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(54) METHOD AND APPARATUS FOR REMOVING SLAG AND BURRS FROM A METAL SURFACE

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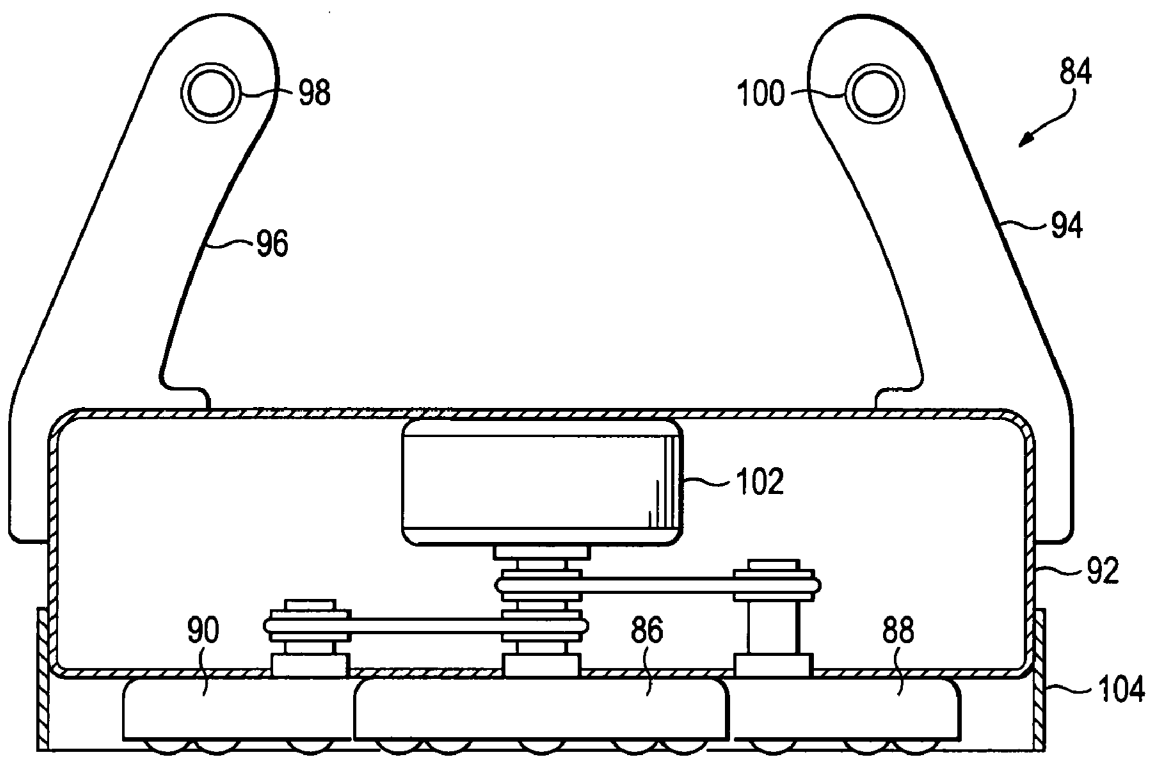
(57) ABSTRACT

A tool for removing slag from a flame-cut edge of metal includes a downwardly facing cup containing a plurality of steel balls. Only a portion of each ball extends from the lower end of the cup. A radially outer wall of the cup slants from a first position at its upper end to a second radially outer position at its lower end. As a result, when the cup rotates, centrifugal force urges the balls downwardly with a force that is proportional to the speed of rotation. As the cup moves over slag, lateral impact from the balls remove the slag. Because the balls are not connected to surrounding structure, they are free to rapidly move upwardly in the cup in response to hitting the edge of the cut. Consequently neither the edge nor the surface of the metal is peened or otherwise marred or disfigured.



