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[54] **PROGRAMMABLE BREAKAWAY CLUTCH SYSTEM WITH COLLAPSIBLE FAILURE MODE**

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[51] **Int. Cl.**[5] **F16D 43/20**

[52] **U.S. Cl.** ..... **192/56 F**; 192/56 R; 464/36; 901/46; 901/49

[58] **Field of Search** ..... 192/56 R, 56 F, 150; 901/29, 46, 49; 464/36, 38, 39

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,488,980	1/1970	Burrough .	
3,626,506	12/1971	Spieth .	
3,638,973	2/1972	Poletti .	
3,819,286	6/1974	Bianchi .	
4,103,849	8/1978	Holt et al. .	
4,176,981	12/1979	Clapper et al. .	
4,188,142	2/1980	Olsson .	
4,245,729	4/1980	Lunke et al. .	
4,328,621	5/1980	Benjamin .	
4,514,616	4/1985	Warner	901/49 X
4,540,331	9/1985	Stanner et al.	901/49 X
4,557,623	12/1985	Tella .	
4,639,184	1/1987	Knasel et al.	901/49 X
4,661,038	4/1987	Kohler et al.	901/49 X
4,700,932	10/1987	Katsuno	901/49 X
4,717,003	1/1988	McCormick et al.	192/56 F
4,725,190	2/1988	Kato	901/49 X
4,848,546	7/1989	McCormick et al.	192/56 F
4,884,670	12/1989	McCormick et al.	192/56 F

FOREIGN PATENT DOCUMENTS

3025952	2/1982	Fed. Rep. of Germany .
216892	2/1985	German Democratic Rep. .
85/00315	1/1985	PCT Int'l Appl. .

OTHER PUBLICATIONS

Robotic Accessories' brochure entitled "Uni-Coupler Safety Joint".

Rumble Equipment advertisement, p. 9, Robotics World, Jan., 1986.

Kuka brochure, pp. 26–27 disclosing collision protective device.

Diagram labeled "G. M. Clutch".

Diagram labeled "Oilfield Tool by Whipstock, Inc.".

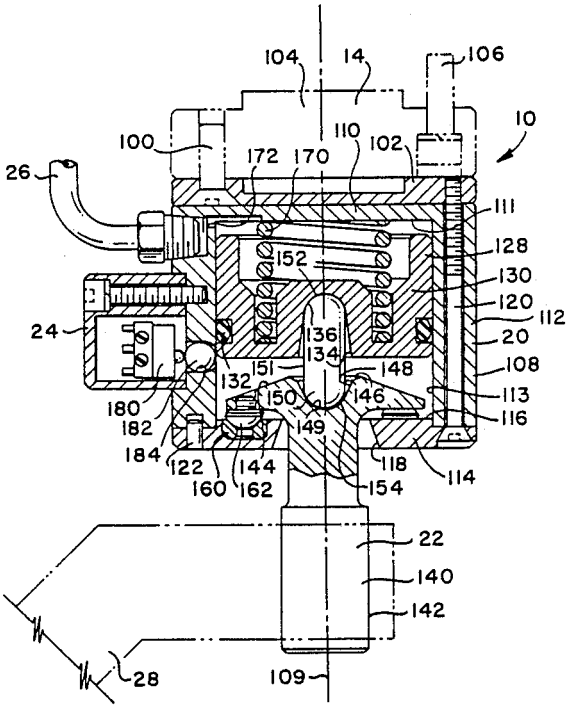
Primary Examiner—Richard Lorence

Attorney, Agent, or Firm—Daniel V. Thompson

[57] **ABSTRACT**

A breakaway clutch for robot end-of-arm tooling includes a housing and movable member constrained within the housing for movement along a central axis. A tool connecting member is linked to the movable member by way of a capsule-shaped link. The tool connecting member is located such that a movable member is in the normal position and the tool connecting member is movable in all directions except in the direction of a front housing wall. The movable member is biased toward the normal position, with the biasing being adjustable to vary the bias and thereby vary the sensitivity of the clutch to forces applied to the movable member by way of the tool connecting member. Movement of the movable member away from the normal position is sensed to send an alarm signal to the robot controller.

