Dec. 22, 1942. A. F. LAPP ET AL 2,305,587

MACHINE FOR MAKING FLEXIBLE METALLIC TUBES

Filed March 14, 1941 4 Sheets-Sheet 1

Fig. 1.

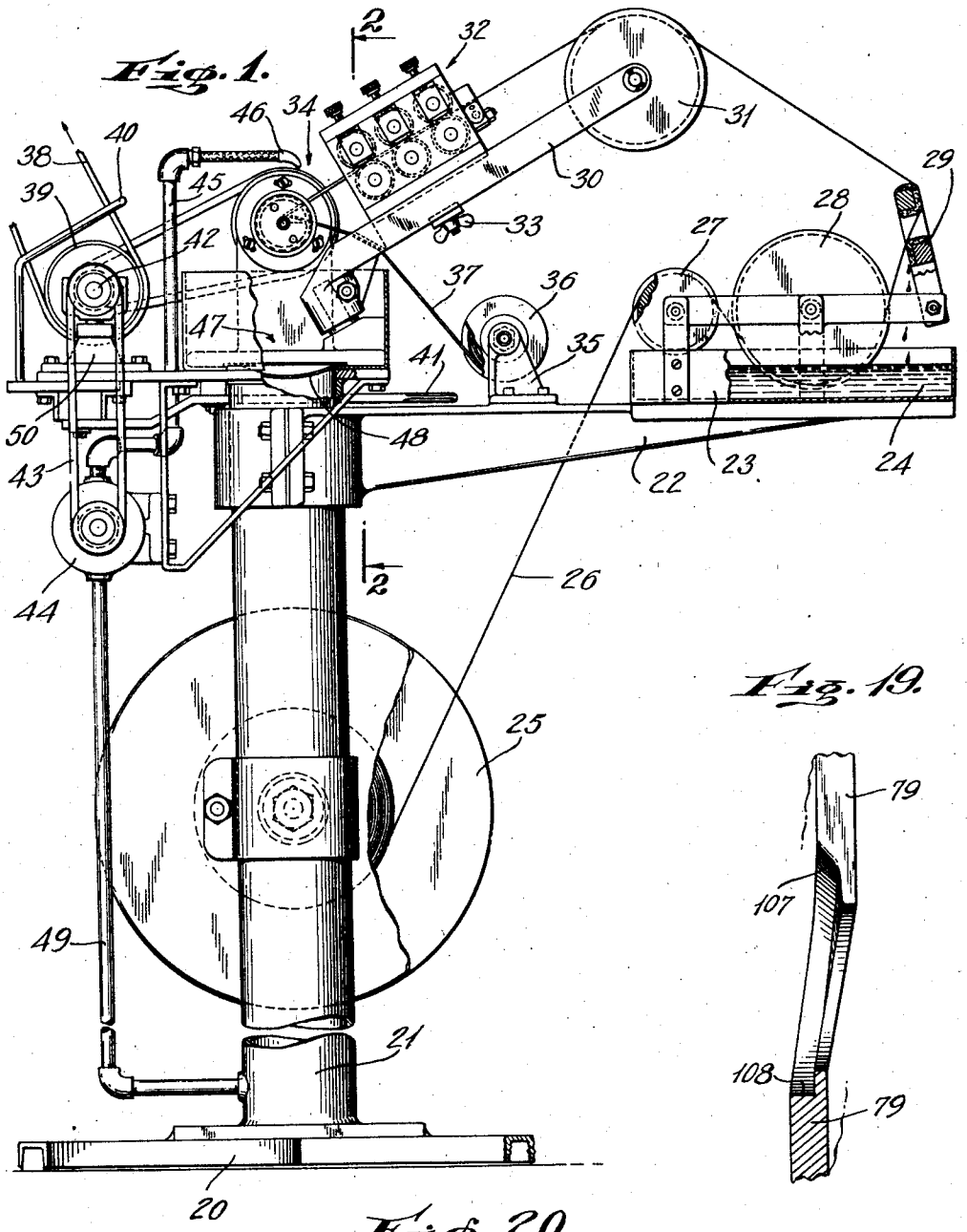
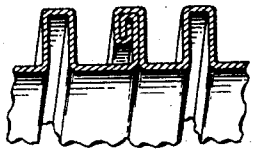


Fig. 19.

Fig. 20.



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Filed March 14, 1941 4 Sheets-Sheet 2

Fig. 2.