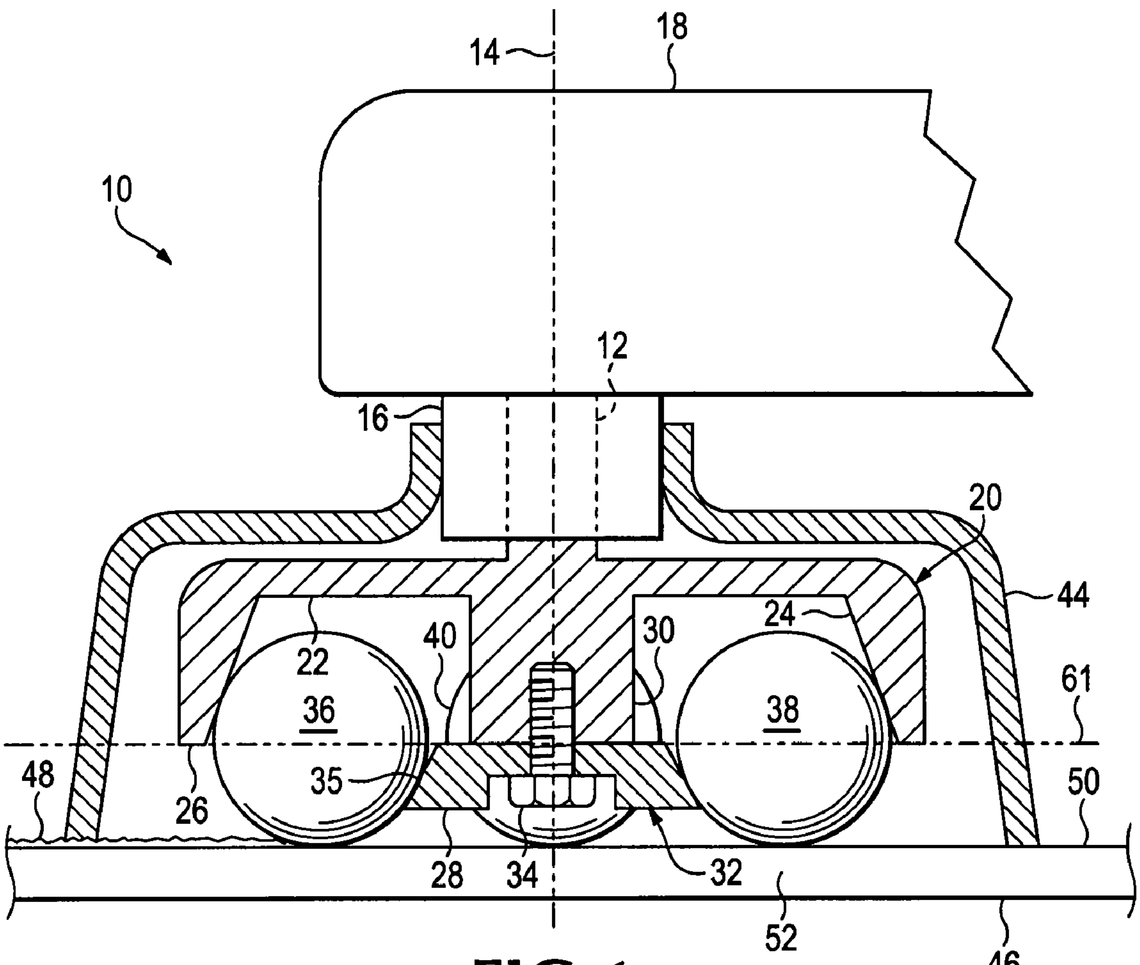


FIG.1

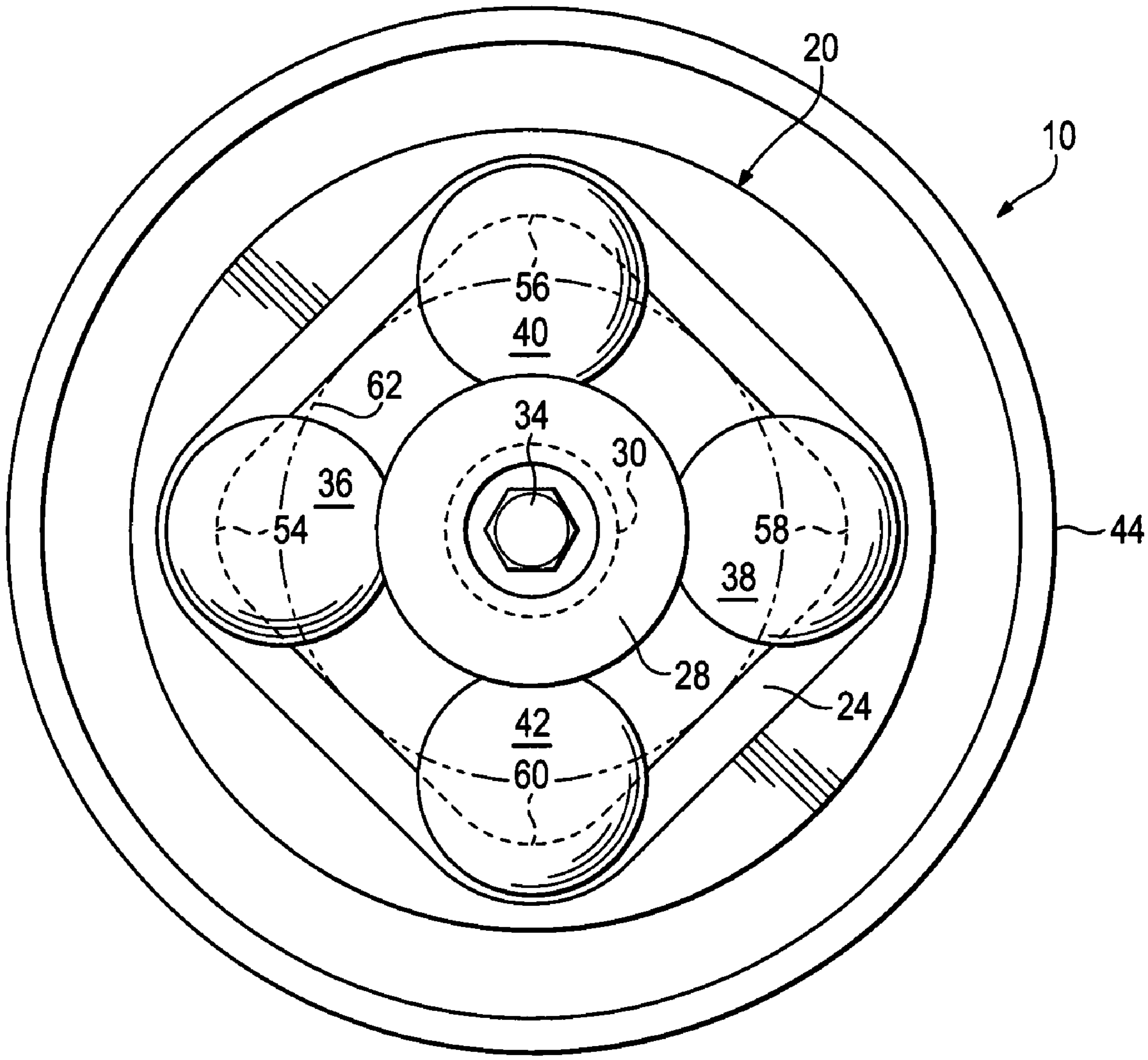


FIG.2

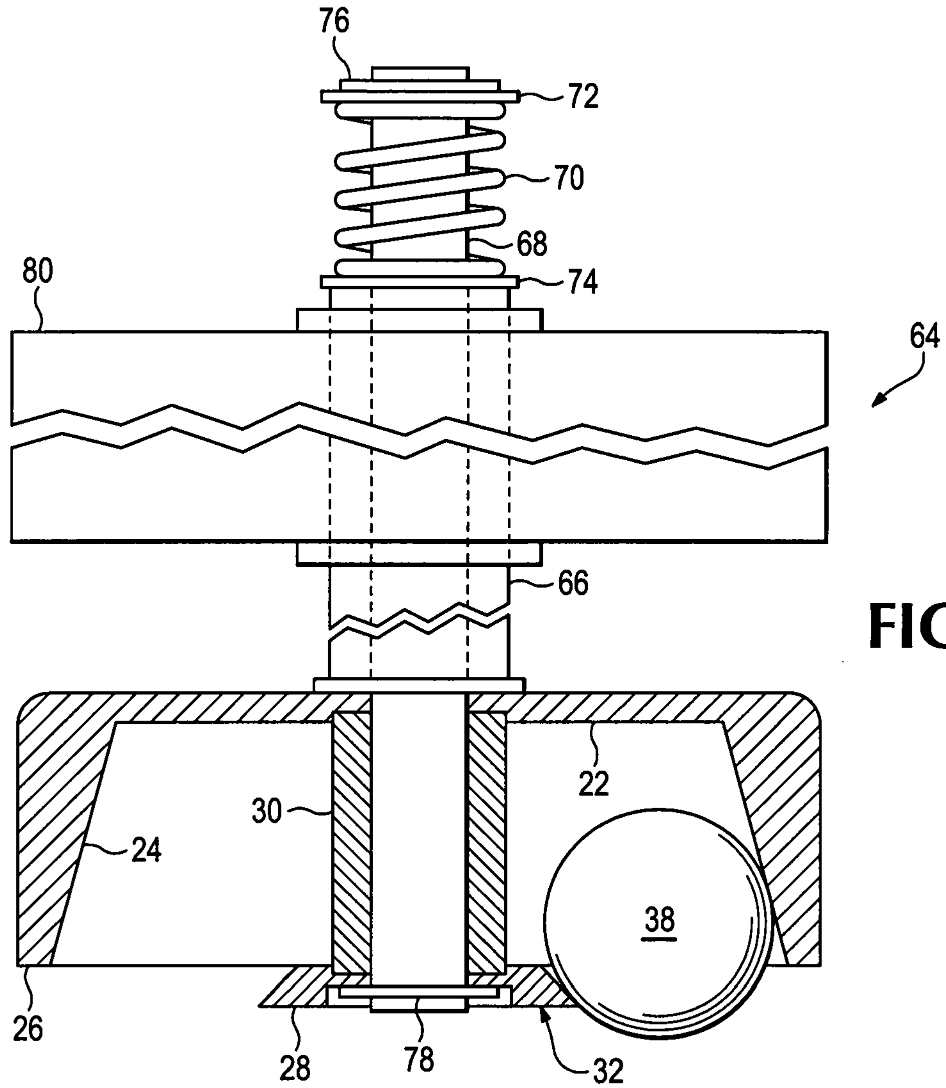

