COMPRESSION TOOL

Filed June 29, 1966 5 Sheets-Sheet 1

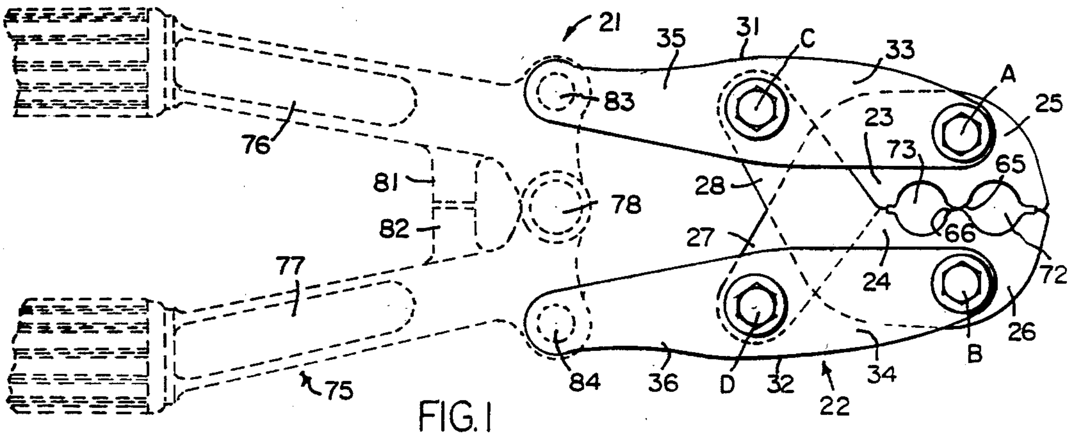

FIG.1

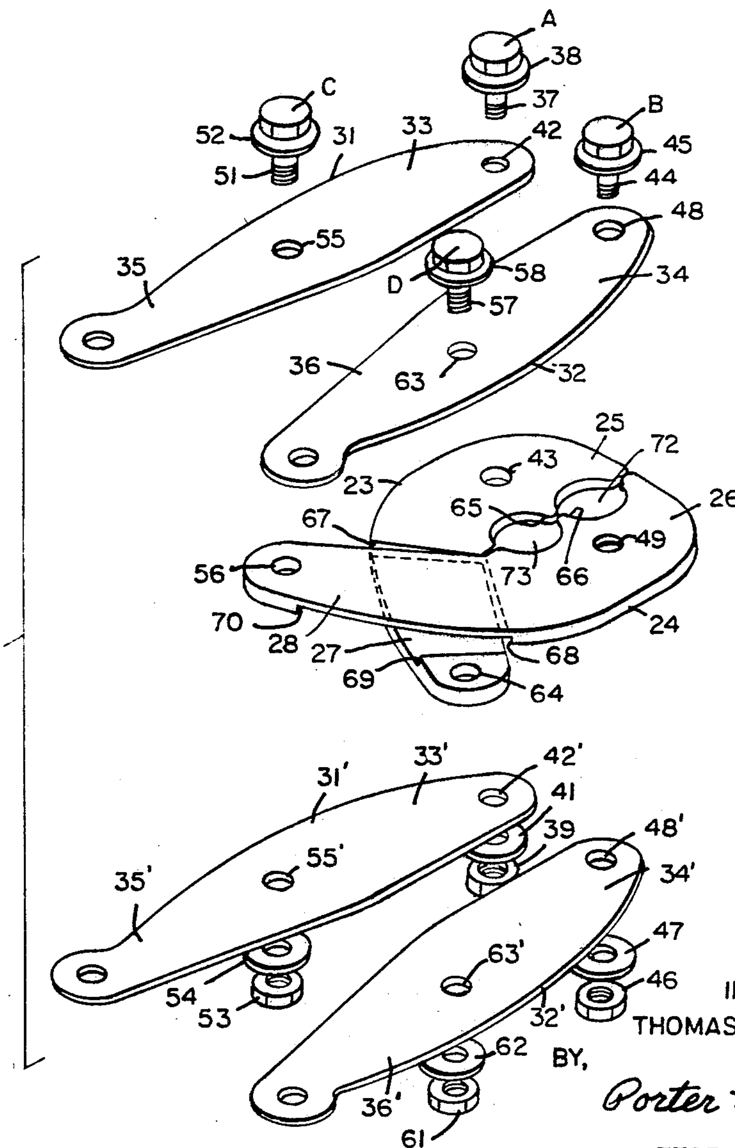

FIG.2

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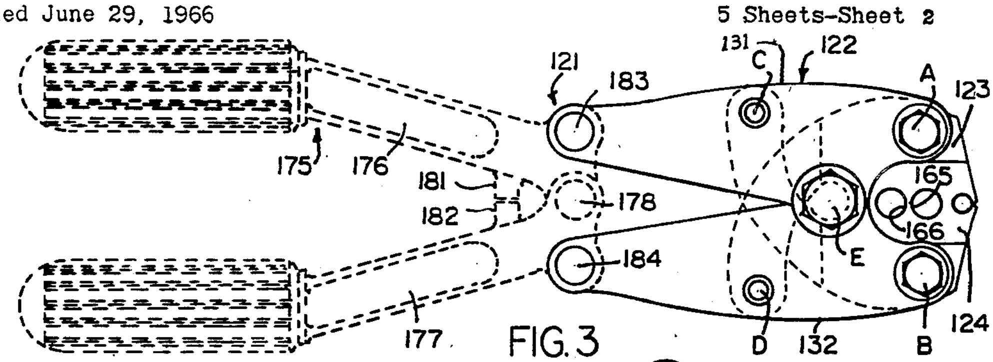

