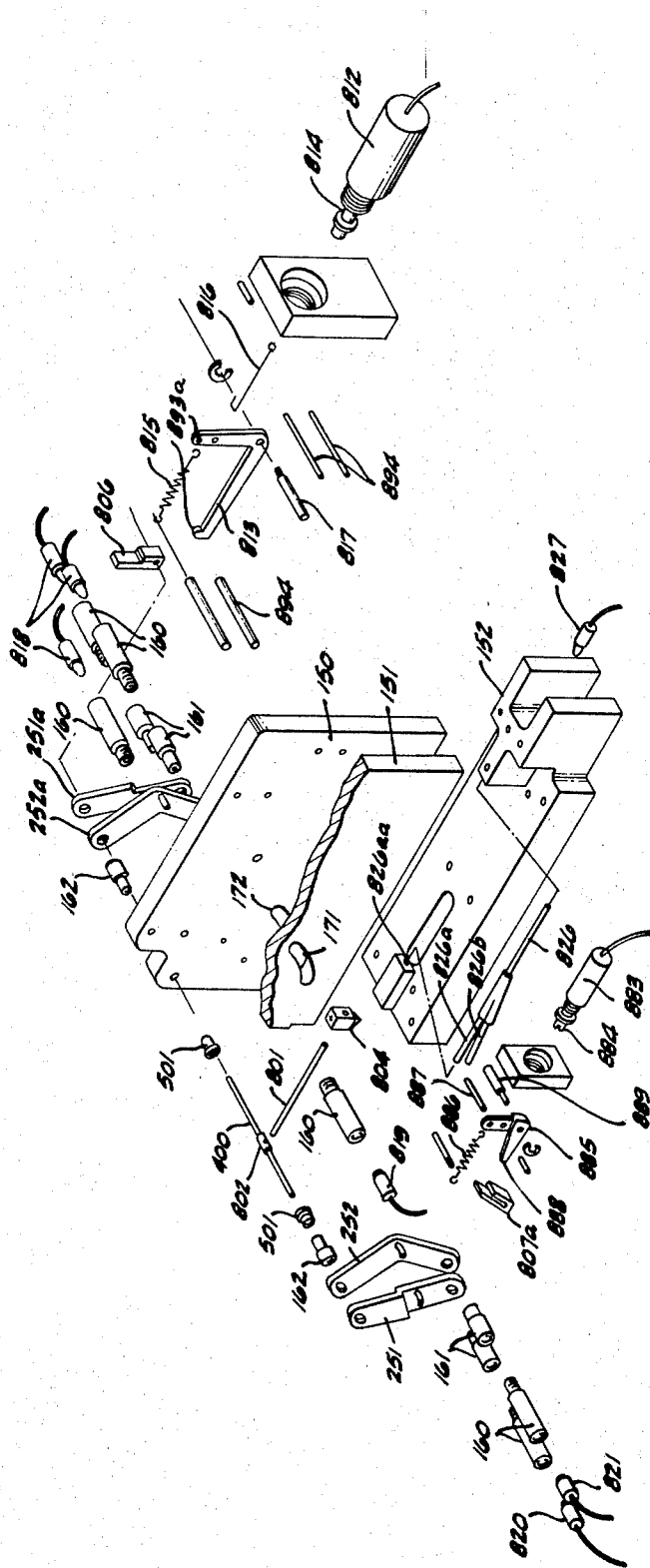
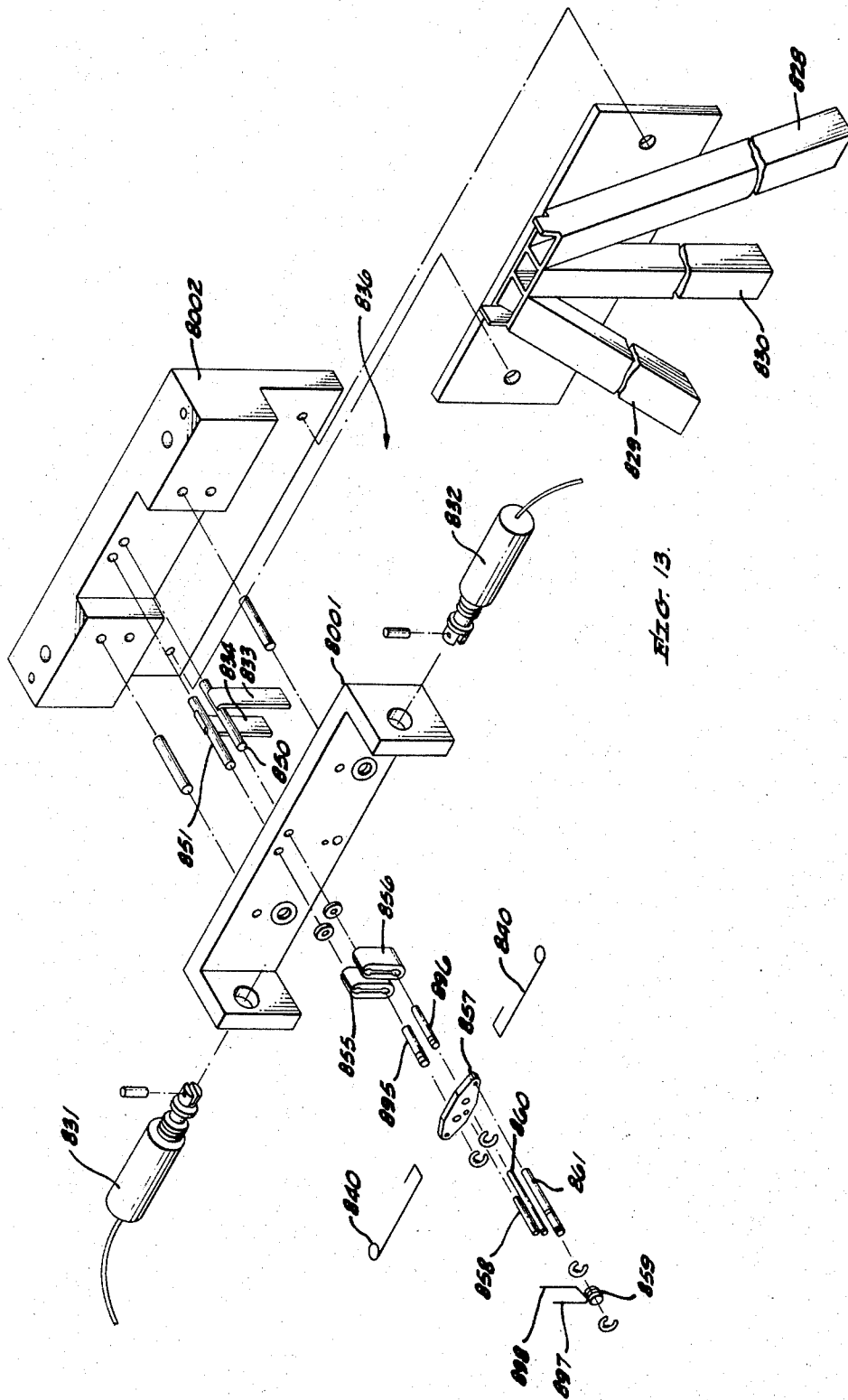


FIG. 12.



HARDNESS TESTING MACHINE

CROSS-REFERENCES TO RELATED APPLICATIONS

The disclosure of the present invention incorporates some of the mechanisms for feeding of contacts toward the hardness testing position which mechanisms are illustrated in my U.S. Pat. No. 3,460,230, issued Aug. 12, 1969, for Electrical Contact Attachment Apparatus, and assigned to the assignee of the present invention. The teachings of this patent are incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a hardness testing machine and method wherein mass production testing of parts to verify their hardness is provided. More specifically, the invention relates to an electrical contact hardness testing machine and method wherein each individual contact is fed along a path where it is tested non-destructively and sorted according to a determination made automatically while testing as to whether the contact will or will not probably crack due to hardness when a wire is crimped in the contact, or as to whether the part has not been tested. Non-testing occurs, for example, due to a malfunction of the machine. The invention permits testing and sorting of substantially 100 percent of the parts at a very high rate of speed, for example, of the order of over 7,000 parts per hour. If the wire crimping portion of the contact is too hard, it will be brittle and the wire will not be properly retained upon crimping and may also be undesirably exposed at an area where it should be protectively surrounded.

2. Description of the Prior Art

Prior art material hardness testers comprise the Rockwell hardness tester, Brinnell hardness tester, Tukon micro-hardness tester, and Herbert pendulum hardness tester. These and other test machines and methods are described in the literature. The Brinnell hardness test, the Rockwell hardness test, the Shore's Scleroscope, the Vickers hardness test, the Knoop hardness test, the Monotron hardness indicator, and Keep's test are described on pages 1,917-1,924 of Machinery's Handbook, by Eric Oberg and F. D. Jones, 18th Edition, 1968, Industrial Press, Inc., 200 Madison Ave., New York, N.Y. 10016.

The Rockwell hardness tester measures hardness by determining the depths of penetration of a penetrator into the specimen under a specified load.

The standard Brinnell method employs calibrated equipment to apply a specified load to the surface of the material to be tested through a hard ball of specified diameter, and to measure the diameter of the resulting permanent impression. The Brinnell hardness number is the value obtained by dividing the applied load in kilograms by the surface area of the impression in square millimeters calculated from the measured diameter of the rim of the impression.

The Tukon micro-hardness tester uses both the Knoop and 136° Diamond Pyramid Indenters with loads of 1 gram to 1,000 grams. It is a delicate instrument, and requires a skilled operator. It also requires expensive specimen preparation, potting, grinding and polishing prior to testing. After test has been made, reading the impression is very difficult and requires the aid of a 50 times magnification microscope and a Filar micrometer eyepiece. The reading must then be transposed from Filar units to Knoop numbers and then to Rockwell hardness B or C scale. This is expensive and time consuming. It may cost as much as \$5.00 per specimen and each measurement may take as long as 45 minutes.

All of the above-mentioned hardness testers measure the displacement of the material when a given load is applied to a penetrator of controlled configuration.

