Aug. 9, 1966 K. BOUSCHART ETAL 3,264,866

ROTATING KNIFE TENDEROMETER

Original Filed Feb. 7, 1962 6 Sheets-Sheet 1

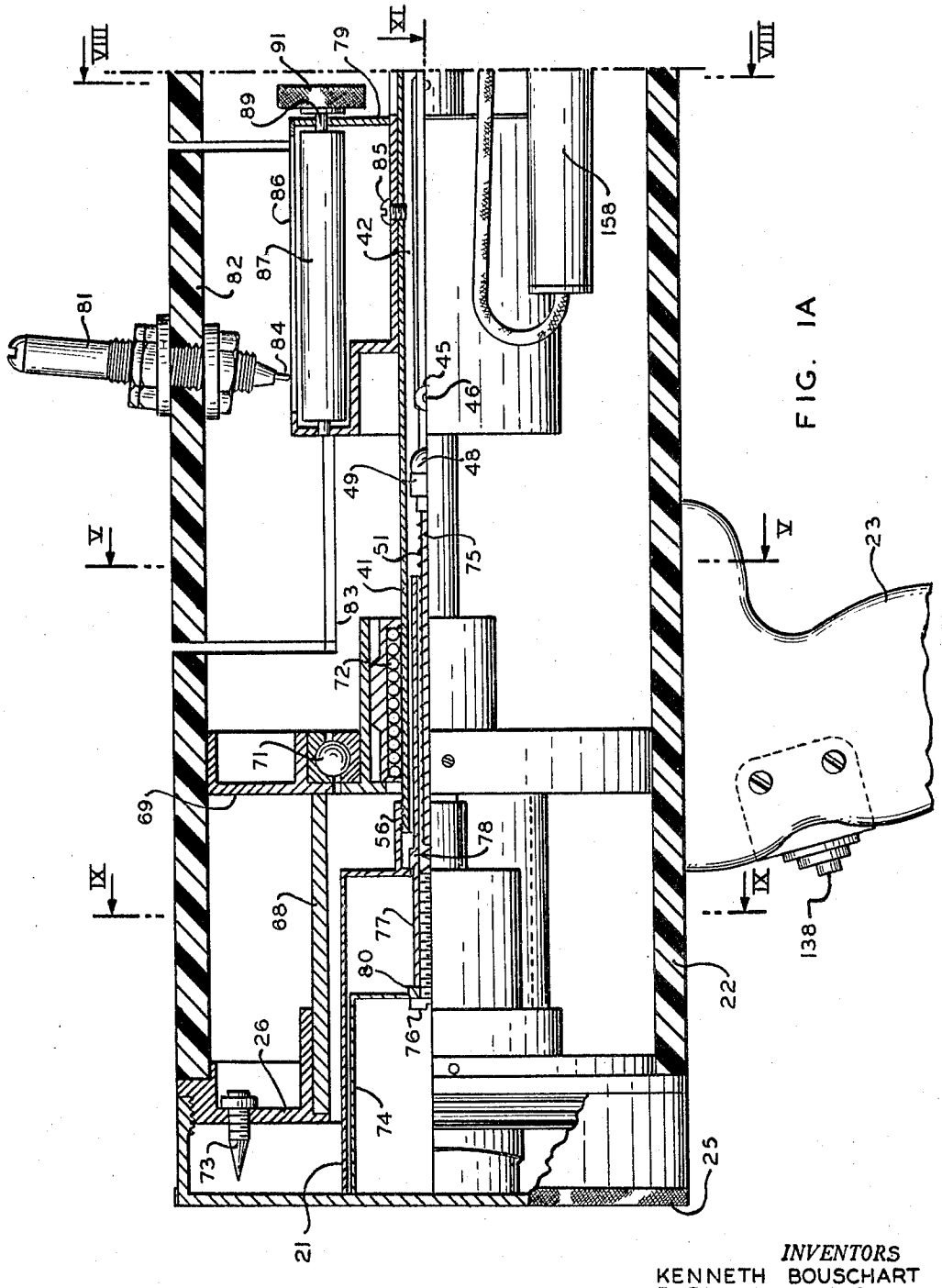


FIG. IA

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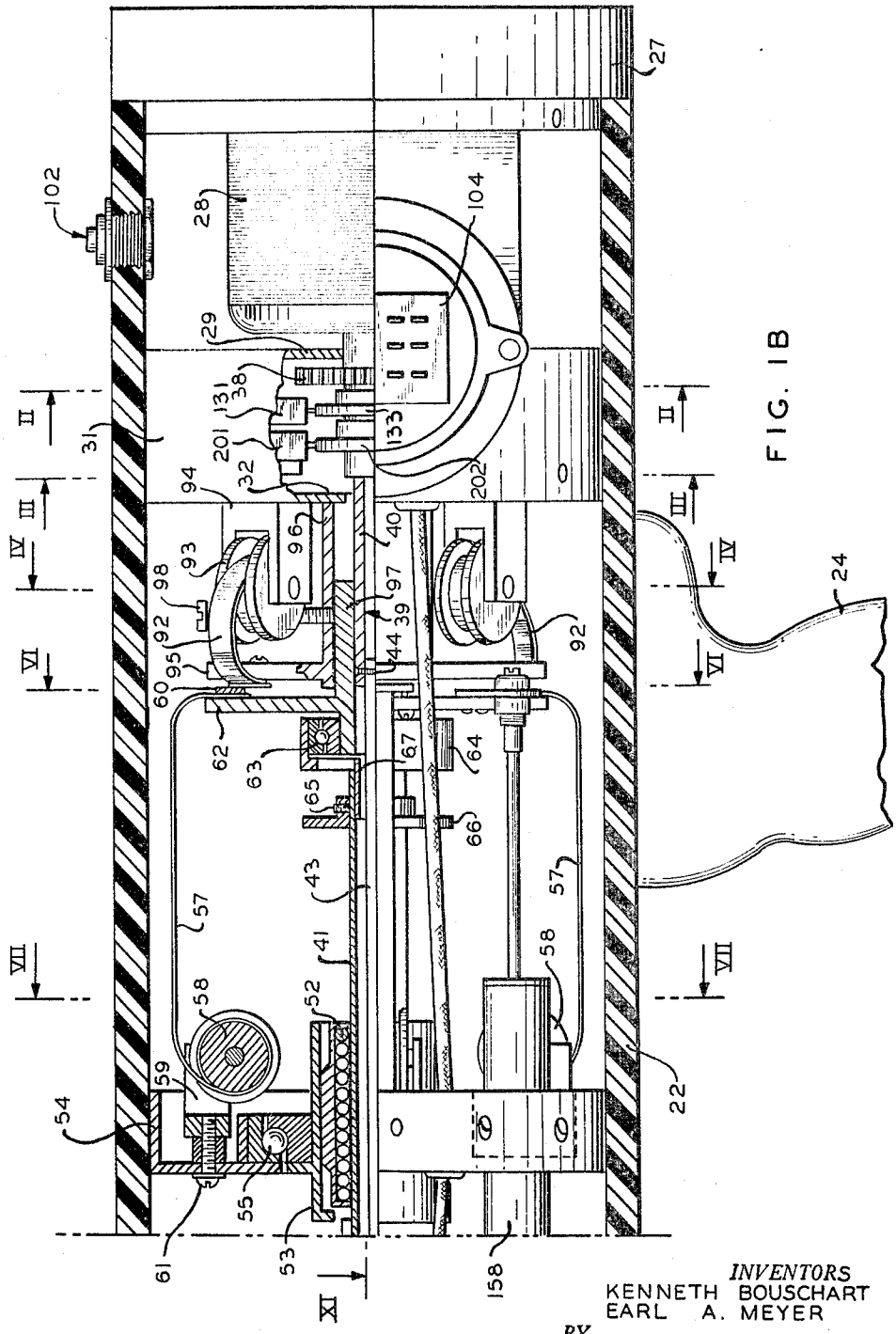