FIG. 3

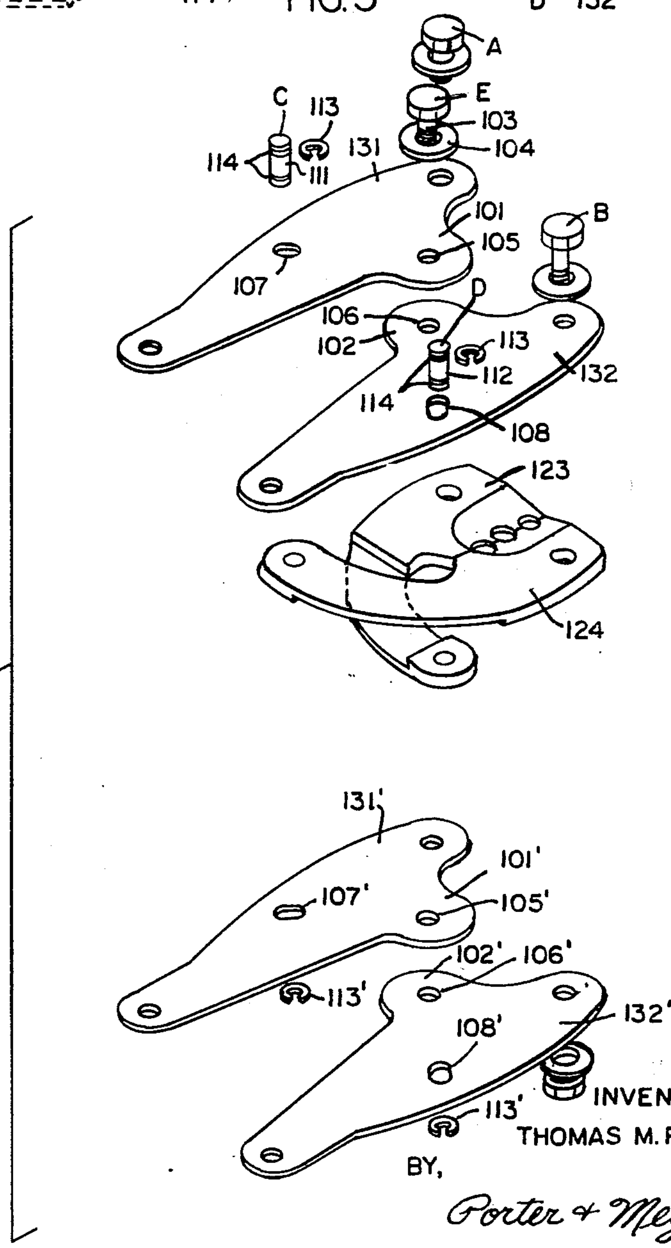

FIG. 4

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COMPRESSION TOOL

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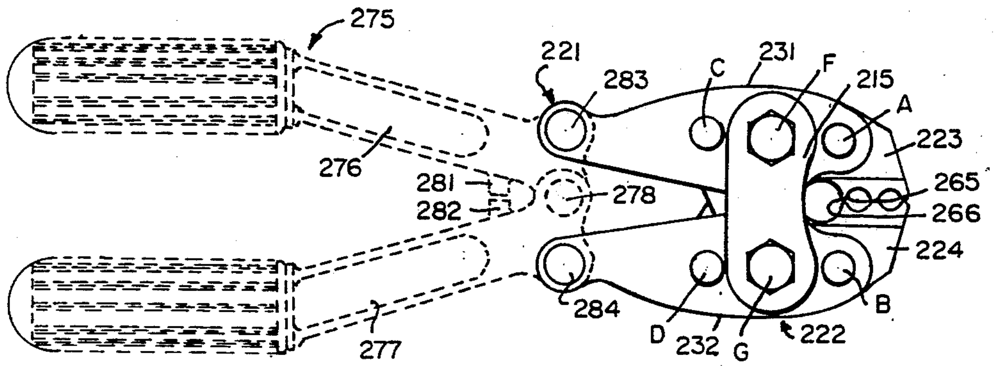

FIG. 5

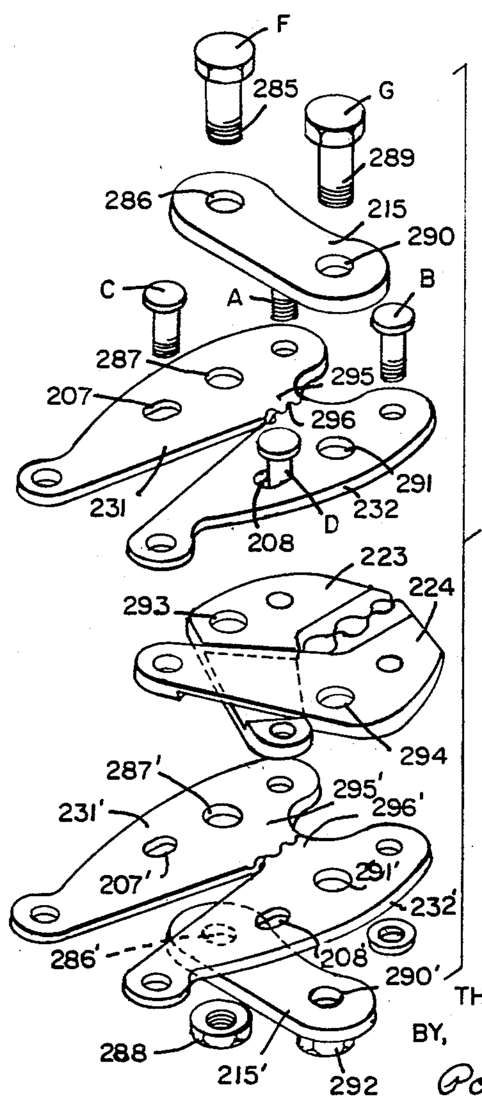

FIG. 6

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FIG. 7

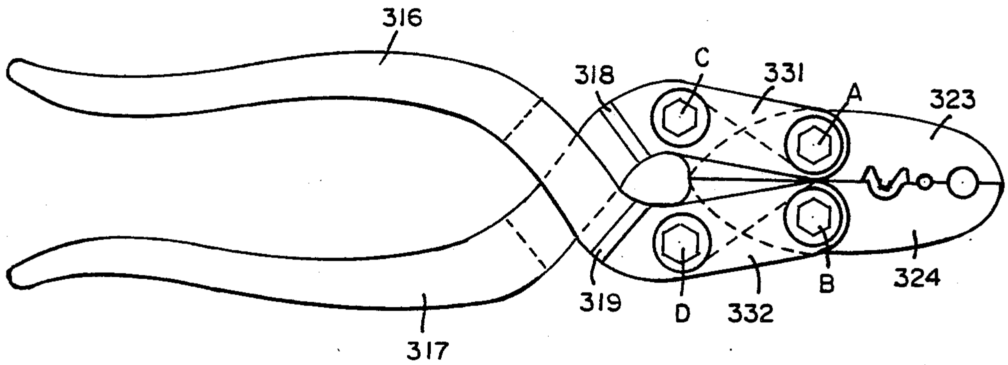
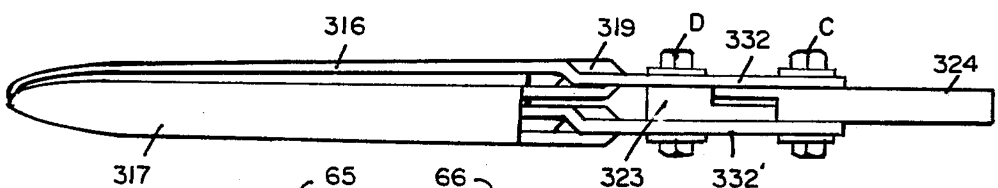