The Herbert pendulum hardness tester is the only method which does not require the displacement of specimen material. It employs an inverted compound pendulum and measures the time required for the pendulum to oscillate five cycles. This time is the Herbert pendulum time hardness number.

A major problem in employing prior art hardness testing machines and methods was that feasibly and economically only a few parts (samples) could be sampled rather than a substantially 100 percent check of hardness of parts. The time it previously took to check a part was of the order of 45 minutes. Prior art machines and methods also tested parts to destruction. Thus, verifying of electrical contact hardness substantially 100 percent was either impossible or impractical in prior art machines or methods. There were also size limitations on prior art parts which could be tested. For example, the Rockwell and Brinnell hardness testers cannot be used on material less than 0.031 inch thick nor on diameters of less than 0.062 inch. The Tukon micro-hardness tester is designed for very small parts but due to the required mounting of the specimen is a destructive test.

Prior art devices and methods were not adaptable to mass production testing of parts to verify hardness. They did not provide pre-knowledge of desired qualities of predicting whether or not a produced and delivered contact will crack due to hardness when the customer crimps a wire in the contact. Further, prior art methods and machines were not fully automatic. They required increased operator time and skill. They did not indicate malfunction of the machines during test of a particular part (indicated in the invention where no test has occurred). They did not indicate non-testing of a part nor sort out parts which had not been properly tested. Prior art methods and machines did not provide for checking a relatively large number of parts in a non-destructive manner. They did not enable sorting out acceptable parts for which suitability could be predicted for further manufacturing operations, particularly as in the present invention where this is done in a reasonable time and in an economically feasible manner.

SUMMARY, ADVANTAGES AND OBJECTS OF THE INVENTION

The invention is directed to a machine and method for non-destructive substantially 100 percent production testing of parts to verify a specific parameter or parameters, e.g., to verify the hardness of the portion to be crimped around wire of each produced electrical contact so as to predetermine suitability for crimped assembled wire and contacts. The machine and method of the invention can, before crimping, test the hardness of the crimping portion. If too hard, the walls of the crimping portion will shatter when the contact is crimped. It is understood, of course, that the contact may alternatively be a contact pin or a contact socket having a wire crimping portion required to be tested. For a period (1) limited to a short time during travel in producing testing, or (2) a longer time in specimen testing, the part to be tested is retained, preferably fixedly clamped against an anvil. A pendulum of desired configuration and mass (small enough to avoid part destruction) is released and allowed to strike the specimen in the desired test area. The reaction or rebounding arc path distance of the pendulum is then (1) detected between selected limits of travel and sorted accordingly into corresponding hardness categories or else (2) measured and converted into a hardness reading.

In production testing, the contact is then released and sorted by appropriate means (preferably automatic) into the part retaining means (as a chute) which has been selected in accordance with the reaction of the pendulum. Thus, the hardness test is performed non-destructively and in the production testing version is sorted by hardness into the correct category at high rates of speed.

In the first embodiment of the invention shown, there are provided after the pin is released down the chute, electrical contact pin retaining means, clamping means, an anvil against which the pin clamping means retains the pin in position, a pendulum with a hammer shaped free end and means to cock and to release the pendulum to strike the specimen when clamped, means responsive to failure to sense pendulum swing back for a predetermined time period after release which in-

icates non-effective clamping or machine failure and which responsively causes the pin to go into a no test indicating bin, means to sense a soft good contact when the backward travel of the hammer is at the lower limit, means to sense a too hard contact when the hammer backward travel reaches a distance indicating too hard a contact and mechanism responsive to the appropriate sensor means to establish a contact path into either a bad contact, good contact, or recycling contact chute. The method and machine lends itself to substantially full automation and the operator, if required, need merely keep the hopper full and remove defective parts to avoid jamming the machine.

The invention provides advantages of enabling substantially 100 percent of hardness or other parameter testing of a mass production run of parts by a non-destructive means and method for a following utilization step. It provides measure and/or indication what happened to the part instead of measuring penetration into the part to determine hardness and category of the tested parts. The rotatably swinging pendulum and hammer configuration enable control of position, action and time of initial swing upon release, return, and recovery. The invention provides ability to test small parts wherein consistent positioning of the part against an anvil of sufficient mass is the only limitation on size and/or thickness. It enables sorting into go, no go, and no test categories. The invention enables parts to be tested at a high rate and to be employable in manufacturing automation. It enables the reduction or minimization of operator time. It is useful for generating certain types of shock. It enables hardness measurement in relative or absolute numbers as illustrated in the second embodiment where mass production measurement is not necessarily involved.

Accordingly, an object of the invention is to provide a feasible and economical means and method of rapidly and non-destructively testing hardness of substantially 100 percent of parts suitable for rapid mass production and automation and to automatically and rapidly sort and parts into go, no go, and no satisfactory completed test verification storage bins or chutes and wherein capability is provided of testing very small parts which may have small thickness and resistance to shock.

Another object of the present invention is to enable rapid non-destructive testing of mass produced parts to verify a parameter such as hardness to predetermine whether the part will enable further manufacturing operations, wherein automation of substantially 100 percent tested parts is facilitated and relatively low operator time, attention and ability are required.

Still another object of the invention is to provide means and a method for striking a part, which is readily controllable, rapid in recovery, and which enables close tolerance absolute or relative numerical or other simple designation measurement of a parameter such as hardness of the part being tested.

The above-mentioned and other features and objects of the present invention will be apparent by reference to the following description taken in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view representing a first illustrative embodiment of a machine of the present invention mounted on a table with portions of the legs broken away and showing a hopper; a track member; a contact aperture and individual contact release means; a pendulum and pendulum rotatably supporting, releasing and cocking assembly; contact pendulum position and condition sensing means; sorting means; and a plural chute assembly;

FIG. 2 is a plan side elevational view partially in section of a portion of the embodiment of FIG. 1 to the right of the arrows 2—2 and with other portions broken away and illustrates the electrical contact release aperture, fall path means, the pendulum release mechanism, the mechanism to sense that the contact has dropped and is properly located, the contact deflec-

tion and steering mechanism, and three chutes into which respectively hard, soft, and non-tested electrical contacts are dropped;

FIG. 3 is an end view of FIG. 2 taken in the direction of the arrows 3—3 and with portions broken away for clarity of illustration;

FIG. 4 is a view taken from the rear of the portion shown enclosed by dashed lines in FIG. 2, and taken from the end in the direction and of the portion enclosed by the arrows 4—4 of FIG. 3, and illustrating the pendulum cocking apparatus of the first illustrative embodiment;

FIG. 5 is an end view of FIG. 4 taken along the lines 5—5, with portions broken away to illustrate in cross-section the pendulum pivot and the portion therearound extending a slight distance above and below the pendulum pivot;

FIG. 6 is an enlarged view of the contact diverting and chute mechanism illustrated within the dashed line circle enclosure in FIG. 2 and showing a central position of the contact diverting means and in dashed lines an alternate good chute contact diverting mechanism position;

FIG. 7 is a view partly in cross-section taken along the lines 7—7 of FIG. 6;

FIG. 8 is a partially schematic and partially pictorial exploded representation of the first illustrative embodiment illustrating essential mechanism to facilitate operational description of contact track release, positioning, clamping, pendulum movement and recocking, and sorting operations;

FIG. 9 comprising FIGS. 9A and 9B taken side by side is a schematic and wiring diagram illustrating the wiring connection to the sensors and the logic and control electrical circuits of the machine of the first illustrative embodiment;

FIG. 10 is an assembled isometric pictorial view with a portion broken away of a portion of the chute fall line assembly showing a support block having a V-shaped contact fall way and separated therefrom a flat upwardly and outwardly flared spring member between which an electrical contact falls, a contact fall interrupt bracket, fiber optics shown in relative position aligned with the block retained sensors in FIG. 10 (and shown housed in FIG. 12 hereinbelow), and also illustrates the contact clamping means of the first illustrative embodiment;

FIG. 11 is an isometric view of a pin contact including the crimping portion which may be tested by the method and machine of the invention and which is shown also by way of illustration in FIGS. 1, 8 and 10 of the first illustrative embodiment;

FIG. 12 is an isometric exploded view of the pendulum, the pendulum supporting, releasing and cocking assemblies, the pendulum position, and soft and hard sensor photodiodes and aligned lamps and the fiber optics of the first illustrative embodiment;

FIG. 13 is an isometric exploded pictorial view of the chute sorting mechanism and the too hard, too soft and no test occurred chutes of the first illustrative embodiment; and

FIG. 14 is a schematic representation of another illustrative embodiment of the invention showing mechanical and photoelectric elements comprising an anvil in which is provided a groove to retain a specimen to be tested, an adjustably supported pair of members which are sensitive to interruptions in a beam of light passing therebetween to generate a signal, a pendulum having a striking hammer; and rotatably supported upon a shaft and wherein relative positioning and adjustability of the adjustably supported elements is such that hardness or other parameters of specimens tested may be relatively and absolutely predetermined.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

1. Structure of the Machine of the First Illustrative Embodiment

Refer to the drawings and in particular to FIG. 1. A feeder bowl or hopper 100 is provided. Hopper 100 stores and dispenses in a predetermined orientation a plurality of rela-

tively small elongated electrical contacts 1200. Contacts 1200 are conventional crimp type removable contacts. The hopper 100 is a vibrating device such as Model 5A-VFC manufactured by Automation Devices, Inc., Erie, Pa. It includes a helical ramp 180 around the inner periphery of the bowl. This device can readily handle small objects such as contacts 1200 and send them up the ramp 180 maintaining the contacts 1200 in a predetermined orientation. As each contact 1200 reaches the top of the ramp 180, it drops into a groove 120 formed by the hopper 100 and a spaced plate or platform 121.