FIG. 1B

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FIG. 2

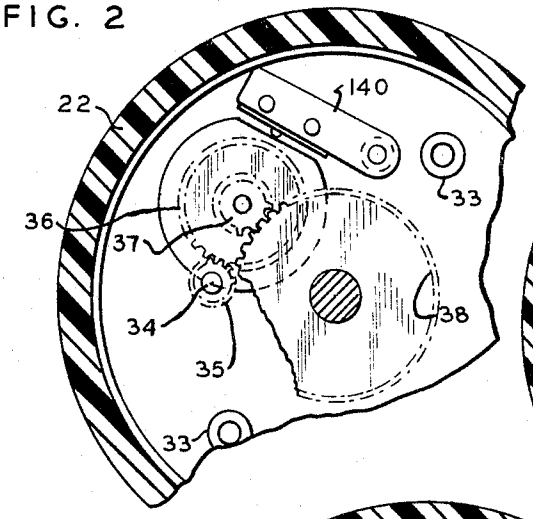
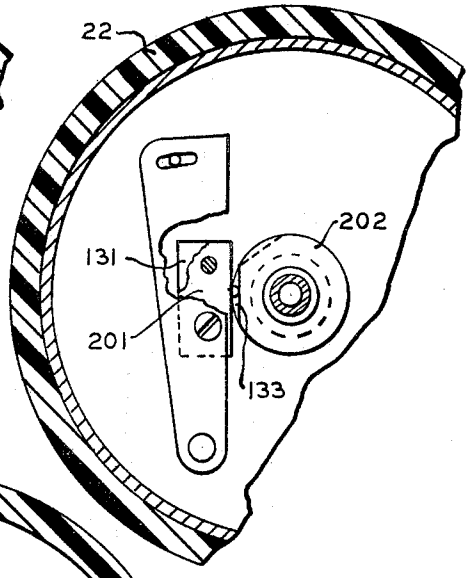


FIG. 3



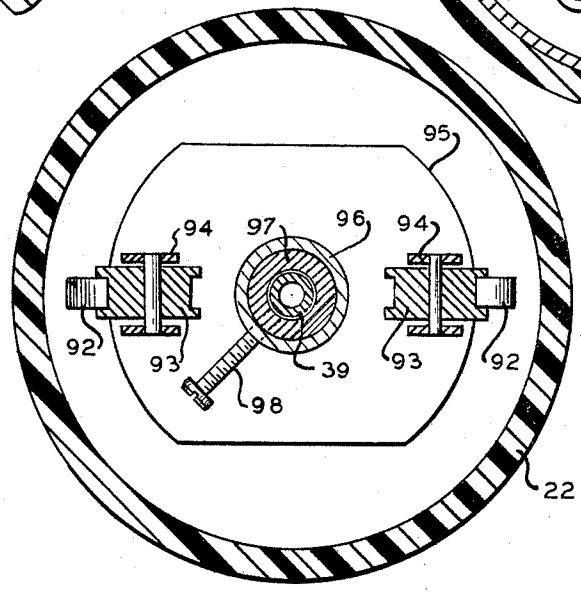


FIG. 4

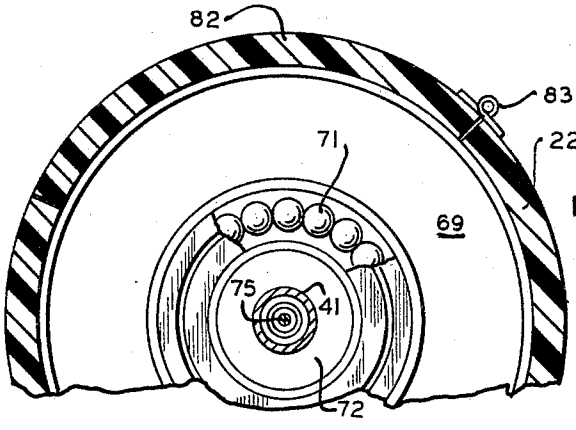


FIG. 5

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FIG. 6

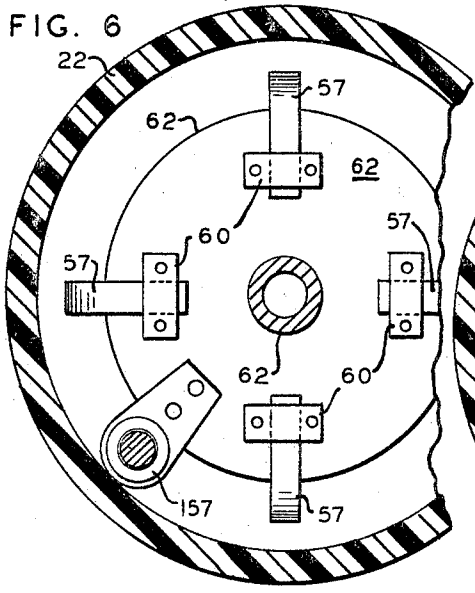


FIG. 7

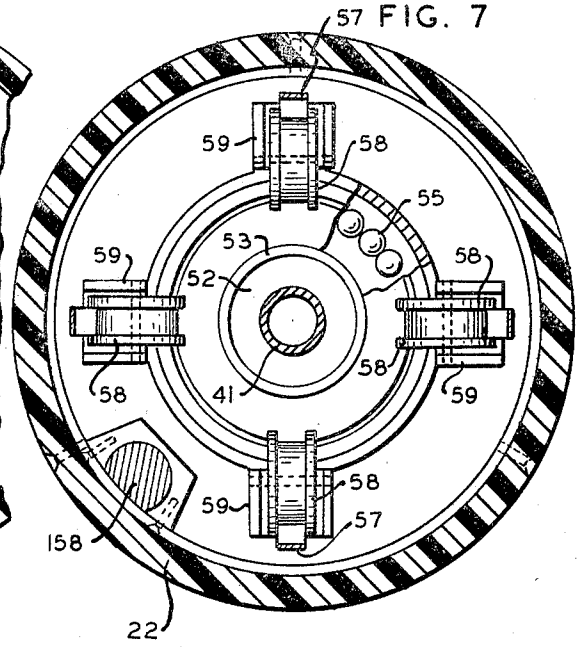


FIG. 8

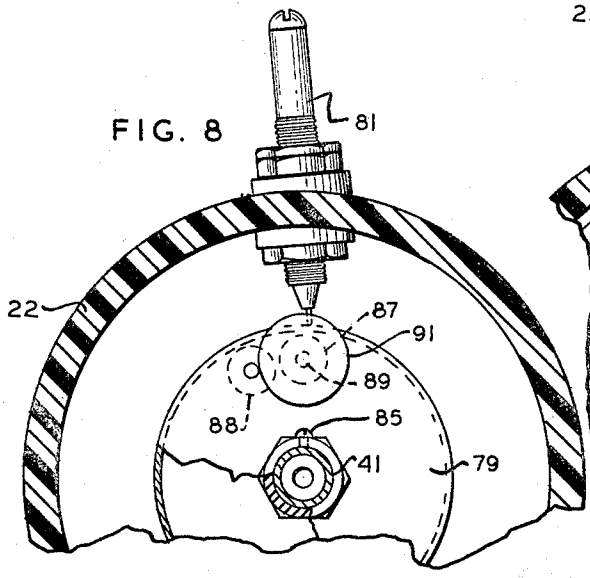
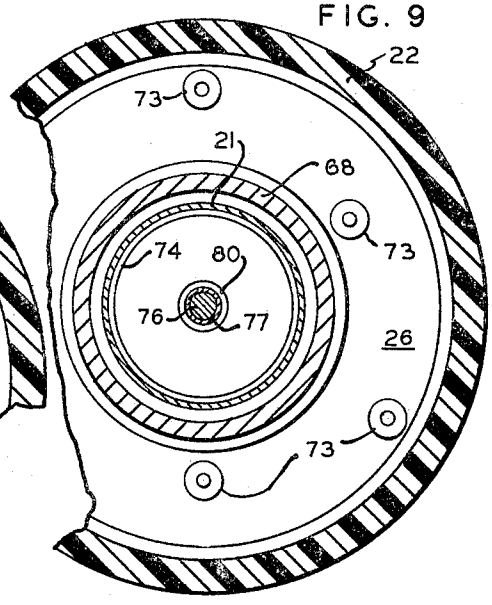


