June 6, 1967 P. J. SPANGLER ETAL 3,323,346

FLUID-ACTUATED HAND TOOL

Filed Jan. 8, 1965 2 Sheets-Sheet 1

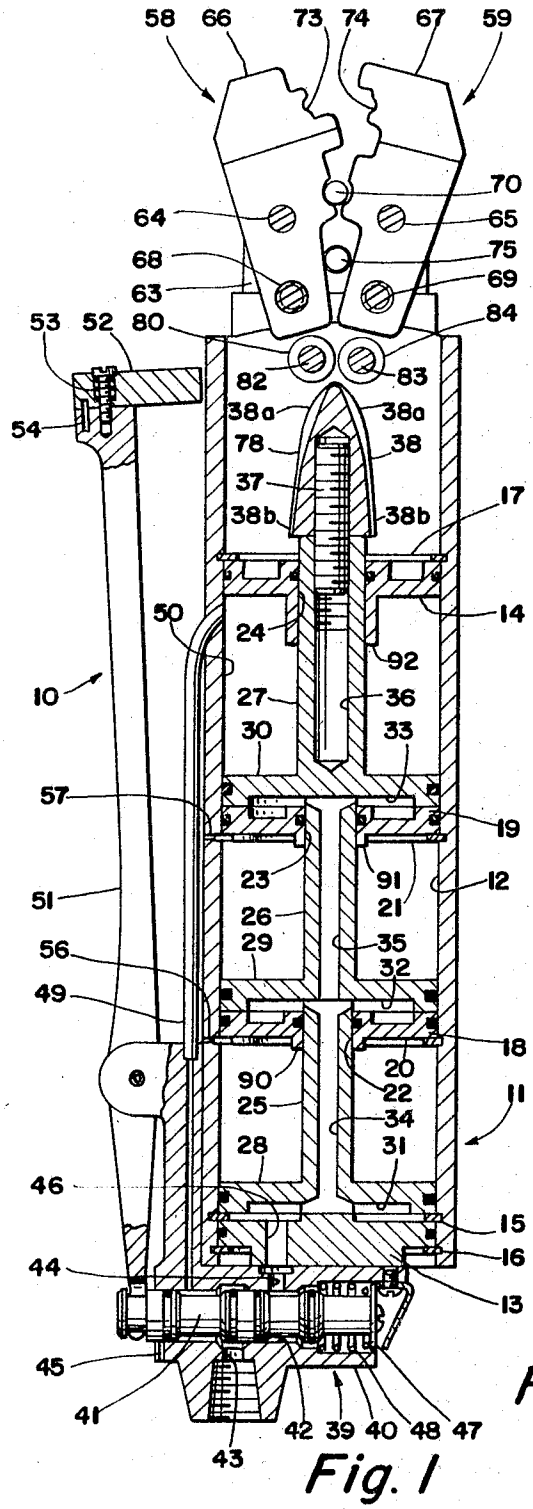


Fig. 1