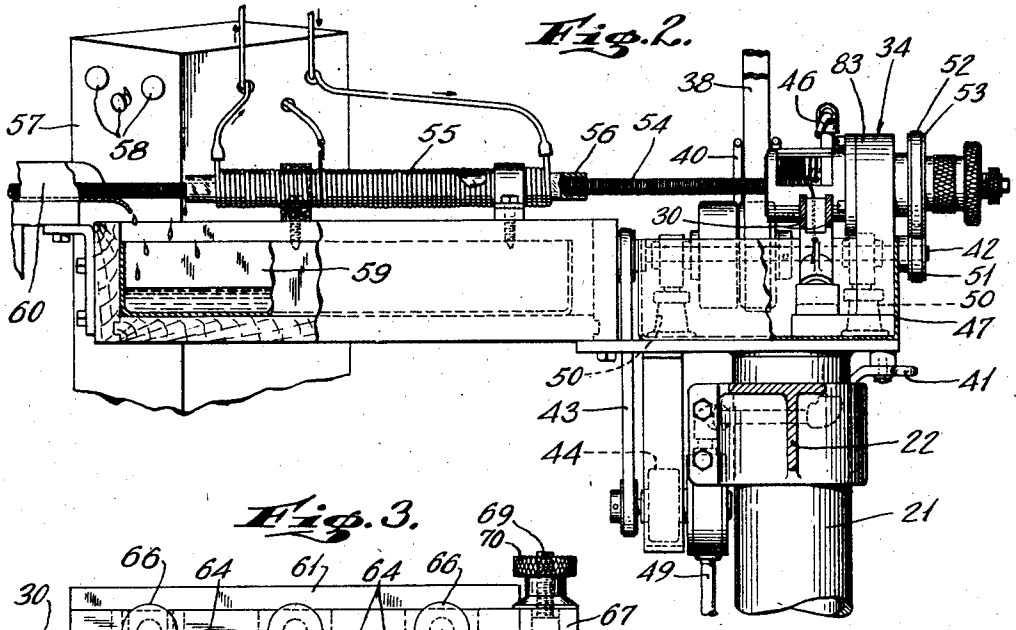


Fig. 3.

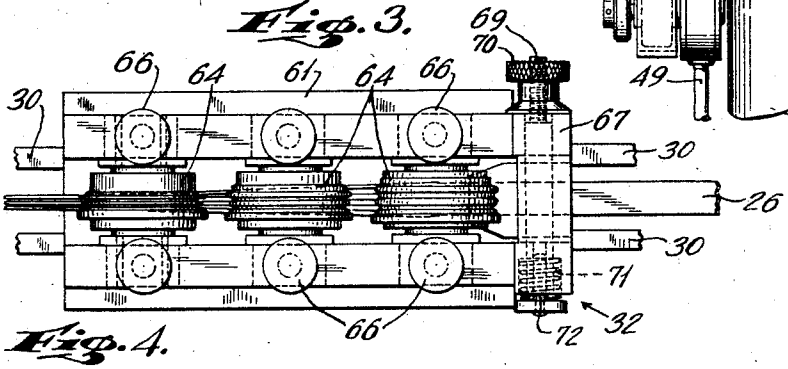


Fig. 4.

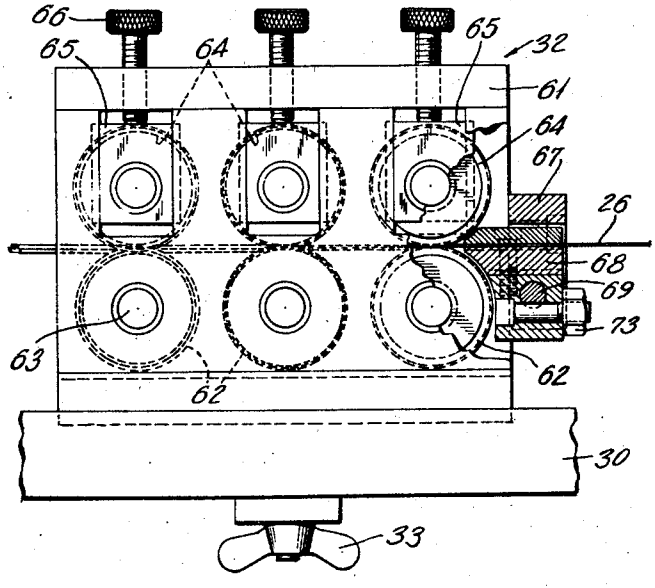
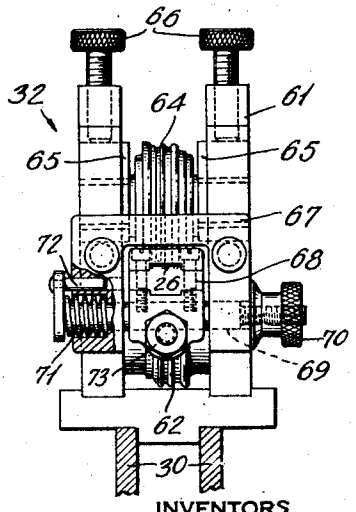


Fig. 5.