FIG. 9



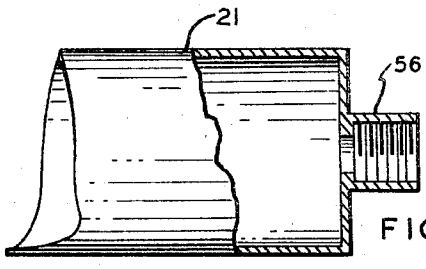


FIG. 10

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ROTATING KNIFE TENDEROMETER

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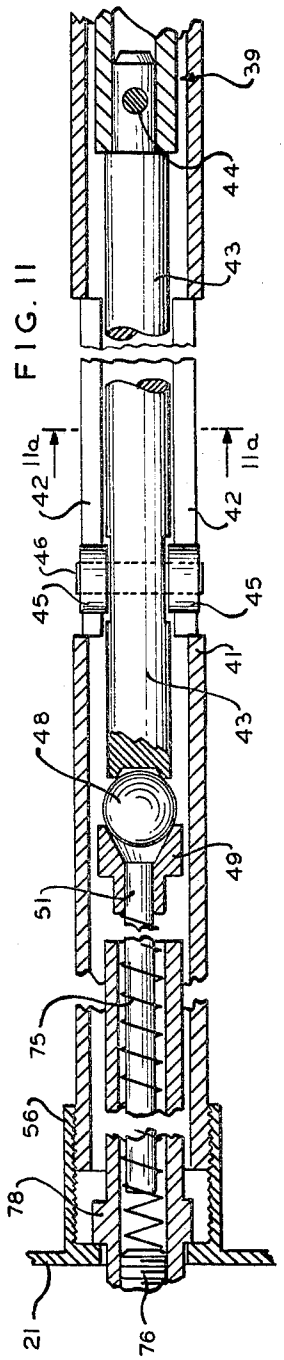


FIG. 11

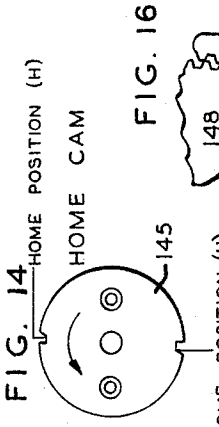


FIG. 14

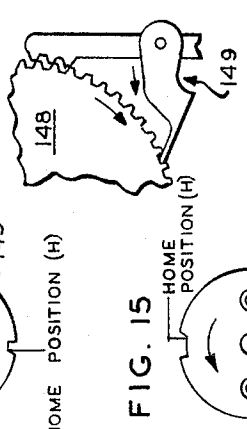


FIG. 16

FIG. 15

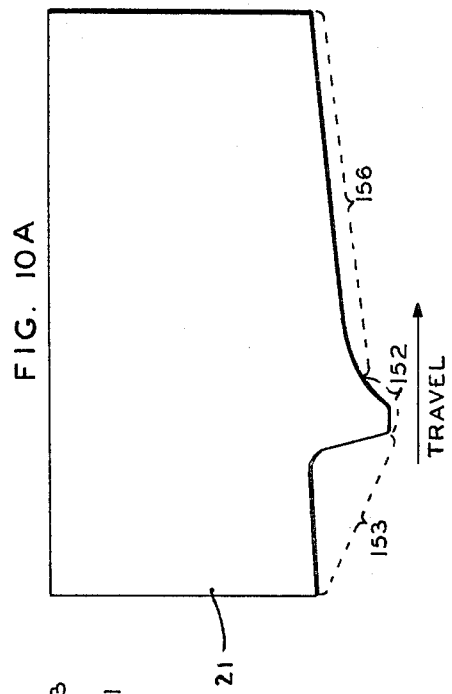


FIG. 10A

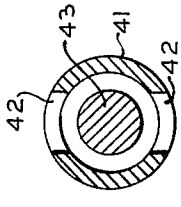


FIG. 11A

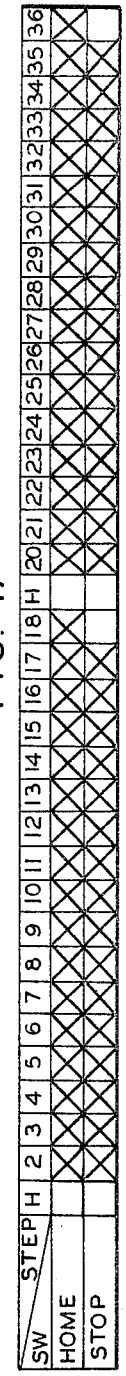


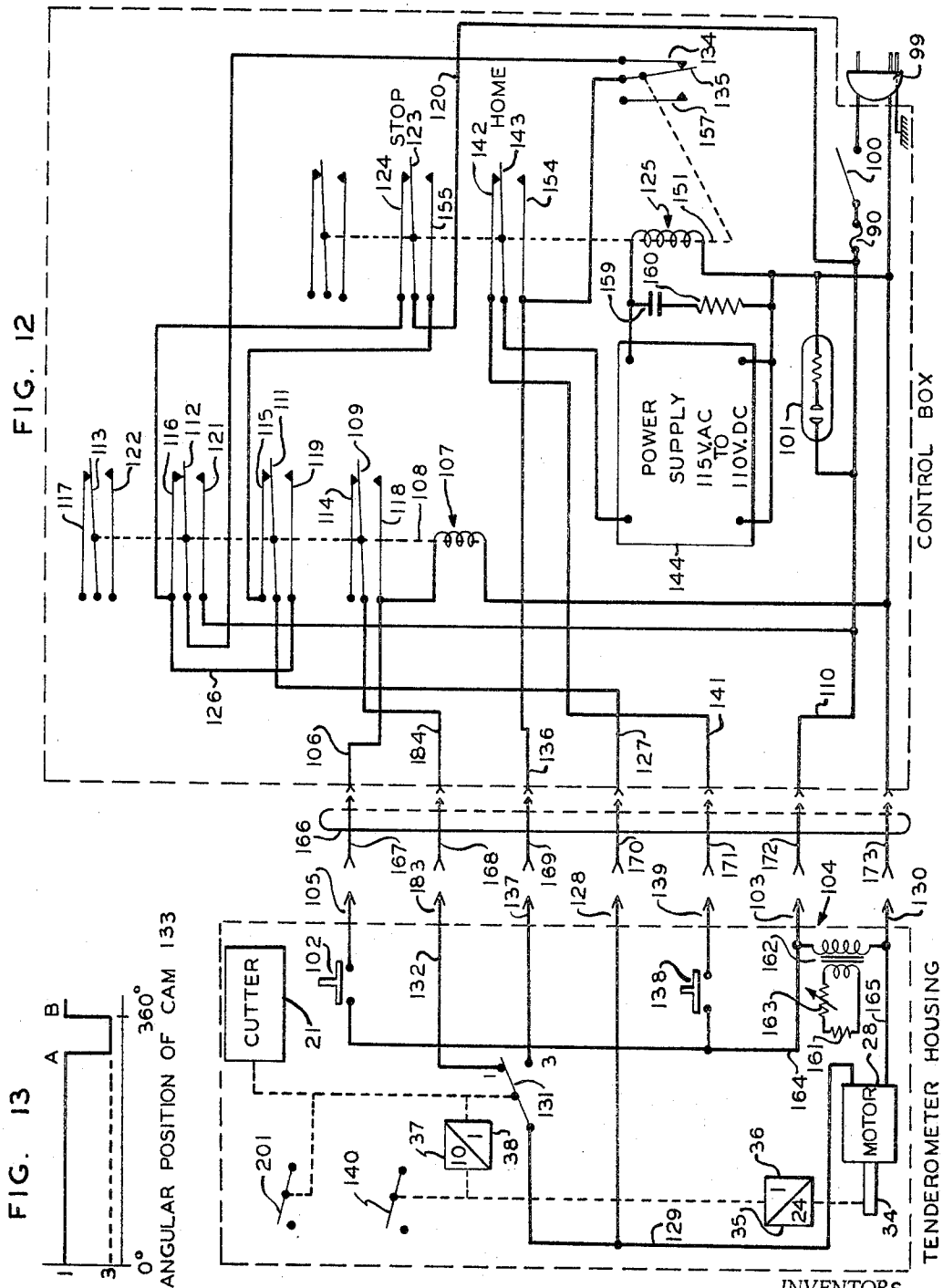
FIG. 17

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United States Patent Office 3,264,866 Patented August 9, 1966