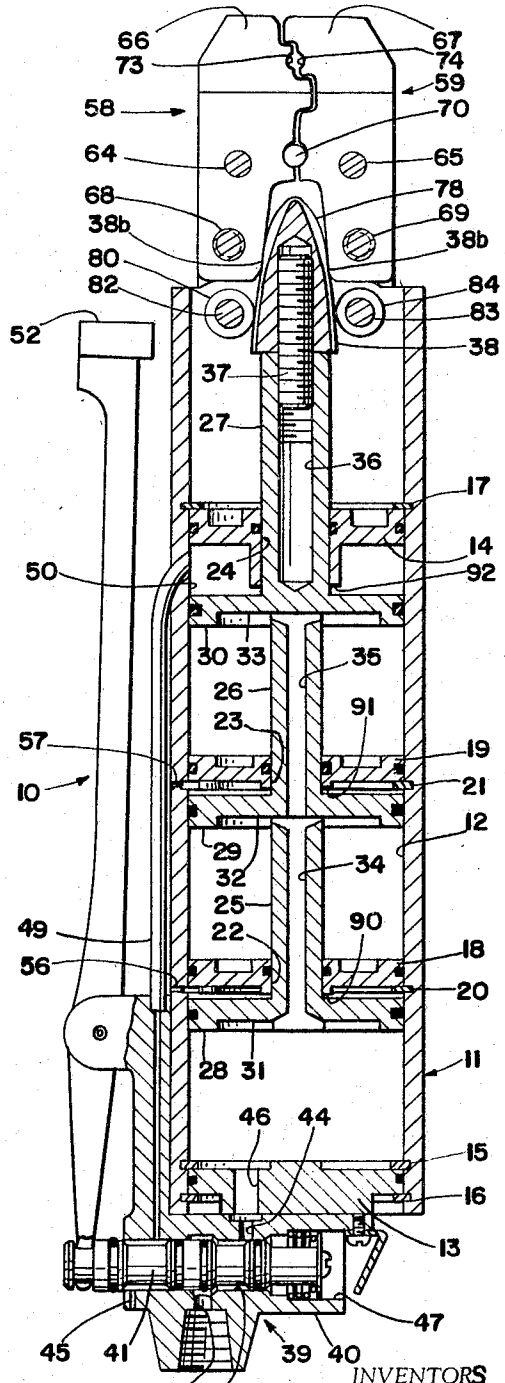


Fig. 2

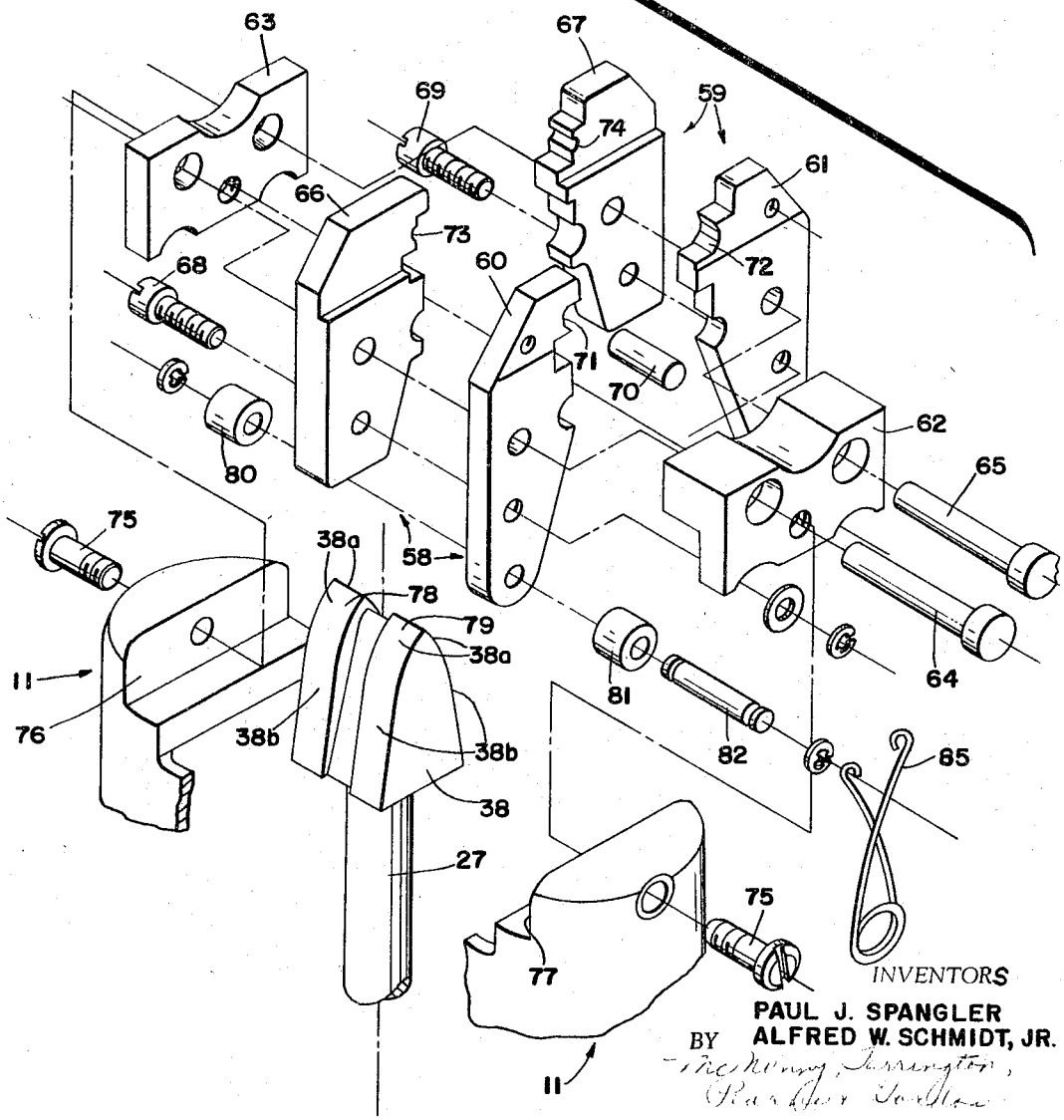
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Fig. 3