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FIG.3

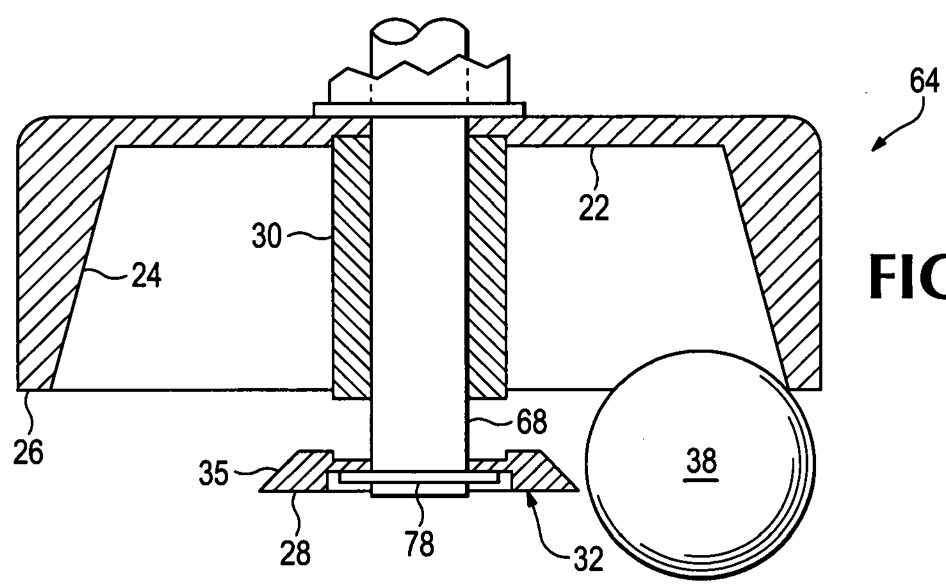
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FIG.4