3,264,866

ROTATING KNIFE TENDEROMETER

Kenneth Bouschart and Earl A. Meyer, Madison, Wis., assignors to Feed Service Corporation, Crete, Nebr., a corporation of Nebraska

Continuation of application Ser. No. 171,713, Feb. 7, 1962. This application Jan. 7, 1964, Ser. No. 339,058
12 Claims. (Cl. 73—78)

This invention relates to a method and apparatus for the measurement of the tenderness of a material and, more particularly, to such for the tenderness testing of meat after slaughter.

This application is a continuation of our co-pending application, Serial No. 171,713, filed February 7, 1962, now abandoned.

Contemporary meat tenderness testing methods and apparatus all have certain characteristics or features which limit the usefulness thereof. Some provide a single value of tenderness over a very small region of the meat whereby, due to the non-homogeneous character of meat, a large number of tests are required to obtain a representative result. Others require that the meat specimen be removed from the carcass for testing. Furthermore, none of the prior art arrangements appears to be capable of determining the tenderness of meat with accuracy.

The tenderness of meat is essentially a subjective evaluation by the person chewing the meat when cooked and in most instances is not truly evaluated independently of such characteristics as flavor, texture, and perhaps juiciness. The degree to which a particular physical or chemical test agrees with an organoleptic test (i.e. a "chew" test) determines the usefulness of such testing procedure. It is common knowledge, however, that it is not always necessary for an individual to actually chew a cooked meat sample in order to form a subjective opinion of its tenderness; he frequently prejudges the tenderness of the meat as he cuts it. If the meat cuts easily with a dull knife, such as a table knife, he expects from his previous experience that it will be tender to chew. If it is very difficult to cut with a dull knife, he expects it to be correspondingly tough to chew. It has now been discovered, (1) that differences in meat tenderness can be detected by a suitably instrumented dull knife device and, (2) that there is a reasonable correlation between a tenderness rating by such a device and an organoleptic test. The method and apparatus of this invention involves the use of a dull knife or cutter. A dull knife with the sharpness of an ordinary table knife is required since a sharp knife, such as a steak knife, minimizes the difference between tough and tender meat, cutting them both easily.

An object of this invention is the provision of a method and apparatus for the testing of meat tenderness in which a plurality of successive passes of a dull knife along a predetermined path on the meat are made, the average depth of meat cut per pass of the knife under substantially constant knife-to-meat force being taken as an indication of the tenderness of the meat.

Another object of the invention is the provision of a method of testing the tenderness of meat which method includes making a plurality of successive cuts with a dull knife along a predetermined path on the meat while maintaining a substantially constant force between the knife and meat determining by physical means the number of the cuts and the total depth of penetration of the dull knife or cutter in the meat, the average depth of meat and sensibly indicating the tenderness of said meat cut being taken as indicative of the tenderness of the meat.

A further object of the invention is the provision of a meat tenderness tester comprising a dull blade, means making a plurality of successive passes of the blade along

a predetermined path on the meat while maintaining a substantially constant force between the blade and meat, and means measuring the depth of meat cut during successive passes.

A still further object of the invention is the provision of a cutter for a meat testing device having a blade which has a dull portion adjacent the tip thereof and a sharp portion adjacent the dull portion for cutting tough sinews.

An additional object of the invention is the provision of a meat tenderness testing apparatus in which a circular cut is made in the meat whereby local variations in tenderness which exist when cutting with and against the meat grain are averaged out in the tenderness measurement.

These and other objects and advantages will become apparent from the following detailed description when taken with the accompanying drawings. It will be understood that the drawings are for purposes of illustration and do not define the scope or limits of the invention, reference being had for the latter purpose to the appended claims.

In the drawings wherein like reference characters denote like parts in the several views:

FIGURE 1A is an axial sectional view of one end portion of a testing device embodying the invention, with parts broken away and parts shown in elevation.

FIGURE 1B is a similar view of the other end portion of the device of FIGURE 1A.

FIGURE 2 is a fragmentary transverse sectional view on the line II—II of FIGURE 1B, in the direction of the arrows.

FIGURE 3 is a fragmentary transverse sectional view on the line III—III of FIGURE 1B, in the direction of the arrows.

FIGURE 4 is a transverse sectional view on the line IV—IV of FIGURE 1B, in the direction of the arrows.

FIGURE 5 is a fragmentary transverse sectional view on the line V—V of FIGURE 1A, in the direction of the arrows.

FIGURE 6 is a fragmentary transverse sectional view on the line VI—VI of FIGURE 1B, in the direction of the arrows.

FIGURE 7 is a transverse sectional view on the line VII—VII of FIGURE 1B, in the direction of the arrows.

FIGURE 8 is a fragmentary transverse sectional view of the testing device, including the recording stylus or pen, on the line VIII—VIII of FIGURE 1A, in the direction of the arrows.

FIGURE 9 is a fragmentary transverse sectional view on the line IX—IX of FIGURE 1A, in the direction of the arrows.

FIGURE 10 is a side elevational view, with parts in axial section, of the cutter of the device of FIGURES 1A and 1B.

FIGURE 10A shows the cutter edge portion developed or flattened.

FIGURE 11 is a fragmentary axial sectional view, to a larger scale, on the lines XI—XI of FIGURES 1A and 1B in the direction of the arrows, and with parts in elevation.

FIGURE 11A is a transverse sectional view on the line 11*a*—11*a* of FIGURE 11, in the direction of the arrows.

FIGURE 12 is a wiring diagram.

FIGURE 13 is a chart showing the action of the cam-operated counter switch of FIGURE 12.

FIGURES 14 and 15 are views of the "home" and "stop" cams, respectively.

FIGURE 16 is a fragmentary view of the stepping relay ratchet wheel and pawl assembly.

FIGURE 17 is a chart showing the action of the "home" and "stop" cams.

Reference is first made to FIGURES 1 to 11, inclusive, wherein there is shown a portable or field model of a meat tenderness testing device embodying this invention. The portable model employs a rotary cutter, or knife, **21** mounted within a hollow cylindrical housing **22** to which hand grips **23** and **24** are secured. When not in use, the front end may be closed by a screw cap **25** threaded thereto, which cap is removed before use.

The front and rear ends of the housing **22** are closed by covers **26** nd **27**, respectively, fixedly secured thereto as by screw fastening means. A desirably synchronous gear-head motor **28** is mounted on a motor mounting wall **29** for rotatably driving the cutter **21**. Said wall **29** is secured over the open end of a cup-shaped part or header **31** and spaced from the circular wall **32** thereof by a plurality of hollow cylindrical members **33**. Said members **33** are held in place by securing means such as screws threaded thereto. The assembled parts **29, 31** and **33** are secured within the housing **22** by suitable means such as screws.

The motor shaft **34** is coupled through reducing gears **35, 36, 37** and **38** to drive means **39**. Said drive means includes a coupling portion **40** and a generally hollow cylindrical portion **41** provided with longitudinal slots **42** intermediate the ends thereof. The drive means **39** is secured to a drive member or shaft **43** of cylindrical shape, as by means of a transverse pin **44**. The member **43** is provided with rollers **45** turnable on a shaft **46** which passes therethrough and which is held in place by suitable means, such as a tight fit. The rollers **45** are turnable so that their shaft **46** is freely slidable along the slots **42** which receive the rollers. The free or front end of the member **43** rotatably supports a ball **48** carried in a socket **49** secured to the adjacent end of a spring-mounted force-transmitting rod **51**.