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FLUID-ACTUATED HAND TOOL

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This invention relates to fluid-actuated hand tools and, more particularly, to fluid-actuated hand tools which may be employed to crimp the ferrule portion of electrical connectors to their conductors.

Fluid-actuated compression tools for forging electrical connectors onto conductors and for other similar operations generally comprise a fluid-actuated piston and a jaw or pair of jaws mechanically actuated by the piston rod. The actuating connection between the piston rod and the jaw or jaws usually includes a linkage or cam arrangement that displaces the jaw or jaws in response to the movement of the piston. The linkage or cam arrangement is such that the initial displacement of the jaw or jaws is relatively large and the final displacement is relatively small with respect to a uniform piston displacement during these periods. The initial displacement of the jaw or jaws or jaws is merely to bring these members into contact with the workpiece. The final displacement comprises the actual crimping operation of the work cycle wherein the workpiece is deformed and, for that reason, the mechanical advantage of the connection between the piston and the jaws should be relatively large, at least during the crimping operation.

Fluid-actuated tools that are now in use are capable of performing the desired crimping operation. These tools, however, have not been wholly acceptable for performing heavy crimping operations where the tool is held in the hand, since the force necessary to perform these operations is proportionate to the size of the piston head and/or the pressure that is applied to the piston head. In either case, the weight of the tool increases for heavy crimping operations, and for those operations a bench-type crimping tool is required.

As was previously stated, fluid-actuated crimping tools are designed so that they deliver their maximum crimping force during the final closure of the crimping jaws. When a workpiece is properly inserted in the crimping jaws, this force is transmitted to the workpiece. If, however, the tool is cycled without a workpiece in the jaws, the force is transmitted to the jaw members themselves. Frequent cycling of the tool without a workpiece in its jaws may cause failure of the jaws, or may cause premature failure of the linkage elements or cam connections due to the suddenly applied force.

It is an object of the present invention to provide a fluid-actuated crimping tool having a multiple piston arrangement that multiplies the crimping force which is applied to the workpiece in accordance with the number of pistons in the tool, without increasing the size or weight of the fluid cylinder.

It is a further object of the present invention to provide a tool which will deliver a predetermined large crimping force to a workpiece when the tool is properly loaded, but which will minimize jaw impact and linkage wear when the tool is cycled in an unloaded condition.

These and other objects and advantages of the invention will become apparent from the following description and accompanying drawings.

In the drawings:

FIG. 1 is a longitudinal, cross-sectional view of a fluid-actuated crimping tool in accordance with the present invention, showing the jaws of the tool in an open condition;

FIG. 2 is a longitudinal, cross-sectional view of the tool according to the present invention, showing the jaws of the tool in a closed condition; and

FIG. 3 is an exploded perspective view of the jaw elements.

Referring to the drawings, and particularly to FIGS. 1 and 2, a fluid-actuated crimping tool **10** is illustrated. The tool **10** includes a body portion **11** having a cylindrical bore **12** therein. The bore **12** is closed at one end by a backing plate **13** and at the other end by a front baffle or web **14**. The backing plate **13** is restrained against longitudinal movement in either direction by C-rings **15** and **16**, and the front web is restrained against movement outwardly in one direction by a C-ring **17**. Movement of the front web **14** inwardly is prevented by frictional resistance and/or air pressure, as will hereinafter become apparent. Intermediate baffles or webs **18** and **19** are provided within the bore **12** and are respectively restrained against longitudinal movement in one direction by C-rings **20** and **21**.