Refer to FIG. 11. The electrical contact 1200 (shown many times magnified) comprises a crimp barrel section 1205. Crimp barrel section 1205 comprises an enlarged diameter portion 1207, a crimp section 1201, and a retaining shoulder 1202. A second retaining shoulder 1203 is provided. Between retaining shoulders 1202 and 1203 may be retained, when the contact 1200 is inserted into a connector body (not shown), a clip member (not shown) in a manner well known in the art and illustrated in catalog sheet A-1009099S (in one exemplified size) in the Master Catalog of the Connecting Devices Division of Hughes Aircraft Company, Newport Beach, Ca. At the end opposite barrel 1205 is an inner contact pin 1204. Alternatively, the contact 1200 may be terminated by an inner contact socket (not shown). The invention is equally suitable for testing hardness of the crimp portion of a socket contact.

Refer again to FIG. 1 in conjunction with FIG. 11. The groove 120 is of a width and depth sufficient to permit each contact 1200 to be oriented with its crimp barrel section 1205 extending upwardly of the groove 120.

Near the end of the groove 120 opposite from that nearest the top of the ramp 180 is a track or guide assembly 114. Track assembly 114 is positioned near the hopper 100 at the end of the groove 120 with one end raised so that the contacts 1200 may be dispensed from the hopper 100 into the track 114. As the contacts 1200 are dispensed from the hopper 100 they slide down the track 114 (which is suitably inclined preferably for optimum sliding rate) under the force of gravity towards the end 211 of the track 114.

The track assembly 114 comprises an elongated structure having two halves 124, 126 which are spaced a predetermined distance apart and are flanged to define a track or groove 128 (see cutaway portion of FIG. 1 and my aforementioned U.S. Pat. No. 3,460,230). As the contacts are dispensed the barrel 1205 of each contact 1200 is supported by the track 114 upper surfaces (not numbered) with the remainder of the contacts 1200 disposed below the groove 128 upper surfaces. Secured to one side of the track assembly 114 are a pair of light sensitive members 138a and 138b. Mechanisms may be employed similar or identical to that illustrated in my aforementioned U.S. Pat. No. 3,460,230 to control the actuation of the vibratory hopper 100 and to separate the contacts 1200 to make sure of proper movement toward the aperture 210 provided at the end of track 114 and to assist the alignment of each of the contacts 1200 in aperture 210. This mechanism may be timed sequentially in each cycle. Thus, as one of the contacts 1200 moves to the edge of the aperture 210 (as described in my aforementioned U.S. Pat. No. 3,460,230), a solenoid (not illustrated) is activated and a plunger (also not illustrated) advances to separate and locate the contact 1200 from any adjacent contact 1200 (to which it may have inadvertently become attached) and the forwardmost contact 1200 is pushed into the aperture 210.

Opposite the switch members 138a, 138b, may be provided a bulkhead unit 143. The light sensitive switch member 138a may be used to deactivate the vibratory hopper 100 when a predetermined maximum number of contacts 1200 are stored in the track 114 and the other light sensitive switch member 138b activates the hopper 100 when the number of contacts 1200 in the track 114 is below a predetermined minimum number. This control is accomplished by mounting a light source (not illustrated) such as a light bulb in the assembly 143 opposite each of the light sensitive switch members 138a, 138b and coupling the light energy to a photo relay by a mirror

and a chamber extending across the track assembly 114 in alignment with the switch members 138a and 138b. When a contact is aligned with these chambers (not illustrated) insufficient light falls upon the photo relay to activate it. This permits the aforementioned activation and deactivation of the vibratory hopper 100. This action and mechanism is described in column 4 of my aforementioned U.S. Pat. No. 3,460,230. As stated, the contacts 1200 are in upright position relatively with the crimp barrel section 1205 uppermost. Below collar 1203 is an extending contact pin 1204 (or alternatively an extending contact socket).

Now refer to FIGS. 2 and 8 in conjunction with FIG. 1. A solenoid 882 and linkage and plunger means 880 are provided and are timed and structured (facilitatable by beveled structure not illustrated) to release only one contact 1200 at a time (for one energization of solenoid 882) past the end 111 of track 114. Upon release the contact 1200 falls freely down chute aperture 210. Aperture 210 is perpendicular to and extends through track 114 (see FIG. 2). Substantially vertically disposed at the bottom of aperture 210 and extending therebelow is a fall chute 211, chute deflection mechanism 836 and a plurality of chutes 828, 829 and 830.

Refer to FIG. 10 in conjunction with FIGS. 1 and 2. Upon leaving the bottom of the aperture 210 (see FIG. 2) the contact 1200 continues to fall along chute 211. A chute block 212 is provided. Block 212 comprises a bevelled portion 217 for easy operator cleaning and repair access and a front V-shaped portion 219. In front of the block 212 and spaced therefrom by spacing bracket 221 is a chute covering plate 220 which covers the V-shaped portion 219 to form chute 211. The upper portion of chute covering plate 220 may be curved back as illustrated by curved back portion 217 to facilitate entrance of the contact 1200 therein in changing position (see FIG. 2) from the aperture 210 (which is perpendicular to the track 114) and sliding into the relatively perpendicular line of fall 214. As illustrated in FIG. 10, the contact 1200 has its pin extending portion 1204 in the line of fall 214 lowermost and the barrel crimp section 1201 uppermost. As illustrated in FIGS. 8 and 10 particularly, a fall interrupt bracket 216 having a projection 218 is provided in order to interrupt the fall of the contact 1200. The bracket 216 is rotatable around pivot 828 so that it may be swung into and out of alignment with the line of fall 214 of chute 211 where it interrupts the inner extending contact pin 1204 of the contact 1200. The plate 220 may comprise two separated sections and aligned with the separations near the bottom of plate 220 (not illustrated) are provided a pair of slot members, one slot placed aligned with the separations and one therebelow and both slots formed (through plate 221) through which light may be transmitted. The block 212 and cover plate 220 are of non-transparent material.

A fiber optics bifurcated member 826 is provided which has an upper branch 826a and a lower branch 826b. Such fiber optics which are capable of transmitting light wherein the light beam enters at the end formed by the junction of branches 826a and 826b and having the beam of light emit from the ends (not numbered) of the branches 826a and 826b are conventional and need not be described. An illuminating lamp 827 is provided to emit light rays through the branches 826a and 826b respectively. Disposed on the opposite side of the aforementioned block 221 slots and plate 220 separation and internally threaded into the block such that their forward receiving photosensitive faces may receive and be responsive to change of impinging light rays or absence of light rays from branches 826a and 826b are an upper photodiode or light sensing device 824 and a lower photodiode or light sensing device 825. The sensor device 824 and the lower sensor device 825 are disposed opposite the respective upper and lower fiber optics branches 826a and 826b and aligned therewith. The aforementioned plate 220 separation and bracket 221 slots (not illustrated) in the plate 220 permit a beam of light to travel from the front face of fiber optics branch 826a to the face of the light sensing device 824 and the light beam from the lower branch 826b front face to be

directed to the aligned face of the light sensing device 825 when a contact 1200 is not in position blocking the path therebetween.

Refer further to FIG. 8 in conjunction with FIG. 12. A pivot rod or shaft 400 is provided. Attached to the pivot shaft 400 are a pair of ball bearings 501. A pendulum 801 which comprises a bracket 802 to fixedly mount the pendulum 801 rod to the shaft 400 and a pendulum hammer 804 which is fixedly attached to the shaft of pendulum 801 and which may have rounded forward edges (not numbered) are provided. A pair of pendulum and light sensor mounting brackets 150 and 151 are provided. Pendulum and light sensor mounting bracket 150 has a groove 172 and formed therein and pendulum and light sensor mounting bracket 151 has an aligned groove 171 formed therein. A plurality of light photodiode or photocell sensors 819, 820 and 821 and a plurality of oppositely disposed lamps or light elements 818 are provided. The grooves 171 and 172 are adjusting grooves for adjustment of sensors 820 and 821 and of their corresponding aligned light elements 818. A plurality of holders 160 for the sensors 819, 820 and 821 for the lights 818 are also provided. The holders 160 are appropriately mounted as illustrated in FIG. 12 in apertures (not numbered) in the pendulum and light sensor mounting brackets 150 and 151. A plurality of bushings 161 are provided into which are threadedly engaged the sensor 819, 820 and 821 respective holders 160 and the lamp 818 respective holders 160. In the case of the holder 160 in which the sensors 820 and 821 are inserted and in the case of the correspondingly aligned holders 160 into which lamps 818 are mounted bushings 161 are force fit bushings. A pair of adjusting linkages 251 and 252 are provided to change the position of the sensors 820 and 821 respectively. Similarly, a pair of adjusting linkages 251a and 252a are provided to change the position of the light cells 118 opposite the respective sensors 820 and 821. A pair of bushings 162 are also provided on either side and insertable into apertures (not numbered and in bracket 151 not illustrated) in the respective pendulum and light sensor mounting brackets 150 and 151. Bushings 162 are standoff bushings respectively for the adjusting linkages 251 and 252 and 251a and 252a respectively so as to enable the adjustment of the sensors 820 and 821 and of the corresponding light cells 818. Also supported on the pendulum pivot shaft 400 are a pendulum release linkage 807a and a pendulum cocking bracket 806. L-shaped pendulum cocking bracket 813 and L-shaped pendulum release bracket 885 are also provided and are rotated around respective pivots 817 and 889. A pendulum release L-shaped bracket stop member 887 is also provided. The pendulum release bracket 885 has a rounded edge 888 to facilitate engagement with the release lever 807a when in pendulum non-engaging position. Similarly, the L-shaped bracket 813 has an upper rounded projection 893a to retain the pendulum cocking bracket 806 when in pendulum cocked position. A fixedly mounted bias spring 815 is provided and interfitted into an aperture 893 formed in the pendulum cocking L-shaped lever bracket 813 to provide proper biasing of the cocking L-shaped lever 813. Similarly, a fixedly anchored spring bias member 886 is disposed in a corresponding aperture (not numbered) in the L-shaped release lever 885 to properly bias the release lever 885. A pendulum release solenoid 883 having a linkage 884 and a pendulum cocking solenoid 812 having a pendulum plunger 814 and a pendulum linkage 816 are also provided for pendulum release and pendulum cocking action respectively. Respective cocking L-shaped bracket stop members 894 and release L-shaped bracket stop member 887 are also provided to limit travel. As illustrated in FIG. 12, appropriate threaded bracket members and other engaging washers and threaded members and the like (not numbered) are conventionally provided for mechanical assembly.