Ball bearings **52** for axial movement are carried within a shaft support and driven member **53**, said member **53** being rotatably mounted with respect to an intermediate support wall **54** by means of ball bearings **55**. The wall **54** is held in place with respect to the housing **22**, as by means of screws or the like. Thus it will be understood that the drive tube **41** is axially movable relative to the drive member **43**, but is relatively rotatably fixed with respect thereto by means of the slot **42** and roller **45** connection. A drive connection to the cutter **21** is thus effected from the motor **28** thru the motor coupling **40**, drive shaft **43**, roller-carrying shaft **46**, rollers **45** and drive tube **41**, which is fixedly secured within the cutter extension or hub portion **56** thereof. The motor mounting wall **29** provides rear-end support for the drive assembly, further support being provided by the walls **54** and **69**.

A constant force along the cutter axis in a forward or left-hand direction, as seen in FIGURES 1A and 1B, is provided by means of four springs **57** comprising bands of stainless steel or the like rolled into coils on spools **58**. The spools **58** are rotatably carried in bifurcated arms **59** fixed to the support wall **54**, as by suitable fastening means such as screws **61**. From these spools **58** the bands extend rearwardly and are fixed to a pressure plate **62** by suitable clamping means, such as the plates **60**. These coiled bands exert a substantially constant force against unwinding and tend to rewind with approximately the same constant force. Thus the pressure plate **62** is urged forward with a constant force supplied thereto by said coiled bands and transmits that force to the drive tube **41** thru ball bearing **63** and a cup-shaped head **64** mounted on the rear end of said drive tube and retaining the ball bearing. The head **64** may be adjustably held in place on the drive tube **41** by having a hub portion press fitted thereinto. Collar member **66** containing a set screw **65** is thereby adjustably mounted on the drive tube **41** in order to limit the stroke thereof to a distance less than the travel of the wiper arm of transducer **158**. This protects the transducer which desirably has only a two-inch travel.

A hollow cylindrical member or housing **68** is disposed between the front cover **26** and a forward wall **69**. The wall **69** acts as a support for the ball bearing **71** which, in turn, supports the ball bearing device **72** which allows for axial movement of the drive tube **41** and the cutter **21** carried thereby. The cover **26** is provided with a plurality of, desirably six, sharply-pointed members or spikes **73** which are adapted to engage the meat sample under test, thereby preventing rotation thereof with the rotating cutter **21** and also stabilizing the instrument. The cap **25** is threaded to the front of the device and protects the pointed members **73** and the cutter **21** when the device is not in use.

Within the cutter **21** is a meat follower **74** in the form of a hollow cylinder with a closing wall at one end forming, in effect, a cup-shaped device. The purpose of the follower is to support the wall of the meat being cut so it does not fall into the groove and be recut. The meat follower is slightly smaller in diameter than the cutter **21** so as to slide therewithin. It is resiliently biased axially toward the left, as viewed in FIGURE 1A, by means of a coil compression spring **75** encircling the rod **51** and acting between the socket **49** and the inner end of a connecting screw **76**.

The screw **76** passes through, and serves to connect, the transverse wall of the follower **74** to a tubular member **77** into which it is threaded. A boss **80** on said transverse wall strengthens it at this point without adding unnecessary weight. The screw also draws the outer end of said member **77** into engagement with the boss **80** around the receiving aperture in said wall. The hub portion **56** of the cutter **21** limits the movement of shoulder **78** which thereby prevents the follower from extending beyond the cutting edge, at the same time allowing the spring **75** to cause said follower to move with the cutter **21** as it advances into the meat being tested. The rearward portion of the tubular member **77**, beyond the shoulder **78**, serves as a housing for the spring **75**.

The recording mechanism for the device includes a drum **79** and a recording pen assembly **81**. The pen assembly is fixedly mounted on a door **82**, pivotally secured to the housing **22** as by means of a hinge **83**, (FIGURE 5). A recording pen **84** is resiliently biased by a spring (not shown) into a chart when mounted on the drum **79** when the door **82** is closed. The drum **79**, with the chart thereon, moves axially with and is rotated with the cutter **21** during a meat-testing operation, by virtue of the connection between the drum **79** and the drive tube **41**, as by means of a screw **85**, while the pen remains fixed with respect to the housing to make a trace on the chart.

The drum **79** is formed with a slit **86** which extends longitudinally and through which the ends of the chart may be inserted and gripped by the paper-winding rollers **87** and **88**. The roller **87** is carried by a shaft **89** rotatively mounted with respect to the drum **79** and provided with a knob **91**. The knob **91** is fixed to one end of the shaft **89** for manual rotation thereon and turnable counterclockwise, as viewed in FIGURE 8, to draw the chart ends between the rollers and the chart tightly on the drum.

When the device is used in a vertical position, that is, with its longitudinal axis vertical and the cutter **21** facing down, it will be apparent that the weight of the reciprocable mechanism, if not compensated for, would add to the force provided by the springs **57** and different indications would be obtained than when operating in a horizontal position. In order to compensate for the weight of the reciprocating mechanism during use in such vertical position, we include two constant-force springs **92** of the same type as the springs **57**.

Said springs **92** are mounted on spools **93** rotatably supported in bifurcated members **94** secured to the wall **32** of the cup-shaped header **31**. The free ends of the

springs are secured to the outstanding flange 95 of a hollow cylindrical member 96. The hub portion of the member 96 may be locked or unlocked with respect to the pressure plate 62, as to a hub portion 97 thereof, by means of a set screw 98. When the screw 98 is tightened on the hub portion 97, the springs 92 exert a constant upward force, or one to the right as viewed in FIGURE 1B, on the reciprocable mechanism to exactly compensate for the weight thereof, whereby the total downward force of the cutter on the meat comprises only that exerted by the springs 57, as in the case of operation in a horizontal position, but where the screw 98 is loosened.

Electrically, there are three distinct operations: "wind," "run" and "home." The "wind" operation provides for one revolution and auotmatic stop to aid in inserting the recording paper; the "run" operation provides for a predetermined number of revolutions and automatic stop for meat testing; and the "home" operation provides for abandoning a test before completion and quickly advancing to the "home" or initial position.

To explain the electrical operation, the three operations in the order listed are: "wind," "run" and "home." Push switch 102 is labeled "wind or home." It is the "wind" switch before and after a test, but it is the "home" switch during a test.

Referring now to the wiring diagram of FIGURE 12, the instrument is readied for operation by connecting the male line plug 99 to a source of 115 volt-60 cycle power and turning on the toggle switch 100 to a circuit protected by fuse 90 or other suitable protective device. Pilot lamp 101 should glow as an indication that the circuit is energized. The "wind" operation is initiated by momentarily depressing the "wind" or "home" push switch 102. This supplies 115 volt power from lead 110 and pin 103 of motor connector device 104 through switch 102 and pin 105 through lead 106 to a coil terminal of relay 107, pulling down on relay armature 108. This removes the movable contacts 109, 111, 112 and 113 from stationary contacts 114, 115, 116 and 117, respectively, and brings them into engagement with stationary contacts 118, 119, 121 and 122, respectively, on relay 107.

A 115 volt circuit then exists from lead 120, movable contact 123 to fixed contact 124 of stepping relay 125, then on through line 126 through fixed contact 119 to movable contact 111, then through lead 127, pin 128 and lead 129 to the motor 28, causing it to start. Also as a branch from lead 129, there is a circuit through counter switch 131 when in the up position illustrated, lead 132 back through pin 183 and lead 184 through relay contacts 109 to contact 118 and on to the same terminal of the coil of relay 107, holding that relay in even after the "wind" or "home" switch 102 is released.