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MACHINE FOR MAKING FLEXIBLE METALLIC TUBES

Filed March 14, 1941 4 Sheets-Sheet 3

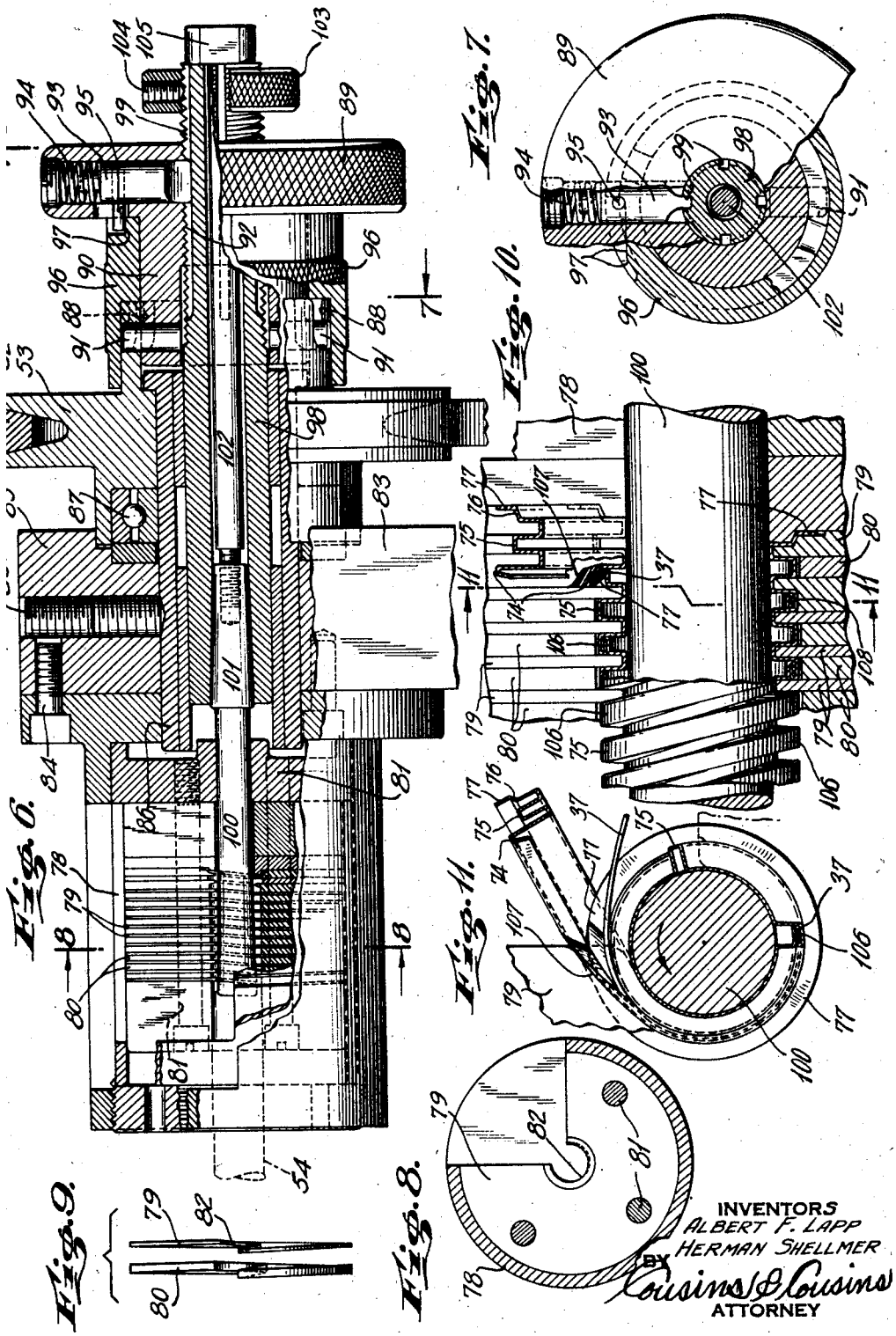


Fig. 6.

Fig. 7.

Fig. 10.

Fig. 11.

Fig. 8.

Fig. 9.

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MACHINE FOR MAKING FLEXIBLE METALLIC TUBES

Filed March 14, 1941 4 Sheets-Sheet 4

Fig. 12.

