Jan. 16, 1962 W. E. STARY 3,016,944

TUBE-EXPANDING DEVICE

Filed Dec. 14, 1956 2 Sheets-Sheet 1

FIG. 1.

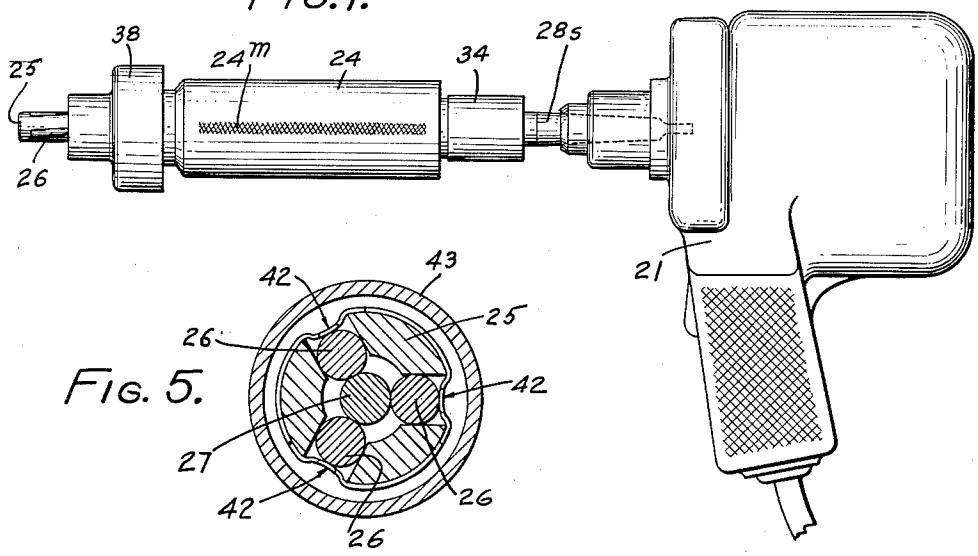


FIG. 5.

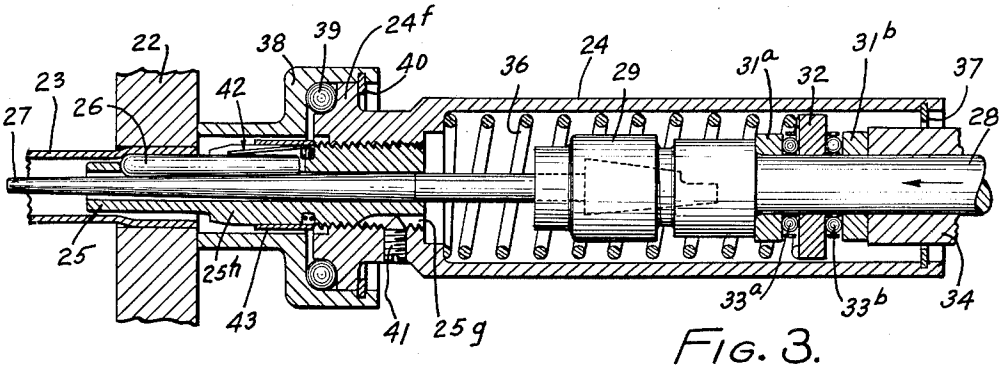


FIG. 3.

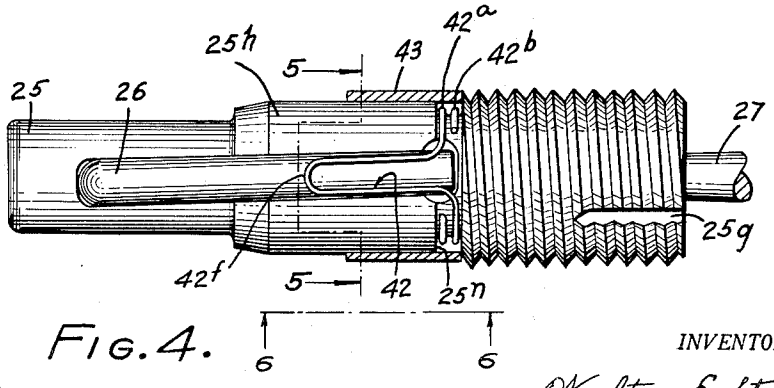


FIG. 4.