4 Claims, 2 Drawing Sheets



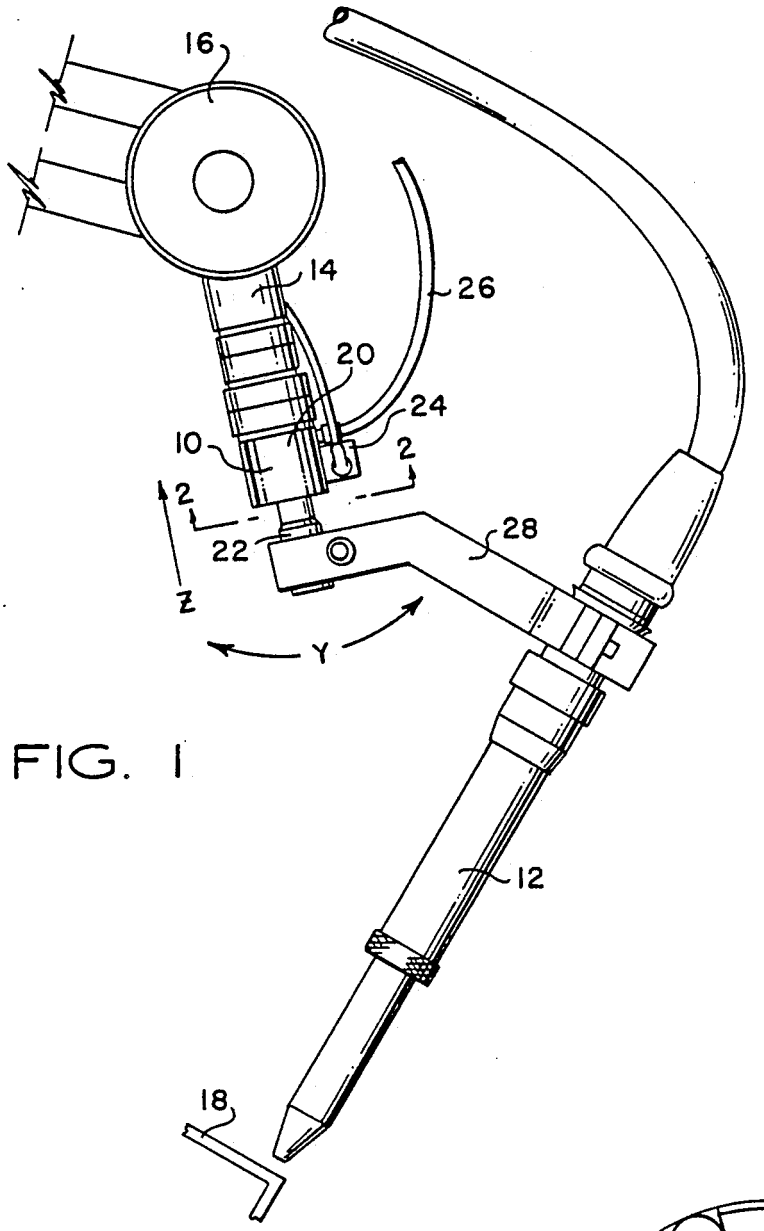

16
14
26
20
24
10
2
2
22
28
Z
Y
12
18

FIG. 1

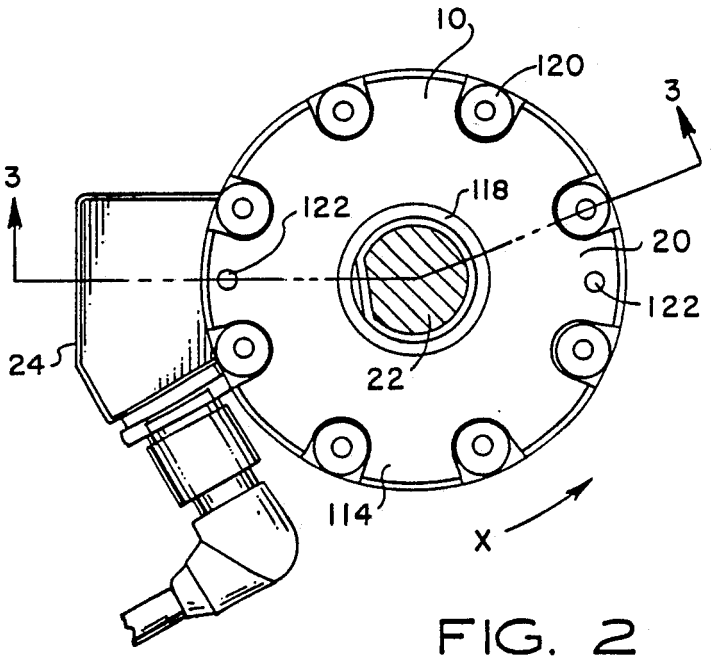

10
120
3
3