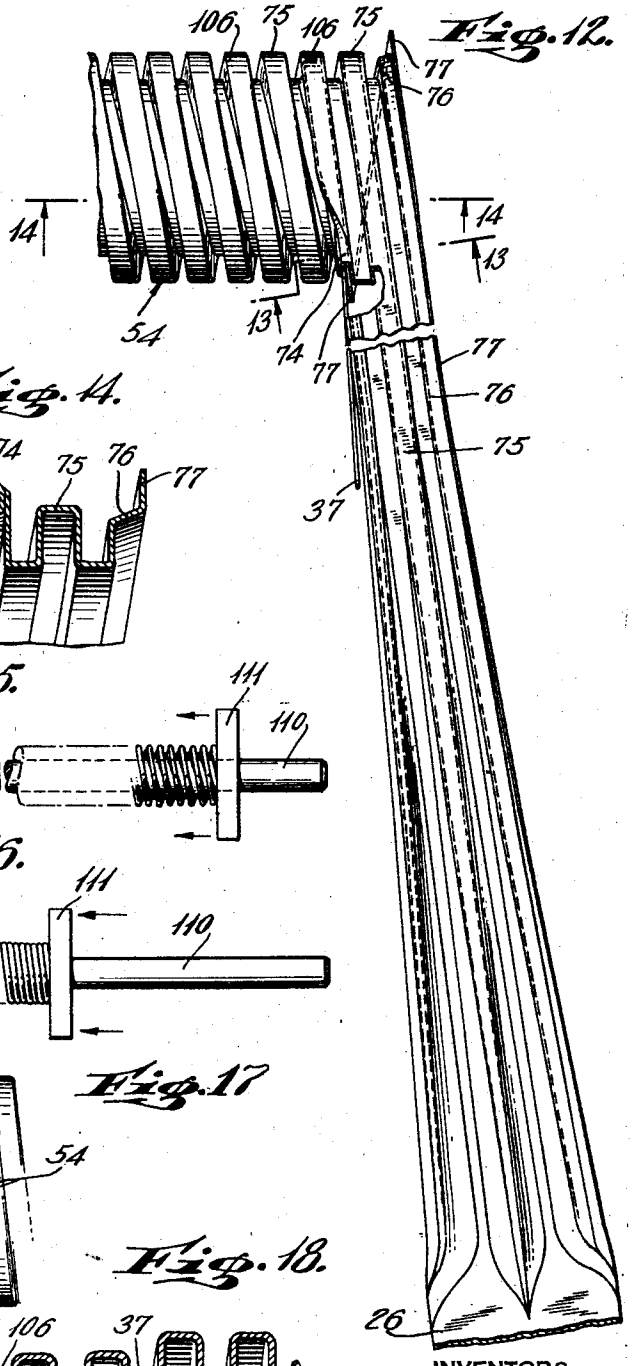


Fig. 13.

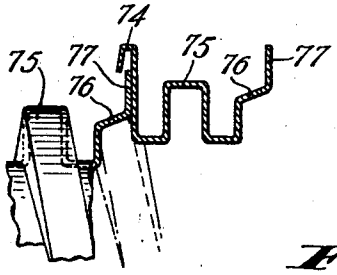


Fig. 14.

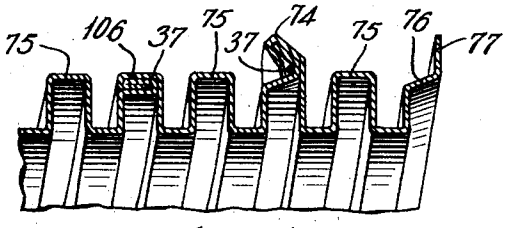


Fig. 15.

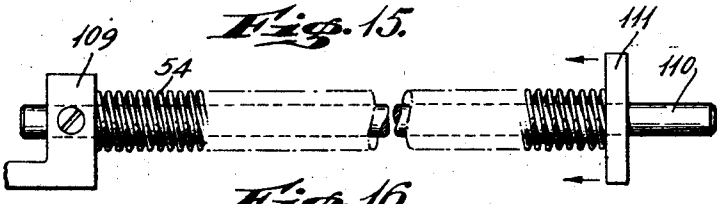


Fig. 16.

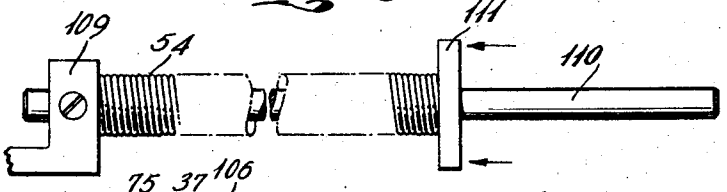


Fig. 17

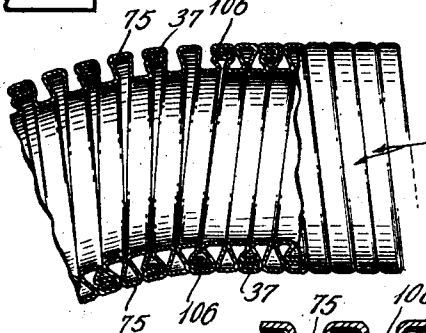
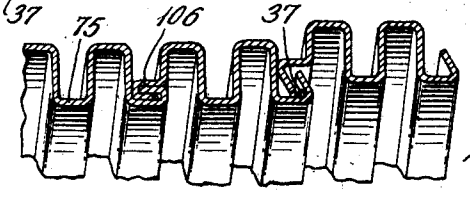


Fig. 18.



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UNITED STATES PATENT OFFICE

2,305,587

MACHINE FOR MAKING FLEXIBLE METALLIC TUBES

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Application March 14, 1941, Serial No. 383,298

15 Claims. (Cl. 113—35)

This invention relates to a machine for producing flexible tubing.

It is common practice to manufacture flexible tubing from a continuous strip formed with convolutions which are interlocked so as to provide a seam. In some applications of flexible tubing, particularly in the aircraft industry, it is essential that the tubing be airtight and watertight. Under the stress of service where the tubing is subjected to intense vibration and other strains, the seams will not stand up and the tubing does not remain fluid tight. The broad object of the present invention is to produce a flexible tube which will withstand the strains of service and yet remain fluid tight, and air tight.