FIG. 8



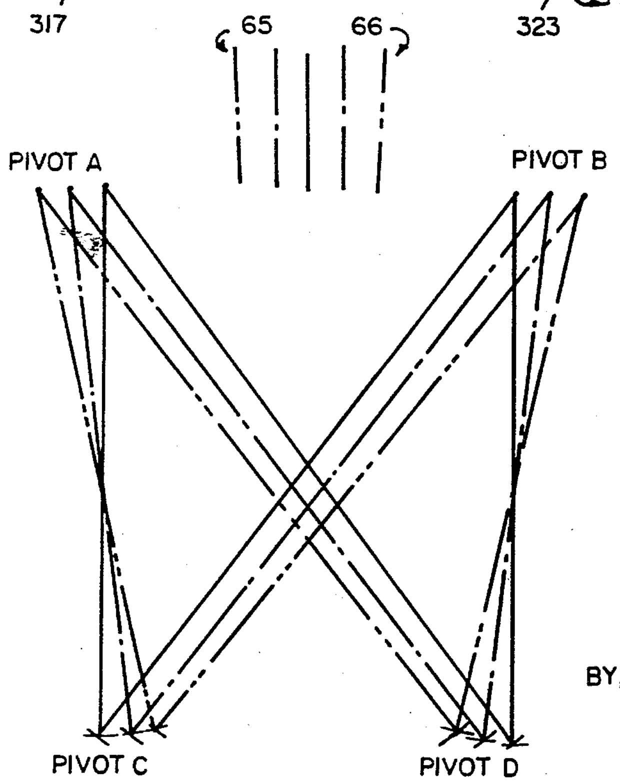


FIG. 9

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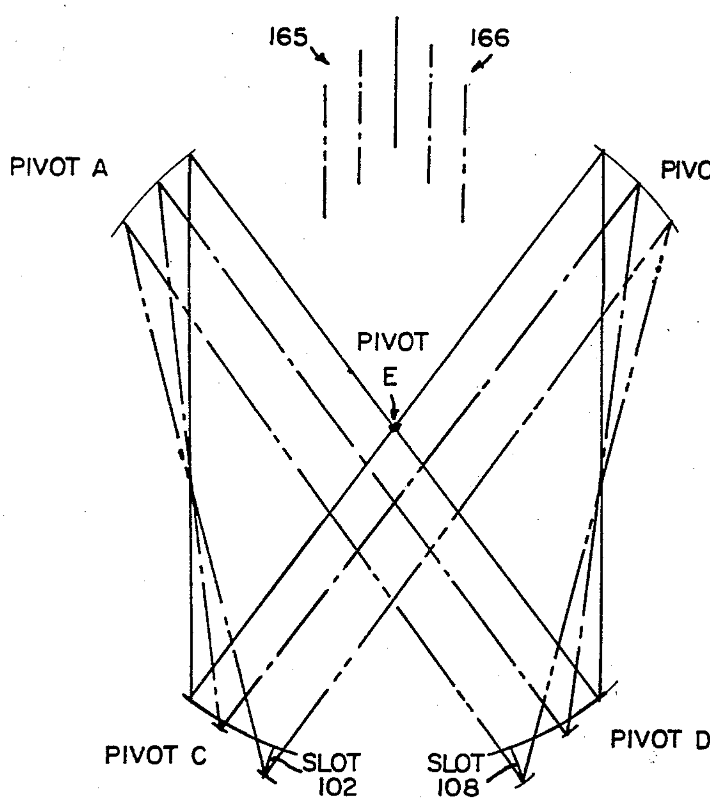

FIG. 10

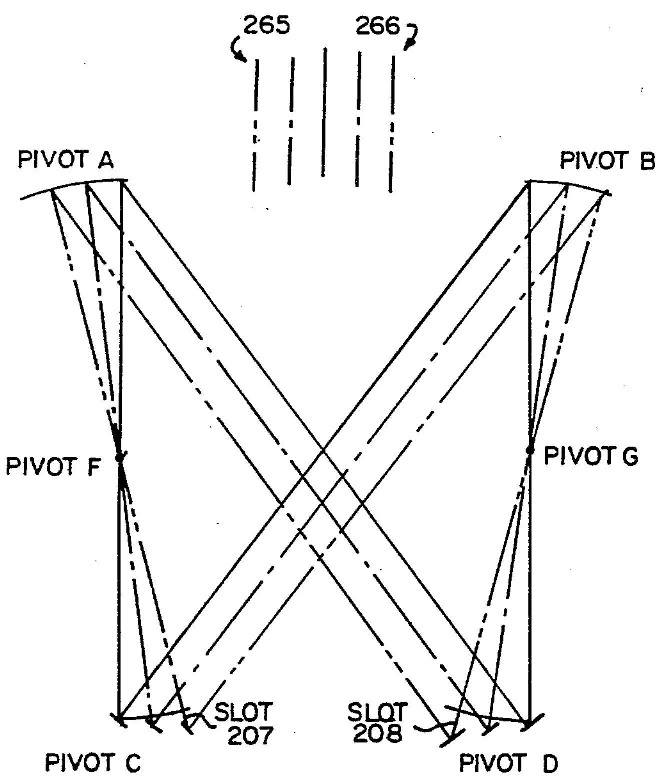

FIG. 11

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United States Patent Office

3,396,571

Patented Aug. 13, 1968

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3,396,571

COMPRESSION TOOL

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Filed June 29, 1966, Ser. No. 561,560
6 Claims. (Cl. 72—410)

ABSTRACT OF THE DISCLOSURE

This invention relates to a compression tool of the general type that is adapted to apply pressure to objects positioned between a pair of opposed movable jaws. The particular object of this invention is to provide jaw actuating and linking means whereby the jaws close with a parallel motion—parallel in the sense that the orientation of the jaws one to the other remains substantially the same during the travel of the jaws.

This is accomplished by pivotally mounting a pair of jaw members to a pair of jaw actuating members in a criss-cross manner. Each jaw member is provided with a working or jaw portion and with a lever portion. Each jaw member is pivotally mounted to one of the jaw actuating members at a point which, in the case of the jaw member, is at a forward position adjacent the jaw portion, and in the case of the jaw actuating member is near one end thereof, and to the other of the jaw actuating members at a point which, in the case of the jaw member, is near the end of the lever portion of that jaw member, and in the case of the actuating member is at a mid-point of said actuating member, i.e. at a point remote from the forward end thereof.

Movement of the pair of jaw members relative to one another is accomplished by moving the free ends of the actuating members relative to one another. Moving the free ends apart closes the jaw portions of the jaw members, moving the free ends together opens the jaw portions. Such movement can be accomplished in a number of known ways.

The key to obtaining the desired parallel motion of the jaw portions of the jaw members in such an arrangement is locating the pivots which connect the jaw members to the actuating members in such a manner that at some point during the full travel of the jaw portions the four pivots form the corners of a rectangle. This alignment or orientation can occur at any point during such travel, at either the full open or full closed position, and if the travel of the jaws is arbitrarily limited, even at a point slightly beyond the open or closed position.

Background of the invention

The compression tool of the present invention was initially developed to overcome a long standing problem in the art relating to the use of wire connecting sleeves. In this art the ends of wires to be connected are slipped into a cylindrical sleeve of malleable metal and the sleeve is then compressed by means of a compression tool at a number of points deforming the metal of the sleeve and forcing the sleeve into firm contact with the wires. Typical patents in this art include: Brenizer, 2,086,400, July 1937; Baxter et al., 2,244,482, June 1941; Klein, 2,327,650, Aug. 1943; Rogoff, 2,635,494, Apr. 1953.