The intermediate webs **18** and **19** and the front web **14** are respectively provided with axial bores **22**, **23**, and **24**. Mounted for reciprocation within the bores **22–24** are pistons **25**, **26**, and **27**. The pistons **25–27** are respectively provided with piston heads **28**, **29**, and **30**. The piston heads **28–30** are respectively provided with recessed face portions **31**, **32**, and **33**. The piston rods **25** and **26** are provided with axial bores **34** and **35**, which provide fluid communication among the recessed portions **31**, **32**, and **33**. The piston rod **27** is provided with a bore **36** which is threaded at one end and which receives a stud **37**. The stud **37** connects the piston rod **27** to a wedge cam **38**.

A conventional, manually operated valve **39** is attached to the backing plate **13**. The valve **39** includes a body **40** and a valve spool **41** slidably mounted in a bore **42** in the body. A pressure inlet port **43** is drilled into the body **40** and communicates with the bore **42**. The port **43** is threaded for connection to a suitable fluid pressure source. The body **40** is further provided with a port **44** for supplying fluid under pressure to the recessed faces of the three piston heads and an exhaust port **45**. The port **44** communicates with a bore **46** in the end plate **13** and the bore **46** in turn communicates with the recessed portion **31** of the piston head **28** and the bore **34**. Fluid communication also exists between the bore **34** and the recessed portion **32**, the recessed portion **32** and the bore **35**, and the bore **35** and the recessed portion **33**.

In the position illustrated in FIG. 1, the passage **46** is blocked from the source of pressurized air by the valve spool **41**, which is positioned to connect the passage **46** through the port **44** to an exhaust passage **47** open to the atmosphere. In this position, however, the valve spool **41** is biased to the right by a spring **48**, as viewed in FIG. 1, so that the passage **43** and, therefore, the source of pressurized fluid is in communication with a passage **49** which leads to a chamber **50** which is defined by the front web **14** and the piston head **30**. The spool **41** may be shifted to the left, as viewed in FIG. 1, by pressing a handle **51** inwardly toward the body **11**. The handle **51** is normally blocked against this inward movement by a safety latch **52**. The safety latch **52** may be released by pulling this latch outwardly against the bias of a spring **53** to release the latch **52** from engagement with a pin **54** so that the latch **52** may be swung away from the body **11**.

When the handle **51** is pressed toward the body **11**, the valve spool **41** is moved to the left against the bias of the spring **48**. As may be seen in FIG. 2, the valve spool has been moved to the left and the inlet port **43** is connected to the port **44**. The passageway **49**, furthermore, is then ported to the atmosphere through the port **45**.

When the port 44 is connected to the source of fluid pressure, the pressure is applied to the spaces defined by the recessed portions 31, 32, and 33 of the piston heads and by the backing plate 13, the web 18, and the web 19. Since the piston heads 28, 29, and 30 present substantially the same area to the pressure, which is uniformly applied thereto, the pistons 25, 26, and 27 tend to move in unison in the cylinder 12 to thereby drive the wedge cam 38 forward. It should be noted that the total force applied to the wedge cam is substantially equal to the total area of the three piston heads multiplied by the actuating fluid pressure admitted through the port 43. The reaction forces on the end plate 13, the web 18, and the web 19 are resisted respectively by the C-rings 16, 20, and 21. As the pistons are driven forward in this manner, air is exhausted ahead of the pistons 28 and 29 through the ports 56 and 57, which are drilled through the body 11 and into the annular recesses provided for the C-rings 20 and 21. The C-rings are positioned in these recesses so that they do not block the ports 56 and 57. The air is exhausted from the chamber 50 through the conduit 49 and then through the port 45, as was previously indicated.