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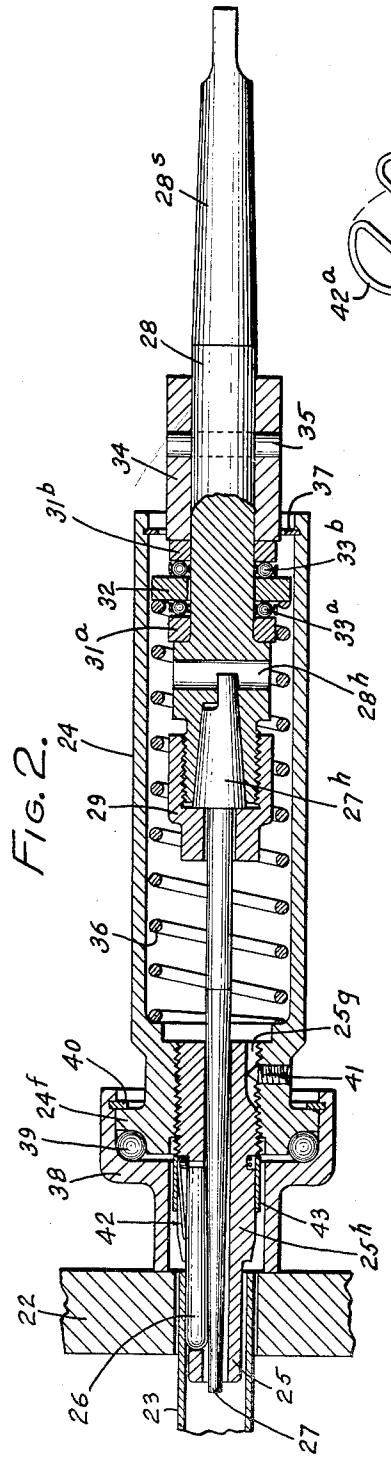


FIG. 2.

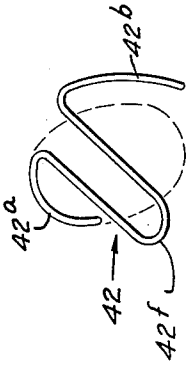


FIG. 7.

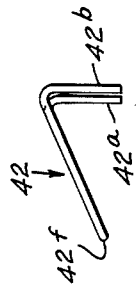


FIG. 8.

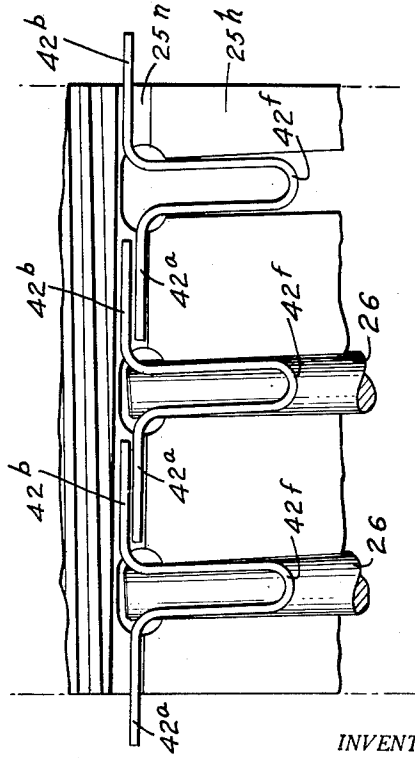


FIG. 6.

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TUBE-EXPANDING DEVICE

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Filed Dec. 14, 1956, Ser. No. 628,258
8 Claims. (Cl. 153—82)

This invention relates to improvements in the roller-type tube-expanding tool. This tool is used to expand a lineal portion of a metal tube by a rolling action to flow the metal so as to thin the tube wall and diametrically enlarge the tube portion to bring it into tight engagement with the tube-hole in which it is being assembled.

A principal use of this tube-expanding tool is to make pressure-tight tube-joints between the ends of tubes and tube-sheets in heat-exchange apparatus. A common form of such apparatus is steam condensers used to condense low-pressure steam to convert said steam back to water which is then returned to the boilers. Many such condensers are quite large, having, at times, 30,000 to 40,000 tubes, with tubes less than 1-inch O.D. and tube-sheets 1 to 1½-inches thick. A considerable amount of time is required to expand such quantities of tube-ends to assemble such a condenser unit, and any improvements reducing the tube-expanding time are valuable improvements in said art.

A type of tube-expanding tool commonly used for this work is known as a self-feeding tool. This self-feeding tool is illustrated and described in a number of U.S. patents, such as the patent issued to Brackett, Patent Number 2,448,512.

This self-feeding type of tool normally has its rolls contained in a roll-cage with the outer edges of the roll-slots being formed inward to form caging-lips, said caging-lips preventing the rolls from falling out of said roll-cage. The roll-cage and mandrel of the tool are free to move, axially, relative to each other. A usual way to keep the mandrel from being pulled out of the roll-cage, or to keep said cage from falling off the end of the mandrel, is to have a retaining nut threadably connected to the small end of the tapered mandrel, with said nut being diametrically large enough so that it cannot pass though the roll-cage bore.