122
118
20
122
24
22
114
X

FIG. 2

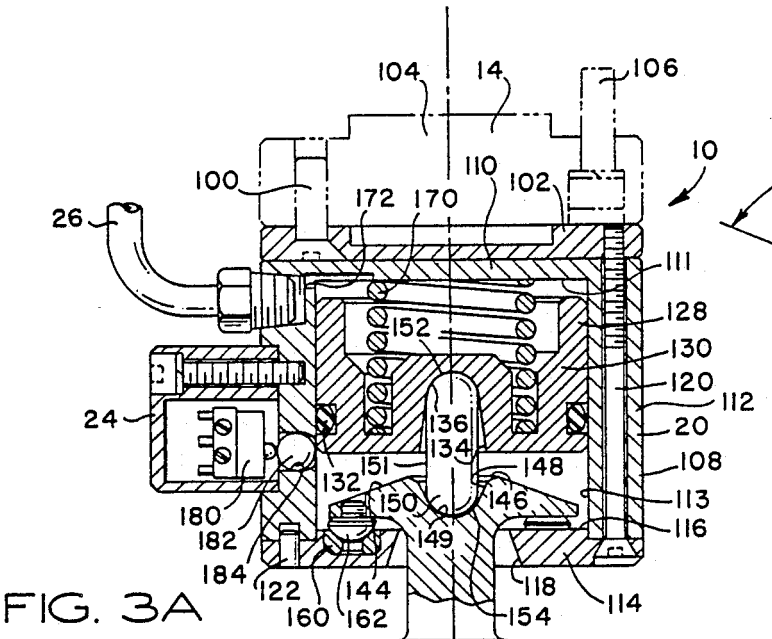


FIG. 3A

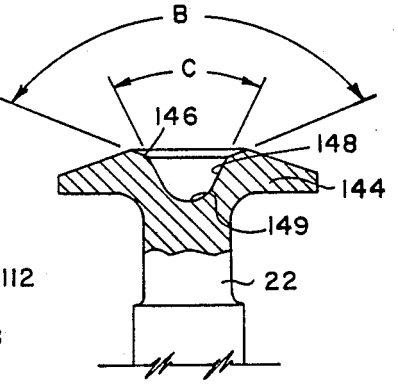
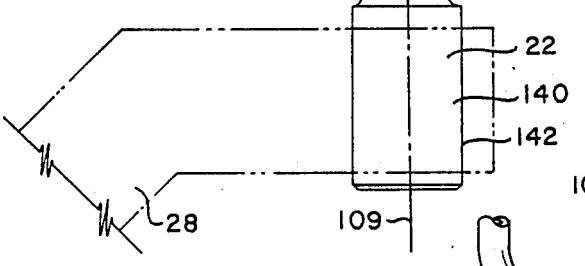