The motor 28 continues to drive in series the reduction gears 35–36, 37–38, the first pair stepping down the speed 24 to 1, as from the motor armature speed of 3600 r.p.m. to a cam shaft speed of 150 r.p.m. and the second pair further stepping down the speed 10 to 1, as to another cam shaft speed of 15 r.p.m., at which speed the drum 79 is adapted to run. The gear train is contained in one assembly with the motor, FIGURE 2, and the cam 133 which operates the counter switch 131 (FIGURE 3). A chart showing the action of the cam-operated counter switch 131 is shown in FIGURE 13. Zero degrees (0°) on the chart represents the point at which the motor is started. When point "A" on the cam 133 of the counter switch 131 is reached, the counter switch movable contact leaves its upper fixed contact and engages its lower fixed contact. Since the counter switch movable contact was supplying the upper fixed contact with 115 volt power to hold in relay 107, the relay now returns to the normal de-energized position. That is, movable contacts 109, 111, 112 and 113 will leave stationary contacts 118, 119, 121 and 122 and return to stationary contacts 114, 115, 116 and 117, respectively.

Relay 107 returning to the normal position would cause the motor to stop running except that the counter switch 131 is now made to engage its lower fixed contact which has 115 volt power on it. This comes about from the input 115 volt power going along lead 120 to stepping relay movable contact 123, to fixed contact 124, then to fixed contact 116, to movable contact 112, back to stepping relay fixed contact 134, movable contact 135, along lead 136 to pin 137 and then to lower fixed contact of counter switch 131.

Therefore, the motor continues to run until point "B" on the cam 133 of counter switch 131 is reached, at which time the movable contact of the counter switch 131 leaves its lower fixed contact and returns to its upper fixed contact. Since the relay 107 is then no longer energized, the motor 28 no longer has a source of 115 volt power and, therefore, stops running. This additional running interval between "A" and "B" is necessary in order for the motor 28 and, therefore, the recording drum 79, to stop in the same location that it does after a run operation, thereby enabling easy insertion and removal of the recording tape. This "wind" operation may be repeated any number of times without affecting the next run operation.

The run operation is initiated by momentarily operating the "run" switch 138. This supplies 115 volt power from lead 110 and pin 103 through pin 139 and lead 141 to stepping relay fixed contact 142 to movable contact 143, to the A.C. to D.C. power supply 144 which applies D.C. to the coil terminals of the stepping relay 125. The desirably .03 microfarad capacitor 159 and the desirably 510 ohm resistor 160 shunting the stepping relay coil terminals are for transient suppression. The stepping relay armature operates as will now be described.

The stepping relay 125 is composed of a cam shaft containing nonmetallic cams 145 and 146, FIGURES 14 and 15, and a metallic ratchet wheel 148, FIGURE 16, containing thirty-six teeth, an electromagnet (see the coil of this in FIGURE 12) and pawl assembly 149, only fragmentarily shown, which operates the ratchet wheel, and the electrical contacts. The electrical contacts are of two types, those which are operated by the cams and those which are operated by the armature of the electromagnet. The electrical position of the single-pole, double-throw cam operated contacts is determined by the cut of the cam. They can be in either one of the two switch positions for any one of the thirty-six cam positions determined by the ratchet wheel. The relay in question has three such single-pole, double-throw cam operated switches each being operated by its own specially cut cam. The first two have been named "home" and "stop" to correspond with the function they perform while the third is a spare for eventual use with the integrating circuit.

The electromagnet operated contacts are similar to those on an ordinary relay in that they operate every time the electromagnet operates. These contacts are also single-pole, double-throw and have been named "interrupter" contacts. They are shown in FIGURE 12 in the de-energized position. The actual stepping or advancing operation is shown in FIGURE 16. Further information may be obtained from page 2 of a brochure titled "Rotary Stepping Switches," published by Automatic Electric, Inc., of Northlake, Illinois. The first three sketches on said page show what happens when the electromagnet is energized. The spring-loaded pawl of the assembly 149 is pulled to the right, engaging the next tooth on the ratchet wheel 148 and storing potential energy in the spring, not shown. Upon de-energizing the electromagnet, the spring pushes the pawl to the left, rotating the ratchet wheel ten degrees ($10° = \frac{1}{36}$ revolution) in the clockwise direction as shown in the last three sketches, the second thereof being reproduced as FIGURE 16. The contacts are shown in the "home" position in FIGURE 12. This is the position in which they remain except during a test. The table of FIGURE 17 shows the position of each cam-operated switch for each of the thirty-six cam positions. "X" on the table indicates the switch position opposite that shown

in FIGURE 12. The switch position indication in the table can be seen to correspond to the cams shown in FIGURES 14 and 15.

Upon releasing the "run" switch **138** the stepping relay armature **151** returns to its original position at the same time advancing the ratchet and cams 10°. FIGURE 17 shows that the cam-operated contacts **143** and **123** of stepping relay **125** change position when advancing from home "H" to "2." In other words, movable contacts **143** and **123** leave stationary contacts **142** and **124**, and move to stationary contacts **154** and **155**, respectively. When this occurs, a 115 volt power circuit is established from the 115 volt supply through lead **120** to stepping relay movable contact **123**, to fixed contact **155**, then to relay fixed contact **115**, movable contact **111**, then through lead **127** to pin **128** and on through lead **129** to the motor **28** causing it to start running. The 115 volt power is also on the movable contact of counter switch **131**. The other motor connection is made through pin **130** of male plug **104** back to the line plug **99**.

Since counter switch **131** engages its upper fixed contact **1** and since the lead **132** from there through pin **183** and lead **184** ends through movable contact **109** at a no connection at fixed contact **114** of relay **107**, nothing else operates at this instant. As the cutter **21** and, therefore, the cam **133** which operates the counter switch **131** near the end of the first revolution, point "A," as indicated on counter switch position chart, FIGURE 13 is reached at which time counter switch movable contact leaves its upper fixed contact **1** and engages its lower fixed contact **3**.

Since there is a 115 volt power on the movable contact of counter switch **131**, the same will be connected to the lower fixed contact thereof, and from there through pin **137**, lead **136**, to stepping relay fixed contact **154** to movable contact **143**, then to the A.C. to D.C. power supply **144** and then to the coil terminals of the stepping relay **125**. This again operates the armature of said relay. When the cam **133** allows the movable contact of the counter switch **131** to leave its lower fixed contact and return to its upper fixed contact, 115 volt power is removed from the stepping relay coil terminals and the stepping relay **125** advances 10° to position "3" of FIGURE 17.

When the cutter **21** has neared the end of each revolution, the counter switch **131** operates as before and causes the stepping relay **125** to advance one position. One the sixteenth revolution (position 17 in FIGURE 17) both the counter switch **131** and the stepping relay armature **151** operate as in previous revolutions. But when the counter switch **131** returns, its movable contact returning to upper fixed contact, the stepping relay **125** advances to chart position 18 at which time the movable contact **123** leaves stationary contact **155** and returns to stationary contact **124**.

Since the stepping relay movable contact **123**, which always has 115 volt power on it, has left stationary contact **155**, this breaks the 115 volt power circuit through relay fixed contact **115** and movable contact **111**, through lead **127** and pin **128**, stopping the motor **28**. At the same time, stepping relay movable contact **123** engages fixed contact **124**, which completes 115 volt power circuit through relay fixed contact **116** to movable contact **112**, and then to the stepping relay **125** fixed interrupter contact **134**, to movable contact **135**, to stepping relay **125** fixed contact **154** to movable contact **143**, to the A.C. to D.C. power supply **144** to again operate the armature **151** of the stepping relay **125**. To this point everything seems to be the same as in previous revolutions.

However, when the stepping relay armature **151** operates, the interrupter movable contact **135** leaves the stationary contact **134** and engages the unconnected stationary contact **157**. This removes the 115 volt power from the A.C. to D.C. power supply **144**, thereby allowing the stepping relay armature **151** to return to the de-energized position and advancing the cams another 10° to the next "home" position, without making another revolution of the cutter **21** in position "18." Since this stepping relay has 36 positions and it is desired to have 16 operating plus 1 "home" position per run cycle, there is room for two run cycles per complete revolution of the stepping relay **125**. This leaves 1 extra position per run cycle or two extra positions per complete revolution of the stepping relay **125**. This is the reason for rapidly passing over position "18."