Thus the tool is a self-contained unit so that in its normal assembled condition, the mandrel remains in the roll-cage and thus keeps the rolls in their caging slots.

A common working condition is that in which the longitudinal axes of the tubes are horizontal and the axis of the expanding tool is also horizontal. When the tool is to be used, the roll-cage is slid forward on the mandrel so that the rolls may radially retract to give the clearance needed to freely insert the tool into the tube-end to be expanded. The retaining-nut on the end of the mandrel prevents the roll-cage from being slid forward too far.

With the tool assembly in a horizontal plane, and with the rolls free to radially move in their slots, the rolls below centerline of the tool do not retract when the roll-cage is slid forward on the mandrel, and these rolls in the lower half of the assembly may remain at the radially-outward limit of their travel-range, as controlled by said caging-lips on the roll-slots.

The front end of these radially-extended rolls may catch on the end of a tube into which the tool assembly is being inserted so as to push said tube out of its proper longitudinal position, or the roll-cage may be pushed back on the mandrel thus expanding the rolls before the tool is properly positioned in the selected tube-end.

A common method for holding the roll-cage forward, and the rolls in their radially collapsed positions, while inserting the tool into a tube-end to be expanded, is that in which the operator grips the roll-cage so as to

hold said roll-cage forward on the mandrel and to hold the rolls in their radially-retracted positions while he gets the rolls started into the tube-end. Then he changes his grip so that the roll-cage can be slid forward into the tube-end to the limit of its forward-travel position as controlled by the stop-collar attached to said cage. During this time, the cage is held forward on the mandrel so that the rolls may remain loose inside their roll-cage and inside the tube-end.

When the roll-cage portion of the tool is inserted into the tube-end with the face of the stop-collar bearing against the face of the tube-sheet, or against the end of the tube, or both, thus establishing the proper working position for the tool, the operator advances the mandrel into its working position by pushing on the driving unit commonly connected to the mandrel, thus initiating the tool work-cycle.

Said driving unit provides the rotary power required to rotate the mandrel so that when the mandrel is advanced sufficiently to radially expand the rolls into firm contact with the inner surface of the tube portion to be expanded to thus give a firm frictional contact between mandrel and rolls, the planetary action of the tool parts is produced with the self-feeding action of the tool giving the additional mandrel advance movement with its associated radial expansion movement of the rolls so that the rolling action of the tool produces the thinning of the wall of the tube-portion being worked to enlarge said tube-portion and bring it into tight engagement with its tube-hole.

It is obvious that the required gripping of the roll-cage, and the changing of the grip, associated with getting the tool into its proper working position, take time and thus slow down the tube-expanding operation. Another factor involved which takes time and thus slows down the cycle time when many tube-ends are being consecutively rolled and expanded is that the frictional heat produced, when the tool works, heats the rolls and roll-cage so that it may become unpleasant or impossible to grip the front portion of the tool to guide the roll-cage assembly into a tube-end because of this portion of the tool becoming too hot. Lubricant is often applied into the tube-ends to reduce the heating effects described above. This adds to the messiness of the operation since a good portion of the lubricant is transferred to the tool parts and brought out of the expanded tube-end on the roll-cage.

A principal object of this invention is to provide a tube-expanding device in which the roll-cage portion of the tool is normally urged forward relative to its mandrel with said relative axial movement being limited so that a mandrel, not having a retaining nut on its forward end, is kept in the tool assembly thereby keeping the rolls of said tool in their roll-slots.

A further object of this invention is to provide an assembly of the above described character in which the axial force required, to obtain said improved results, is a nominal amount having substantially no effect on the forces required to operate, and the controlling "feel" developed in, the self-feeding tool assembly as heretofore commonly used.

A further object of this invention is to provide a tool assembly wherein all rolls are retained in contact with the tool mandrel so that when the mandrel is in its retracted position all rolls are also retracted, thus eliminating the need for caging-lips on the roll-slots, to keep the rolls from falling out of the tool assembly, and thus permitting the tool to be freely inserted into a tube-end with no danger of an extended roll catching on the tube-end.

Other objects will be described in the specification and claims submitted herewith.

The drawings illustrate a preferred form of the inven-

tion without limiting the improvements in their useful application to the particular construction and arrangements shown, which, for the purposes of explanation, have been made the subject of illustration.

In said drawings:

FIG. 1 is a side elevation of a tool assembly incorporating the improvements of this invention, with said tool assembly connected to a driving unit which provides the work-producing power required by the tool.