In compression tools of the type illustrated in these patents, the sleeve is compressed between identical compressing grooves or dies which have a smaller effective diameter than the diameter of the sleeve. The dies are provided on the mating surfaces of the outer lever portion of a pair of jaws. The jaws are pivotally secured to each

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other at a fulcrum behind the compression grooves by means of a strap extending between the jaws. The free ends of the jaw members normally are pivotally mounted to a pair of toggle-jointed handles. Closing the handles separates the free ends of the jaw members thereby closing the dies.

This construction permits a very high degree of compression force to be developed at the compression dies with a reasonable force on the handles. However, overcompression of the sleeve is prevented since the movement of the compression dies toward each other is limited by the fact that the primary toggle is designed to go beyond dead center at the point of closest approach of the dies. Indeed, Baxter et al. at the section between page 2, col. 1, line 50 and page 2, col. 2, line 11 estimates that with a tool having over-all length of less than a foot, it is possible to develop an effective force of over 4,000 pounds at the die with a force of only 25 pounds applied at the handle.

As mentioned above, the effective diameter of the die portions at the closest approach of the two jaw members is substantially less than the outside diameter of the sleeve. The excess metal is forced out from the portion of the sleeve in actual contact with the dies generally between the gap between the flat portion of the jaws on both sides of the dies as the jaws close. Normally, the tool is made so that the flat surfaces of the jaws are parallel at the point of closest approach, and the jaws are relieved or separated one from the other in this position sufficiently to provide a space for the storage of this excess displaced metal. Otherwise the stroke might be limited by the pressure developed by the flat portions of the jaws acting on the excess metal thus preventing the dies from reducing the diameter of the sleeve to the predetermined value.

On the other hand, in the open position the jaws must open wide enough so that the sleeve will pass through the open ends into contact with the die portions. However, if the jaws are pivotally mounted at a fulcrum (or a pair of fulcrums connected by a strap) it is obvious that during a given movement of the handle that portion of the jaws further away from the fulcrum or fulcrums will travel a greater distance than do those portions of the jaws closer to the fulcrum. Thus as the dies are forced into compressive contact with the sleeve that portion of the dies closest to the fulcrum will come into contact with the sleeve first, and the compressively deforming force will be applied progressively in a direction away from the fulcrum as the dies close.

Because the compressive force on the sleeve is progressively applied toward the region away from the fulcrum of the compression tool, more of the excess metal is forced out on the side away from the fulcrum than on the side closest to the fulcrum. This excess of flash tends to stretch the metal of the sleeve laterally, and if permitted to occur along a line on one side of the sleeve in the successive compressings of that sleeve deforms the sleeve from a generally cylindrical shape to a "banana" shape (i.e. generally the shape of a segment of a toroid). This banana effect is more pronounced the thicker the wire (and hence the sleeve) and is very objectionable in the case of the joining of heavy wires desgined to carry high tension electricity. For example, a sleeve ten inches long connecting a one inch cable may have its middle portion displaced by the banana effect by as much as 2 or 3". A curved junction of this magnitude can seriously weaken the wires in the vicinity of the sleeve.

One way that the banana effect can be avoided using a conventional compression tool is to alternate the direction in which successive compressions of the sleeve are made by orienting the handles of the compresison tool in different directions relative to the sleeve as the successive compressings are made. This, however, most frequently is impractical, if not impossible.

The principal object of this invention is to eliminate the banana effect by providing a tool wherein the flash is equal on either side of the sleeve in each compressed area. This is accomplished by so mounting the jaws of the compression tool that there is little or no change in the orientation of those jaws one to the other during the operational stroke of the tool. By providing a compression tool with jaws having such parallel motion it has been found that the banana effect can be effectively eliminated even though each successive compressing of the sleeve occurs with the tool oriented in a single direction.

While the linkage developed to accomplish this result was designed specifically with a wire sleeve compression tool in mind, it is obvious that merely by changing the shape of the mating surfaces of the jaws the tool can be adapted to carry out a number of other common functions, such as punching, cutting and the like, where it is desirable to maintain the orientation of the jaws either parallel to each other, or at a constant angle to each other during the entire operational stroke of the tool. It will also be understood that while the preferred embodiment of this invention shows a tool capable of developing high compressive forces the linkage which causes the parallel motion of the jaws is adapted to be utilized in a variety of ways. For example, a hand tool can be fashioned merely by extending the jaw actuating members rearwardly in the form of crossed handles. Alternatively if one clamps one of the jaws or one of the jaw actuating members to a surface a tool will result having this same parallel motion actuable by a single handle. Similarly the tool can be actuated by driving either the upper or lower pair of pivots laterally as by hydraulic pistons.

Description of the invention

The invention as described in the following description is best understood with reference to the accompanying drawings, in which:

FIG. 1 is a plan view of the preferred embodiment of the compression tool of the present invention.

FIG. 2 is an exploded perspective of the head portion of the tool shown in FIG. 1.

FIG. 3 is a plan view of an alternate embodiment of the tool shown in FIG. 1.

FIG. 4 is an exploded perspective of the head portion of the tool shown in FIG. 3.

FIG. 5 is a plan view of a second alternate embodiment of the tool shown in FIG. 1.

FIG. 6 is an exploded perspective of the head portion of the tool shown in FIG. 5.

FIG. 7 is a plan view of a hand tool version of the embodiment shown in FIG. 1.

FIG. 8 is an elevation of the tool shown in FIG. 7.

FIG. 9 is a diagram showing the relative positions of the pivots and of the mating surfaces of the jaws at various degrees of opening of the jaws of the embodiment shown in FIG. 1.

FIG. 10 is a diagram showing the relative positions of the pivots and of the mating surfaces of the jaws at various degrees of opening of the jaws of the embodiment shown in FIG. 3.

FIG. 11 is a diagram showing the relative positions of the pivots and of the mating surfaces of the jaws at various degrees of opening of the jaws of the embodiment shown in FIG. 5.

Referring then to the preferred embodiment shown in FIGS. 1 and 2, the head portion **22** of tool **21** comprises two elongated jaw members **23** and **24** each having a jaw portion **25** and **26** respectively, and a lever portion **27** and **28** respectively and two jaw actuating members **31** and **32** each having a jaw member actuating portion **33** and **34** respectively, and a lever portion **35** and **36** respectively.

As shown each jaw actuating member comprises a pair of members identical to each other in general shape, one disposed in the tool, when assembled, above the plane of the assembled jaw members—the other disposed below. This duplication of each jaw actuating member is done to equalize the pressures exerted on the pivots which join the members and to avoid cocking forces. Since the duplicated parts are operationally identical, and are duplicated only as an obvious mechanical expedient corresponding portions on each such duplicated pair are identified by the same reference numeral with the lower member being characterized by the addition of a prime. It is to be understood of course that the same mechanical advantage could be obtained by providing duplicated jaw members if adapted to be arranged above and below non-duplicated jaw actuating members. Of course, if the mechanical advantages resulting from such duplicated parts is unnecessary neither part need be duplicated. It is to be understood, therefore, that whenever the term "jaw member" or "jaw actuating member" or the like is used in this specification or in the claims without other qualification the term includes duplicated such members as well as non-duplicated such members as the case may be.