The number of predetermined revolutions can be changed from one to seventeen by changing the "stop" cam **146** to allow the "stop" movable contact **123** to return to the stationary contact **124** after the desired number of revolutions, thereby repidly advancing over the unused positions. The "run" cycle could also be extended up to 35 revolutions by providing only one "run" cycle per stepping relay revolution. It is helpful to notice that only stepping relay **125** operates during a "run" operation and that only relay **107** operates during a "wind" operation.

The "home" operation, used to abandon a test prior to completion, is initiated by depressing and holding the "wind" or "home" switch **102**. To follow the circuits, it must be remembered that the stepping relay **125** movable contacts **143** and **123** are engaged with stationary contacts **154** and **155**, respectively, since this is during a "run" operation. When the "wind" or "home" switch **102** is depressed, 115 volt power is applied through pin **105** and lead **106** to the relay **107** coil terminals.

This operates relay **107**, causing movable contacts **109**, **111**, **112** and **113** to leave stationary contacts **114**, **115**, **116** and **117**, and engage stationary contacts **118**, **119**, **121** and **122**, respectively. This completes a circuit from the 115 volt power supply to relay **107** fixed contact **121** to movable contact **112**, then to stepping relay **125** interrupter contact **134**, to contact **135**, then to stepping relay **125** contact **154** to contact **143**, then to the A.C. to D.C. power supply **144** which operates said stepping relay.

However, operation of the stepping relay **125** causes the interrupter movable contact **135** to leave the stationary contact **134** which removes the 115 volt power from the A.C. to D.C. power supply **144**, thereby causing the stepping relay **125** to return to the de-energized position and advancing the cams 10°. This, however, causes the interrupter movable contact **135** to return to the stationary contact **134** which again completes the circuit to operate the stepping relay **125**. This making and breaking of the circuit to the stepping relay coil causes the rachet and cam assembly to rapidly advance to the "home" position, at which point the "home" movable contact **143** leaves the stationary contact **154** and returns to the stationary contact **142**. This stops the rapid advance as indicated by the stopping of the "clicking" sound. This is the indication of when it is time to release the "wind" or "home" switch **102**.

It will be noted that when the stepping relay **125** has returned to "home" position, the circuit is ready to go into a "wind" operation. Since the "wind" or "home" switch **102** is not released until after the stepping relay has stopped in the "home" position, the device will be in a "wind" operation for up to one revolution of the cutter **21**, depending upon when the revolution of said cutter, the "home" position of the said stepping relay is reached.

From the foregoing it will be seen that we have devised an instrument particularly adapted for testing the tenderness of meat and wherein a chart is produced on a piece of paper wound on a drum which rotates with the "tenderometer" knife and on which a trace is made by a stylus which may be a ball-point pen **84** held stationary with respect to an enclosing housing. The indication of tenderness may be obtained by first removing the chart from the drum and laying it flat. The area bounded by the traces drawn on the second and last revolutions, and bounded on the sides by lines essentially perpendicular to the traces with loci at the starting and end points of each trace, represents the relative tenderness of the meat.

The second rather than the first trace is used to avoid anomalies which sometime result as the cutter seats in on the first trace. The greater the area, the more tender the meat. The area can be measured by any convenient method, including mechanical methods such as with a planimeter.

It will also be understood that, although we have referred to meat, yet we do not wish to be limited to use of the instrument solely on meat as it is just as well adapted for testing the ease with which other products may be cut or penetrated, such products including plastics and gelatins. In standardizing the instrument, it is intended to first calibrate it with a specific reproducible material such as foamed polystyrene, otherwise known as "Styrofoam."

Although not essential to the invention, a potentiometer **158**, secured to the housing and having a wiper contact movable axially with the cutter, may be provided to actuate an electrical instrument in correspondence with the penetration of the cutter into the meat.

The rotary cutting action described herein is not mandatory but is convenient and desirable. Straight line cutting in the same direction or even reciprocating cutting are examples of other types of cutting action which might also be used. Regardless of the cutting motion employed, the indication of tenderness is the average depth of meat cut per knife passage under constant conditions. The rotary motion tends to average out location variations in tenderness which exist when cutting with and against the meat grain.

It will be understood that the parts of the instrument not shown in FIGURES 1 to 11, inclusive, may be housed in a suitable control box (not shown). Thus, the control box may have all the parts of the wiring diagram enclosed in the dashed area on the right in FIGURE 12.

The shape of cutter **21**, cutting edge down, is illustrated in FIGURE 10A where the cutter is slit and opened up on a plane surface. The direction of travel is to the right, as shown by the arrow, with the relatively dull cutting edge portion shown at **152**. Proceeding to the left from the lowermost portion of the blade, the edge rises sharply to provide a relief in the region **153**. The sharp rise here allows the cutter to respond rapidly in faithfully tracing the tenderness profile when irregularities, such as sinews, are passed over, thereby giving a true point by point indication. The region **156** serves a dual function as a pilot in advance of the relatively dull cutter portion **152** as well as a relief in addition to **153** to insure that the cutting edge **152** is the only portion of cutter **21** in contact with the bottom of the cut. Since regions **153** and **156** do no cutting whatsoever, they are left completely dull.

The cutter **21** as originally developed had a very sharp portion called the "sinew cutter" in the **156** region, practically at the **152–156** boundary. A sinew, if uncut, could mask a very tender portion under the sinew. The purpose of the sinew cutter was therefore to cut the sinew after a few revolutions when further penetration into the meat would put the sharp sinew cutter in contact with the sinew. The function of this former sinew cutter is now performed by the presently somewhat less dull cutting edge **152** of the cutter **21**. This eliminates the very sharp sinew cutter which would not be conducive to long term reproducibility because of rapid dulling.

In the operation of the device, the cutter **21** is rotated at a low speed of, say 15 revolutions per minute by the motor **28**. Since the cutter and chart drum **79** are mounted on the same shaft, they obviously rotate together at the same speed. As the blade of the knife penetrates into the meat upon rotation thereof, the drum chart moves downwardly relative to the pen and a trace is made on the chart. In the unrolled condition of the chart, there appears, a single trace for each revolution of the knife. It will be apparent that adjacent traces will be spaced further apart when the meat is tender and closer together where the meat is tough.

A numerical index of tenderness can readily be obtained by measuring the area between the second and last trace of each set. The larger the area, the more tender the region tested. The area thus measured will represent a value corresponding to the average point by point tenderness obtained on the particular test. In comparing the tenderness of one meat sample with another on a uniform scale, it is necessary to adopt standard conditions. All factors, except the meat sample itself, should remain constant from test to test; this includes the number of revolutions, blade configuration, blade dullness, and the normal force exerted by the rotating blade on the meat.

In using the instrument, the control box power cord plug **99** is connected to a source of 115 volt, 60 cycle power. A cable, shown schematically in FIGURE 12, is used to connect the control box to the male plug **104** mounted on the desirably transparent plastic housing **22** of the instrument. The protective cover **25** is removed from the cutter end of the instrument.

A mode of operation is selected, that is, vertical or horizontal, by either engaging or disengaging the counterbalance plate **95**. For vertical operation, the cutter **21** is depressed to the fully retracted position and the counterbalance set screw **98** is tightened on the pressure plate hub **97** as illustrated in FIGURE 1B. For horizontal operation, set screw **98** is left loose. The power is applied by operating the toggle switch **100** on the control box. The adjacent pilot light **101** should glow, indicating that the instrument is ready to operate.

The chart-paper door **82** may now be opened. One end of a desirably 9 inch long piece of 2¼ inch paper tape is placed in the recording drum slot and the winding knob **91** on top of the drum **79** turned just enough to grip the paper. The "wind" or "home" button **102** may now be momentarily pressed to cause the drum to rotate one revolution. When it stops, the free end of the paper is inserted in the same slot and the wind knob turned until said paper is drawn up tightly. The chart-paper door **82** should now be closed and latched, bringing the stylus or pen **84** into contact with the paper.

