March 23, 1943. R. K. ODOR 2,314,510

MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

Filed July 6, 1939 7 Sheets-Sheet 1

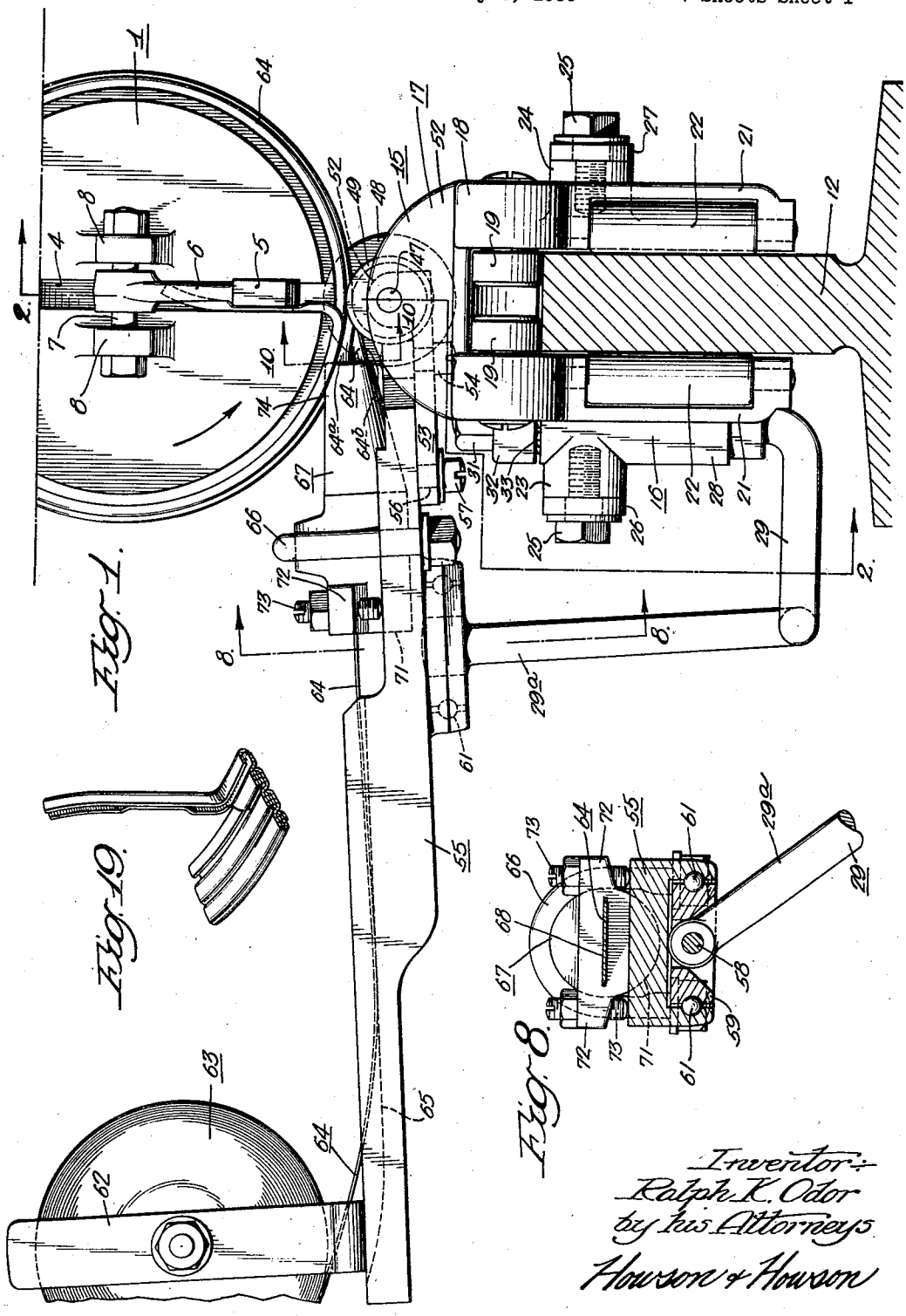


Fig. 1.

Fig. 10.

Fig. 8.