The wedge cam 38 is positively retracted by releasing the handle 51. When the handle is released, the spring 48 returns the spool 41 to the position shown in FIG. 1, and the port 43 is connected to the conduit 49 to pressurize the chamber 50 and thereby drive all the pistons back to the position indicated in FIG. 1. The pressure which had been employed to drive the pistons forward is exhausted through the port 44 and the exhaust passage 47. The ports 56 and 57 prevent any tendency for a vacuum to form as the piston heads are driven back to the position shown in FIG. 1. Thus, it may be seen that by pressing the handle 51 toward the body 11, the wedge cam 38 is driven forwardly with a force that is a function of the number of pistons and the applied pressure; and when the handle 51 is released, the wedge cam 38 is driven rearwardly by the application of pressure to the piston head 30.

When the wedge cam 38 is driven forwardly in the manner previously indicated, jaws 58 and 59 are closed, and these jaws are opened upon retraction of the wedge cam 38. The jaws 58 and 59 may be designed to perform any of a variety of forming or fabricating operations. In the drawings, however, the jaws 58 and 59 are of the type which are intended to crimp the ferrule portion of an electrical connector to an electrical conductor and its surrounding insulation.

The jaw 58 includes a jaw plate 60, and the jaw 59 includes a jaw plate 61 which cooperates with the plate 60. The jaw plates 60 and 61 are each disposed between and pivotally connected to a pair of end blocks 62 and 63 by pivot pins 64 and 65 which extend through both end blocks and respectively through the jaw plates 60 and 61. The crimping jaws 58 and 59 further include a pair of insulation crimping plates 66 and 67, and the pins 64 and 65 also extend through these crimping plates. The insulation crimping plates 66 and 67 are respectively fixed to the jaw plates 60 and 61 by cap screws 68 and 69. The jaw plates 60 and 61 and the insulation crimping plates 66 and 67 are pivoted for relative rocking movement about a rocking pin 70 interposed between and engaged by concave edge portions of all four of these jaws plates and insulation crimping plates. The pin 70 serves to hold the jaws 58 and 59 in alignment during jaw closure to insure that the jaws will cooperate to define the desired ferrule crimping surface.

The jaw plates 60 and 61 are provided with opposed ferrule forming die portions 71 and 72, respectively, which may be designed to provide a crimp of any desired configuration to the ferrule portion of an electrical connector when the jaws are closed. The crimping plates 66 and 67 are also provided with opposed ferrule forming die portions 73 and 74, respectively. The die portions 73 and 74 are intended to crimp the insulation sleeve of an

electrical connector onto the insulation covering of the electrical conductor.

Although the crimping plates 66 and 67 are shown to be fixed to the jaw plates 60 and 61 by the cap screws 68 and 69, the crimping plates 66 and 67 may be provided with means to adjustably lock these plates in any desired position relative to the jaw plates 60 and 61 to accommodate insulated conductors of varying insulation thicknesses. Such an adjustable locking means is illustrated in the copending application of Richard B. Freeman, Serial No. 222,566, now abandoned.

The jaws 58 and 59 and the end blocks 62 and 63 are fixed to the end of the body 11 by a pair of screws 75 which extend from opposite sides through the body 11 and into the blocks 62 and 63, respectively. The blocks 62 and 63 are respectively mounted in recesses 76 and 77, which are provided in opposed inner faces of a yoke formed on the end of the body 11. The jaws 58 and 59 are mounted so that the jaw plates 60 and 61 are in planar alignment with the axis of the piston 27 and so that a pair of cam faces 78 and 79 on the wedge cam 38 pass on either side of the jaw plates 60 and 61 when the wedge cam 38 is driven forwardly in the previously described manner.

A pair of cam followers 80 and 81 are rotatably mounted on a pin 82 which extends through the lower end of the jaw plate 60. A pin 83 (FIGS. 1 and 2) extends through the lower end of the jaw plate 61. A cam follower 84 (FIGS. 1 and 2) is provided on one end of the pin 83 and another cam follower (not shown but corresponding to the cam follower 81) is provided on the other end of the pin 83.

The upper ends of the jaws 58 and 59 are normally biased apart by a spring 85 which is connected to the ends of the pins 82 and 83 to urge the lower portions of the jaws 58 and 59 together.

When the wedge cam 38 is driven upwardly in the previously described manner, the cam followers 80 and 81 are separated from the cam follower 84 and its corresponding cam follower (not shown) by the cam surfaces 78 and 79 so that the jaws 58 and 59 will be rocked about the rocking pin 70 as a fulcrum and closed to define a desired ferrule crimp. Conversely, when the wedge cam 38 is retracted in the previously described manner, the spring 85 urges the jaws 58 and 59 apart.