As further illustrated in FIG. 12, a support or base 152 is provided for holding the provided fiber optics 826. The upper fiber branch 826a is mounted in aperture 826aa as illustrated in FIG. 12 and the lower branch of the fiber optics portion

826b is similarly mounted in the corresponding member (not illustrated) in the base support 152. As illustrated in FIGS. 1 and 12, the base support 152 and the pendulum and light sensor mounting brackets 150 and 151 are respectively assembled so as to support the fiber optics 826, sensors 819, 820 and 821, lights 818 and pendulum cocking and release mechanisms (as described for the bracket 813 and 885 and associated elements discussed in the several pages hereinabove).

Refer further to FIGS. 8 and 10. Contact pin clamp bracket 803 is appropriately attached to the plunger 890 of part clamp solenoid 808 which are provided. The clamping bracket 803 clamps the contact 1200 when contact 1200 is in its fall interrupt position resting upon the projection 218 of the bracket 216. The bracket 216 is appropriately fixedly mounted by fixed mounting means 807a to the standoff bracket plate 221.

A plurality of solenoids comprising a part track release solenoid 882, a part clamp solenoid 808, a pendulum release solenoid 883, a pendulum cocking solenoid 812, a part stop release solenoid 809, a part too hard solenoid 831, and a soft annealed good contact solenoid 832 are provided. Provided and connected responsive to part clamp solenoid 808 is a memory circuit 808a. A pendulum cocking time delay circuit 892 is provided to actuate a pendulum cocking solenoid 812. A part time release time delay circuit 899 is provided and connected to trigger part stop release solenoid 809. A timer pendulum rebound circuit 811 is provided and is connected responsive to sensor 819. A relay memory circuit 822 is provided and is connected to actuate sensor 820. A relay memory circuit 823 is provided and is connected to actuate sensor 821.

Lamp 27 is positioned adjacent to and aligned with the end entrance to provide light to the fiber optics. The clamping bracket 803 has formed therein a rectangular shaped aperture 805 through which the pendulum hammer 804 front rounded end is rotated to impinge upon the contact 1200 when in bracket 216 supported condition.

Now refer to FIG. 13 in conjunction with FIG. 8 and FIG. 2. Refer also to FIGS. 6 and 7. As illustrated in FIGS. 2 and 8, at a relatively short distance below the bracket member 216 in the line of fall of the contact 1200 are provided chute deflection means 836. Chute deflection means 836 comprises a pair of chute deflection plates 833 and 834 which are fixedly mounted to a pair of rotatable shafts 850 and 851 respectively. As illustrated in FIG. 13, a pair of bracket members 8001 and 8002 are respectively provided into which are mounted the shafts 851 and 850 and apertures (not numbered) are provided such that the forward end of the shaft 850 and 851 extend therethrough and are separated by washers (not numbered) from bifurcated double apertured bracket means 855 and 856. The upper apertures respectively (not numbered) of brackets 855 and 856 each clampingly engage the respective shaft member 851 and 850. In the lower apertures, (not numbered) of brackets 855 and 856 are respectively bearingly mounted pins 895 and 896. At their ends opposite the brackets 855 and 856 the pins 895 and 896 are respectively mounted in apertures (not numbered) in a chute plate rotating link 857. At the ends of chute plate rotating link 857 are a pair of apertures (not numbered) into which are inserted respectively provided linkage wire members 840.

A too hard solenoid 831 and a soft, good contact solenoid 832 are provided. The plunger (not numbered) of too hard solenoid 831 in connected to linkage 840 at the shaft 895 side and the plunger (not numbered) of soft annealed good contact solenoid 832 is connected to the linkage 840 which appears in the aperture disposed toward the good contact side pin 896. A pin member 858 is fixedly attached to a lower central aperture (not numbered) provided therefor in chute rotating link 857. Immediately below the pin 858 is provided a pin 860 which is suitably supported to the machine frame by means (not shown) to be fixedly aligned with the pin 858 when the pin 858 is in central solenoid 831 and 832 unenergized conditions and from which pin 858 shifts laterally when solenoid 831 or 832 is activated. A shaft member 861, also fixedly supported to the machine frame by means (not shown) at the central

(solenoid 831 or 832 unenergized) position of the adjusting linkage 857 is provided. Provided is also a spring member which comprises several turns of coiled wire 859 which are wound around the shaft 861 and a pair of offset protruding wire members 897 and 898 respectively which are bent angularly upwardly and outwardly and bent again to extend upwards freely to engage the left and right sides (as shown in FIG. 8) of the pins 860 and 858. As will be hereinafter shown, the movement of the chute plate rotating link 857 and therefore of the pin 858 causes bias to be applied to the corresponding spring extending members 897 and 898 such that upon release to extended position of the corresponding solenoid 831 or 832 which caused displacement of the link 857, the link 857 is restored (or held) after solenoid deactivation (or while deactivated) by spring action to the central chute 830 recycle or non-operative contact inserting position of chute deflection plates 833 and 834.

Refer to FIGS. 1, 2 and 8 in conjunction with FIG. 13. A plurality of chutes comprising soft acceptable annealed contact chute 828, hard unacceptable contact chute 829 and a centrally disposed no test occurred chute 830 are provided. As will be hereinafter described in operation, the entering contact deflection chute means 836 are enabled by action of the mechanism of FIG. 13 (the lower portion of FIG. 8, 1, 2 and 7) to cause entry of the contacts 1200 in accordance with contact hardness condition sensing into the soft chute 828, the hard chute 829 or in the case of contact hardness non-sensed time lapse into the no test chute 830 respectively.

Refer to FIG. 9. FIG. 9 illustrates solid state practical logic circuits utilizable to operate the machine of the first illustrative embodiment of the present invention.

The electrical units of FIG. 9 are conventional units designed for the machine tool industry and obtainable from the Square D Company, 4041 N. Richard Street, Milwaukee, Wisconsin 53212. Most of the units of FIG. 9 are obtainable under the trademark NORPAK of that company. Employed in the FIG. 9 circuit are two Nor-20 Pack Type L-2 Units, wherein 36 NOR gates are used: six gates for input forming, 10 gates for single shot pulsing (timing), six gates for three memory flip-flops and 14 gates are used as logic gates. Also obtainable under the NORPAK trademark from that company are employed seven output amplifiers type TO-4, 24 VD, 30 watts, seven places; one amplifier power supply type A-301, 24 V. DC, 300 watts; one Main Logic Power Supply type P-1, for 125 NOR units, 100 patch wires of suitable lengths, one taper pin and insulator kit (100 pins and insulators); and one taper pin crimping tool; all obtained from the Square D Company and which are employed for or in the illustrated circuit of FIG. 9. Additionally, 1/2 single shot multivibrators built as instructed of NORPAK Type L-2 units are utilized in the FIG. 9 circuit and also employ some of the 10 capacitors and nine resistors (of values indicated in the table hereinbelow). As illustrated in the upper left portion of FIG. 9, the Main Logic Power Supply, Type P-1 comprises unit 901 which as described hereinabove contains 125 NOR units. Power supply 901 supplies -20 volt, common abbreviated "com." in FIG. 9, and +20 volt power and its output of 6 volt AC continuous pulses can be utilized to power lamps 818 and 827. As illustrated in the left hand side of FIG. 9, a 6 volt transformer supplied AC power supply 903 output is utilized to power lamps 818 and 827 (see FIGS. 8, 10 and 12 for example).

An amplifier power supply 902 which may be a NORPAK type A-301, 24 volt DC, 300 watts rated supply is provided and supplies -24 volts power to one side of the part track release solenoid 882, the part clamp solenoid 808, the pendulum release solenoid 883, the pendulum cocking return solenoid 812, the part stop release solenoid 809, the contact crimp portion too hard solenoid 831 and the soft acceptable annealed contact solenoid 832. The solenoids are depicted by resistor symbols in the schematic diagram. All of the solenoids 882, 808, 883, 812, 809, 831 and 832 are conventional Dormeyer 24 volt solenoids obtainable from a variety of distributors. Solenoids 882, 808, 883, 809, 831 and 832 are P2-202L,

30.5 ohms, 0.83 amps rated solenoids and solenoid 812 is rated at 82 ohms and 0.31 amps. All of the solenoids 882, 808, 883, 809, 831 and 832 have plunger members which retract when the solenoid is energized and as illustrated in FIG. 8 linkages are employed to reverse the movement where extending plunger movement upon actuation is desired. Solenoid 812 is a P6-2L solenoid.

The NOR gates of FIG. 9 are solid state (transistor) circuits wherein when the inputs are all "zeros" (0), the output is a "one" (1) and if any input is not a zero, the output is a zero (0).

A power supply 903 is provided and comprises a transformer (not illustrated). The transformer of power supply 903 provides 6 volts AC across the lamps 818 and 827 as illustrated in FIG. 9. Optionally, the 6 volt AC output from the Main Logic Power Supply 901 could be utilized.

A switch SW1 is provided. Minus 20 volts input from supply or source 901 is applied through a NOR gate N901 to provide a zero output which is applied as one input to NOR gate N910. The sensors 824, 819, 820, 821 and 825 corresponding to those in FIG. 8 are illustrated at the left of FIG. 9. Responsive to energization of each of these sensors 824, 819, 820, 821 and/or 825, as described hereinafter in the operational discussion of FIG. 8, respectively NOR gates N902, N903, N904, N905 and N906 have 1's or 0's applied for corresponding required output. Responsive to the 0 output of NOR gate N901, NOR gate N910 receives a first 0 input (indicated L = 0). Connected responsive to NOR gate N902 are (1) a NOR gate N912 which is also connected to the output of NOR gate N911, (2) a 5.1 millisecond single shot pulse multivibrator delay unit 951, and (3) a NOR gate N907. Responsive to the output of NOR gate N903 is connected a 75 millisecond (single shot multivibrator) delay unit 952. Responsive to the NOR gate N904 is connected a NOR gate N908. A NOR gate N913 is connected responsive to NOR gate N908. Responsive to the NOR gate N905 is connected a NOR gate N909. The output of NOR gate N906 which is responsive to output from sensor 825, is applied to the input of a NOR gate N911. Responsive to the multivibrator 952 is connected an inverter I900. The output of the inverter I900 is fed into a pair of NOR gates N916 and N917 and also as a second input to NOR gate N910. The output of NOR gate N916 is fed as one of the inputs to NOR gate N913. The other input to NOR gate N913 is the output of NOR gate N908. Connected responsive to delay unit 951 is a memory 808a (see FIG. 8). Memory 808a is connected in a binary cell arrangement.