The two jaw members **23** and **24** are connected to the two jaw actuating members **31** and **32** by four pivots indicated generally at A, B, C and D. Pivot A which preferably comprises a bolt **37** having a head engaging washer **38**, a cooperating nut **39** and a nut engaging washer **41**, passes through an aperture **42** formed near the end of jaw actuating portion **33** of jaw actuating member **31**, through an aperture **43** provided near the forward end of the jaw portion **25** of jaw member **23** and through aperture **42'** in portion **33'** of jaw actuating member **31'**.

Pivot B which likewise preferably comprises a bolt **44** having a head engaging washer **45**, a cooperating nut **46** and a nut engaging washer **47**, passes through an aperture **48** formed near the end of jaw actuating portion **34** of jaw actuating member **32**, through an aperture **49** provided near the forward end of the jaw portion **26** of jaw member **24** and through aperture **48'** in portion **34'** of jaw actuating member **32'**.

Pivot C which preferably comprises a bolt **51** having a head engaging washer **52**, a cooperating nut **53** and a nut engaging washer **54** passes through an aperture **55** formed at an intermediate portion of jaw actuating member **31** defining the intersection between the jaw actuating portion **33** and the lever portion **35** of that member, through an aperture **56** formed near the end of lever portion **28** of jaw member **24** and through aperture **55'** in jaw actuating member **31'**.

Pivot D which likewise preferably comprises a bolt **57** having a head engaging washer **58**, a cooperating nut **61** and a nut engaging washer **62** passes through an aperture **63** formed at an intermediate portion of jaw actuating member **32** defining the intersection between the jaw actuating portion **34** and the lever portion **36** of that member through an aperture **64** formed near the end of the lever portion **27** of jaw member **23** and through aperture **63'** in jaw actuating member **32'**.

In summary then, pivot A connects the forward end of jaw actuating member **31** with the forward end of jaw member **23**: Pivot B connects the forward end of jaw actuating member **32** with the forward end of jaw member **24**; pivot C connects the rear end of jaw member **24** with jaw actuating member **31**; and pivot D connects the rear end of jaw member **23** with jaw actuating member **32**.

An essential requirement of the defined structure is that pivot points A, B, C and D (i.e. the axes of the respective pivots) lie at the respective corners of a rectangle at some point during the full stroke of tool **21**. This requires that jaw actuating members **31** and **32** extend substantially parallel to each other, and that jaw members **23** and **24** criss-cross one another. As long as these requirements are met there remains a substantial latitude in the shape and placement of the various operative elements provided of course that provision is made that the parts not interfere with one another during the stroke. In the case of a tool designed to exert high compressive forces such as that shown in FIGS. 1 and 2 it is preferred to locate pivot points A and B directly behind the operative faces or mating surfaces **65** and **66** of jaw members **23** and **24** opposite about the mid-point of such surfaces. In this case, lever portions **27** and **28** of jaw members **23** and **24** preferably originate at the rear end of mating surfaces **65** and **66** and extend diagonally across the head **22** to pivots D and C respectively. In order that the lever portions **27** and **28** of jaw members **23** and **24** can slide past one another without interference the opposing surfaces of lever portions **27** and **28** can be cut away as indicated at shoulders **67** and **68** respectively and shoulders **69** and **70** respectively. Alternatively the lever portions **27** and **28** can be vertically offset from the remainder of jaw members **23** and **24** in which case space compensating shims should be provided as appropriate at pivots A, B, C and D.

Since mating surfaces **65** and **66** remain substantially parallel to each other during the entire stroke jaw members **23** and **24** can be extended if desired substantially ahead of pivots A and B with lever portions **27** and **28** extending, if desired, more or less directly between pivots A and D in the one case and pivots B and C in the other. As shown in FIGS. 1 and 2 the mating surfaces **65** and **66** of jaw members **23** and **24** are provided illustratively with die portions indicated generally at **72** and **73**.

In order to maintain the desired parallelism between the mating surfaces **65** and **66**, the clearance between the respective pivots A, B, C and D and the apertures through which they pass, should be as small as possible with a close fit being desirable. In many instances, it may be desirable to provide a bearing or a bearing surface between the respective apertures and the cooperating pivot members.

The high compression version of tool **21** as shown in FIG. 1 is provided with a conventional toggle handle indicated generally at **75**. Handle **75** comprises two handle members **76** and **77** pivotally joined at pivot **78**. Abutting stop members **81** and **82** are provided on the inner side of handle members **76** and **77** respectively to limit the motion of these handle members toward each other. Handle member **76** is pivotally mounted at **83** to the rear portion of lever portion **35** of jaw actuating member **31**, and handle member **77** is pivotally mounted at **84** to the rear portion of lever portion **36** of jaw actuating member **32**. Pivots **78**, **83** and **84** are preferably aligned such that pivot **78** is located just beyond dead center when stop members **81** and **82** come into contact with each other. Permitting the toggle joint to go beyond said center not only limits the compressive travel that can be applied to an object grasped between the jaws but insures that that travel will be reproduceable in successive strokes.

The relative proportions of the various elements, such as the length of the handle **75**, the spacing of pivots **83** and **84**, the distance between pivots A and C and pivots B and D, the distance between pivots A and B and pivots C and D, and the distance between pivots B and **83** and pivots D and **84** and the like, may be varied according to the purpose for which the tool is to be used in accordance with well developed mechanical principles. It will be noted in this connection that if the mechanical advantage afforded by lever portions **35** and **36** of jaw actuating members **31** and **32** is not desired, it is possible to eliminate lever portions **35** and **36** and join handle **75** to head **22** at pivots C and D.

As pointed out above, an essential requirement for the arrangement of the present invention is that pivot points A, B, C and D form the respective corners of a rectangle at some point during the full stroke of tool **21**. Some understanding of the reason for this requirement can be derived from the diagram in FIGURE 9 which shows the relative position of pivots A, B, C and D and mating surfaces **65** and **66** at various degrees of opening of tool **21**. The diagram also shows the deviation from exact parallelism of mating surfaces **65** and **66** at various degrees of opening.

To accentuate the deviation of mating surfaces **65** and **66** from exact parallelism, the diagram of FIG. 9 has been drawn on a limiting condition wherein pivots A, B, C and D form the corners of a rectangle when mating surfaces **65** and **66** are in mating condition. In practice any deviation from exact parallelism can be reduced by so designing the tool that this condition exists at the mid-point of the design stroke.