FIG. 2 is a longitudinal sectional view of a tube-expanding tool constructed to include the improvements of this invention, with the tool inserted into a tube-end to be expanded, and with the mandrel of said tool assembly advanced to radially expand the rolls of said tool to bring said rolls into firm contact with the inner surface of said tube-end to give the firm contact, between mandrel and rolls, required to produce the self-feeding tube-expanding action of the tool.

FIG. 3 is another longitudinal sectional view of the tool of FIG. 2 with the mandrel additionally advanced and the tube-end expanded into its tube-hole.

FIG. 4 is a side elevation of the roll-cage portion of the above tool assembly with a part broken away to better show the roll-retaining feature of this invention.

FIG. 5 is a transverse vertical section on the line 5—5 of FIG. 4, looking in the direction of the associated arrows.

FIG. 6 is a developed view of the peripheral surface of the portion of the roll-cage contained between the arrows associated with the line 6—6 of FIG. 4, for a roll-cage containing three rolls, with one of said three rolls removed from its roll-slot.

FIG. 7 shows an isometric view of one of the roll-retaining springs shown in the developed view, FIG. 6.

FIG. 8 shows a side elevation of the roll-retaining spring of FIG. 7.

Referring to the drawings, **21** designates a power unit which may be used to provide rotary power for driving the tool, **22** a portion of a tube-sheet, and **23** a tube having an end positioned in its assembly position in a tube-hole in tube-sheet **22**.

The tube-expanding device comprises a tubular spring housing **24** with threaded bore at its front end, with said threaded bore providing means for threadably connecting roll-cage **25** to said spring housing **24**. The several tapered rolls **26**, confined in the conventional, tapered and angled, roll-slots in roll-cage **25**, are sized proportionally to the wall thickness of the forward tubular portion of roll-cage **25** so that said rolls **26** project beyond the cylindrical surface of the working-length portion of roll-cage **25** to make their contact with the inner surface of tube-end **23** while said rolls simultaneously project inward into the longitudinal bore through roll-cage **25** to make their required working contact with tapered mandrel **27**.

Tapered mandrel **27** connects to drive shaft **28** by any means suitable for transmitting the rotating, pushing, and pulling forces applied on said mandrel **27** by said drive shaft **28**. The connection shown in the drawings shows a mandrel having a tapered head **27*h*** with said head **27*h*** having a driving tang and with said drive shaft **28** having a socket to suit said tapered head **27*h*** with driving tang, and with the end of said drive shaft **28** having an external thread on which may be assembled the mandrel-retaining nut **29**.

The socket-end of said drive shaft **28** may be provided with a cross-drilled hole **28*h*** suitably positioned to provide means for knocking-out head **27*h*** of mandrel **27** by a conventional tapered drift-pin, with nut **29** being loosened or removed to permit such axial movement of tapered head **27*h***.

Drive shaft **28** is fitted with a bearing such as the double-acting thrust bearing shown, said bearing consisting of outer races **31*a*** and **31*b***, inner race **32**, and the two series of annularly positioned balls confined in their respective ball-cages, said ball and ball-cage assemblies being designated as **33*a*** and **33*b***. Said double-acting thrust bearing is confined in a fixed axial position on drive shaft **28** between the shoulder at the rear of the socket-head portion on drive shaft **28** and the front face of sleeve **34** positioned in fixed engagement on the spindle of drive shaft **28** by means of pin **35** which connects sleeve **34** to drive shaft **28** through the suitably sized and positioned hole passing through said two members.

The above described double-acting thrust bearing assembly serves the following described functions in the device assembly. Inner race **32** is connected, by the means shown and hereinbefore described, to drive shaft **28** with said connecting means providing a connection having a minimum frictional drag when drive shaft **28** rotates and inner race **32** remains stationary. The external diameter of inner race **32** gives proper clearance for a free-sliding fit in the bore of spring housing **24**. The external diameter of outer race **31*a*** and ball and ball-cage assembly **33*a*** is less than the external diameter of inner race **32** to provide clearance so that spring **36** freely clears said outer race **31*a*** and ball-cage assembly **33*a*** so that spring **36** bears against the surface of inner race **32**.

Spring **36** is a compression spring, one end bearing against the face of inner-race **32**, and the other end bearing against the seat at the front end of the spring-bore portion of spring housing **24**. Thus spring **36** normally urges drive shaft **28** back, tending to eject drive shaft **28** from spring housing **24**. Drive shaft **28** is confined inside spring housing **24** by retaining ring **37** fitted in a suitable groove near the rear end of the bore of said spring housing **24**.