Similarly, a binary cell or flip flop memory device 822 is connected to the outputs of NOR gates N917 and N913. Connected responsive to the NOR gate N909 is a NOR gate N918. The second input to NOR gate N918 is responsive to the output of NOR gate N916. The second input to NOR gate N910 is the output of inverter I900 which was connected responsive to 75 millisecond delay 952. The second input to NOR gate N911 is the output of NOR gate N906. Responsive to NOR gate N916 are connected delay units 955 and 956. A NOR gate N925 is provided and provides an input to delay unit 956. The output of delay unit 956 is applied as the third input to NOR gate N910. The binary cell or memory 823 is respectively connected to the output of NOR gates N917 and N918. A plurality of NOR gates N921, N922, and N923 are provided. The output of NOR gate N910 is applied to NOR gate N911 along with the output of NOR gate N906. The output of NOR gate N912 is connected to 57 millisecond time delay unit 953. NOR gate N912 is connected responsive to the inputs from NOR gate N911 and N902 and memory 808a. The output of time delay circuit 953 is connected to a logic signal inverter I901 from where the output is fed back to 193 millisecond delay 901 and thence into NOR gate N925 along with the output of memory 808a. The output of logic signal inverter I901 is also connected to an amplifier 910. Part track release solenoid 882 is connected to amplifier 910. Part clamp solenoid 808 is connected responsive to the output of amplifier 911 which is connected responsive to the output of memory

808a. Pendulum release solenoid 883 is connected responsive to the output of amplifier 912 which is connected responsive to the output of 57 millisecond delay unit 954. Unit 954 is connected responsive to the output of NOR gate N921. The output of NOR gate N916 is applied to delay units 955 and 956. The output of 113 millisecond delay unit 955 is inverted in inverter 1902, amplified in amplifier 913 and applied to the pendulum cock solenoid 812. The outputs of NOR gate N916 and a NOR gate N925 are connected to the 57 millisecond delay unit 956. The output of delay unit 956 is amplified in amplifier 914 and applied to part stop release solenoid 809. A 113 millisecond delay unit 957 is connected responsive to the NOR gate N922. A 113 millisecond delay unit 958 is connected responsive to the NOR gate N923. Two inputs to each of NOR gates N922 and N923 are applied from memory 822 and inverter 1900. The third inputs to NOR gates N922 and N923 are from the outputs of memory 823. The output of 113 millisecond delay unit 957 is inverted in inverter 1903, amplified in amplifier 915 and applied to contact too hard solenoid 831. Unless a fault occurs, alternatively, responsive to NOR gate N923 the 113 millisecond delay unit 958 output is inverted in inverter 1904, amplified in amplifier 916 and drives soft annealed good contact solenoid 832.

Since the operation and design of such circuits is conventional and the circuits are readily designed with reference to NORPAK Technical Manual, Solid State Control, copyright 1969 by the aforementioned Square D Company, further operation and details will not be described as design and operation are apparent from the drawings and their indicated symbols of inputs and outputs and equations. For purposes of abbreviation, in the drawing symbols of inputs, outputs and equations, energized conditions of the solenoids are indicated by the symbols as follows: No. 1 indicates solenoid 882 condition, No. 2 indicates solenoid 802 condition, No. 3 indicates solenoid 883 condition, No. 4 indicates solenoid 812 condition, No. 5 indicates solenoid 809 condition, No. 6 indicates solenoid 831 condition and No. 7 indicates solenoid 832 condition. The bar over a symbol indicates "not," e.g., No. 1, No. 2, etc. indicates corresponding solenoid "not energized" condition. The symbol L indicates switch SW1, A indicates sensor 824, B indicates sensor 819, C indicates sensor 820, D indicates sensor 821, and E represents sensor 825, and the bar over A, B, C, D or E indicates "not."

While it is nowise to be considered as limiting the scope of the invention, in one practical example of the logic circuit configuration illustrated in FIG. 9, there is utilized the following parts and values of resistors, capacitors, and delay circuits.

Resistors	Value (ohms)
R901	10 K
R920	3.9K
R921	3.9K
R922	3.9K
R923	3.9K
R924	3.9K
R951	22 K
R952	22 K
R953	15 K
R954	15 K
R955	22 K
R956	15 K
R957	22 K
R958	22 K
R991	15 K
R992	15 K
R993	15 K
R994	15 K
R995	15 K
Capacitors	Value (microfarads)
C901	68 mfd
C902	.5 mfd
C951	1 mfd
C952	15 mfd
C953	15 mfd
C954	15 mfd
C955	22 mfd
C956	15 mfd
C957	22 mfd
C958	22 mfd
Single Shot	
Multivibrator	

Delay Circuits	Delay (milliseconds)
901	193 MS
951	5.1 MS pulse
952	75 MS
953	57 MS
954	57 MS
955	113 MS
956	57 MS
957	113 MS
958	113 MS

Thus, for example, upon energization of the solenoid 882 with the switch SW1 in closed position, the NOR gate N901 applies zero input as indicated to the NOR gate N910. With a further input of $\bar{B}=0$ from the inverter 1900 and with the solenoid 809 in off condition (809 or No. 5), the NOR gate N910 is energized. In accordance with the output equation with the proper output from the NOR gate N906 (sensor 825 not lit by a beam of light) this causes NOR gate N911 to be energized. When the required other conditions are present and after the delay of delay unit 953, inversion in inverter 1901, amplification in amplifier 910 and energization of solenoid 882 as indicated by the diagram occurs. The part release solenoid No. 1, 882, responsively contracts plunger 880. Upon contracting plunger 880 forces a single contact 1200 into track aperture 211 (see FIGS. 1 and 8). Solenoid 882 remains energized for about 50 milliseconds by the circuit. The contact 1200 then falls freely through the chute on fall line 214 toward the part clamp test station during a minimum of the next 140 milliseconds (as computed for free fall). If contact 1200 bumps against the containing side of track aperture 210 or chute 211 it takes longer to fall. Projection 218 of bracket 216 (see FIG. 8) interrupts the fall of contact 1200, at which time interruption of light causes a signal on sensor 824 to energize the part clamp solenoid 808, the signal passing through NOR gate N902, delay unit 951, memory 808a, and amplifier 911 to effect clamping by clamp 803. Since the operation of the remaining circuits of FIG. 9 is readily apparent and obvious, the description hereinabove and the illustration, connections, symbols and equations of FIG. 9, in the interest of clarity, further description of operation of each of the subcircuits of the FIG. 9 circuit will not be made except for further reference hereinbelow to the function, sequence and timing of operations.

During this period, the interruption of light to sensor 824 also causes sensor 824 to energize the pendulum release solenoid 883 for about 50 milliseconds. The pendulum 801 starts to move down about 50 milliseconds after energizing solenoid 883 and moves down during the next 100 milliseconds past the sensors 821 and 820 while these sensors are inactivated and too fast past sensor 824 to activate sensor 824 by having its beam of light from the fiber optics 826a interrupted until the pendulum hits the contact 1200, stops at impact and then rebounds. The pendulum rebound timer circuits 811 activate sensor 819 during the start of rebound up time of the pendulum 801. Near the end of the pendulum rebound time (about 85 milliseconds), the pendulum cocking solenoid 812 is energized and during the next 100 milliseconds the pendulum is picked up and cocked. During this time interval, (shortly after the time required if the pendulum hits a hard contact and passes sensor 821) the part stop release solenoid 809 is energized for about 50 milliseconds and causes the bracket 216 and its projection 218 to be pivoted out of the way of the pin 1200. The pin 1200 then falls down towards the chute entering contact deflector means 836. Upon release of the bracket 216, for 100 milliseconds, if the part is too hard sensor 821 causes energization of too hard solenoid 831 for 100 milliseconds after relay memory 823 stops operating which energizes solenoid 831 to move deflecting means 836 to divert the contact 1200 into the "too hard" bin or chute 829. If relay memory 822 is turned on and the hammer passes sensor 820 but during the memory period the sensor 821 does not initiate a signal by the hammer 804 passing it, then during these 100 milliseconds and good soft part release solenoid 832 is energized the moves the deflection means 836 to divert the contact 1200 into the good soft chute 828.

Upon interruption of the beam of light to sensor 825 by contact 1200 upon its free fall to the deflection means 836, sensor E initiates action to after appropriate delay cause part track release solenoid 882 to actuate plunger 880 and start another contact 1200 through the test cycle.

After operation of part track release solenoid 882, if there is no sensor 824 response in about 200 milliseconds, indicating the contact is stuck, a part release timer circuit prevents the part release from test station solenoid 809 from acting and further action of part track release solenoid 882 to inject another contact into aperture 210 is prevented.

The above timing and action is provided by the circuit of FIG. 9 responsive to the switch SW1, the sensors 824, 819, 820, 821 and 825, the logic and timing circuits and the solenoids 882, 808, 883, 812, 809, 831 and 832, therein illustrated.