In order to overcome this difficulty it has been known in the past to introduce a thread of solder into the seam of the tubing and, by the application of heat, provide a soldered joint. The objection to such construction is that each convolution of the tube is a seam, which seam in continuous, and of necessity a considerable portion of the stress of flexing the tube must be carried by the seam, with the result that even a soldered seam is subject to breakdown. A flexible tube can be made so that apparently no stress is applied to the seam with the result that no breakdown will occur by reason of the seam opening. This result is accomplished by providing a strip of metal having a plurality of convolutions so that only every second or third convolution forms the seam. Accordingly, the primary object of this invention is to provide a flexible tube formed of a single strip having interlocked edges and provided with intermediate convolutions to permit flexibility without imposing strain on the seams.

A further object of the invention is to provide a simple machine for carrying the foregoing objects into effect which machine may be readily used for manufacturing tubing of various sizes. A further, more specific object of the invention is to provide a machine having a compound die so that by change of parts of the die different sizes of tubing may be made.

The invention consists of the construction, combination and arrangement of parts described and claimed.

In the accompanying drawings, forming part hereof, is illustrated one form of embodiment of the invention, in which drawings similar reference characters designate corresponding parts, and in which:

Figure 1 is a side elevation showing the general setup of the machine;

Figure 2 is a vertical section, partly in elevation, and partly in perspective, taken approximately on lines 2—2 of Figure 1, looking in the direction indicated by the arrows.

Figure 3 is a plan view of the die plate and dies for preforming the strip;

Figure 4 is a side elevation of the dies shown in Figure 3, partly broken away;

Figure 5 is an end elevation of the dies shown in Figure 3, partly broken away;

Figure 6 is a longitudinal section, partly in elevation, through the operating head of the machine, showing the forming die and the driving mechanism together with the clutch means.

Figure 7 is a transverse section, partly broken away, taken approximately on line 7—7 of Figure 6, looking in the direction indicated by the arrows;

Figure 8 is a section, taken approximately on line 8—8 of Figure 6, looking in the direction indicated by the arrows;

Figure 9 is an expanded edge elevation of one forming die and the spacer which separates it from the succeeding die;

Figure 10 is an enlarged, fragmentary transverse section, taken through the forming die;

Figure 11 is a transverse section, taken approximately on line 11—11 of Figure 10, looking in the direction indicated by the arrows;

Figure 12 is a side elevation of a section of tubing with an extended portion of the strip material shown in perspective.

Figure 13 is a fragmentary detail in section, taken approximately on line 13—13 of Figure 12, looking in the direction indicated by the arrows, and showing the contour of the strip material after having been preformed in the die of Figures 3, 4 and 5;

Figure 14 is a fragmentary detail in section, taken approximately on line 14—14 of Figure 12, looking in the direction indicated by the arrows;

Figure 15 is a side elevation of a section of tubing mounted on a fixture for the purpose of longitudinal compression after the tubing has been made;

Figure 16 is a view similar to Figure 15, but showing the tubing after it has been compressed;

Figure 17 is an enlarged section, partly in elevation, after the tube has been compressed, showing the flexibility of the tube without flexing the seam;

Figure 18 is a fragmentary detail in section of a modified type of tube in which the seam is formed at the base rather than at the crown of the convolutions; and,

Figure 19 is a fragmentary detail showing the contour of the seam-forming die at the point where the preformed strip enters the dies and at the point where the seam is completed by turning the edge of the strip over on the adjacent edge of the next convolution.

Figure 20 is a fragmentary detail in section of a tube in which the seam is formed at the crown of the convolutions.

Referring to the drawings, and particularly Figure 1, 20 designates a base on which is mounted a hollow stand 21. Carried by the stand 21 is a horizontal arm 22 on which is mounted a bath tank 23 containing flux 24. Carried by the stand 21 is a reel 25 having a supply of strip material 26 which is fed over a wheel 27, carried by the tank 23, and under a wheel 28 so that the strip 26 is covered on both sides with the liquid flux 24.

The strip 26 then passes through a wiping element 29 which is so arranged that the surplus flux on both sides of the strip 26 is removed and the strip 26 proceeds with an even coating of flux on both sides. The flux 24 may be of any well known composition, common in the art of soldering. The advantage of applying the flux to the strip is that all parts of the eventually soldered seam will have an application of flux applied thereto, whereas, if the flux is merely applied to the solder it may not be dispersed throughout the seam, and a weak soldered seam will result.

Carried above the stand 21 is a forked adjustable bar 30 which supports on its outer end a wheel 31 over which the strip 26 passes to a set of dies which are designated generally as 32. The dies 32 are more fully disclosed in connection with the description of Figures 3, 4 and 5, and their function is to preform the strip 26 to the contour shown in Figure 13. The dies 32 are adjustable on the bar 30 and are held in adjusted position by a wing nut 33.

After leaving the dies 32 the strip 26 proceeds to the operating head designated generally as 34 and as more fully disclosed in connection with the description of Figures 6, etc., where the actual flexible tube is formed.

Carried by the support arm 22 is a bracket 35 on which is mounted a spool 36 of solder 37. In a tube-forming operation, as hereinafter described, the thread of solder 37 is introduced in the seam during the forming operation so that the solder 37 is completely disposed in the seam.