Since roll-cage **25** is connected to spring housing **24**, the spring action which pushes back drive shaft **28** serves to retract tapered mandrel **27**, connected to said drive shaft **28**, relative to roll-cage **25** so that rolls **26** of the expanding tool may be retracted. Similarly, retaining ring **37** limits the axial movement of drive shaft **28** and thus limits the axial retracting movement of mandrel **27** so that mandrel **27** is not pulled out from between the several rolls **26** of the tool assembly. Thus the tool assembly, in its normal position, is a semi-solid assembly with mandrel **27** retracted relative to roll-cage **25**, so that rolls **26** may be radially retracted in their respective roll-slots, with said semi-solid assembly condition being produced by the spring force, produced by spring **36**, pushing inner race **32** into firm contact with retaining ring **37**.

Drive shaft **28** may have a tapered shank, such as tapered shank **28*s***, for connecting said drive shaft, and thus connecting said device, to the power unit supplying the rotating force used to drive the tool.

The stop collar which limits the depth roll-cage **25** may be inserted into a tube-hole is the conventional anti-friction type permitting the thrust face of said collar to remain stationary while roll-cage **25** and connected spring housing **24** rotate during the tube-expanding operation.

The stop collar may be as shown with thrust flange **24*f*** being an integral part of spring housing **24**. Thrust sleeve **38** is connected to thrust flange **24*f*** through the annular series of balls **39** and retaining ring **40** to give a single-direction anti-friction thrust bearing with retaining ring **40** being the keeper to hold the bearing parts in assembly.

It is often desirable to vary the projection of the rolls ahead of the face of the stop collar to thus select a desired length of the tube-joint to be expanded. This is accomplished in the form of the device illustrated by axially adjusting the position of the roll-cage **25** relative to spring housing **24** by rotating the parts in their threaded connection. As roll-cage **25** is advanced, or retracted, relative to spring housing **24**, the projection of rolls **26**, ahead of the face of stop collar **38**, is increased or de-

creased. Set screw 41 engaging in groove 25*g* locks the assembly of roll-cage 25 and spring housing 24 to hold a selected axial position of these mating members.

As hereinbefore described, a principal feature of this invention is the means for holding the rolls inward against the mandrel of the tool, to thus keep said rolls from falling out of the assembly and eliminating the need for caging-lips on the roll slots, and to always keep the rolls in contact with the mandrel so that as said mandrel is retracted, said rolls radially retract. This is accomplished by roll-retaining springs 42, shown in detail in FIGS. 4, 5, 6, 7 and 8.

The requirements for a spring to successfully retain the rolls are that it have a good expansion range without being overstressed, that it exert a sufficient force on a roll that it is retaining to lift said roll, against gravity, to thus retract said roll, and that it be of such design that it does not take up too great a portion of the roll-length, for it is obvious that the length-portion on which said spring is working must be outside the tube-joint being expanded and thus is a not-working portion of the length of said rolls and their confining roll-cage.

Spring 42 accomplishes the above requirements by virture of its unique shape. Said spring 42 may be considered as being of three principal parts, the U-shaped finger portion 42*f*, and the two support-leg portions 42*a* and 42*b*. In operation, the end of finger 42*f* bears against the surface of roll 26 to push roll 26 inward toward the longitudinal axis of the tool assembly. Thus finger 42*f* acts as a cantilever spring and is subjected to bending stresses identical to those in a cantilever beam loaded at one end. If all the deflection and stresses were taken in the finger (cantilever) portion of the spring, the spring would be overstressed and permanently deformed, or said spring would soon break from fatigue failure resulting from the magnitude of the stresses imposed on said spring.

This unique design transfers a considerable portion of the deflection and stresses to torsional deflection and stresses in the legs 42*a* and 42*b*. This is accomplished by forming said roll-retaining springs to provide large-radius bends between the finger and leg portions of said springs so that a considerable portion of the deflection and stresses imposed on said finger portion of a spring may be readily transmitted around said gradually-curved bends and converted into said torsional deflections and stresses in said support-leg portions of a roll-retaining spring.

Curved support-legs 42*a* and 42*b*, freely confined in the annular cavity contained between spring-groove 25*n*, in roll-cage 25, and the inner surface of spring-retaining band 43, serve to anchor and support said spring assembly against the cantilever-type loading applied on finger 42*f*, and to allow support-leg portions 42*a* and 42*b* to torsionally twist with said torsional deflection being a maximum at the point immediately adjacent to finger 42*f* portion of said spring, and with said torsional deflection fading out as the torsional reaction is absorbed by said support-leg portions, 42*a* and 42*b*, of said spring assembly.

Thus bending stresses in the cantilever beam, finger, portion 42*f*, of said roll-retaining spring are kept within safe limits to give spring 42 a good service life.