To perform a test, the instrument is placed firmly and squarely in contact with the exposed muscle region of a round of meat or any other sort of material, the tenderness or permeability of which is to be tested. For comparative test purposes, if on meat, it is important that the test be performed in the same region each time. While exerting a force of two pounds or more, the run switch **138**, which may be on the forward handle **23**, is pressed. This starts the revolution sequence. At the end of the elected number of revolutions the instrument will stop.

The instrument is then withdrawn and the chart-paper door opened. The chart paper is removable upon unwinding the knob **91**. To read the indicated tenderness, the total area between the second and last traces of the recorder pen is determined. The area can be measured with a planimeter.

If it is desired to abandon a test before completion, the instrument can be cycled to the starting position quickly by depressing the "wind" or "home" button **102** until the "homing" is completed as indicated by the stopping of the control box clicking. The instrument may continue running up to one more revolution at this time.

If the recording stylus of the assembly **81** is a pen containing ink which flows too slowly for effective operation at low temperatures such as those in meat coolers, it is desirable to heat it electrically. This may be accomplished by incororating in the pen a resistor **161** energized from the secondary winding of a transformer **162** through a control rheostat **163**. The primary winding of the transformer may receive power by connection across leads **164** and **165**, as illustrated in FIGURE 12.

Instead of having the pins **105, 183, 137, 128, 139, 103** and **130** directly engaging corresponding sockets on the control box for respective connection with the leads **106, 184, 136, 127, 141, 110** and the grounded lead from the desirably grounding type plug **99**, we desirably employ a detachable cable diagrammatically represented at **166**. Thus, such a cable includes leads **167** to **173**, inclusive. The left hand end of each of these leads, as viewed in FIGURE 12, terminates in a socket for respectively receiving the pins **105, 183, 137, 128, 139, 103** and **130**. The right hand end of each of the same leads terminates in a pin adapted to be received in sockets respectively terminating the left hand ends of the leads **106, 184, 136, 127, 141, 110** and the grounded lead from plug **99**, also as viewed in FIGURE 12.

Having now described our invention in detail in accordance with the patent statutes, those skilled in this art will have no difficulty in making changes and modifications in the individual parts or their relative assembly in order to meet specific requirements or conditions. Such changes and modifications may be made without departing from the scope and spirit of the invention as set forth in the following claims.

We claim:

1. Apparatus for determining the tenderness of a material comprising a dull cutter, means successively passing the cutter along a predetermined path on the material under test to cut the same, means maintaining a substantially constant force between the cutter and material during each cutting pass, and means for determining the average penetration per cutting pass of said cutter into said material for a plurality of such passes.

2. Apparatus according to claim **1** including means continuously recording the penetration of the cutter relative to a predetermined reference point.

3. Apparatus according to claim **1** wherein the means successively passing the cutter along a predetermined path on the material includes a rotatable shaft upon which the cutter is mounted, and means rotating the shaft so that the cutter makes a circular cut in the material.

4. Apparatus according to claim **3**, wherein the material is meat.

5. Apparatus according to claim **1** wherein said cutter has a blade with an edge, said edge having a relatively dull cutting portion dropping sharply as a relief at the rear end of said cutting portion and preceded by a gently rising portion to function as an additional relief and a pilot for the cutting portion.

6. Apparatus according to claim **5**, wherein the cutter is formed at the edge portion of a hollow cylinder, and the cutting edge is generally helically shaped.

7. A tenderness testing apparatus comprising a cutter having an edge, a rotatable shaft, means securing the cutter to the rotatable shaft with the edge displaced from the shaft axis, means rotating the shaft, a chart drum secured to the shaft and rotatable therewith, and a stylus adapted to engage a strip of paper when on the chart drum.

8. An instrument for determining tenderness comprising a hollow cylindrical housing, a hollow cylindrical cutter closed by a wall at its rear end and disposed in and mounted for axial movement with respect to said housing, a wall in and extending transversely of said housing, an electric motor disposed in said housing and carried by said wall, drive means for said cutter extending from said motor, a connection between said motor and said drive means, said drive means including a hollow cylindrical portion, a drum carried by said hollow cylindrical portion, means to mount a strip of recording paper on said drum, a stylus carried by said housing and adapted to make a graph on the paper as the drum turns and moves axially with said hollow cylindrical portion, a shaft connected to said drive means coaxial with and disposed in said hollow cylindrical portion, means for transmitting rotary motion, while allowing relative axial motion, between said shaft and hollow cylindrical portion, a hollow cylindrical follower disposed in and movable with respect to said cutter, a rod extending rearwardly from said follower through the rear wall of said cutter, and means resiliently biasing said follower outwardly with respect to said cutter, away from said shaft, and disposed inside of said hollow cylindrical portion, to allow said follower to trail the cutter in the axial direction as the material being tested is cut.

9. An instrument for determining tenderness comprising a hollow cylindrical housing, a hollow cylindrical cutter closed by a wall at its rear end and disposed in and mounted for axial movement with respect to said housing, a wall in and extending transversely of said housing, an electric motor disposed in said housing and carried by said wall, drive means for said cutter extending from said motor, a connection between said motor and said drive means, said drive means including a hollow cylindrical portion, a drum carried by said hollow cylindrical portion, means to mount a strip of recording paper on said drum, a stylus carried by said housing and adapted to make a graph on the paper as the drum turns and moves axially with said hollow cylindrical portion, said hollow cylindrical portion being provided with longitudinally extending slots, a shaft connected to said drive means coaxial with and disposed in said hollow cylindrical portion and a pin extending transversely through said shaft, a drive roller on each end portion of said pin and each disposed in one of the slots in said hollow cylindrical portion for transmitting rotary motion, while allowing relative axial motion, between said shaft and hollow cylindrical portion, a hollow cylindrical follower disposed in and movable with respect to said cutter, a rod extending rearwardly from said follower through the rear wall of said cutter, and means resiliently biasing said follower outwardly with respect to said cutter, away from said shaft, and disposed inside of said hollow cylindrical portion.

10. An instrument for determining tenderness comprising a hollow cylindrical transparent housing, front and rear covers closing the ends of said housing, a hollow cylindrical cutter closed by a wall at its rear end, disposed in, and mounted for axial movement with respect to said housing, hand grips projecting laterally from said housing, a screw cap threaded to the front end portion of said housing, a wall in and extending transversely of said housing, an electric motor disposed in said housing and carried by said wall, drive means for said cutter extending from said motor, reducing gears between said motor and said drive means, said drive means including a coupling portion and a hollow cylindrical portion, a recording drum carried by said hollow cylindrical portion, means to mount a strip of recording paper on said drum, a stylus carried by said housing and adapted to make a graph on the paper as the drum turns and moves axially with said hollow cylindrical portion, resilient means to exert uniform outward axial force on said hollow cylindrical member to urge said cutter against material being tested, means to resiliently counterbalance the cutter and parts which move therewith when the apparatus is used with its axis disposed vertically, said hollow cylindrical portion being provided with registering, longitudinally extending slots, a shaft connected to said drive means coaxial with and disposed in said hollow cylindrical portion, a pin extending transversely through said shaft, a drive roller on each end portion of said pin and each disposed in one of the slots in said hollow cylindrical portion for transmitting rotary motion, while allowing relative axial motion, between said shaft and hollow cylindrical portion, a hollow cyindrical follower disposed in and movable with respect to said cutter, a rod extending rearwardly from said follower through the rear wall of said cutter, and means resiliently biasing said follower outwardly with respect to said cutter, away from said shaft, and disposed inside of said hollow cylindrical portion.

11. An instrument as recited in claim 10, wherein the front cover carries pointed members for engaging material under a test.

12. An instrument as recited in claim 10, including an electric circuit to the motor and switches mounted on the hand grips for controlling said circuit.

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