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MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

Filed July 6, 1939 7 Sheets-Sheet 2

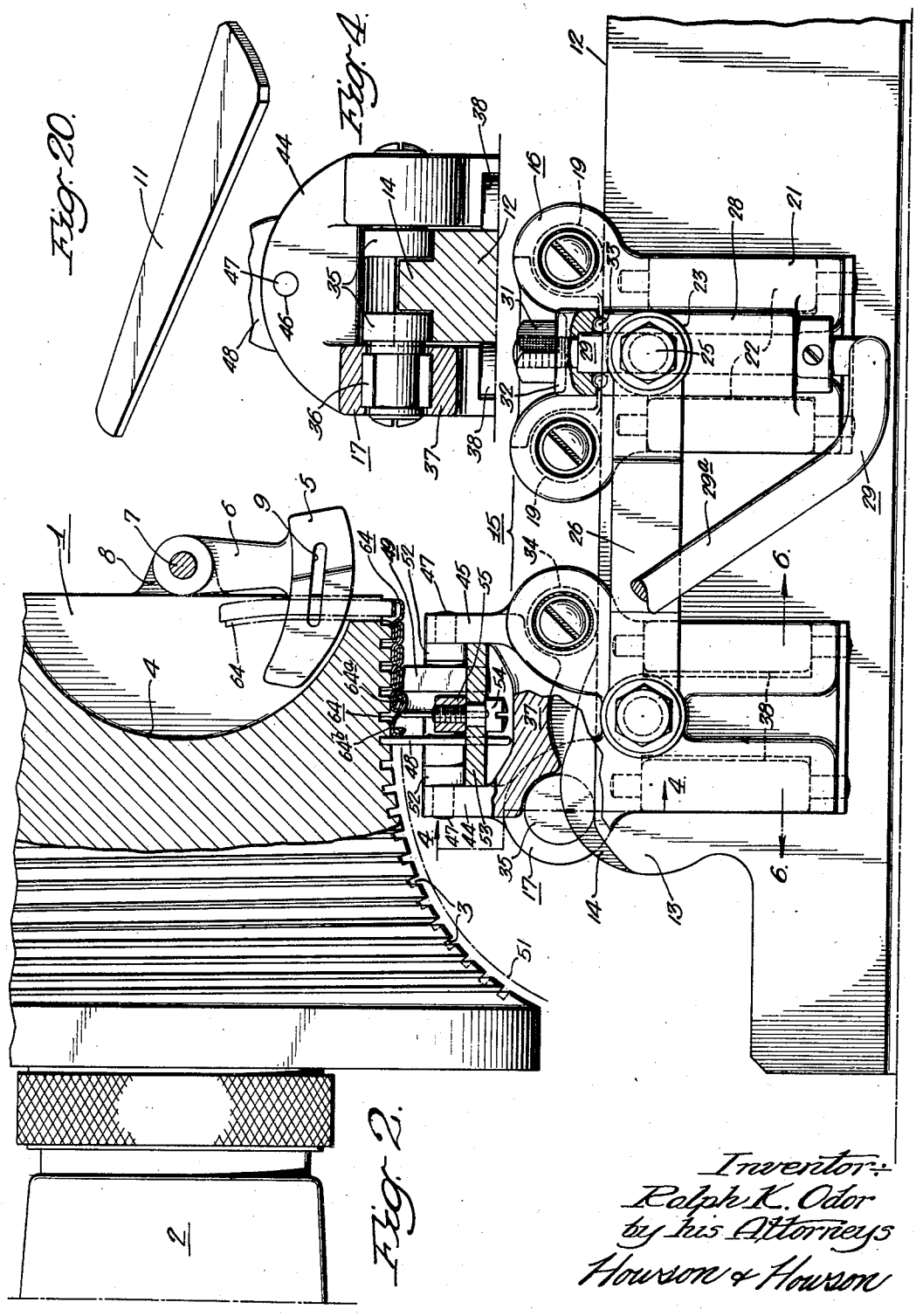


Fig. 2.

Fig. 2a.

Fig. 2c.