In FIG. 9 pivots A, B, C and D are located at the corner of the rectangle which, as originally drawn, was exactly 3" x 4" when mating surfaces **65** and **66** are in mating contact. This is the position indicated by the solid unbroken lines. The mating surfaces were then moved ½ inch apart (¼ inch on each side) the position indicated by the lines broken with a single dash and one inch apart (½ inch on each side) the position indicated by the lines broken with the double dash, and the position of pivots A, B, C and D were plotted under each condition.

It will be noted that in the structure shown in FIGS. 1 and 2, the distance between pivot A and pivot C is fixed, the distance between pivot A and pivot D is fixed, the distance between pivot B and pivot C is fixed and the distance between pivot B and pivot D is fixed, but that the pivots are otherwise not connected. Similarly the distance between any given point on mating surface **65** and pivot A is fixed, and the orientation of surface **65** is at a constant angle to the line connecting pivots A and D. Likewise the distance between any given point on mating surface **66** and pivot B is fixed, and the orientation of surface **66** is at a constant angle to the line connecting pivots B and C.

For convenience in plotting the diagram the respective positions of A and B were plotted along a single horizontal line, and the distances separating the two mating surfaces **65** and **66** were plotted along this same line. The lines indicating the orientation of surfaces **65** and **66** were projected from the distance marker in each instance. For this reason the lines indicating the relative positions of surfaces **65** and **66** do not necessarily show the exact location of the successive positions of surfaces of the finite length shown, but rather should be considered to be a section of a somewhat longer surface.

Since the distances between the connected pivots remains constant the successive positions of pivots C and D were located by intercepting arcs of the proper length swung from points A and B. The orientation of surfaces **65** and **66** was plotted at a constant angle to the lines connecting pivots A and D and pivots B and C respectively.

It will be noted for the particular arrangement selected in FIG. 9 that surfaces **65** and **66** remain apparently parallel through a degree of separation representative of a one-half inch separation where the pivots are initially arranged on a three inch by four inch rectangle, and become slightly non-parallel when the degree of separation becomes equivalent to one inch. In this latter position the outer ends of mating surfaces **65** and **66** are slightly more separated than the inner ends, the degree of deviation from parallelism being in the order of 2½ degree on each side. It will be noted in this connection that merely by moving mating surfaces **65** and **66** relative to pivots A and B such that pivots A, B, C and D form the corners of the rectangle at the mid-point of the stroke, surfaces **65** and **66** would remain apparently parallel in the particular arrangement shown during a stroke equivalent to one well in excess of one inch in the dimensions initially plotted in FIG. 9.

Similar results are obtained with a wide variety of relative spacing of pivot points A, B, C and D. Similar plots have been made with the pivot points arranged as a square, as a tall thin rectangle, and as a wide short rectangle with similar results. In each case the mating surfaces remain for all practical purposes apparently parallel for a substantial distance on either side of the position where the pivot points form the corners of a rectangle.

It will be understood from the geometry of the defined arrangement that the position of the so-called mating surfaces **65** and **66** relative to each other, and to pivot points A and B respectively, is completely arbitrary. The change of orientation of the surfaces to each other during a stroke is determined solely by the change in the orientation of the line connecting pivots A and D to the orientation of the line connecting pivots B and C. Thus depending on the purpose for which the tool is designed, jaw portions **25** and **26** of jaw members **23** and **24** respectively can be arranged so that mating surfaces **65** and **66** are in an off-set non-center line position; that they never come into contact with each other as in a clamping type tool; that they overlap at some point in the stroke as in a cutting type tool; or that they are non-parallel (in which case the relative angle one to the other will remain substantially unchanged during the stroke).

In view of the fact that the motion of jaw portions **25** and **26** relative to one another is independent of the shape or relative position of such jaw portion, and in view of the fact that parallel or substantially parallel motion between surfaces **65** and **66** persists over a relatively wide range on either side of the position where pivots A, B, C and D form the corners of the rectangle, it is possible to obtain the benefits of the present invention especially where the desired stroke is relatively small in proportion to the spacing of the pivot points, or where absolute parallelism over the entire stroke is not a necessity under conditions where pivots A, B, C and D approach the positions where they would form the corners of a rectangle, but where they are prevented from actually assuming such position because of some limitation of the stroke such as that imposed by an interference between parts. The term "full stroke" as used in the specification and claims is intended to include such situations where pivot points A, B, C and D are arranged so that they approximate at some point during the actual stroke of the tool the orientation where each forms the corner of a rectangle, but where the actual stroke of the tool is in some way limited to less than the "full stroke" where such orientation would occur.

The embodiment shown in FIG. 1 is preferred even though the mating surfaces **65** and **66** do not remain absolutely parallel to an extended stroke since the parts comprising head **22** are firmly attached to one another at pivot points A, B, C and D. This arrangement minimizes the possibility of wear and the possibility of the resulting loss of parallelism due to play between the parts at the pivots.

A higher degree of parallelism throughout an extended stroke can be achieved by pivotally attaching the two jaw actuating members **31** and **32** together. However, in such a case it is necessary to allow for a slight degree of relative movement at either pivots A and B or at pivots C and D and preferably at pivots C and D between the parts thus connected. This can be done without introducing any unregulated play between the parts such as to engender a loss in parallelism by providing a short parallel-sided slot in jaw actuated members **31** and **32** at pivots C and D radial to the pivot points joining members **31** and **32** as located in the particular jaw actuating member. While such an arrangement does produce a higher degree of parallelism, it is considered to be slightly less desirable than the arrangement shown in FIGS. 1 and 2 since it is possible, especially in tools developing a high degree of compressive force, that the walls of such slots and/or of the pivots arranged in such slots may wear after extended use resulting in unregulated play that may result in a loss of parallelism.

One such arrangement is shown in FIGS. 3 and 4. Since the parts of the arrangement shown in FIGS. 3 and 4 are substantially identical to most of those of the arrangement shown in FIGS. 1 and 2 the description herein will be limited merely to a description of the differences. For convenience, the reference numbers assigned to the various parts shown in FIGS. 3 and 4, which are functionally identical to parts shown in FIGS. 1 and 2, are the same as those used in connection with FIGS. 1 and 2 except that they are increased by 100. Thus the tool which was referred to generally in FIGS. 1 and 2 as **21** is referred to in FIGS. 3 and 4 as **121**.

The principal difference between the embodiment shown in FIGS. 1 and 2 and that shown in FIGS. 3 and 4 is that jaw actuating members **131** and **132** (and **131'** and **132'**) are each provided with inwardly extending and overlapping extensions **101** and **102** respectively, and are pivotally connected together by a pivot E. Pivot E which preferably comprises bolt **103**, head engaging washer **104** and a nut and nut engaging washer (not shown) passes through apertures **105** and **105'** in extensions **101** and **101'** respectively, and apertures **106** and **106'** in extensions **102** and **102'**. As in the case of pivots A, B, C and D in the embodiment shown in FIGS. 1 and 2, care should be taken to avoid any free play at pivot E.