FIG. 5



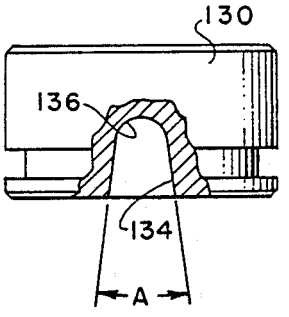


FIG. 4

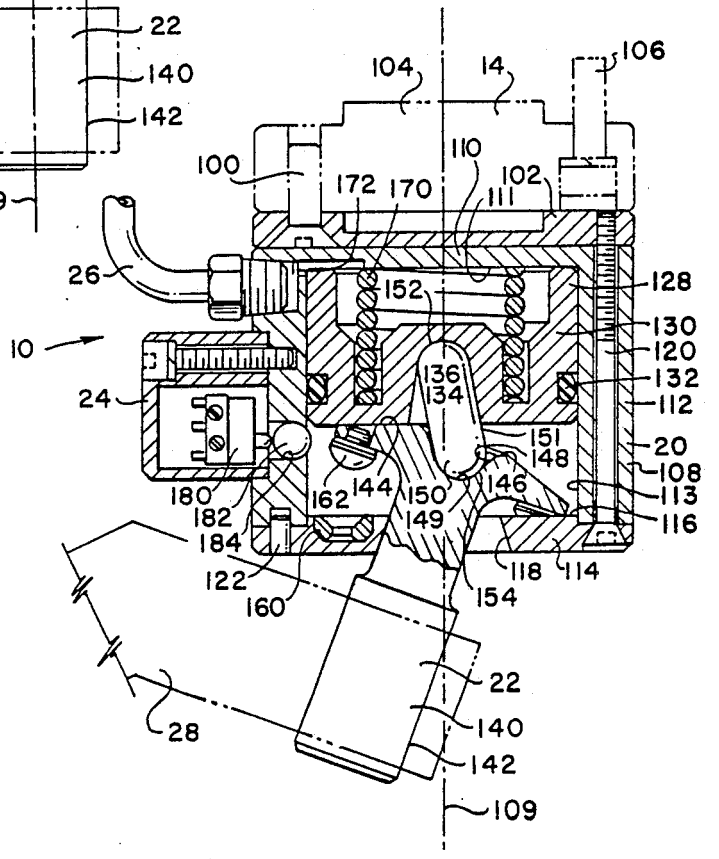


FIG. 3B

PROGRAMMABLE BREAKAWAY CLUTCH SYSTEM WITH COLLAPSIBLE FAILURE MODE

TECHNICAL FIELD

This invention relates to robotic tooling, and more particularly to an overload sensitive clutch for connecting a tool to the end of a robot arm.

BACKGROUND OF THE INVENTION

A problem in the use of robots in tooling operations is the problem of overload on the robot arm. This may occur if the robot arm or tool collides with something or if the tool gets stuck in the workpiece.

Several devices have been proposed and are in use that detect stresses and overloads on the robot arm and immediately shut down the robot when overload is detected in order to avoid damage to the robot or to the workpiece. These devices include expandable breakaway joints and connectors that break away when the robot arm experiences an overload.

For example, the devices shown in our U.S. Pat. Nos. 4,717,003 and 4,848,546 are expandable clutches useful in most robotic tooling situations. It has been found, however, that a collapsible clutch is preferable for use when the tool is an arc welding electrode, as collisions with the work piece are a more common occurrence. An expandable clutch as shown in our previous patents may not trip at a low enough threshold to protect the welding torch from damage if a collision puts the clutch into a compression failure mode. It has also been found that the ball and socket type of connection utilized in our expandable clutches is inappropriate for use in a collapsible clutch due to excessive friction between the parts, causing nonrepeatability.

SUMMARY OF THE INVENTION

The invention includes an adjustable clutch for use with robot end-of-arm tooling that provides a means for sensing movement of a tool attached to the clutch. The clutch includes a sealed piston movable member held within a chamber. The movable member is attached by a link to a tool connecting toggle. The piston is capable of lateral movement within the chamber, and the sensitivity of the breakaway clutch is adjusted by biasing the movement of the piston. In the preferred embodiment, the piston is biased using spring means and by introducing pressurized air into the piston chamber. A sensing device detects movement of the toggle relative to the clutch to shut down the robot when an overload is encountered.

The present invention provides a breakaway clutch having a collapsible failure mode. The clutch is ideal for use with arc welding tooling. The clutch has a sensor capable of detecting movement of the tool in relation to the clutch and of tripping an emergency stop when the movement is beyond a predetermined range of movement allowed. The clutch restores itself to a normal position when the overload is relieved.

According to one embodiment of the invention, the clutch includes a clutch housing that defines a piston cavity, a piston contained within the cavity, and a toggle that is attached to the piston through the housing by a link. The clutch includes biasing means to bias the piston in a direction toward the toggle. The toggle has locating means for positioning the piston in a normal operational position in relation to the housing and proximity sensing means for sensing deviations of the toggle from its normal position. In a preferred embodiment, the link is a capsule-shaped solid body engaged with frustroconical/spherical internal walls in the piston and toggle.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and additional objects and advantages of the invention will be more apparent when the following detailed description is read in conjunction with the accompanying drawings, wherein like reference characters denote like parts in all views and wherein:

FIG. **1** is a side view of a robot arm utilizing the clutch of the present invention;

FIG. **2** is a sectional view of the clutch of FIG. **1** taken along lines **2—2**;