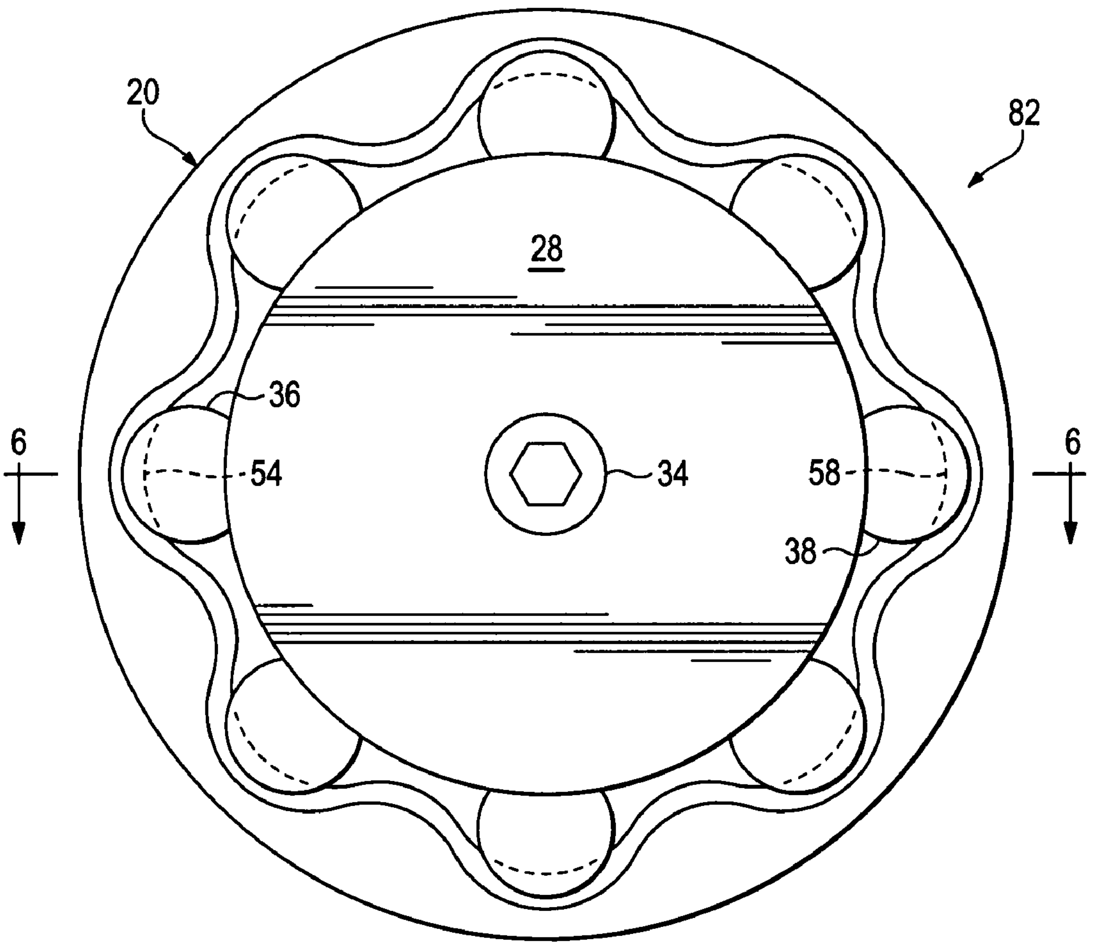

FIG.5

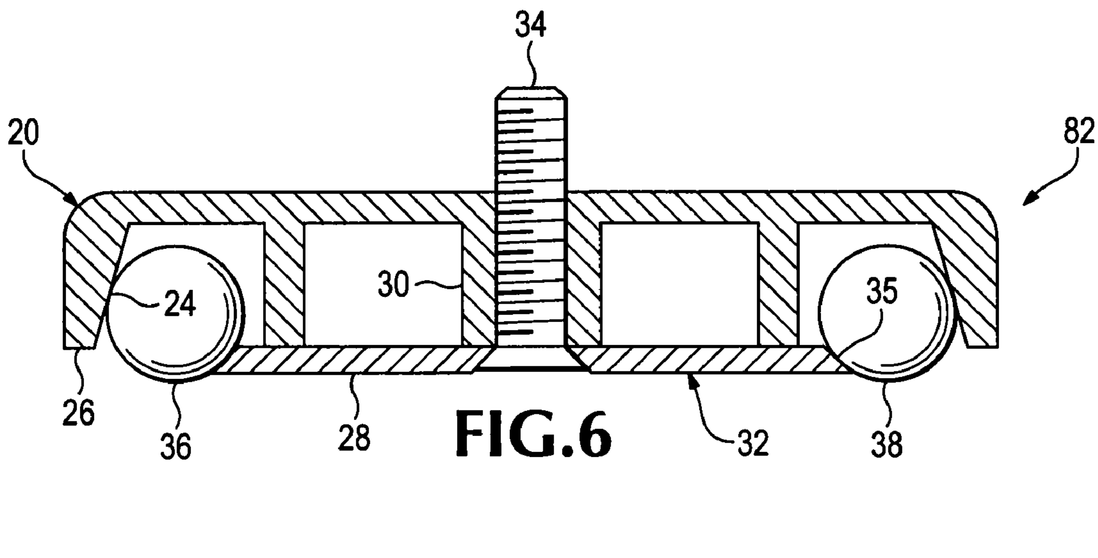

FIG.6

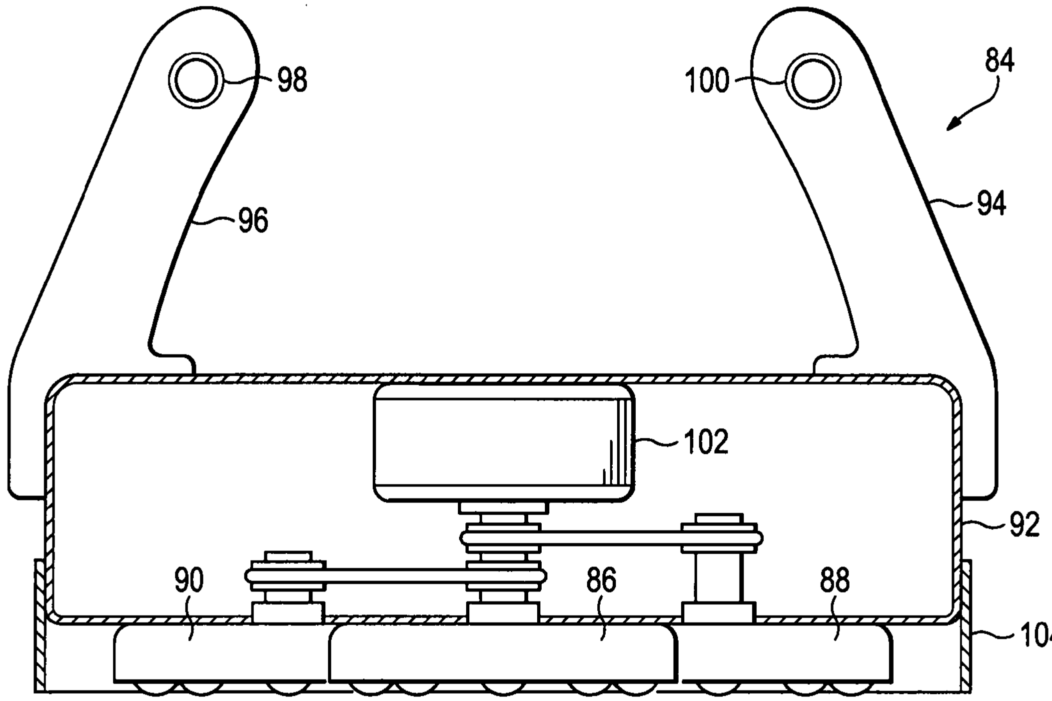

FIG.7

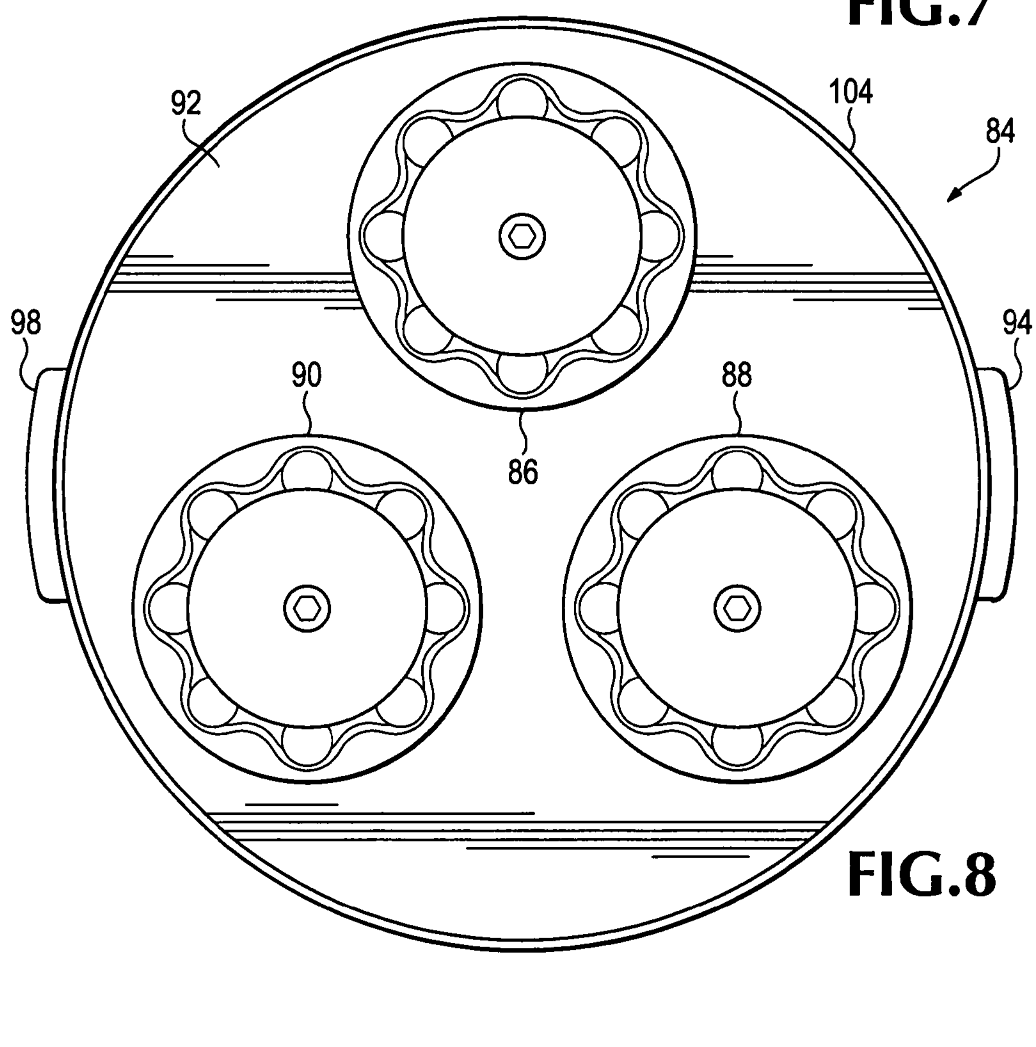

FIG.8

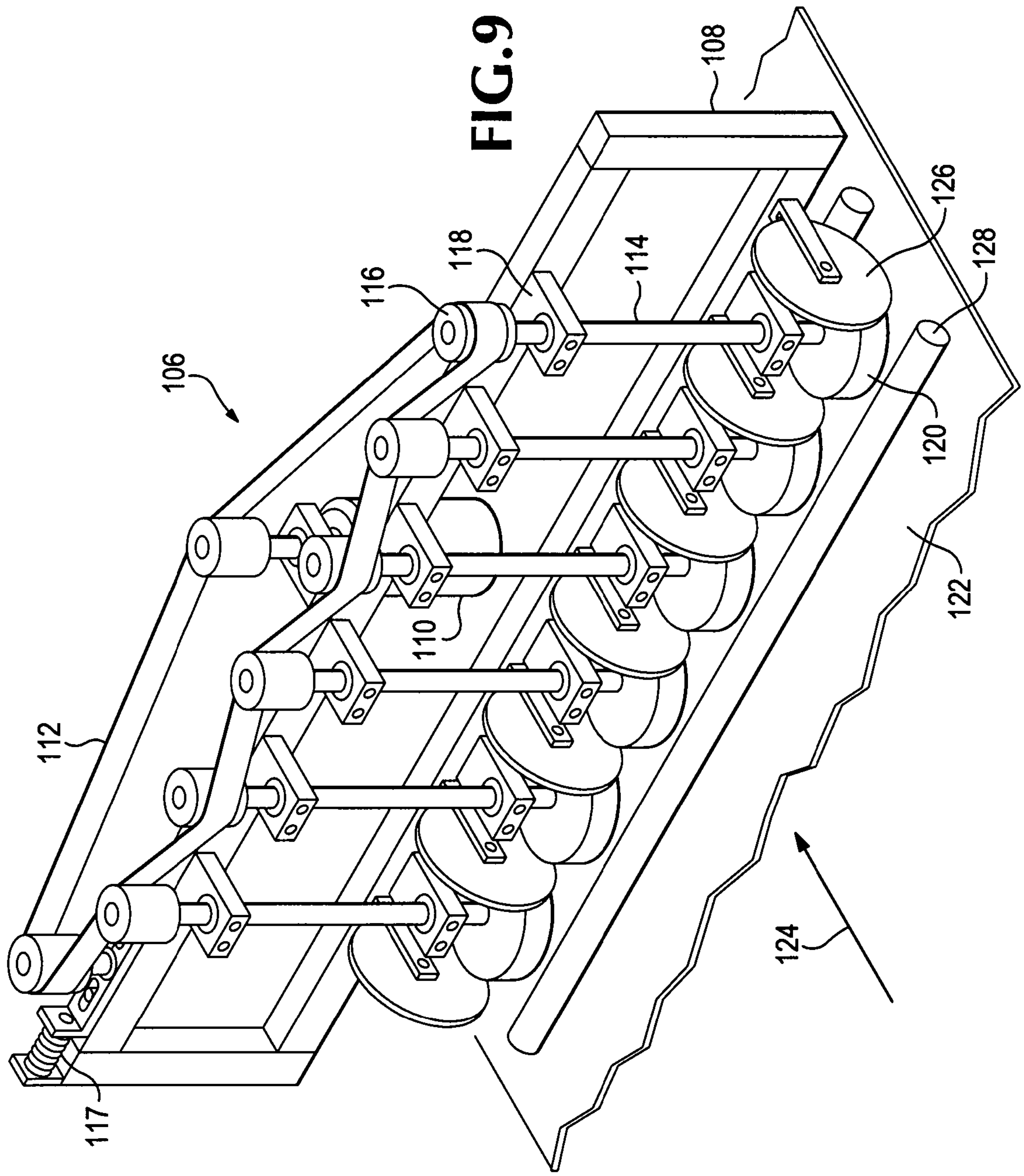

FIG. 9

METHOD AND APPARATUS FOR REMOVING SLAG AND BURRS FROM A METAL SURFACE

FIELD OF THE INVENTION

[0001] The present application relates to a method and apparatus for smoothing a metal surface and more particularly to removing slag and/or burrs from a metallic surface adjacent a cut.

BACKGROUND

[0002] Steel plate that is flame cut to a particular size and shape or which includes flame-cut openings is widely used to build a variety of metal products. When such metal is cut, using an oxygen-torch flame or by other means, burrs and/or slag often extend above the surface of the metal adjacent the cut. In many applications these irregularities must be removed before the metal part is incorporated into an assembled product.

[0003] There are currently several approaches to burr or slag removal. Hand-held grinders, wire wheels, hammers, chisels, or the like, must be used for large metal slabs after they have been cut. Some applications are suitable for motorized machines having conveyor belts that operate in conjunction with wire wheels, abrasive discs, or sanding belts. Smoothing small parts may be accomplished using hand-held devices or the parts may be fed into a deburring machine or tumbled or vibrated in tubs with abrasive stones.

[0004] In addition to the foregoing, some applications use rollers or spherical metal balls that apply pressure to the surface of the metal. These are then moved across the surface of the metal resulting in lateral impact to the slag or burr, which knocks it off.

[0005] The hand-held devices are noisy and when used on big pieces may require the operator to work while kneeling. The ensuing noise, dust, and discomfort make this a difficult job for which it is hard to find and keep workers.