Pivots A, B, C and D are, as in the embodiment shown in FIGS. 1 and 2, so located as to form the corners of a rectangle at some point during the full travel of the jaws. Pivot E is located at the center of this rectangle, that is at the intersection of the line connecting pivots A and D with the line connecting pivots B and C. Lever portions **127** and **128** of jaw members **123** and **124** are modified in shape to clear pivot E during the opening and closing of tool **121**.

Quite obviously if the four members, i.e. jaw members **123** and **124** and jaw actuating members **131** and **132** are joined together at the five points indicated by pivots A, B, C and D, and if the relative motion of the members to each other is limited merely to rotation at each of these points, there could be no relative movement between the four members, but rather they would be locked into a single position. The reason for this of course is that if pivots A, B, C and D form the corners of a rectangle and pivot E lies at its center, then pivots A, B, C and D all lie on a circle drawn about pivot E at its center with pivots A and D and pivots B and C lying on the opposite ends of diameters of that circle. Since any chord of a circle other than a diameter is shorter than the diameter, relative motion between the pivots is prevented unless the distance between pivots A and C and between pivots B and D or the distance between pivots A and D and pivots B and C is permitted to vary.

It has been found that if the distance between pivots A and D and between pivots B and C is maintained constant, and if the distance between pivots A and C and between pivots B and D is permitted to vary by permitting either pivots A and B or pivots C and D to move in a direction radial to pivot E then tool **121** will open and close with abutting surfaces **165** and **166** remaining substantially parallel over an extended stroke. Preferably this freedom to move is provided at pivots C and D and is provided by substituting slots **107** and **108** in jaw actuating members **131** and **132** for apertures **55** and **63** in jaw actuating members **31** and **32** as shown in the embodiment of FIGS. 1 and 2. Slots **107** and **108** are both straight sided and of a width merely to receive pivots C and D without any excess free or side play. The axis of slot **107** is aligned with the center of aperture **105** and the axis of slot **108** is aligned with the center of aperture **106**.

Pivots C and D in the embodiment shown in FIGS. 3 and 4 are shown as posts **111** and **112** rather than as bolts. Posts **111** and **112** are locked into place by split locking collars **113** which snap into cooperating grooves **114** provided in posts **111** and **112**. This is an alternative form of pivot that could be used at any location.

The geometry of the embodiment shown in FIGS. 3 and 4 is shown in FIG. 10. Here as in FIG. 9 pivots A, B, C and D were originally plotted at the corners of a rectangle three inches by four inches when mating surfaces **165** and **166** were in mating contact, and the location of the pivots and the orientation of the mating surfaces is shown for separations of the mating surfaces of one-half inch and one inch. In FIG. 10 pivot E is taken as the point of reference and its position remains unchanged.

When arranged in the rectangular orientation pivots A, B, C and D all lie on a circle having pivot E as its center. In plotting the positions of pivots C and D at the stages representative of a ½ and 1 inch opening the distance between pivots A and D and between pivots B and C was maintained constant and the successive locations of pivots C and D was determined by the intersection of an arc of that length from the new positions of pivots A and B with lines drawn radially from pivot E. The distance between the successive locations of pivots C and D, and the circle drawn about pivot E represents the necessary length of slots **107** and **108**. The base of the lines representing the successive position of mating surfaces **165** and **166** is located on the line connecting pivots A and B in the corresponding successive position, and the lines representing mating surfaces **165** and **166** are drawn at a constant angle to the lines connecting pivots A and D and pivots B and C respectively.

It will be noted that mating surfaces **165** and **166** insofar as can be observed, remain absolutely parallel during the entire opening plotted. In the proportions plotted the necessary length of slots **107** and **108** is about ¼ inch.

As before a number of different combinations having widely varying proportions have similarly been plotted and it has been observed that mating surfaces **165** and **166** remain substantially parallel in each instance over an extended degree of opening. In this instance also the degree of parallelism between **165** and **166** can be improved if such improvement is possible by so locating pivots A, B, C and D that they form the corners of a rectangle midway through the stroke of tool **121**. In this particular embodiment such an arrangement has the added advantage of minimizing the length of slots **107** and **108** for, as it will be noted, the location of pivots C and D will always move away from pivot E on either side of the rectangular configuration.

A second alternative embodiment is shown in FIGS. 5 and 6. Here too, some of the parts common to all three embodiments are identified by the same reference number prefixed in this case by 200. In tool **221** jaw actuating members **231** and **232** are connected by strap **215** and pivots F and G. Pivots F and G are so located that when pivots A, B, C and D are arranged as the corners of a rectangle, pivot F is at the mid-point of the line connecting pivots A and C and pivot G is at the mid-point of the line connecting pivots B and D.

Structurally pivot F comprises a bolt **285** that passes through aperture **286** in strap **215** through aperture **287** in jaw actuating member **231** through aperture **287'** in jaw actuating member **231'** and through aperture **286'** in strap **215'** and is secured by nut **288**. Pivot G comprises bolt **289** that passes through aperture **290** in strap **215** through aperture **291** in jaw actuating member **232** through aperture **291'** in jaw actuating member **232'** and through aperture **290'** in strap **215'** and is secured by nut **292**. In this instance rather than shaping jaw members **223** and **224** to avoid contact with pivots F and G, jaw members **223** and **224** are each provided with an enlarged opening **293** and **294** respectively adapted to permit the passage of pivots F and G therethrough without contact therebetween.

For the same general reasons that apply in the case of the embodiment shown in FIGS. 3 and 4, either pivots C and D or pivots A and B must be permitted to move relative to pivots F and G if there is to be any relative movement between the jaw members and the jaw actuating members. This preferably is accomplished by providing a slot **207** in jaw actuating member **231** to accommodate pivot C and a slot **208** in jaw actuating member **232** to accommodate pivot D. Slot **207** is arranged radially to pivot F and slot **208** is arranged radially to pivot G.

If desired, the facing edge of jaw actuating members **231** and **232** may be provided with interacting gear segments or teeth **295** and **296** respectively. Gear segment **295** is a circular section having pivot F as its center and gear segment **296** is a circular section of the same radius as segment **295** having pivot G as its center. Since the motion of jaw actuating members **231** and **232** is limited in this embodiment to rotation about pivots F and G respectively, the presence or absence of gear segments **295** and **296** has no effect on the action of head **222** of tool **221**.