When the wedge cam is driven forwardly, the cam followers initially traverse a curved portion 38*a* of the wedge cam 38. During this traversal, the jaws are rapidly closed so that the ferrule forming die portions 71–74 engage the connector to be crimped. The cam followers then follow a substantially straight portion 38*b* of the wedge cam 38 and during this traversal, the ferrule is deformed and coined onto its conductor. This final displacement of the jaws is very slight and since it occurs during the major portion of the travel of the wedge cam 38, a maximum mechanical advantage is developed between the pistons and the jaws. Normally, this final displacement takes place during the crimping of an electrical connector onto its conductor and the crimping force developed by the jaws is transmitted to the connector. In some instances, however, the tool may be accidentally or deliberately cycled without a workpiece in the jaws and, in those instances, the full crimping force would normally be absorbed by the jaws and the pivot pins 64 and 65. The tool according to the present invention, however, is designed so that upon completion of a crimping operation, or if the tool is cycled without a workpiece in the jaws, the force absorbed by the jaws beyond a predetermined point of desired and correct jaw closure would be no greater than the force acting upon the piston head 30. The manner in which this function is accomplished will now be explained.

Referring again to FIGS. 1 and 2, the C-rings 17, 21, 20, and 15 are positioned in the bore 12 so that the piston

head 29 will travel a greater distance than the piston head 28 and so that the piston head 30 will travel a greater distance than the piston head 29. Thus, when the pistons 25–27 are driven forwardly, the ends of the pistons 25 and 26 will be respectively butting against the bottoms of the recess 32 in the piston head 29 and the recess 33 in the piston head 30. The wedge cam 38 is designed so that the die surfaces 71–74 will define a desired ferrule crimping surface just prior to the actual jaw closure. When this jaw relationship is established, the ends of the pistons 25 and 26 are still transmitting force to the bottoms of the recesses 32 and 33. This relationship of the parts of the device in established when a connector is properly positioned in the jaws and the relationship is illustrated in FIG. 2. It should be noted that in this position the piston heads 28, 29, and 30 have traveled the same distance and are respectively spaced from cylindrical stop members 90, 91, and 92, which are respectively provided on the webs 18, 19, and 14.

If a connector is not in the jaws and the tool is cycled, the piston head 30 is driven against its stop member 92. This movement of the wedge cam 38 brings the jaws to a fully closed position, but the stop member 92 limits this movement and prevents the development of an excessive force between the jaw members. The piston head 29 is similarly driven against its stop member 91 and the piston head 28 is similarly driven against its stop member 90. When the piston head 29 butts against its stop member 91, however, the piston rod 26 no longer contacts the bottom of the recess 33. The pressure driving the piston head 29 forwardly is therefore resisted solely by the stop member 91, and the web 19 is held against the C-ring 21 by the pressure developed between the piston head 30 and the web 19. Similarly, when the piston head 28 butts against its stop member 90, the end of the piston rod 25 no longer contacts the bottom of the recess 32. The force acting upon the piston head 28 is therefore transmitted to the stop member 90, and this force is resisted by the pressure between the piston head 29 and the web 18.

Thus, it may be seen that if the tool is cycled without an electrical connector properly positioned in its jaws, only about one-third of the normal crimping force will be transmitted to the jaws, the balance of the total normal crimping force being transmitted to and shared by the C-ring 17 and the C-ring 16. Of course, the tool may be designed so that the jaws absorb more than one-third of the crimping force if it is necessary or desirable to fully close the jaws while the full force is applied to the jaws during a crimping operation. When a predetermined point of correct jaw closure is achieved, however, this force may be decreased in the manner previously indicated to prevent the application of excessive force to the jaws.