[0006] Both the motorized machine and hand-held devices tend to mar, gouge, and deform the otherwise smooth edge and/or surface of a metal plate when used to smooth the edge of a cut. Many applications require a smooth metal surface for either aesthetic or functional reasons. Prior art rollers and metal balls suffer from this same disadvantage, i.e., the pressure against the edge or the smooth metal surface results in gouging and deformation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** comprises a partly-sectional view of an embodiment of a tool constructed in accordance with the invention.

[0008] FIG. **2** comprises a bottom plan view of the tool of FIG. **1**.

[0009] FIG. **3** comprises a partly-sectional view of another embodiment.

[0010] FIG. **4** comprises a partial view of FIG. **3** with the head positioned to release a steel ball contained therein.

[0011] FIG. **5** comprises a bottom plan view of another embodiment.

[0012] FIG. **6** comprises a view taken along line **6-6** in FIG. **5**.

[0013] FIG. **7** comprises a hand-held tool incorporating multiple heads like the one shown in FIGS. **5** and **6**.

[0014] FIG. **8** is a bottom plan view of the hand-held tool of FIG. **7**.

[0015] FIG. **9** comprises an motorized machine incorporating multiple heads constructed in accordance with the invention.

DETAILED DESCRIPTION

[0016] Indicated generally at **10** in FIG. **1** is a hand-held tool constructed in accordance with the present invention. Tool **10** includes a drive shaft **12** having an upper end operatively connected to a motor (not visible) that rotates drive shaft **12** about a vertical axis **14**. A shaft housing **16** is connected to an arm **18**. The housing contains and protects the drive shaft and is fixed relative to the arm.