The geometry of the motion of the jaws and the pivots of tool **221** the embodiment illustrated in FIGS. 5 and 6, is shown in the diagram of FIG. 11. Here as in the case of FIGS. 9 and 10, an arrangement was selected such that pivots A, B, C and D are arranged as the corners of a rectangle 3 inches by 4 inches as originally plotted when mating surfaces **265** and **266** are in mating position, and the relative positions of pivots A, B, C and D and the orientation of mating surfaces **265** and **266** were plotted for a one-half and one inch total separation of mating surfaces **265** and **266**. In plotting the diagram of FIG. 11 pivots F and G (i.e. strap **215**) are selected as the reference point and their position remains fixed. In plotting the successive positions of the pivots, the distance between pivots A and D and between pivots B and C remain constant and the location of pivots C and D in successive positions was determined by plotting the intersection between an arc of that length about pivot A or B, as the case may be with a line drawn radially from pivot F in the case of pivot C and a line drawn radially from pivot G in the case of pivot D. In the successive positions pivots A and B remain on an arc drawn about pivots F and G respectively and the necessary length of slots **207** and **208** can be determined by the distance between the location of pivot C or D in the successive positions and an arc of similar radius about pivot F or G which arcs by definition pass through pivot C or D when pivots A, B, C and D are in their rectangular orientation. As before the spacing between the mating surfaces is determined on a line drawn between the successive positions of pivots A and B and the orientation of mating surfaces **265** and **266** is developed by projecting a line in each successive instance from the appropriate point at a constant angle in the case of mating surface **265** to the line connecting pivots A and D, and in the case of pivot **266** to the line connecting pivots B and C.

It will be noted that during an opening equivalent to a total of one inch on the dimensions plotted, there is no apparent loss of parallelism between mating surfaces **265** and **266**. As in the case of the other embodiments shown in FIGS. 9 and 10, an even higher degree of parallelism between **265** and **266** could be obtained by arranging the tool so that the rectangular configuration of pivots A, B, C and D occurs at the half open point. It will be noted that the required length of slots **207** and **208** in the arrangement as plotted is somewhat less than the required length of slots **107** and **108** as shown in FIG. 10, and that even this required length of slots **207** and **208** could be reduced even further for pivots A, B, C and D to be arranged to present a rectangular orientation at the mid-point of the stroke. As in the case of the embodiment shown in FIGS. 9 and 10, a number of different arrangements of pivots A, B, C and D having widely different proportions have been plotted, and it has been found that mating surfaces **265** and **266** remain substantially parallel over extended degrees of opening.

So far in this description of the invention the three embodiments of the present invention have been shown as tools capable of developing high compressive forces, and which have employed toggle jointed handles for this purpose. Any other three embodiments can be provided as for example, a hand tool without using a toggle jointed handle. Such a version is shown in FIGS. 7 and 8.

The version shown in FIGS. 7 and 8 is the same embodiment as that shown in FIGS. 1 and 2 adapted as a hand tool. As before the same numbers will be used to identify the same parts, except that in this instance such reference numbers will be prefixed by 300, and for the most part only those things which are different will be explained in any detail.

To convert any of these reembodiments to a hand tool it is merely necessary to provide jaw actuating members **331** and **332** with rearward extensions shaped to form crossed handles **316** and **317**. One way to accomplish this is as shown to form handles **316** or **317** by forming a piece of metal into a generally U-shaped cross section, having a generally horizontally extending portion on both top and bottom joined by a generally vertically extending web. The vertically extending web can be removed at the start of the cross over area with the horizontally extending portions continued to form jaw actuating members **331** and **331'** in the case of handle **317** and jaw actuating members **332** and **332'** in the case of handle **316**. Since jaw actuating members **331** and **332** and jaw actuating members **331'** and **332'** lie in the same plane under pivots A, B, C and D it is necessary to provide a vertical offset in at least the crossover area to avoid interference between the handles, this can be accomplished by offsetting each slightly more than one-half of the web thickness in an opposite direction as shown at **318** and **319**.

As indicated above, any of the three basic embodiments of the invention can be fitted as a hand tool merely by extending the jaw actuating members rearwardly as handles. Such tools can be designed for either one hand or two hand operation. In the case of one hand operation the handles are crossed in any suitable manner so that the jaws can be closed by merely squeezing the handles. A spring action acting to force the handles apart may be provided if desired. In the case of a tool designed for a two hand operation the handles may or may not be crossed as desired, remembering that if the handles are not crossed the jaws are closed by opening the handles and opened by closing the handles.

As mentioned above, the tool can also be actuated by providing means such as hydraulic cylinders which will move either pivots A and B or pivots C and D laterally, this being the full equivalent of the motion imposed by any kind of a handle arrangement. These and other means for actuating head **22** will be obvious to any practitioner skilled in the art.

I claim:

1. A compression tool of the type having a pair of opposed open-ended jaws which are movable relative to each other and are adapted to receive an object therebetween and releasably to apply pressure thereto, the jaws of said tool each having a pressure-applying surface which during the movement of said jaws remains in an orientation which is effectively constant relative both to itself and to the other said surface, said tool comprising:

a first and a second elongated jaw member each said jaw member having a forwardly extending jaw portion including said pressure applying surface and a rearwardly extending lever portion;

a first and a second elongated jaw actuating member;

said first jaw member pivotally mounted at a point adjacent its jaw portion to a point near the forward end of said first jaw actuating member,

said second jaw member pivotally mounted at a point adjacent its jaw portion to a point near the forward end of said second jaw actuating member,

said first jaw member pivotally mounted at a point adjacent the end of its lever portion to a point on said second jaw actuating member remote from the forward end thereof,

said second jaw member pivotally mounted at a point adjacent the end of its lever portion to a point on said first jaw actuating member remote from the forward end thereof;

and means for moving the rearward ends of said jaw actuating members laterally relative to each other,

the pivots connecting said first and said second jaw members to said first and said second jaw actuating members being so located that the four said pivots simultaneously occupy the four corners of a rectangle at one point during the full travel of said jaws.

2. A compression tool as claimed in claim **1** wherein said first and said second jaw actuating members are pivotally attached to each other at a point lying at the center of the rectangle formed by the first four recited said pivots when said pivots are in rectangular orientation, and wherein either the forward pair or the rearward pair of the said first four recited said pivots are each permitted to move relative to the associated said jaw actuating member in a direction radial to the last recited said pivot.

3. A compression tool as claimed in claim **1** wherein said first and said second jaw actuating members are each pivotally attached to a strap extending therebetween, the pivot between said strap and said first jaw actuating member being located mid-way between the forward and the rearward pivots associated with said first jaw actuating member when the first four recited said pivots are in rectangular orientation, the pivot between said strap and said second jaw actuating member being located midway between the forward and the rearward pivot associated with said second jaw actuating member when the first four recited said pivots are in rectangular orientation, and wherein either the forward pivots associated with both said jaw actuating members or the rearward pivots associated with both said jaw actuating members are each permitted to move relative to the associated said jaw actuating member in a direction radial to the pivot connecting the said jaw actuating member with said strap.

4. A compression tool as claimed in claim **1** wherein said first and said second jaw actuating member are each provided with a rearwardly extending lever portion.

5. A compression tool as claimed in claim **4** wherein the rearwardly extending lever portion of said first and said second jaw actuating members are each pivotally attached to one member of a toggle handle.

6. A compression tool as claimed in claim **4** wherein the rearwardly extending lever portion of said first and said second jaw actuating member are each provided with a handle member, said handle members arranged in a crossed position relative to the associated said jaw actuating members.

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