When the crimping tool operates without an electrical connector properly positioned in its jaws, as just described above, the force acting on the C-ring 17 is no greater than the force resulting from the fluid pressure on the piston head 30, since the piston head 30 is not contacted by the piston rod 26. The force acting on the C-ring 16 is, of course, no greater than the force resulting from the pressure on the end plate 13. Therefore, when the tool is cycled without a connector in its jaws, the forces acting on the C-rings 20 and 21 are balanced, since the pressure between the piston head 30 and the web 19, the pressure between the piston head 29 and the web 18, and the pressure between the piston head 28 and the end plate 13 are all equal. Since the normal crimping forces applied by the piston heads 31 and 32 are neutralized in this manner before the jaws can be subjected to the full, normal crimping force in a fully closed condition, the jaw actuating force is thereby reduced to the product of the pressure of the actuating fluid and the effective area of only one of the three piston heads.

In light of the above teachings, many modifications and variations of the invention will become apparent to those skilled in the art. It is to be understood, therefore, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically disclosed.

What is claimed is:

1. A fluid-actuated tool for crimping ferrules, said tool comprising a body having a cylindrical bore therein, means defining at least two adjacent compartments in said bore, a first piston in a first one of said compartments, said first piston having a piston head dividing the first compartment into first and second pressure chambers and having a piston rod extending through an end wall of said second chamber, an additional piston in each other compartment, each additional piston having a piston head dividing each other compartment into first and second chambers and having a piston rod extending through an end wall into an adjacent compartment, the piston in the compartment adjacent said first one of said compartments extending into said first pressure chamber of said first compartment, a pair of jaws mounted on one end of said body for pivotal movement toward and away from each other, jaw actuating means acting between said jaws and the piston rod of said first piston for forcing the jaws toward each other in response to forward movement of the piston rod of said first piston, means for admitting pressurized fluid to each first chamber and for simultaneously exhausting fluid from each second chamber to thereby drive each piston and piston rod forward with the piston rod of each additional piston abutting the head of a piston in an adjacent compartment so that the jaws are moved toward each other.

2. A fluid-actuated tool for crimping ferrules, said tool comprising a body having a cylindrical bore therein, means defining at least two adjacent compartments in said bore, a first piston in a first one of said compartments, said first piston having a piston head dividing the first compartment into first and second pressure chambers and having a piston rod extending through an end wall of said second chamber, an additional piston in each other compartment, each additional piston having a piston head dividing each other compartment into first and second chambers and having a piston rod extending through an end wall into an adjacent compartment, the piston in the compartment adjacent said first one of said compartments extending into the first pressure chamber of said first compartment, a pair of jaws mounted on one end of said body for pivotal movement toward and away from each other, jaw actuating means acting between said jaws and the piston rod of said first piston for forcing the jaws toward each other in response to forward movement of the piston rod of said first piston, means for admitting pressurized fluid to each first chamber and for simultaneously exhausting fluid from each second chamber to thereby drive each piston and piston rod forward with the piston rod of each additional piston abutting the head of a piston in an adjacent compartment so that the jaws are moved toward each other, means for blocking the forward travel of the piston in the compartment adjacent said first one of said compartments when the jaws have been moved a predetermined distance toward each other so that any further travel of said jaws is caused solely by the fluid pressure in the first pressure chamber of said first compartment.

3. A fluid-actuated tool for crimping ferrules, said tool comprising a body having a cylindrical bore therein, means defining at least two adjacent compartments in said bore, a first piston in a first one of said compartments, said first piston having a piston head dividing the first compartment into first and second pressure chambers and having a piston rod extending through an end wall of said second chamber, an additional piston in each other compartment, each additional piston having a piston head dividing each other compartment into first and second chambers and having a piston rod extending through an end wall into an adjacent compartment, the piston in the compartment adjacent said first one of said compart-

ments extending into the first pressure chamber of said first compartment, a wedge cam connected to the piston rod of said first piston, a pair of jaws mounted on one end of said body for pivotal movement toward and away from each other, jaw actuating means acting between said jaws and the piston rod of said first piston for forcing the jaws toward each other in response to forward movement of said wedge cam between the other ends of said jaws, means for admitting pressurized fluid to each first chamber and for simultaneously exhausting fluid from each second chamber to thereby drive each piston and piston rod forward with the piston rod of each additional piston abutting the head of a piston in an adjacent compartment so that said wedge cam moves the jaws toward each other, means for blocking the forward travel of the piston in the compartment adjacent said first one of said compartments when the jaws have been moved a predetermined distance toward each other so that any further travel of said jaws is caused solely by the fluid pressure in the first pressure chamber of said first compartment.