[0017] A cup **20**, also referred to herein as a head, is connected to the drive shaft via a mechanical coupling, e.g., a threaded connection (not visible). As a result, when the motor runs, cup **20** rotates about axis **14**. The cup includes a cavity **22**, also referred to herein as an annular groove. A substantially planar surface **24** forms a side wall that defines one side of the cavity. The cup further includes downwardly directed surfaces **26**, **28**, which are also substantially planar. A central post **30** is formed within the cavity about axis **14**. A disc **32**, also referred to herein as a retainer, is mounted on the lower end of post **30** via a countersunk bolt **34**, which is received in a threaded connection formed in the center of the post. Disc **32** includes a frusto-conical surface **35**. Three steel balls **36**, **38**, **40** are received within the cup. A fourth ball **42** is visible in the view of FIG. **2**. The balls are substantially identical and have substantially the same diameter.

[0018] A flexible guard **44** is shaped like a downwardly-directed cup and seals at its upper end around shaft housing **16**. The lower end thereof engages against a substantially planar workpiece **46**, in this case a piece of metal plate that has been flame cut, thus leaving a line of slag **48** that extends above a substantially planar surface **50** of the metal plate along a cut edge **52**. In the view of FIG. **1**, the slag to the right of ball **36** has been removed by lateral impact of the balls in a manner that will soon be explained.

[0019] As can be seen in FIG. **2**, the downwardly directed opening of cup **20** is substantially square with curved lobes, like lobes **54**, **56**, **58**, **60** formed in each of the corners. As a result, when cup **20** rotates, each of the balls is retained in a different one of the lobes under the action of centrifugal force. This keeps the cup assembly balanced during rotation.