The two side members of finger portion 42*f*, of roll-retaining spring 42, are of different length to thus put legs 42*a* and 42*b* in separate parallel planes, as shown in FIG. 8, to facilitate assembly. This gives an assembly as illustrated in FIG. 6, with leg 42*a* of one spring member lying beside leg 42*b* of an adjacent spring member, with said leg members 42*a* and 42*b* being freely supported in the hereinbefore described annular spring cavity so that each support-leg member may separately act to absorb its share of the spring-loading reactions.

The maximum length for a 42*a* support-leg, as illustrated in FIG. 6, is the circular distance between 42*f* finger portions of two adjacent roll-retaining springs 42. Obviously, for a spring with balanced stresses and deflections in each side member of finger 42*f*, support-leg 42*b* should be substantially the same length as leg 42*a*. The circumferential length of the support-legs portion of a roll-retaining spring is the sum of the circular lengths of leg 42*a* and leg 42*b* plus the width of finger 42*f*. As shown in FIG. 6, the circumferential length for the support-legs portion of a roll-retaining spring is limited to a maximum length of slightly less than two-thirds of the mean circumference of annular groove 25*n*, for the conventional three-roll expanding tool. A support-legs portion of such circumferential length, for a roll-retaining spring 42, when confined in said annular cavity formed by spring-groove 25*n* and spring-retaining band 43, gives ample caging and support to develop the distribution of deflections and stresses in the finger and leg members as hereinbefore described.

Spring-retaining band 43 may be a press fit on the hub portion 25*h*, of roll-cage 25, to thus remain in its assembly position confining the support-legs of the several spring units in their working positions. Said enlarged hub portion 25*h*, of cage 25, also serves to provide space for the radial movement of the finger portions of the several roll-retaining springs so that the radial movement of rolls 26 is not restricted by spring-retaining band 43.

A design feature of the roll-cage 25 contributing to the successful operation of this unique roll-retaining spring is the removal of the sharp corners between roll-slots and spring groove to provide clearance for said gradually-curved bends between finger and support-leg portions of spring 42. This is accomplished in the illustrated form of the device by the semi-circular cutouts through the tubular wall of the hub portion of roll-cage 25. Said semi-circular cutouts also facilitate the machining of the roll-slots to provide a flat of sufficient width at the rear end of said roll-slots.

Mitering the corners between roll-slots and spring groove, in roll-cage 25, to a depth equal to the depth of said spring groove, would serve equally well for providing adequate clearance for the bends between finger and leg portions of the several roll-retaining springs 42.

Spring 36 is preferably of a design having a low spring-constant value so that said spring 36 has a maximum amount of deflection with a minimum change in force, and spring 36 is preferably of a design applying a nominal axial force between drive shaft 28 and spring housing 24. The axial force needed to keep roll-cage 25 forward relative to mandrel 27 is usually a few pounds and the additional force required to obtain full-stroke axial advancing of drive shaft 28 relative to spring housing 24 may be on the order of one pound.

For example, a tool assembly for a ⅝ O.D., 16 gage, tube, having a maximum mandrel advance stroke of 2 inches is very satisfactory with a 4-pound force imposed between drive shaft 28 and spring housing 24 when mandrel 27 is fully retracted in roll-cage 25. Spring 36 used in this assembly requires an additional one-pound of force to collapse said spring 36 to give the full 2-inch advancing of mandrel 27 relative to roll-cage 25. Thus the pushing force, applied by the operator, to advance mandrel 27 into working position is something less than 5 pounds. Since said operator must exert a pushing force of some 50 pounds to get the required expansion of the tool, in a tube-end, to give a rapid start to the self-feeding action, there is no increased fatigue factor involved in using this device. The axial component of the self-feeding force developed, which is the force drawing the mandrel forward to further expand the tool assembly as a tube-end is being rolled and expanded, is several hundred pounds. Thus it is obvious that the very slight difference in opposing force, applied by spring 36, as the self-feeding action of the tool occurs, is of no significance on the end result of the tube-expanding action. The variation of this opposing force applied by spring 36 is a resultant of the

final axial-advance position of said mandrel 27 and is a variation in force of a small fraction of one pound.

FIG. 1 shows the exterior surface of spring housing 24, and shows thereon the longitudinal knurl 24*m*. The longitudinal mark 24*m*, may be said knurl, a group of one or more longitudinally scribed lines, or any other type of marking which can be felt or seen by the operator using said tool. Mark 24*m* may be used to give the operator a tactual or visible indication of the number of turns made by said spring housing, and thus the number of turns of the connected roll-cage 25, thereby giving the operator an indication of the degree of the tube-expanding work done, for those sets of conditions wherein the number of revolutions of said roll-cage, and the consequent expansion of said rolls of said tool, may give an indication of the degree of expanding of the tube-end being expanded.