2. Operation of the First illustrative Embodiment

Refer to FIG. 1. The contacts 1200 which are stored in the hopper 100 are vibrated along the ramp 180 until they drop into the groove 120. The groove 120 is of width and depth sufficient to permit each contact 1200 to be orinated with the barrel 1205 extending upwardly of the groove 120. The track member or guide device 114 is positioned near the hopper 100 at the end of the groove 120 with one end raised so that the contacts 1200 are dispensed from the hopper 100 into the track. The track 114 is inclined from the horizontal so as to permit gravity alone to cause a succession of contacts 1200 to move along the track 114 to the gating mechanism 880. At the gating mechanism 880 the most forward pin of the row of pins 1200 is restrained. The first contact may be released by manually overriding the part track release solenoid 882 to release one contact 1200 down aperture 210. For subsequent contacts 1200, as will be hereinafter described, where the contact 1200 drops past the position where it is blocked by the fall interrupt bracket 216, it interrupts the beam of light between the opposite lighted fiber optics branch 826a and sensor 825. Actuation of sensor 825 showing that the contact 1200 has been released in turn causes the part track release solenoid 882 to operate the gating mechanism 880 which permits the next contact 1200 to be dropped down the chute opening or aperture 210.

Refer principally to FIG. 8. The contact 1200 then drops until the end of the inner extending contact pin 1204 of contact 1200 is stopped by the blocking action of the projection 218 of bracket 216 which at that time is in contact pin blocking position as illustrated in FIG. 8. Upon dropping into the position wherein the contact pin 1200 has its pin 1204 end resting upon bracket 216, pin 1200 interrupts the beam of light between the end of the fiber optics branch 826a of fiber optics 826 which is lit by lamp 827 and the oppositely disposed and aligned upper photodiode or sensor 824. Blocking of this beam of light causes the sensor 824 to be activated. Activation of sensor 824 causes the pendulum release solenoid 883 to be actuated. Upon actuating solenoid 883 by sensor 824, the solenoid plunger 884 retracts and permits the pendulum release bracket 885 to rotate away from the stop 887 and elongate the spring bias member 886. Upon rotation away from the anchor of spring bias member 886 the lever 885 pivots around pivot pin 889 and the rounded edge 888 of bracket 885 moves in a clockwise direction which releases the lever arm 807a from the position shown in phantom so that it is free to drop to the position where it is shown solid. The pendulum 801 then is freed to rotate downwards and rotates in bearings 501 on pendulum pivot rod 400 and the pendulum hammer 804 is rotated relatively rapidly in pendulum swinging operation downward and then through the rectangular aperture 805 in contact pin clamp bracket 803 and strikes the contact member 1200. The contact 1200 is backed by the chute block or anvil 212 as illustrated in FIG. 10. The rounded nose edge of the hammer 804 strikes the contact 1200 which in the usual (machine operative) case is fixedly supported and clamped by contact pin clamp bracket 803 in the front V-shaped groove portion 219 of the anvil backing member 212.

The clamping of contact 1200 by pin clamp bracket 803 has occurred also by interruption of the beam of light to sensor 824 as will now be explained.

Upon interruption of the beam of light from branch 826a to sensor 824, in addition to actuating the pendulum release solenoid 883, the sensor member 824 also simultaneously actuates the part clamp solenoid 808 which causes the plunger 890 to retract and to pull the clamping bracket 803 against the contact 1200 to clamp the contact 1200 between the bracket 803 and the wall of the groove 219 in the anvil support 212.

Upon activation of the pendulum release solenoid 883 and swinging the pendulum 801 in a downward arc, the curved or snub nosed end of the hammer 804 after passing through the aperture 805 in clamping bracket 803 on its downward swing strikes the opposed face of the crimp section 1201 of the contact 1200 while it is being held by the clamp 803 in fixed position against the anvil 212. In accordance with the degree of softness or hardness of the contact crimp section 1201 material which it strikes, the hammer portion 804 of the pendulum 801 bounces back in a return arc distance in accordance with the hardness of the struck material of spring section 1201.

Upon its downward arc motion upon release to strike the crimp portion 1201 of the contact 1200, the hammer portion 804 of the pendulum member 801 blocks the beam of light between the sensor 819 and its aligned lamp 818. Upon interrupting this beam of light, sensor 819 turns on the power to the relay memory circuits 822 and 823 respectively to permit sensors 820 and 821 to initiate operations in accordance with their sensing. That is, on the downward swing of the pendulum 801, the delay circuit 822 associated with sensor 820 and the delay circuit 823 associated with sensor 821 are in off condition and disabled from operation. Upon hammer 804 blocking the beam of light to sensor 819 from its aligned lamp on the downward forward motion toward the contact 1200, this interrupting of the light beam to sensor 819 causes the sensor 819 to enable the relay memory circuits 822 and 823 such that on the backward swing after hitting the contact 1200, the hammer 804 if it passes the sensor 820 causes sensor 820 to activate the relay memory 822 and if it passes sensor 821 it causes activation of the relay memory 823 which has now been enabled by the action of sensor 819. If sensor 820 is not passed on the return swing of hammer 804 there is a machine fault such as improper clamping of contact 1200. It should be understood, that the sensors 820 and 821 and sensor 819 are not immediately acting and that alternatively it would be possible if the hammer 804 were traveling fast enough (as on the forward swing) to have the interval of passing the faces of the sensor members 820 and 821 short enough so that the circuit would not be activated on that swing. However, it has been found that positive action is more desirable and that the additional enabling action of sensor 819 is preferable for greater certainty of proper testing of each contact 1200 (or other part). At the end of its travel, the hammer 804 which has come to a dead stop, in any case would actuate the sensor 819 because of the time delay involved in hammer 804 impinging against the contact, stopping and reversing its direction of motion. That is, due to the impact of hammer 804 and its reversal of direction a time delay sufficient to actuate sensor 819 is provided. Similarly, since on the upward return bounce or stroke of hammer 804 there is not the downward acceleration provided by gravity, the hammer 804 and pendulum 801 are traveling on pivot 400 at a much slower rate. The hammer therefore passes across the sensor 820 and/or the sensor 821 for a sufficient interval to enable actuation of the sensor passed by the interruption of the beam of light from their aligned lamps 818 and the corresponding actuation of enabled relay memory circuits 822 and 823.

The hardness of the contact determines the distance that the hammer 804 travels when it bounces back from contact crimp section 1201. If a soft and therefore acceptable contact, the length of travel of hammer 804 is such as to reach the position where the line of sight between lamp 818 and sensor 820 is blocked and this indicates a soft and acceptable contact.

Accordingly, actuation of relay memory 822 is activated. If the contact is too hard, however, the hammer will not only travel past sensor 820 but will reach the face of sensor 821 and therefore block the beam of light between the lamp 818 and the sensor 821 to actuate the relay memory 823. On its backward travel, not only is the backward travel slower but also the time involved in the stopping at the height of backward travel and in changing direction is such as to insure actuation of sensor 820 and where too hard a contact, actuation of sensor 821. The return arc motion following the impact against the contact 1200 and the bouncing toward the sensors 820 and 821 is followed by a start downwards of the pendulum 801 and its hammer 804 toward the contact 1200 to strike it a second time. However, (ordinarily) this motion is interrupted before the hammer 1204 on the second downward return passes the sensor 819 again due to the closely regulated timing interval of the pendulum cocking time delay circuit 892.

The sensor 824 which causes enabling of the pendulum release solenoid 883 and the part clamp solenoid 808 also performs a third function of simultaneously initiating a time delay circuit 892 which after a given time delay causes the pendulum cock return solenoid 812 to operate. This time delay of time delay unit 892 is such that the pendulum 801 after its first striking the contact 1200 and bouncing back toward sensor 820 or 821 as applicable and accordance with hardness, cannot return a second time to strike the contact 1200. The time delay 892 is so regulated that the pendulum cock solenoid 812 goes into operation before that time to cause the plunger 814 to retract which in turn retracts the linkage 816 and causes the L-shaped pendulum cocking bracket 813 to rotate in a clockwise direction around pivot 817 and force the underside of the pendulum cocking lever 806 in an upward direction. This in turn causes the pivot 400 to rotate in a clockwise direction and causes the pendulum 801 to return to cocked position. In cocked position, the projection 893a of the pendulum cocking bracket 813 retains the pendulum cocking lever 806 in pendulum raised condition. When the pendulum cocking bracket 813 has raised the lever 806 to its uppermost position on the top radius of the projection 893a, the pendulum release lever 807a which is rotated upwardly simultaneously with rotation of the lever 806 is retained in cocked position by spring biased rotation around pivot 889 of the portion 888 of the L-shaped pendulum release bracket 885 until the underside of bracket 807a rests in semipermanent resting position upon the top of the radius 888. The pendulum 801 is thereby retained again in cocked position by the lever 807a resting on rounded edge 888. The bracket 813 is then free to drop by action of the bias spring 815 which holds the bracket 813 against the stop 894 (still referring to FIG. 8). At this time, the pendulum 801 is in upwardly cocked position and the relay memories 823 and 822 respectively contain the information as to whether the contact crimp section 1201 is hard or soft.

Depending upon the hardness indicated by the relay memory 822 or 823 respectively, the contact crimp portion too hard solenoid 831 or the annealed soft enough good contact solenoid 832 will be correspondingly activated. If the contact 1200 is a too hard or bad contact solenoid 831 will retract its plunger (not numbered), drawing the chute plate rotating link 857 to the left as shown in FIG. 8. If the contact 1200 is annealed such that its crimp section 1201 is of the proper softness, the solenoid 832 will draw the link 857 to the right by retracting its plunger. To the link 857 are perpendicularly fastened a pair of arms 855 and 856. The arms 855 and 856 at the top fixedly support the pins 850 and 851. To the pins are fixedly mounted the respective plates 834 and 833.