[0020] In operation of the tool **10**, a user of the tool stands adjacent cut edge **52** of workpiece **46**. The tool is positioned as shown in FIG. **1**, except that each of balls **36-42** rests on the surface of the work piece as does substantially the entire lower circumference of guard **44**. It can be seen that the balls are retained within cup **20** by virtue of the distance between surface **35** on disc **32** and surface **24** on cup **20** being less than the diameter of each of the balls. Because the balls are not anchored to any surrounding structure, they may be forced up into cavity **22** by the weight of the tool. But guard **44** may be rigid enough to hold the tool in the configuration shown in FIG. **1**.

[0021] When the motor (not visible) rotates shaft **12**, cup **20** begins clockwise rotation about axis **14** thus driving each of the balls into a respective one of lobes **54-60** as shown in FIG. **2**. It should be noted that the tool could also utilize counter-clockwise rotation. As shaft **12** rotates, the balls move in a circular path **62** indicated by a dashed circle. Centrifugal force along an axis **61** urges each of the balls against radially inner surface **24** of the cup. Because surface **24** has a radially inward slant from top to bottom, centrifugal force acting on each ball urges the ball in a downward direction. The faster the rotation, the greater the centrifugal force, and thus the greater the downward force exerted by each of the balls. As a result, the downward force exerted by the balls may be varied depending on the height of the slag line, the hardness of the metal plate or slag, or other environmental factors that might dictate a greater or lesser downward force applied by the balls.

[0022] The downward force exerted by each of balls may be enough to extend each ball to its lowermost position as shown in FIG. **1**. After starting, the operator moves tool **10** toward edge **52** far enough so that circular path **62** extends over the edge and begins moving the tool from left to right. As ball **38** moves off of edge **52** it may drop a small amount if the weight of the tool prevents the centrifugal force from driving each of the balls to their lowermost position. When the ball continues its circular path **62** it comes back over edge **52** onto surface **50** of the workpiece and hits slag line **48**, thus removing a small amount of slag. Similarly, if any slag remains in the wake of the leading end of the tool, the ball moving along the circular path and off of edge **52** at the trailing end of the tool will impact it again. In other words, slag line **48** is struck by balls approaching edge **52** from off of the workpiece on the leading end of the tool and is struck by balls approaching the edge from over surface **50** of the workpiece at the trailing end of the tool. In sum, the line of slag is hit from two substantially opposing directions.

[0023] If the balls are fully lowered as they all rotate on surface **50** of the workpiece, after the tool is moved to the edge, as described above, each ball strikes slag line **48** with the lowermost portion of the ball substantially tangent to surface **50**. The balls, however, may not be fully extended due to the weight of the tool. If so, the balls drop responsive to the force of gravity after they move over edge **52** off of surface **50** at the trailing end of the tool. The lowermost portion of each ball may be 1/64 inch to 1/32 inch below surface **50** as it moves across edge **52** and back over the surface at the leading end of the tool. This effectively removes the slag without denting, beveling, or chamfering edge **52** because the balls are free to move upwardly in the cup and may do so very rapidly in response to the ball striking the slag line slightly below surface **50**. After rapid upward movement from such an impact, the centrifugal force again moves the ball to surface **24**, which forces the ball down into position for again striking slag line **48**. As a result, slag is effectively removed and neither surface **50** of the workpiece nor edge **52** is damaged. The space within the cup also permits bits of slag knocked from the slag line to fall easily from the cup, as opposed to becoming jammed between one of the balls and the cup.

[0024] Turning now to FIGS. **3** and **4**, indicated generally at **64** is another tool according to the present invention. Structure that corresponds generally to previously-identified structure in tool **10** retains the same identifying numeral in tool **64**. Tool **64** includes a cylindrical main shaft **66** and a ball retention shaft **68** that is received within the main shaft. A ball retention spring **70** is constrained between a pair of washers **72**, **74** that are received over ball retention shaft **68**. A retainer clip **76** engages with ball retention shaft **66** just above washer **72**. As a result, spring **70** biases ball retention shaft upwardly relative to main shaft **66**. Disc **32** is connected to ball retention shaft **68** via a retainer clip **78**, which is engaged with the ball retention shaft in a countersunk bore on the underside of disc **32**. Spring **70** therefore urges disc **32** into engagement with the lower end of post **30**. This retains the balls—only one of which, ball **38**, is shown—within the cup.

[0025] A splined pulley **80**, shown in somewhat schematic form, is keyed to main shaft **66**. A suitable motor (not shown) engages pulley **80** via a belt (also not shown) to impart rotation to the main shaft for turning the head of tool **64**.

[0026] In general, tool **64** operates similarly to tool **10**. Tool **64**, however, facilitates quick and easy release of each of the balls, like ball **38**, from the cup. This is achieved by simply applying downward pressure to ball retention shaft **68** at the upper end thereof. When shaft **68** moves downwardly relative to main shaft **66**, thus compressing spring **70**, disc **32** moves downwardly relative to the lower end of post **30**, as shown in FIG. **4**. In this position, the distance between surfaces **24**, **35** is greater than the diameter of each of the balls thus allowing them out of the cup as shown for ball **38** in FIG. **4**. In tool **10**, disc **32** is removed by unscrewing bolt **34** to release the balls from the cup.

[0027] Turning now to FIGS. **5** and **6**, indicated generally at **82** is a portion of another tool according to the present invention. As with tool **64**, structure that corresponds generally to previously-identified structure in tool **10** retains the same identifying numeral in tool **82**. Rotation of cup **20** and the action of the balls, like balls **36**, **38** in FIGS. **5** and **6**, on slag adjacent a flame cut edge is generally as described above. Tool **82**, however, includes more than 4 balls in cup **20**, namely 8 balls. This requires 8 corresponding lobes, like lobes **54**, **58**, which receive balls **36**, **38** when cup **20** rotates. Each of the other balls is received in a corresponding lobe as shown in FIG. **5**. Increasing the number of balls increases the rate at which a slag line is hit per revolution of cup **20**. As a result, slag may be removed more quickly using tool **82**.