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MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

Filed July 6, 1939 7 Sheets-Sheet 3

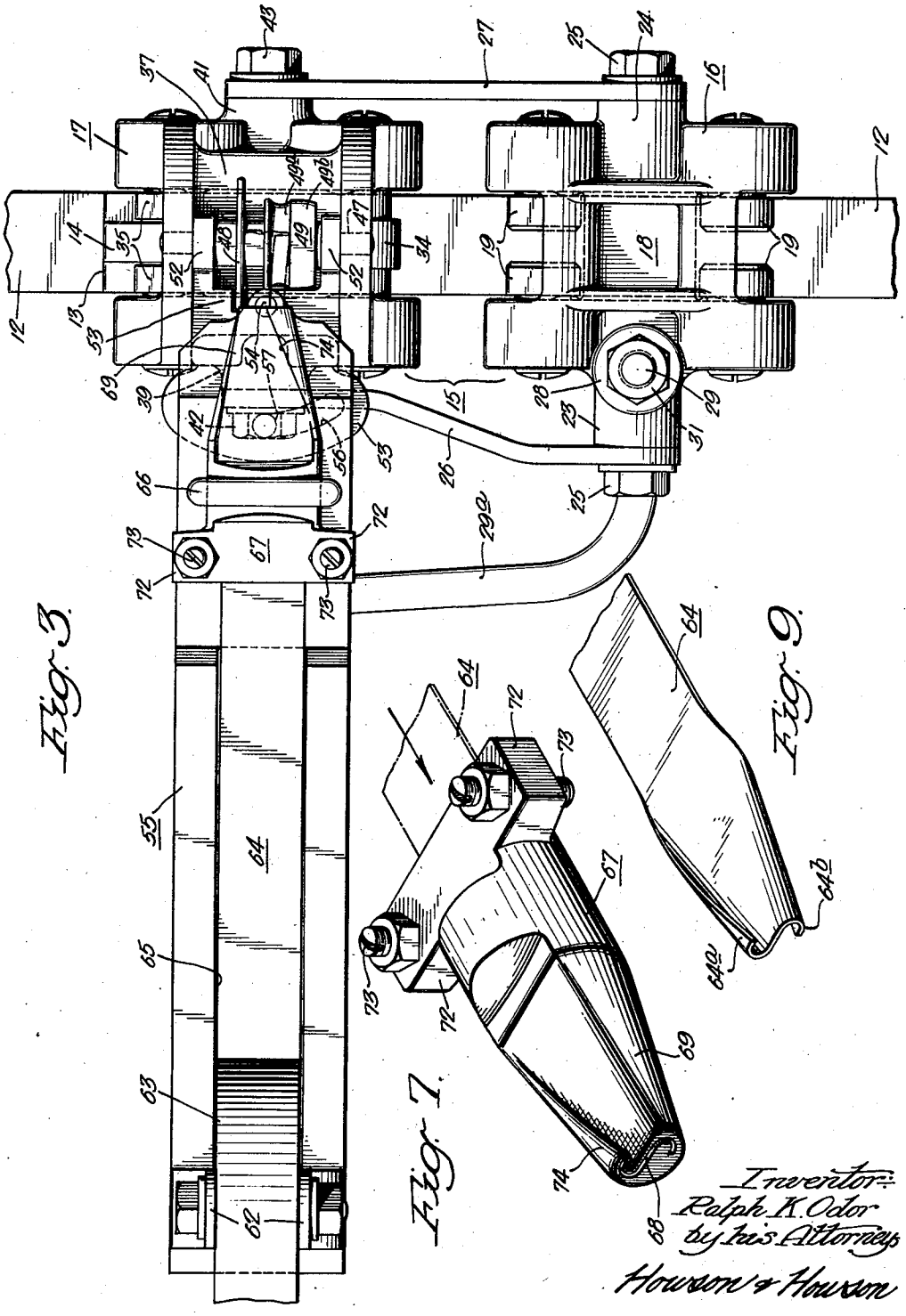


Fig. 3.

Fig. 7.

Fig. 9.

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MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