As hereinbefore described, the illustrations show a preferred form of the device. It will be apparent to those skilled in the art that other combinations of parts may be used to perform the tube-expanding operation in this improved manner. Several such examples of other combinations of parts are described in the following paragraphs.

The stop collar arrangements illustrated in applicant's Patent Number 2,772,716, issued December 4, 1956, may be used with this device. Such an arrangement requires the threaded-shank portion of roll-cage 25 be lengthened to provide a seat for the separate stop collar. Mandrel 27 of such an assembly would be correspondingly lengthened. This arrangement permits a greater adjustment of the penetration of the roll-cage into a tube-end to be expanded.

A roll-cage of the types illustrated in FIG. 2 and FIG. 3 of the above described patent, Number 2,772,716, may be used with this device. Said roll-cages have the outer edges of their roll-slots formed inward to provide caging-lips to retain the rolls in said roll-cages, thus eliminating the need for roll-retaining springs 42. This combination may be used in applications where a long and pointed form may be used on the front end of rolls 26. The long, pointed, form gives a roll assembly with ends of rolls concealed inside the periphery of roll-cage 25 so that said roll-ends cannot catch on the end of a tube in which the tool is being entered, and so that any of said rolls which may be in a radially-extended position, in their roll-slots, such as the rolls below the horizontal centerline of said roll-cage, may be radially floated inward as said tool is entered into a tube-end to be expanded. Such an assembly has the improvement of the roll-cage remaining forward, relative to the mandrel of said assembly, without the operator needing to use one hand to hold said roll-cage forward to permit said rolls in said roll-cage to be in their radially retracted positions.

An alternate method of confining the roll-retaining springs in position, with their support-leg portions freely contained in groove 25*n*, in roll-cage 25, is to use a short length of a closely-coiled wire spring member, being in effect a tube similar to band 43, but by virtue of its being a coiled spring which may be twisted, with said twist tending to unwind said coil, so as to open up the I.D. of said coil, to thus provide a band having an adjustable I.D. A short tab, extending forward on the front end of said coil, formed by bending the end of the wire normal to the lay of said coil and in the plane of the cylinder formed by said coil, may be used as a convenient means for gripping said coil to thereby apply said untwisting force.

Said coil-spring type of band eliminates the need for close-limit tolerances on the O.D. of hub 25*h*, of roll-cage 25, and in the I.D. of band 43, such as are required if band 43 is a metal tube and is to be a press fit on said hub 25*h*.

While the invention has been described with reference to the particular devices illustrated, it is to be appreciated that it is not so limited. It is rather of a scope commensurate with the scope of the sub-joined claims.

What I claim as my invention is:

1. A device for expanding a tube-end into its tube-hole, by means of a roller-type tube-expanding tool having a tapered mandrel, a plurality of expanding rolls, and a tubular roll-cage with roll slots formed therein, with said expanding rolls and said roll cage mounted about said mandrel so that said rolls are radially movable in the roll slots in said roll cage and rotatable in and with said roll cage, about said mandrel; comprising a tubular spring housing cooperatively connected to a drive shaft so as to permit relative rotatable and axial movement between said spring housing and said drive shaft, with said relative axial movement being limited by said connecting means, with a spring housed in said spring housing so as to be freely rotatable with said spring housing, relative to said drive shaft, said spring normally urging said spring housing axially forward, relative to said drive shaft, to the forward limit of said relative axial movement between said spring housing and said drive shaft, wherein means are provided for connecting said roll cage to said spring housing, and means are provided for connecting said tapered mandrel to said drive shaft.

2. A device as in claim 1; wherein at least some of said roll slots are angularly cocked so that said expanding rolls contained in said angularly-cocked roll slots are cocked to effect a self-feeding action of said mandrel.

3. A device as in claim 1; wherein a plurality of roll-retaining springs are cooperatively connected to said roll cage, said roll-retaining springs acting to radially retain said expanding rolls in said tool assembly, each of said roll-retaining springs being a formed wire having a U-shaped finger connected to two support legs, said finger being formed to lay on one of said rolls in said roll cage, said finger projecting angularly from the plane of said support legs, an annular cavity in said roll cage, said annular cavity comprising an annular groove in the periphery of said roll cage circumscribed by a band supported by the peripheral surface of said roll cage adjacent to said annular groove, said annular cavity being positioned in the shank portion of said roll cage to thereby be positioned outside the working-length portion of said roll cage, said support legs, of said roll-retaining springs, being formed to lay in said annular cavity in said roll cage, the overall circular length of the support legs portion of each said roll-retaining spring being less than two-thirds the mean circumference of said annular cavity, said roll-retaining springs being cooperatively connected to said roll cage by having said support legs of said springs caged in said annular cavity in said roll cage.