[0028] Turning now to FIGS. **7** and **8**, indicated generally at **84** is another tool according to the invention. This hand-held tool incorporates three cups, like cup **20** in tool **82**, each with **8** corresponding balls. It should be appreciated that the invention may be implemented in a similar tool incorporating cups from any of the other embodiments. The tool includes **3** heads **86**, **88**, **90**, which are each substantially identical to the head shown in FIGS. **5** and **6**. The heads are mounted on a body **92** that includes a pair of handles **94**, **96**. A power switch **98**, **100** is located on each handle. The switches control power, which may be electrical, air, or some other source, to a motor **102** that is received within body **92**. A flexible debris shield **104** contains bits of slag removed by impact of the balls.

[0029] The motor shaft directly drives one of heads **86**, **88**, **90** with the other two being driven by belts engaged with pulleys on the motor shaft and on the shaft of each of the other two heads, as shown. As a result, when one of power switches **98**, **100** is switched, all three head rotate to remove slag as described above. The action of three heads each containing 8 balls increases the impacts delivered by the balls to a slag line (not shown in FIGS. **7** and **8**) over the previously described tools.

[0030] Turning now to FIG. **9**, indicated generally at **106** is a motorized machine according to the invention. Machine **106** includes a frame **108** having a motor **110** mounted thereon. A serpentine drive belt **112** connects the motor to a plurality of drive shafts, like drive shaft **114**, via a pulley, like pulley **116**. Tension is maintained in the drive belt via a belt tension spring **117**. A bearing block holds each shaft in place, like bearing block **118** holds shaft **114**. A head or cup, like cup **120**, is mounted on the lower end of each shaft. Each of the cups includes a plurality of balls and is constructed and operates like any of the heads in the previously described tools.

[0031] A conveyor belt **122** is located beneath the cups, like cup **120**. The conveyor belt supports and transports a workpiece (not shown) beneath the row of cups in the direction of arrow **124**. A plurality of hold-down discs, like hold-down disc **126**, and hold-down rollers, like hold-down roller **128**, holds the workpiece in position as it moves beneath the cups.

[0032] Machine **106** permits fine adjustment of where each of the balls strikes the flame-cut edge of a workpiece relative to the surface of the workpiece. As discussed in connection with tool **10** above, it may be desirable to adjust the relative positions of the cups and workpiece so that the lowermost portion of each ball is about 1/64 inch or 1/32 inch below the surface of the workpiece as the ball strikes the edge and slag line when moving from off the workpiece to over the workpiece. This provides a strong impact to dislodge slag. And because the ball can move freely within the cup responsive to the impact, neither the edge nor the surface of the workpiece is peened, marred or otherwise disfigured.

[0033] Some embodiments of the invention have been described above, and in addition, some specific details are shown for purposes of illustrating the inventive principles. However, numerous other arrangements may be devised in accordance with the inventive principles of this patent disclosure. Further, well known processes have not been described in detail in order not to obscure the invention. Thus, while the invention is described in conjunction with the specific embodiments illustrated in the drawings, it is not limited to these embodiments or drawings. Rather, the invention is intended to cover alternatives, modifications, and equivalents that come within the scope and spirit of the inventive principles set out in the appended claims.

1. An apparatus for removing irregularities from the surface of a substantially planar workpiece comprising:
- a head including a cavity that communicates with a substantially planar surface of the head;
- a rotary drive for rotating the head about a first axis thereby creating centrifugal force along a second axis substantially normal to the first axis;
- at least one ball contained within the cavity;
- a retainer for retaining a portion of the ball within the cavity while permitting a portion of the ball to extend from the cavity; and
- a substantially planar surface defining a wall of the cavity, the ball being forced into the wall and against the retainer with a force substantially proportional to such a centrifugal force, the ball sliding across the surface of the workpiece when said apparatus is in operative condition.

2. The apparatus of claim **1** wherein the cavity is sufficiently large to permit the ball to be received entirely within the cavity responsive to a force urging the ball away from the workpiece when said apparatus is in operative condition.

3. The apparatus of claim **1** further comprising a guard surrounding the head and having a lower surface that engages the substantially planar surface of the workpiece when said apparatus is in operative condition.

4. The apparatus of claim **1** wherein the cavity contains a plurality of balls.

5. The apparatus of claim **4** wherein the cavity includes a central post and the retainer is mounted on the end of the post.

6. The apparatus of claim **5** wherein the retainer comprises a substantially round disc.

7. The apparatus of claim **4** wherein the cavity comprises an annular groove in which the balls are received, the centrifugal force maintaining at least two balls in at least one opposing pair when the apparatus is in operative condition.

8. The apparatus of claim **7** wherein the retainer is operatively connected to the head radially inwardly from the annular groove.

9. A method for removing surface irregularities from a substantially planar workpiece comprising:
- rotating a downwardly directed cup over the work piece;
- providing a plurality of balls within the cup;
- restraining the balls so that only a portion of each ball extends beneath the lower surface of the cup during rotation; and
- urging the balls against the surface of the workpiece.

10. The method of claim **9** wherein the method further comprises:
- rotating the cup at a first speed at which the balls exert a first amount of downward pressure; and
- rotating the cup at a second faster speed at which the balls extend a second greater amount of downward pressure.

11. The method of claim **9** wherein the cup includes a sloping side and wherein the method further comprises substantially restraining the balls to predefined radial positions on the cup side.

12. The method of claim **11** further comprising permitting substantially vertical movement of each ball along the cup side.

13. An apparatus for removing irregularities from the surface of a substantially planar workpiece comprising:
- a downwardly directed cup constructed and arranged for rotation over the workpiece;
- a plurality of balls contained within the cup; and
- a retainer associated with the cup for retaining the majority of each ball within the cup.

14. The apparatus of claim **13** wherein the balls are urged against the surface of the workpiece when said apparatus is in operative condition, the cup being sufficiently large to permit the balls to be received entirely within the cup responsive to a force urging the ball away from the workpiece.

15. The apparatus of claim **13** further comprising a guard surrounding the cup and having a lower surface that engages the substantially planar surface of the workpiece when said apparatus is in operative condition.

16. The apparatus of claim **13** wherein the cup includes a central post and the retainer is mounted on the end of the post.

17. The apparatus of claim **16** wherein the retainer comprises a substantially round disc.

18. The apparatus of claim **13** wherein a centrifugal force maintains at least two balls in at least one opposing pair when the apparatus is in operative condition.

* * * * *