FIG. **3A** is a partial sectional view taken along lines **3—3** of FIG. **2** showing the normal position of the clutch;

FIG. **3B** is a partial sectional view taken along lines **3—3** of FIG. **2** showing the overload position of the clutch;

FIG. **4** is a partially broken away side view of a piston; and

FIG. **5** is a partially broken away side view of a toggle.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention provides an "on the fly" adjustable clutch for use with robot end-of-arm tooling. The clutch is positioned between the robot arm and the tool and provides a means for sensing motion of the tool relative to the clutch that would indicate an overload on the system. The clutch is adjustable under program control so as to vary the load capacity and resistance of the clutch to handle various types and sizes of tools with varying sensitivity and is therefore ideal for use in interchangeable tooling systems. The clutch may be used in combination with a robot having an emergency stop, or other stop means, so that when an overload is sensed by the clutch it trips the emergency stop thereby preventing damage to the robot, the tool or to the workpiece.

Referring initially to FIGS. **1** and **2**, a clutch **10** according to the present invention attaches an arc welding torch **12** to end **14** of robot arm **16**. Torch **12** is shown in position to weld workpiece **18**. The exterior portions of clutch **10** include a housing **20**, a toggle **22**, electrical connector **24**, and a compressed air line **26**. Torch **12** is attached to toggle **22** by way of arm **28**. It is important to sense forces and moments on torch **12** in the X, Y and Z directions, so that abnormal forces and moments may be utilized to shut down robot arm **16**. Forces in the Z direction are sensed in order to enable a compression failure mode.

Referring now to FIGS. **3A** and **3B** in addition to FIGS. **1** and **2**, clutch **10** is attached to end **14** of the robot arm by way of bolts **100** extending through rear mounting plate **102** into an insulating robot adapter plate **104**. Plate **104** is attached to the robot arm by way of bolts **106**.

Housing body **108** is a generally tubular member having circular cross-sections about central axis **109**. A rear housing wall **110** includes a rear cavity wall **111**. Side housing wall **112** has an inner side cavity wall **113**. A front housing cover **114** provides a forward cavity wall **116**. Front housing cover **114** has a centrally lo-

cated opening defined by wall **118**. Front housing cover **114** and housing body **108** are fixed to rear mounting plate **102** by way of bolts **120** and locating pins **122**.

A movable member includes piston **130** and O-ring **132** confined within the cavity formed by walls **111**, **113** and **116**. Wall **113** is cylindrical about central axis **109**. Movable member **128** is capable of linear movement along central axis **109** from a normal position within the cavity shown in FIG. **3A** wherein piston **130** is spaced apart from rear cavity wall **111**. Movable member **128** is movable in the direction of rear cavity wall **111** to a position where piston **130** contacts wall **111**, as shown in FIG. **3B**. Movable member **128** includes an inwardly tapering frustroconical internal side wall **134** joined to a semi-spherical internal end wall **136**. Internal side and end walls **134** and **136** are coaxial with central axis **109** and open in the direction of front cavity wall **116**. A tool connecting member **140** includes toggle **22** and arm **28**. Tool connecting member **140** has an external end **142** adapted for connecting clutch **10** to a tool. Tool connecting member **140** has an internal end **144** within the cavity, and internal end **144** has inwardly-tapering frustroconical internal first and second side walls **146** and **148**, respectively, joined to a semi-spherical internal end wall **149**. Internal side and end walls **146**, **148** and **149** are coaxial with central axis **109**, and open in the direction of the rear cavity wall **111**.

Link **150** spans between tool connecting member **140** and movable member **128**. Link **150** is a capsule-shaped solid body having a cylindrical side wall **151**. Link **150** has semi-spherical external end walls **152** and **154** engaging with internal end walls **136** and **149**, respectively, in the movable member and tool connecting member. Movable member **128** and tool connecting member **140** are spaced apart by link **150**, and forces upon tool connecting member **140** are applied to movable member **128** by way of link **150**.

Tool connecting member **140** is located within the cavity by way of conical seats **160** and spherical pins **162**. Preferably, five seats **160** and pins **162** are provided in a asymmetrical pattern to provide a single return orientation for tool connecting member **140**. Seats **160** are fixed in front housing cover **114**. Tool connecting member **140**, link **150** and movable member **128** are dimensioned such that movable member **128** is in the normal position shown in FIG. **3A** when tool connecting member **140** is located such that pins **162** are seated in seats **160**. Tool connecting member **140** is movable in all directions except in the direction of front cavity wall **116**.