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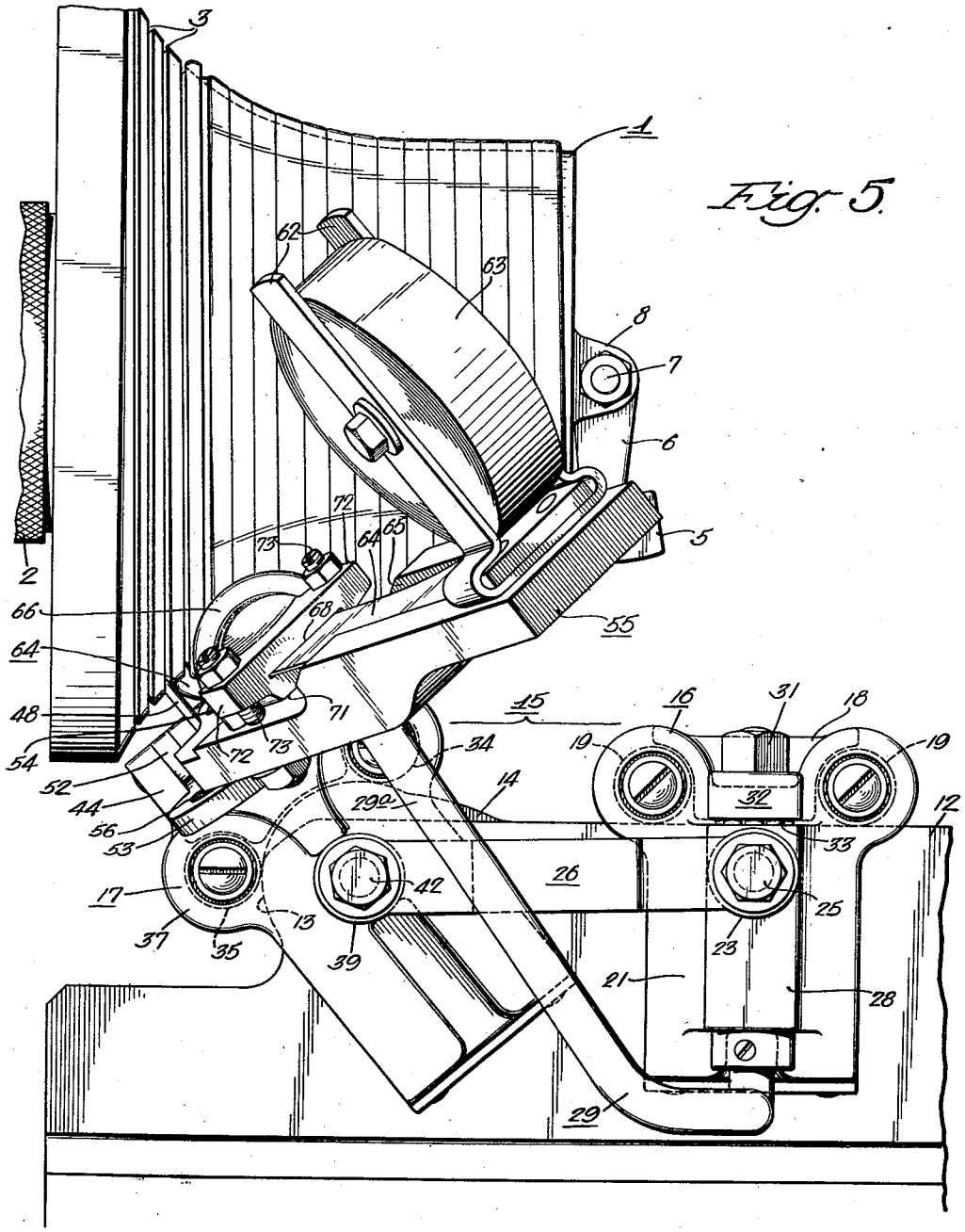


Fig. 5.

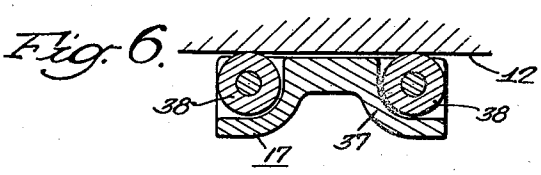


Fig. 6.

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MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

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Fig. 9a.

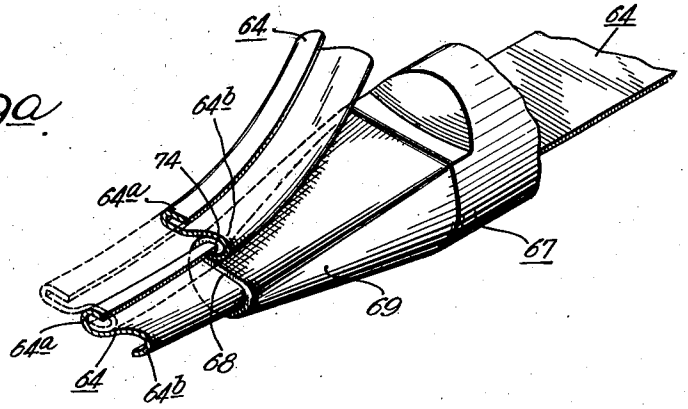


Fig. 22.