The operating head 34 is actuated through the medium of a drive belt 38 connected to the usual idler and drive pulleys 39, the change from idler to drive pulley being accomplished by an ordinary shift 40 actuated by a control lever 41, in the well known manner. A drive shaft 42 is operated by the drive pulley 39, and operates a belt 43 to a pump 44 for supplying a lubricant to the tube forming die through a pipe 45 having a nozzle 46 at a position above the operating head 34.

Under the operating head 34, which includes the forming dies, hereinafter described, is disposed a catch basin 47 provided with a strainer 48 through which the lubricant may be returned to the hollow stand 21 from which it repeats the cycle of flow through a return pipe 49, and the pump 44, to the nozzle 46. The lubricant used may be of any desired composition well known in the art for its intended function.

Referring to Figure 2, it will be readily observed that the shaft 42 is supported from the usual bearing supports 50 and is provided with a pulley 51 which drives a belt 42, and a pulley 53 which operates the head 34. When the machine is operated the flexible tube is formed in the forming dies and progresses to the left of Figure 2 as a completed tube 54 having the solder 37 incorporated in the seam. The tube 54 then passes through a heating coil 55 which surrounds a glass or other suitable tube 56 and forms part of a high frequency electrical induction heat apparatus designated generally as 57 which is provided with the usual controls 58. The coil 55 is normally copper tubing and not only acts as conductor, but carries a flow of water for cooling purposes. The use of high frequency induction heat is well known in other arts, and need not be fully described here. It uses a high frequency oscillator producing high frequency alternating current, which, when passed through the inductive coil 55 produces a rapidly alternating magnetic field. When the tube 54 is passed through the field a high, readily controlled heat is applied to the tube 54. This quickly melts the solder 37 and causes an even dispersion of the solder through the entire seam by reason of the fact that the entire strip 26 is coated on both sides with the flux 24.

Below the heating coil 55 is disposed a trough 59 adapted to catch any surplus flux or lubricant which may drip from the finished tube. As the tube 54 proceeds to the left of Figure 2 it is received in a chute 60 which may be of any desired length and is preferably straight to prevent flexing of the tube 54 until the solder 37 has set and the tube 54 has cooled. When any desired length of the tube 54 has been made, or when all of the material on the reel 25 has been used up, the finished tube 54 may be removed from the chute 60 for further processing, as hereinafter described.

Referring to Figures 3, 4 and 5, the performing die 32 consists of a roller die case 61 in which are mounted a set of three progressive dies 62, rotatable on fixed stub shafts 63. The three dies 62 are progressive, the first die serving to make grooves in the strip 26, the second die being intended to form the grooves into definite depressions, and the third die to continue the operation to form the strip 26 to the contour finally secured, as shown in Figure 13. Complementary dies 64 are provided for each die 62 and are held in floating blocks 65 in the die case 61. Pressure screws 66 are provided so that proper adjustment may be made between the dies 64 and the dies 62.

On the front of the die case 61 is mounted an extension 67 carrying an adjustable block 68 for aligning the strip 26 with the dies 62 and 64. A transverse shaft 69 carrying an adjusting nut 70 is provided for aligning the strip 26 to the block 68 with the dies 62 and 64. The shaft 69 is provided with a spring 71 and a pin 72 which is mounted in the die case 61 to prevent turning of the shaft 69. By adjustment of the nut 70 the block 68 may be moved laterally to bring the strip 26 into proper register with the dies 62 and 64. A stud 73 is provided to engage in a cut-away portion of the shaft 69 so as to lock the same in any position which may be fixed by adjustment of the nut 70.

When the strip 26 leaves the left hand dies 62 and 64 it has the contour as shown in Figure 13, having a hooked portion 74 on its left side, intermediate convolutions 75, an angular extension 76 and an upstanding flange 77. This contour is necessarily a function of the contour of

the dies 62 and 64, and particularly the left hand die, as shown in Figures 3 and 4.

After leaving the preforming dies 32, the strip 26 enters the fixed dies in the head 34; see Figures 6 and 10. This head comprises a die case 78 which is substantially cylindrical in shape, the front portion being cut away to permit ingress of the tube material. In this die case 78 are disposed a number of die plates 79 separated from one another by spacers 80. The die plates and spacers are substantially discs in shape, having one quadrant removed, as shown in Figure 8. The die plates and spacers are maintained in proper position by means of dowels 81 which extend through appropriate openings, and are threaded into the right hand wall of the die case 78. The die plates 79 and the spacers 80 are provided with arcuate openings 82 in their centers, and instead of being flat are convoluted, that is offset laterally, so that the resulting tube will have the desired pitch.

A bearing block 83 is provided and the die case 78 is secured to the bearing block by means of screws 84. A set screw 85 holds a sleeve 86 in place, and there is provided the usual ball bearing assembly 87 to permit rotation of the pulley 53, the right hand side of which is provided with bayonet slots 88. A hand wheel 89 having a hub 90 provided with pins 91 is disposed against the pulley 53, and the pins 91 are adapted to be engaged in the bayonet slots 88 for the purpose of driving the wheel 89. The hub 90 is provided with screw threads 92 for the purpose of receiving a threaded hollow shaft 98.