Refer to FIG. 13 in conjunction with FIG. 8. The leg 855 is fixedly attached to pivot means 895 and the leg 856 is fixedly attached to pivot means 896. When too hard a contact 1200 is indicated and the solenoid 831 causes its plunger accordingly to retract, the link 857 is pulled by linkage 840 to the left as shown in FIGS. 8 and 13. This causes the legs 855 and 856 to rotate simultaneously in a counterclockwise direction. Upon

thus rotating, the plates 834 and 833 which are fixedly attached to the respective pins 851 and 850 are deflected until they are aligned in angular relationship to the vertical in directions which are parallel to the contact bad chute 829. Similarly, upon retraction of the plunger of solenoid 832 in the case of a good soft contact crimp section 1201 the action of the link 857 causes the brackets 855 and 856 to rotate in a counterclockwise direction which in turn turns the fixed pins 850 and 851 to rotate in the counterclockwise direction to rotate the baffle plates 833 and 834 to a position where they are respectively aligned in the direction of the corresponding edges of the good contact crimp section chute 828. The pin 858 is fixedly attached to the link 857 and the pin 860 is fixedly attached to the machine support. Spring member 859 comprises upstanding hairpin like members 897 and 898 which surround the pins 860 and 858 and are reversely wound around the shaft 861. The tension caused by the reversing of the spring 859 around the shaft 861 holds its spring legs 898 and 897 adjacent to the outer circumference of the pins 858 and 860. Therefore, when the link 857 moves to the left or right, the legs 897 and 898 of spring 859 are accordingly deflected around the pivot point formed by pin 860 and are biased such that upon the end of the action of the corresponding solenoid 831 and 832 the spring 859 returns the pin 858 and therefore the link 857 to its central normal position which is aligned with the recycle vertical chute 830. The recycle chute 830 is useful in the situation where for some reason there has been no indication of either too hard or too soft which actuates the solenoid 831 or 832. This occurs when there is some malfunction in the equipment such that either the part does not clamp or for some reason the pendulum has not suitably struck an anvil backed and clamped pin 1200. Also, burnout or failure of any of the sensors 819, 820, 821, 824 or 825 will cause this recycle condition. Without actuation of solenoids 832 or 831 therefore, it is not indicated that a contact 1200 has been properly tested and the contact 1200 is dropped into the recycle chute. After repair of the machine has been effected or the malfunction has ceased to exist, this contact 1200 may again be tested.

Assume, that the contact 1200 is at the point of the cycle where softness or hardness has been detected and the plates 833 and 834 have been correspondingly moved: Refer back to the action of the stop bracket 216 in retaining the contact 1200. When the contact 1200 first passes the sensor 824 to interrupt the beam of light from the end of fiber optics branch 826a, the sensor 824 in addition to actuating the pendulum release solenoid 883 and the part clamp solenoid 808 and the time delay circuit 892 on the pendulum solenoid 812 also causes a time delay circuit 899 to operate. After a time delay of circuit 899 sufficient to enable the clamping and pendulum action to take place has elapsed, the time delay circuit 899 actuates the part stop release solenoid 809. The plunger of solenoid 809 retracts and causes the bracket 216 to pivot in a counterclockwise direction around pivot 828 and against the biased action of bias spring 810 thereby permitting the contact 1200 to fall through further on the line of fall 214 towards the chute entering contact deflection means 836. Upon falling this far, the contact 1200 interrupts the beam of light from the end of the fiber optics branch 826a toward the sensor 825. Sensor 825 under this condition actuates an inhibit circuit which prevents further action of any of the solenoids 882, 808, 883, 809, 812, 831 or 832 and corresponding movements of the parts of the equipment until the contact 1200 has completely dropped past the sensor 825 and the beam of light between the end of fiber strand 826b and the sensor 825 is restored. Thus, the sensor 825 prevents an additional contact 1200 from being put into the block until the contact 1200 has passed the sensor 825.

When the contact 1200 has dropped past the sensor 824, the beam of light from the end of fiber strand 826a of fiber optics 826 to the sensor 824 is no longer interrupted. The beam of light accordingly actuated the sensor 824. The sensor 824 upon being actuated in turn actuates the part track release

solenoid 882 to cause the gating mechanism 880 to again be operative and the next contact 1200 is permitted to fall down the fall line 214 to start of the next cycle.

The natural fall due to gravity of the contact 1200 is rapid enough such that the contact 1200 clears the stopping position of bracket 216 during the period that the solenoid 809 is actuated to retract its plunger and overcome the bias of spring 810. However, the bias of the spring 810 is such that the bracket 216 is restored to contact 1200 stopping position against stop pin 838 before such time as the next contact 1200 allowed to drop through the chute 210 has dropped with its end against the support bar 216.

The time delay circuit 899 was actuated upon the initial interrupting of the line of sight from the strand 826a to the photodiode or sensor 824. The time delay of the time delay circuit 899 is sufficient to enable the pendulum part striking, the clamping action, the return motion and the recocking of the pendulum 801 to occur. At the end of this time, the part stop release solenoid 809 is operated such that it retracts the fall interrupt bracket 216 permitting the contact 1200 to drop through the chute past bracket 216. As soon as contact 1200 has dropped to block the beam of light between fiber optics 826b and sensor 825, responsive to its beam of light being interrupted, sensor 825 inhibits the entire mechanism from further action. When the contact 1200 falls past the sensor 825 thereby again opening the beam of light from branch 826b to sensor 825, the sensor 825 stops inhibiting the remainder of the circuit. When the contact 1200 has passed the sensor 824 down the chute the sensor 824 on having the light restored causes the part track release solenoid 882 to operate. At the same time it stops the power being applied to solenoid 809 and permits retraction of the fall interrupt bracket 216 by the bias spring means 810, the plunger of solenoid 809 being permitted to extend outwardly until the edge of the bracket 216 hits the stop 838. The timing is such and the spring 810 has a strong enough bias so that restoration of the pin stopping position of bracket 216 occurs before the next contact 1200 (when the part track release solenoid 882 causes its gating mechanism to release the contact 1200 into the aperture) falls a distance sufficient for the bottom edge of inner contact extending pin 1204 to reach the top of fall interrupt bracket 216.

3. Structure of the Apparatus of the Other Illustrative Embodiment

Refer to FIG. 14. This embodiment enables determination within close tolerance of specimen hardness or other physical parameters desired to be measured in relative or absolute values. An L-shaped anvil member 301 is provided having a base 303, an upstanding portion 317 and a groove 302. A part (not illustrated) to be tested may be fitted and secured in groove 302. Adjacent to and in stand-off relationship to the base 303 is secured a frame 304. Through frame 304 is formed an arcuate groove 305. A similar frame having formed an arcuate groove (both not illustrated) is provided on the opposite side of the base 303. A threaded pin member 306 dimensioned to fit within groove 305 in adjustably securable closely inter-fitting slidable relationship is provided. A first nut 307 and a second nut (not illustrated) oppositely disposed may be threaded at the respective front and rear of frame 304 onto the pin 307 to place the pin 307 at an adjustably set position. A similarly adjustably securable lamp holder 308 correspondingly secured in a frame (not separately illustrated) on the opposite side of base 303 is provided. A sensor 309 is fixedly supported on pin 306. A lamp 310 is fixedly supported on adjustable securable bracket lamp holder 308. Machine washers may be provided in a manner conventional to the art between nut 307 and frame 304 and the frame secured to the opposite side of base 303 and its nuts correspondingly threaded on a threaded portion (not illustrated) of lamp holder 308. By suitable manipulation, the sensor 309 and the lamp 310 are aligned so that the sensitive face of sensor 309 receives a beam of light from lamp 310 when the beam is not interrupted and the lamp is on. Sensor 309 may be a photodiode or other type of light sensor similar to the sensors

of the hereinabove described first illustrative embodiment. Responsive to sensor 309 sensing interruption of the beam of light between lamp 310 and sensor 309 (for a sufficient duration necessary to its response time) may be provided an electrical resistance meter 311 or other suitable indicating means 311. Such meters and indicators are conventional. A pendulum 312 is provided having a rotatable pendulum support 313, a bar 318 and a hammer 314. Hammer 314 has a part striking face (not numbered). Pendulum 313 is rotatably mounted by suitably supported bearing means 315 on an axis 316. The relative positioning of the axis 316, pendulum 312 and pendulum hammer 314 and the pendulum effective radius from axis 316 to the center of the striking face of hammer 314 in relation to the groove 302 and the axis between the faces of sensor 309 and lamp 310 and the relative positioning and curvature of the arcuate groove 305 and the opposite arcuate groove in the opposite frame (not illustrated) are such that at any adjusted aligned position of the sensor 309 and lamp 310, the hammer 314 of the pendulum 312 may be suspended at any desired point to the right as shown in FIG. 14 of the sensor 309 and it will, due to the force of gravity and by virtue of its suspension, move in an arcuate path pass to interrupt the beam of light between lamp 310 and sensor 309, striking the part contained in groove 302, stop for an instant at impact, and then rebound to return in the opposite direction along the same arcuate path. The sensor may have a sensing time such that it generates a signal and actuates the meter or other indicator 311 responsive to the interruption of the beam of light only on the slower rebound rate time. Optionally with a faster sensor 309, its actuation and responsive operation of each of the interruptions occasioned by the passing of hammer 314 both forwardly and in the return path between lamp 310 and sensor 309 and meter 311 may record interruptions accordingly. Thus, the pendulum 312 may be supported from a given height, released to strike the part in groove 302 and will bounce back and the sensor 309 and lamp 310 may be fixedly adjusted in the groove 305 and the opposing groove (not illustrated) until a recording is received. The position of the aligned lamp 310 and sensor 309 when return passing is indicated determines the relative or absolute hardness or other physical parameter measured.

4. Operation of the Second Illustrative Embodiment

In operation, a part (not illustrated) is placed into groove 302. The aligned sensor 309 and lamp 310 are placed at an approximate position at which the pendulum is expected to rebound. The hammer 314 of the pendulum 312 is placed at a predetermined arcuate distance from groove 302 at least the distance of sensor 309 from groove 302 and usually further and dropped.

The aligned sensors 309 and lamp 310 assemblies are moved in a direction away from the groove 302 until an indication is no longer received. Means (not shown) preferably are provided to gang movement of these assemblies after adjustment to align. If desired, micrometer or other fine adjustment means may be provided such that this movement of the sensor 309 may be accurately made and/or indicated. If desired, at the first absence of indication, the sensor 309 and aligned lamp 310 can be advanced in the return direction until an indication that the pendulum has rebounded to interrupt the line of sight therebetween has been received. Variations and other methods and apparatus including advancement of the lamp 310 and sensor 309 assemblies reversely from indication of interruption to lack of such interruption are apparent in the light of this description.