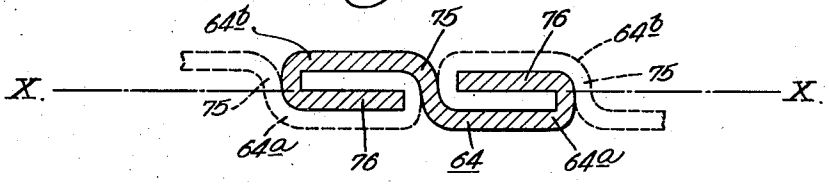


Fig. 23.

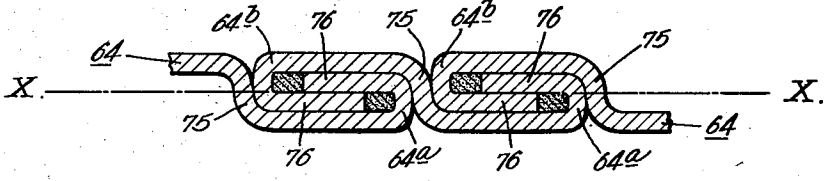
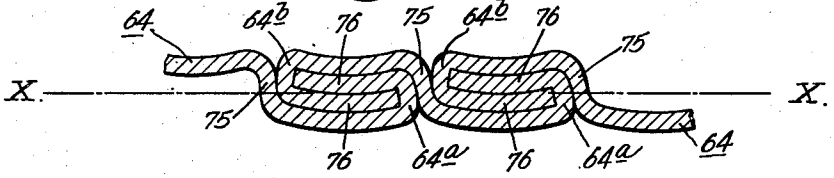


Fig. 24.



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MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

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Fig. 17.

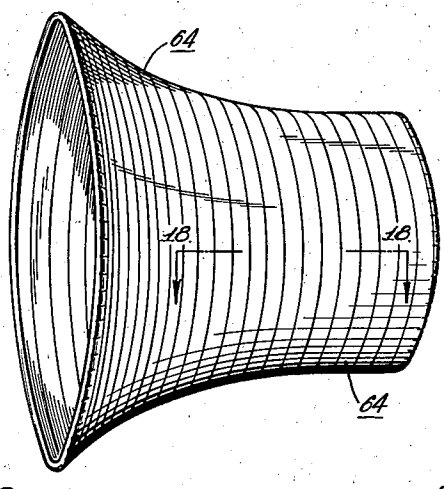


Fig. 18.

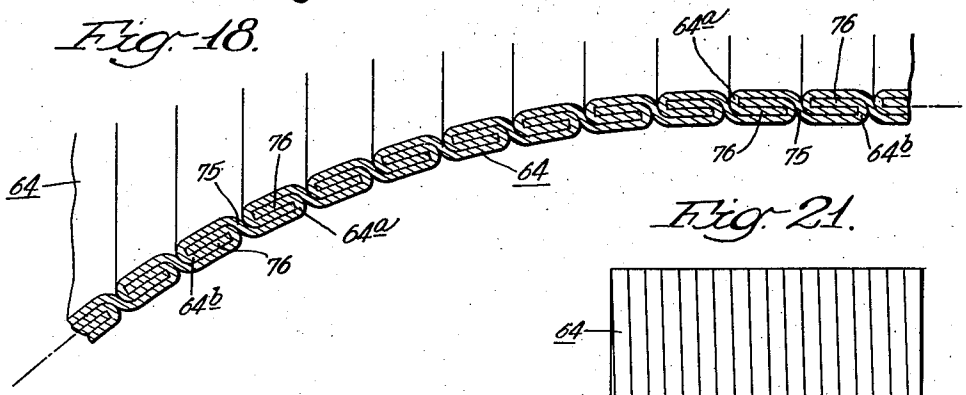


Fig. 21.