4. A fluid-actuated tool for crimping ferrules, said tool comprising a body having a cylindrical bore therein, means defining at least two adjacent compartments in said bore, a first piston in a first one of said compartments, said first piston having a piston head dividing the first compartment into first and second pressure chambers and having a piston rod extending through an end wall of said second chamber, an additional piston in each other compartment, each additional piston having a piston head dividing each other compartment into first and second chambers and having a piston rod extending through an end wall into an adjacent compartment, the piston in the compartment adjacent said first one of said compartments extending into the first pressure chamber of said first compartment, a wedge cam connected to the piston rod of said first piston, a pair of jaws mounted on one end of said body for pivotal movement toward and away from each other, jaw actuating means acting between said jaws and the piston rod of said first piston for forcing the jaws toward each other in response to forward movement of said wedge cam between the other ends of said jaws, means for admitting pressurized fluid to each first chamber and for simultaneously exhausting fluid from each second chamber to thereby drive each piston and piston rod forward with the piston rod of each additional piston abutting the head of a piston in an adjacent compartment so that said wedge cam moves the jaws toward each other.

5. A fluid-actuated tool for crimping ferrules, said tool comprising a body having a cylindrical bore therein, means defining at least two adjacent compartments in said bore, a first piston in a first one of said compartments, said first piston having a piston head dividing the first compartment into first and second pressure chambers and having a piston rod extending through an end wall of said second chamber, an additional piston in each other compartment, each additional piston having a piston head dividing each other compartment into first and second chambers and having a piston rod extending through an end wall into an adjacent compartment, the piston in the compartment adjacent said first one of said compartments extending into said first pressure chamber of said first compartment, a pair of jaws mounted on one end of said body for pivotal movement toward and away from each other, jaw actuating means acting between said jaws and the piston rod of said first piston for forcing the jaws toward each other in response to forward movement of the piston rod of said first piston, means for admitting pressurized fluid to each first chamber and for simultaneously exhausting fluid from each second chamber to thereby drive each piston and piston rod forward with the piston rod of each additional piston abutting the head of a piston in an adjacent compartment so that the jaws are moved toward each other, said compartment defining means blocking the forward travel of each additional piston when the jaws have been moved a predetermined distance toward each other so that any further travel of said jaws is caused solely by the fluid pressure in the first pressure chamber of said first compartment and so that the force exerted on each defining means by each additional piston is balanced by the pressure in an adjacent first chamber.

6. A fluid-actuated tool for crimping ferrules, said tool comprising a body having a cylindrical bore therein, means defining at least two adjacent compartments in said bore, a first piston in a first one of said compartments, said first piston having a piston head dividing the first compartment into first and second pressure chambers and having a piston rod extending through an end wall of said second chamber, an additional piston in each other compartment, each additional piston having a piston head dividing each other compartment into first and second chambers and having a piston rod extending through an end wall into an adjacent compartment, the piston in the compartment adjacent said first one of said compartments extending into the first pressure chamber of said first compartment, a wedge cam connected to the piston rod of said first piston, a pair of jaws mounted on one end of said body for pivotal movement toward and away from each other, jaw actuating means acting between said jaws and the piston rod of said first piston for forcing the jaws toward each other in response to forward movement of said wedge cam between the other ends of said jaws, means for admitting pressurized fluid to each first chamber and for simultaneously exhausting fluid from each second chamber to thereby drive each piston and piston rod forward with the piston rod of each additional piston abutting the head of a piston in an adjacent chamber so that said wedge cam moves the jaws toward each other, said compartment defining means blocking the forward travel of each additional piston when the jaws have been moved a predetermined distance toward each other so that any further travel of said jaws is caused solely by the fluid pressure in the first pressure chamber of said first compartment and so that the force exerted on each defining means by each additional piston is balanced by the pressure in an adjacent first chamber.

7. A fluid-actuated tool for crimping ferrules in accordance with claim 1, further comprising means for admitting fluid pressure to the second pressure chamber of said first compartment and for simultaneously exhausting fluid from each first chamber to thereby drive each piston and piston rod rearwardly to open said jaws.

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