One modification of the illustrative embodiments, for example, might involve the provision of a potentiometer, the setting of which may be utilized to determine relative or absolute hardness or other physical characteristics upon rebound of the pendulum 312 (or the pendulum 801 of the first illustrative embodiment).

Another modification of the illustrative embodiments involves the use of a camera recording, for example, a polaroid camera. In such case, just before the pendulum is permitted to

drop, the film may start to be exposed by opening the shutter on the camera. Within about one-half second after opening the shutter, the pendulum may be dropped. Approximately 10 seconds after the shutter is opened, it may be closed. After developing, there appears to view a time exposure of the travel of the pendulum. The highest peak determines how far the pendulum rebounded the first time when it was released.

While salient features have been illustrated and described with reference to particular embodiments, it should be readily apparent that modifications can be made within the spirit and scope of the invention, and it is therefore not desired to limit the invention to the exact details shown and described.

What is claimed is:

1. Apparatus to determine non-destructively the relative hardness of each of a plurality of similarly shaped small parts in manufacture comprising:
 - a. means to move each of said parts along a path,
 - b. means to temporarily interrupt the part movement along said path,
 - c. a backing support block of a mass significantly larger than the mass of the said part for supporting said part during said temporary interrupt,
 - d. reboundable striking means operative while said part is being supported by said backing support block to strike said part nondestructively and rebound therefrom, and
 - e. means responsive to the rebound reaction of said striking means to classify said part according to hardness.
2. The apparatus of claim 1, said apparatus further comprising:
 - a. clamping means to clamp said part to said backing support block during the striking action.
3. The apparatus of claim 2 wherein:
 - a. said striking means further comprises a pendulum fixedly supported so that its free end strikes a predetermined portion of the part, and
 - b. said classification is according to the hardness of said predetermined portion.
4. The apparatus of claim 3 wherein said means responsive to the reaction of said striking means further comprises:
 - a. sensing means responsive to rebound distance of said pendulum free end after striking said part.
5. The apparatus of claim 4, said apparatus further comprising:
 - a. means responsive to said sensing means to classify said parts into good, bad and non-tested categories,
 - b. a plurality of part storage means to respectively receive good parts, bad parts and non-tested parts, and
 - c. means to selectively divert said parts into said good, bad and non-tested part storage means in accordance with the aforesaid classification of said parts.
6. A machine for non-destructive testing of the hardness of the crimp portions of substantially all electrical contacts in a production run and sorting accordingly of the contacts, said machine comprising
 - a. a hopper to advance said contacts to a hopper outlet,
 - b. a sloping track adapted to receive said contacts and move them by gravity,
 - c. aperture means directed substantially perpendicularly to said track and disposed at the end of said track,
 - d. part track released means disposed to permit said contacts to move into said aperture one at a time,
 - e. chute means disposed substantially perpendicularly and at an angle with said aperture,
 - f. said chute means comprising a block having groove means substantially vertically disposed therealong in which to receive said contacts in barrel uppermost position,
 - g. interrupt bracket means to temporarily stop one of said contacts at a predetermined location in its path down said chute,
 - h. fiber optics means responsive to a lamp to direct a beam of light in the path of said contact at positions above and below said interrupt bracket means,

- i. first light beam emitting and aligned light sensor means responsive to said interrupted light when said contact is in bracket interrupted position,
 - j. solenoid means responsive to sensing of interruption of said beam of light by said sensor means to thereby cause clamping of said contact against said block within said groove at a portion wherein hardness is to be tested,
 - k. said clamping means having an aperture formed therein,
 - l. a pendulum having a fixed rotatable portion disposed above said interrupt bracket means, a hammer and a shaft disposed between said fixed portion and said hammer whereby said pendulum hammer is freely swinging when permitted to rotate,
 - m. bearing means to permit said pendulum to rotate,
 - n. pendulum release means actuated by said sensor upon interruption of said light to release said pendulum in a downward arcuate path such that said hammer travels downwardly at a relatively fast rate,
 - o. said aperture in said clamping bracket being aligned with said hammer in its downward position such that said hammer strikes said contact crimp portion the hardness of which is to be measured,
 - p. said hammer upon striking said contact crimp portion substantially stopping at impact and traveling in a return arcuate path reversed to said downward arcuate path at a slower rate of speed,
 - q. a second light sensor means responsive to said hammer when it is in stopped and slowly traveling return path position,
 - r. a third and a fourth light sensor means and aligned light beam emitting means,
 - s. relay memory means for each of said third and fourth sensor means respectively actuated by said second light sensor means when the hammer interrupts a beam of light between light beams and said second sensor means,
 - t. said third and fourth sensor relay memory means being respectively responsive to enabling by said second sensor means by interruption of said beam of light by said hammer on its stop and return path to be actuable by said third and fourth sensor means,
 - u. pendulum recocking means responsive to said second sensor means before said pendulum returns to again strike said contact,
 - v. soft, hard, and non-tested contact chutes,
 - w. means responsive to passing of said hammer to interrupt the beam of light between said third and fourth sensor means and their respective aligned lights to correspondingly divert said contacts into said soft and hard contact chutes and to non-passing of said third sensor means to pass a said contact into said non-tested chute,
 - x. means including time delay and bias means to retract said fall interrupt bracket member out of interrupt position,
 - y. path means following said interrupt bracket to reactuate said part track release means to permit another contact to fall into position.
7. Apparatus to determine the hardness of a part in manufacture comprising:
 - a. means to move said part along a predetermined path,
 - b. means to temporarily interrupt the part movement along said path, said interrupt means comprising:
 1. a bracket,
 2. means to move said bracket to selectively block and unblock said part from moving past said interrupt means,
 3. an anvil against which said part is positioned when blocked,
 4. a clamping bracket to clamp said part to said anvil,
 - c. divergent path means positioned along said predetermined path after said interrupt means and including a path for soft parts and a path for hard parts,
 - d. means to strike said part during the temporary interruption of said part movement,
 - e. first time delay means for actuating said striking means,

- f. first sensing means responsive to the positioning of said part adjacent to said interrupt means to activate said first time delay means to in turn actuate said striking means,
- g. second, third and fourth sensing means for sensing the passage of said striking means through respective positions during the striking operation, 5
- h. second time delay means actuated by said second sensing means to activate said third and fourth sensing means, thereby causing said third and fourth sensing means to be responsive to the passage of said striking means during its rebound stroke, and 10
- i. diverting means actuated selectively by response of said third sensing means but not of said fourth sensing means, and by response of both said third and fourth sensing means, to respectively route said part into said path for soft parts and said path for hard parts. 15
- 8. The apparatus of claim 7, said apparatus further comprising:
 - a. a part not tested path divergent from said divergent path means, and 20
 - b. delay means responsive to said second sensing means to route said part into said part not tested path unless said third sensing means detects the passage of said striking means.
- 9. The apparatus of claim 7, wherein said means to strike further comprises: 25
 - a. a pendulum having a hammer portion, and
 - b. means to rotate said pendulum to strike said part.
- 10. Apparatus to determine hardness of a part in manufacture comprising: 30
 - a. means to move said part along a path having a track portion,
 - b. means to release said part on said track portion,
 - c. means to interrupt temporarily the movement of said part along said path, said interrupt means comprising: 35
 - 1. a support block, and
 - 2. a clamping bracket movable into proximity to said block;
 - d. pendulum striking means having a free end for striking said part during the temporary interruption of part movement, 40
 - e. means to move said clamping bracket away from said block after said pendulum striking means has struck said part, thereby allowing said part to continue movement along said path, 45
 - f. means responsive to the continuation of movement of said part past said interrupt means to actuate said means to release,
 - g. means to sense the temporary interruption of movement of said part and upon said sensing to sequentially: 50
 - 1. cause said clamping bracket to clamp said part against said block,
 - 2. release said pendulum means to strike said part, and
 - 3. cause said pendulum means to be recoiled, and
 - h. means responsive to the rebound reaction of said pendulum striking means to classify said part according to hardness after said temporary interruption of movement and while said part is still on said path. 55

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- 11. The apparatus of claim 10, said apparatus further comprising:
 - a. means to release the free end of said pendulum striking means from a position higher than the position at which it strikes said part so that said free end falls by gravity force,
 - b. first sensing means to sense commencement of striking means return movement,
 - c. second sensing means to sense striking means return movement indicating a soft part,
 - d. third sensing means to sense striking means return movement indicating a hard part,
 - e. a pair of memory means responsive to said means to sense commencement of striking means return movement to activate said second and third sensing means respectively, and
 - f. diverting means positioned in said path after said interrupt means to divert said part into soft, hard or non-tested chutes, said diverting means being responsive selectively to striking means return movement past said second sensing means only, or past both said second and third sensing means, or to failure of said striking means to rebound.
- 12. The apparatus of claim 10 wherein said means to divert said part further comprises
 - a. a pair of plates substantially parallelly aligned and rotatable, and
 - b. solenoid means selectively responsive to said striking means passing said second sensing means or passing both said second and said third sensing means to respectively effect rotation of said parallel plates to alignment with said soft chute or said hard chute, and non-responsive in the absence of said striking means passing said second sensing means so as to not divert said plates from a position aligned with said non-tested chute.
- 13. A method of rapidly and non-destructively performing a hardness testing operation on a series of small, similarly shaped parts being manufactured comprising:
 - a. moving the parts along a path,
 - b. temporarily interrupting said movement and fixedly supporting the parts one by one against a backing support block positioned along said path,
 - c. momentarily striking each part non-destructively with a reboundable member in a fixed path directed toward each part while it is in supported position, said reboundable member having a predetermined amount of kinetic energy just prior to the moment of striking,
 - d. sensing the kinetic energy of said reboundable member just after the moment of striking, and
 - e. automatically physically sorting the parts in accordance with the results of the sensing into acceptable, nonacceptable, and indeterminate categories.
- 14. The method of claim 13 wherein:
 - a. the striking operation is performed by releasing from a predetermined position a pendulum member rotatably supported about an axis above said part, and
 - b. the sensing operation is performed by sensing the distance of rebound of said pendulum member.

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