Borne in the wheel 89 is a dog 93 actuated by a spring 94, the dog being provided with a laterally extending pin 95. A sleeve 96 is secured around the hub 90 and the extension of the pulley 53 is provided with a cam surface 97 against which the pin 95 is adapted to ride. Threaded to the hub 90 is the hollow shaft 98 formed with a plurality of slots 99 in any of which the dog 93 may engage as shown in Figure 7.

A mandrel 100 is carried by the hollow shaft 98 and is provided with a very slight taper at the portion which contacts the tube material 26. The shank of the mandrel 100 is provided with a standard Morse taper 101 to enter the hollow shaft 98. A rod 102 is threaded into the shank of the mandrel 100 and is provided on its outer end with a head 105 having flat surfaces so that it may be engaged by a wrench for the purpose of adjusting the mandrel 100. The right hand end of the hollow shaft 98 is provided with a hand adjusting wheel 103 held in place by a set screw 104.

In the tube forming operation the preformed strip 26 is set into the dies 79, which, as best shown by Figure 10, are of a shape to form the contour of the strip. The actual tube forming operation is performed by the die which receives the hook portion 74 of the strip, and folds it over on to the extension 77 of the preceding convolution. As the strip 26 enters the forming die the thread of solder 37 is passed into the seam so as to lie at the junction of the off-set portion 76 and the annular flange 77 of the strip 26. Figure 19 shows the contour of the die which forces the hook portion 74 on to the flange 77. As the material enters the die 79 it rides against a cam face 107, which gradually emerges from the shape shown at 107 to the square shape as shown at 108. This causes the hook portion 74 to be folded over with the thread of solder 37 incorporated in the seam, as shown in Figure 14. When the folding action is complete the outside diameter of the finished seam 106 is the same as the outside diameter of the free intermediate convolution 75.

The entire movement of the strip material 26 through the forming dies and through the preforming dies, is by virtue of the friction between the mandrel 100 and the material in the process of being formed. In order to start or stop the mandrel 100 it is necessary only to rotate the sleeve 96 so that the pin 95 rides up on the cam 97, and disengages the dog 93. The hand wheel 89 may then be turned so as to disengage the pins 91 from the bayonet slots 88 of the pulley 53. Upon retraction of the wheel 89 to the right, as shown in Figure 6, it carries with it the hollow shaft 98.

As the finished seam 106 is progressively completed, the tube moves to the left and may be immediately heat treated as shown in Figure 2, or any desired length of the finished tube may be made and subsequently treated as a separate operation.

After the completed tube has been heat treated, it is desirable to compress the same longitudinally so as to afford greater flexibility without imposing strain on the seam 106. Referring to Figures 15 and 16, a fixed bracket 109 is provided, which holds one end of a shaft 110. The shaft 110 may be rigid, but it is preferably an untempered flexible shaft. The tube 54 is slipped on the shaft 110 and a sliding block 111 is provided to compress the tubing. The block 111 may be operated by mechanical power, but it has been found very efficient to force the block 111 against the end of the tube by manual pressure. The compression of the tube reduces the length of the tube by approximately 40%, and causes a change in the pitch at the convolutions. The free convolutions are then curved in cross-section, as shown in Figure 17, and the tube may be readily flexed without any movement of the seam 106, since the movement is entirely taken up by the convolutions between the seams.

It will be obvious that by simple changes in the die plates 79 and the spacers 80, various types of tubing may be made, as for example, that shown in Figure 18, in which the seam is at the base of the convolution, rather than the crown. Likewise, by appropriate substitution of die plates 79, tubing may be formed having two or more convolutions intermediate of each seam. Tubing of varying diameters may be made on the same machine by the substitution of different sizes of die plates 79 and spaces 80, together with a corresponding substitution of the mandrel 100 for a different size.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a machine for making flexible tubing, a forming die comprising a die casing, a plurality of convoluted die plates therein, a plurality of independent similarly convoluted spacer plates separating said die plates, a mandrel to feed material for forming a tube through the die plates in said casing, and means to rotate said mandrel.

2. In a machine for making flexible tubing, a forming die comprising a die casing, a plurality of helically twisted changeable die plates therein, a plurality of separate similarly twisted changeable spacer plates separating said die plates to facilitate the formation of tubes of

various sizes, a mandrel to feed material for forming a tube to the die plates, and means to drive the mandrel.

3. In a machine for making flexible tubing, a forming die comprising a die casing, a plurality of convoluted die plates therein, a plurality of independent spacer plates intermediate said die plates, said die plates being substantially disc shaped and having a sector thereof cut away and having an arcuate opening in the center thereof, a mandrel to feed material for forming a tube through the die casing, and means to drive the mandrel.

4. In a machine for making flexible tubing, a forming die comprising a die casing, a plurality of helically flexed die plates therein and a plurality of spacer plates of lesser diameter separating said die plates, said die plates being substantially circular, lacking a sector and having an opening in the center thereof, a mandrel to feed material for forming a tube to the die, and means to drive the mandrel, the wall of said opening being on a curve to control and define the pitch of the convolutions of the tube.