A spring **170** biases movable member **128** towards the normal position established by the linkage to tool connecting member **140** and the locating pins and seats. Movable member **128** is also biased towards the normal position by way of variable air pressures applied through air line **26** to the cavity by way of passageway **172**. Thus, the sensitivity of clutch **10** to forces and moments applied to the movable member **128** by way of the tool connecting member **140** is variable.

Movement of the movable member **128** away from the normal position shown in FIG. **3A** is sensed by way of a microswitch **180** fixed within electrical connector **24**. Microswitch **180** is actuated by a bearing ball **182** constrained for linear movement within a cylindrical wall **184** formed in housing body **108**.

Referring now to FIGS. **4** and **5**, internal side wall **134** in piston **130** preferably has a taper A of about 13°. First internal side wall **146** of toggle **22** preferably has a taper B of about 137°, and second internal side wall **148** preferably has a taper C of about 52°.

In operation, any compression force on tool connecting member **140** having a component in the Z direction or a moment having a component in the X or Y direction will apply force by way of link **150** to movable member **128**. If the force and/or moments exceed a threshold predetermined by the bias on movable member **128** by way of spring **170** and air pressure in line **26**, movable member **128** will shift away from the normal position shown in FIG. **3A** to a position exemplified by FIG. **3B**. In FIG. **3B**, movable member **128** has moved in the direction of rear cavity wall **111** to an extent that bearing ball **184** has been allowed to move inwardly. In the normal position, bearing ball **184** is forced outwardly by piston **130**, thereby causing microswitch **180** to indicate normal operation. When bearing ball **184** shifts inwardly due to movement of movable member **128**, microswitch **180** sends an alarm signal to the robot controller.

An important feature of the invention is the capsule-shaped link **150**, which allows a virtually friction-free linkage between toggle **22** and piston **130**. The spherical end walls of link **150** allow unlimited relative rotation between the two members, while compression forces are transmitted by the linkage. The linkage exerts a virtual perpendicular friction-free load between toggle **22** and piston **130**.

Having described only a single embodiment of the invention, it will be apparent to those skilled in the art that there may be many changes and modifications to this invention without departing from the spirit and scope of the invention.

What is claimed is:

1. A breakaway clutch for robot end-of-arm tooling, comprising:

a housing having a cavity, said cavity being defined by a forward cavity wall, a rear cavity wall and a side cavity wall, with said side cavity wall being cylindrical about a central axis;

a movable member confined within the cavity, said movable member capable of linear movement along said central axis from a normal position within said cavity spaced apart from said rear cavity wall to a position spaced more closely to said rear cavity wall, said movable member including an inwardly-tapering frustroconical internal side wall joined to a semi-spherical internal end wall, and said internal side and end walls being coaxial with said central axis and open in the direction of said front cavity wall;

a tool connecting member having an external end adapted for connecting the clutch to a tool, said tool connecting member having an internal end within said cavity, said internal end having an inwardly-tapering frustroconical internal side wall joined to a semi-spherical internal end wall, and said internal side and end walls being coaxial with said central axis when said movable member is in said normal position and open in the direction of said rear cavity wall;

a link spanning between said tool connecting member and said movable member, said link having semi-spherical external end walls engaged with said internal end walls of said movable and tool connecting members, such that said movable member and tool connecting member are spaced apart and

forces upon said tool connecting member are applied to said movable member;

means for locating said tool connecting member such that when said movable member is in said normal position said tool connecting member is located with respect to said front cavity wall and movable in all directions except in the direction of said front cavity wall;

biasing means for biasing said movable member toward said normal position established by said means for locating, said biasing means being adjustable to vary the bias and thereby vary the sensitivity of said clutch to forces applied to said movable member by way of said tool connecting member; and

sensing means for sensing movement of said movable member away from said normal position.

2. The clutch of claim 1 where said link is a solid body having a cylindrical side wall between said semi-spherical end walls of said link.

3. The clutch of claim 1 wherein said frustroconical internal side wall in said movable member has a taper of about 13 degrees.

4. The clutch of claim 1 wherein said frustroconical internal side wall in said tool connecting member has a taper of about 52 degrees.

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