4. A roller-type tube-expanding tool having a tapered mandrel, a plurality of expanding rolls, and a tubular roll cage with roll slots formed therein, with said expanding rolls and said roll cage mounted about said mandrel so that said rolls are radially movable in the roll slots in said roll cage and rotatable in and with said roll cage, about said mandrel; wherein a plurality of roll-retaining springs are cooperatively connected to said roll cage, said roll-retaining springs acting to radially retain said expanding rolls in said tool assembly, each of said roll-retaining springs being a formed wire having a U-shaped finger connected to two support legs, said finger being formed to lay on one of said rolls in said roll cage, said finger projecting angularly from the plane of said support legs, an annular cavity in said roll cage, said annular cavity comprising an annular groove in the periphery of said roll cage circumscribed by a band supported by the peripheral surface of said roll cage adjacent to said annular groove, said annular cavity being positioned in the shank portion of said roll cage to thereby be positioned outside the working-length portion of said roll cage, said support legs, of said roll-retaining springs, being formed to lay in said annular cavity in said roll

cage, the overall circular length of the support legs portion of each said roll-retaining spring being less than two-thirds the mean circumference of said annular cavity, said roll-retaining springs being cooperatively connected to said roll cage by having said support legs of said springs caged in said annular cavity in said roll cage.

5. A tool as in claim 4; wherein at least some of said roll slots are angularly cocked so that said expanding rolls contained in said angularly-cocked roll slots are cocked to effect a self-feeding action of said mandrel.

6. A roll-retaining spring for a roller-type tube-expanding tool, said tube-expanding tool having a tapered mandrel, a plurality of expanding rolls, and a tubular roll cage with roll slots formed therein, with said expanding rolls and said roll cage mounted about said mandrel so that said rolls are radially movable in the roll slots in said roll cage and rotatable in and with said roll cage, about said mandrel, said roll-retaining spring being a formed wire having a U-shaped finger connected to two support legs, said finger being formed to lay on one of said rolls in said roll cage, said finger projecting angularly from the plane of said support legs, said roll cage having an annular cavity, said annular cavity comprising an annular groove in the periphery of said roll cage circumscribed by a band supported by the peripheral surface of said roll cage adjacent to said annular groove, said annular cavity being positioned in the shank portion of said roll cage to thereby be positioned outside the working-length portion of said roll cage, said support legs, of said roll-retaining spring, being formed to lay in said annular cavity in said roll cage, the overall circular length of the support legs portion of said roll-retaining spring being less than two-thirds the mean circumference of said annular cavity, said roll-retaining spring being cooperatively connectable to said roll cage by having said support legs of said spring caged in said annular cavity in said roll cage to thereby provide means for said roll-retaining spring to act radially to retain a said expanding roll in said tool assembly.

7. A roll cage for a roller-type tube-expanding tool, said tube-expanding tool having a tapered mandrel, a plurality of expanding rolls, and said roll cage, said roll cage being tubular with roll slots formed therein, said expanding rolls and said roll cage being mountable about said mandrel with said rolls radially movable in the roll slots in said roll cage and rotatable in and with said roll cage, about said mandrel; wherein an annular groove in the peripheral surface of said roll cage provides means for producing an annular cavity in said roll cage, said annular cavity being obtained by cooperatively connecting a circumscribing band supported by the peripheral surface of said roll cage adjacent to said annular groove, said annular groove being positioned in the shank portion of said roll cage to thereby position said annular cavity in said shank portion of said roll cage to thus position said annular cavity outside the working length portion of said roll cage, said annular cavity providing means for cooperatively connecting a plurality of roll-retaining springs, said roll-retaining springs acting to radially retain said expanding rolls in said tool assembly, each of said roll-retaining springs being a formed wire having a U-shaped finger connected to two support legs, said finger being formed to lay on one of said rolls in said roll cage, said finger projecting angularly from the plane of said support legs, said support legs being formed to lay in said annular cavity in said roll cage, the overall circular length of the support legs portion of each said roll-retaining spring being less than two-thirds the mean circumference of said annular cavity, a plurality of said roll-retaining springs being cooperatively connectable to said roll cage by having said support legs of said springs caged in said annular cavity in said roll cage.

8. A roll cage as in claim 7; wherein at least some of said roll slots are angularly cocked so that said expanding rolls contained in said angularly-cocked roll slots are cocked to effect a self-feeding action of said mandrel.

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