5. In a machine for making flexible tubing, a forming die comprising a die casing, a plurality of die plates therein, a plurality of spacer plates separating said die plates, a mandrel to feed material for forming a tube to the dies, means to drive the mandrel comprising a hollow shaft to carry the mandrel, a drive pulley, a collar to drive the shaft, and connecting means between the collar and said drive pulley.

6. In a machine for making flexible tubing, a forming die comprising a die casing, a plurality of die plates therein, a plurality of spacer plates separating said die plates, a mandrel to feed material for forming a tube to the dies, means to drive the mandrel comprising a hollow shaft to carry the mandrel, a drive pulley, a collar to drive the shaft, and a disengageable connecting means between the collar and said pulley.

7. In a machine for making flexible metallic tubes, a former head including a die casing, a plurality of dies therein having spacers therebetween, a mandrel to feed a preformed metal strip to the dies to form coils therefrom, a sleeve enclosing said mandrel, a drive pulley, a collar fixed on said sleeve and having disengageable connections with said pulley, means to apply solder to the strip as it advances between said dies, and means for heating the coils to fuse the solder.

8. In a machine for making flexible metallic tubes, a former head including a die casing, a plurality of dies therein having spacers therebetween, a power driven mandrel to move said strip into engagement with said dies, means to engage and disengage the power drive to said mandrel, a flux bath through which said strip is drawn, wipers to remove excess flux from the surfaces of said strip prior to passage into the dies, means to supply a thread of solder to the strip as it advances into said dies, means to lubricate the strip in its passage between said dies, and means to cause the solder to coalesce with the edges of the strip upon its emergence from the dies.

9. In a machine for making flexible metallic tubes, a former head including a die casing, a plurality of paired dies in said casing, a mandrel to move a preformed single unitary metal strip between said dies, said dies being replaceable and having spacers therebetween, a tank containing a bath of liquid flux through which the strip passes, means to remove excess flux from each side of the strip, means to preform the strip prior to entering said dies, means to apply a thread of solder to one of the edges of said strip while passing through said dies, and means to melt the solder upon emergence of the tube formed by said dies.

10. In a machine for making flexible metallic tubes from a single unitary metal strip, a series of pairs of dies for progressively forming the strip to present opposed interengageable edges and one or more channelled wales spaced parallel therewith, a power driven mandrel on which the strip is coiled upon its passage from said dies, a plate die casing, a plurality of substantially circular plate dies spaced uniformly in said casing and disposed circumjacent said mandrel and coil, said plate dies progressively causing seam interlocking of the strip edges and rectification of the intervening wale or wales to form a uniform helically convoluted tube.

11. In a machine for making flexible metallic tubes from a single unitary metal strip, a series of pairs of dies for progressively forming the strip to present opposed interengageble edges and one or more channelled wales spaced intermediate the edges, a controllably driven mandrel on which the strip is tightly coiled as it emerges from said dies, a casing, a plurality of plate dies fixed in said casing, spacers arranged therebetween, said plate dies being substantially three-quarters of a circle, helically shaped in cross section, concentric with said mandrel and adapted to cause the edges of the strip to interlock forming a helically convoluted tube, means to supply lubricant to the tube during its passage through said plate dies, and means to seam the interlocked edges with solder.

12. In a machine for making flexible metallic tubes from a unitary metal strip, a series of revoluble dies to progressively form the strip with opposed interengageable edges and a continuous raised wale therebetween, a rotating mandrel to grip the strip and cause its advancement through the dies, a housing around said mandrel, a series of cam disc formers fixed in said housing to progressively cause interlocked engagement of the strip edges, said cam discs coiling the strip around the mandrel in uniform convolutions with its wale intermediate thereto, means to enter a thread of solder between the interlocked edges of the strip, means to supply lubricant to said cam disc formers, and means to set the solder.

13. In a machine for making flexible metallic tubes from a unitary metal strip, a series of revoluble dies to progressively form the strip with opposed interengageable edges and a continuous raised wale therebetween, a rotating mandrel to grip the strip and cause its advancement through the dies, a housing around said mandrel, a series of cam disc formers fixed in said housing to progressively cause interlocked engagement of the strip edges, said cam discs coiling the strip around the mandrel in uniform convolutions with its wale intermediate thereto, means to enter a thread of solder between the interlocked edges of the strip, and a high frequency electrical induction tube through which the coils are passed to melt the solder.

14. In a machine for making flexible metallic tubes from a continuous strip having preformed interengageable edges and a raised central channel, a rotating mandrel, a series of cam plates about said mandrel, said mandrel drawing the

strip through said plates unseaming the edges and rectifying the channel, said cam plates shaping the seam and channel to present uniform convolutions.

15. In a machine for making flexible metallic tubes from a strip, a rotatable mandrel, a die therearound, said mandrel drawing the strip through said die, said die having means to interfold the edges of the strip at alternate convolutions of the tube, the intermediate convolutions being unseamed and uniform therewith and said die introducing metallic means to render the interfolded convolutions hermetically sealed.

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