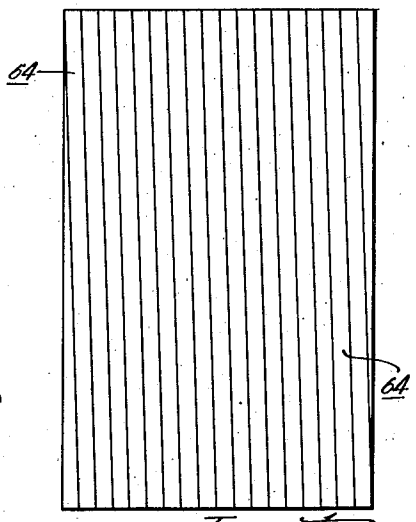
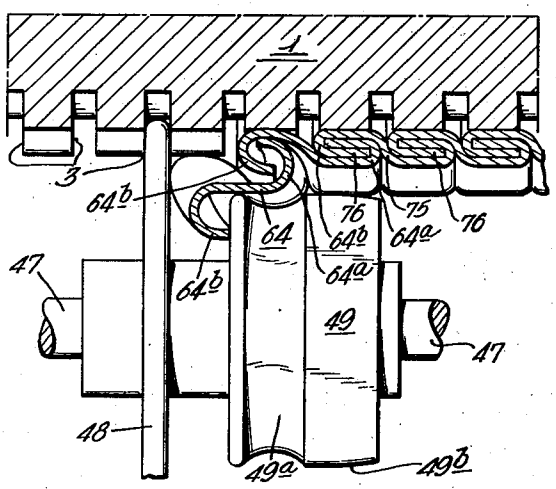


Fig. 10



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MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

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Fig. 12.

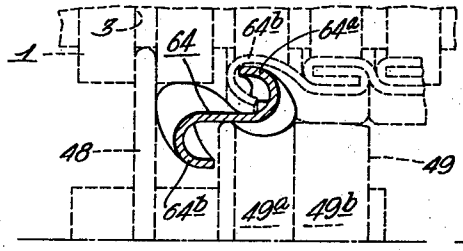


Fig. 13.

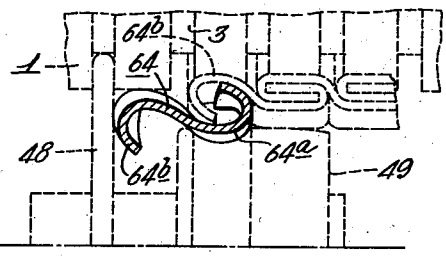
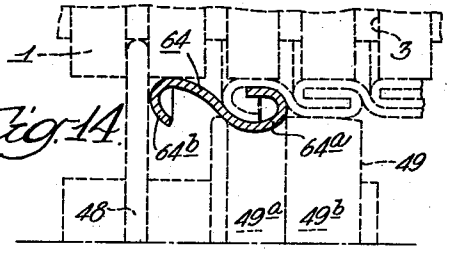


Fig. 14.



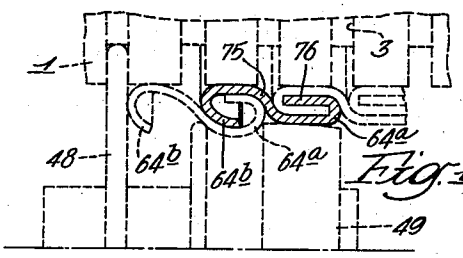


Fig. 15.

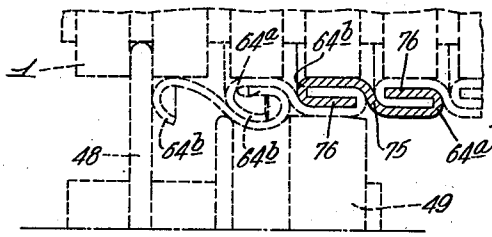


Fig. 16.

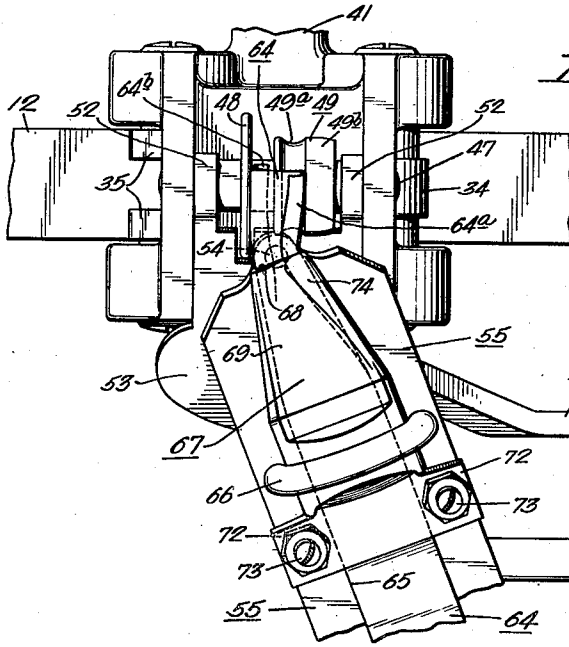


Fig. 11.

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Patented Mar. 23, 1943

2,314,510

UNITED STATES PATENT OFFICE

2,314,510

MACHINE FOR MANUFACTURING FABRICATED METALLIC STRUCTURES

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Application July 6, 1939, Serial No. 283,107

10 Claims. (Cl. 113—35)

This invention relates to mechanism for fabricating sheet metal structures.

A principal object of the invention is to provide a machine for fabricating sheet material and tubular metallic structures of a character hereinafter described.

Another object of the invention is to provide a machine adapted to produce fabricated tubular sheet metal structures in various forms other than cylindrical, and more particularly a tubular structure having the flared end formation previously set forth.

The invention further resides in the various mechanisms and elements of mechanism hereinafter described and illustrated in the attached drawings, wherein:

Figure 1 is an end elevational and partial sectional view of a fabricating machine made in accordance with my invention;

Fig. 2 is a side elevational and partial sectional view of the essential elements of the machine;

Fig. 3 is a top plan view of a portion of the machine shown in Fig. 1;

Fig. 4 is a section on the line 4—4, Fig. 2;

Fig. 5 is a side elevational view of the fabricating mechanism illustrating one of the operations of the machine;

Fig. 6 is a section on the line 6—6, Fig. 2;

Fig. 7 is a detached view in perspective of the forming die constituting one of the elements of the mechanism;

Fig. 8 is a section on the line 8—8, Fig. 1;

Fig. 9 is a view in perspective of a fragment of the strip material upon which the machine operates in the fabricating process, showing the manner in which the strip is shaped in the forming die illustrated in Figs. 7 and 8;

Fig. 9a is a fragmentary view in perspective illustrating a function of the forming die;

Fig. 10 is an enlarged sectional view illustrating another element of the mechanism and the manner in which the strip material is worked into the fabricated structure;

Fig. 11 is a fragmentary plan view showing certain elements of the mechanism and illustrating a further step in the fabricating procedure;

Figs. 12 to 16, inclusive, are diagrammatic sectional views illustrating various steps in the production of the fabricated structure;

Fig. 17 is a perspective view of a tubular fabricated structure made in accordance with my invention;

Fig. 18 is an enlarged sectional view taken on the line 18—18, Fig. 17;

Fig. 19 is a fragmentary view in perspective illustrating the mode of initiating the fabricating operation;

Fig. 20 is a view in perspective of the wedge element employing in the operation of the winding mechanism;

Fig. 21 is a view illustrating a fabricated metallic sheet made in accordance with my invention;

Fig. 22 is a diagrammatic sectional view illustrating the structure of the fabricated metallic strip;

Fig. 23 is a view similar to Fig. 22 showing a modification, and

Fig. 24 is a view illustrating a further modification within the scope of the present invention.

With reference to the drawings, the machine therein illustrated as one embodiment of my invention comprises a rotary form 1 which is shaped externally to the contour of the required tubular structure. This form is mounted in the present instance upon one end of an arbor 2 which is connected with a suitable source of power, not shown. The form 1 is provided with a continuous convolute groove 3 which extends continuously from one end of the form to the other, the convolutions being uniformly spaced axially of the form and being formed so that at each point throughout its length it extends inwardly from the peripheral surface of the form in a direction substantially normal to the surface at that point. This is best illustrated in Fig. 2. At its outer end, the form is provided with a slotted recess 4, see Figs. 1 and 2, and cooperating with this recess for a function hereinafter described is a segmental wedge element 5, this element being formed at the lower end of an arm 6 which depends from a hinge pin 7 supported at the end of the form 1 within bosses 8. As shown in Fig. 2, the wedge element 5 is provided with a longitudinal slot 9 which, when the element is in the operative position as illustrated in this figure, extends in part into the slotted recess 4. The slot 9 provides for freeing the wedge from the slotted recess 4 by forcible insertion of a wedge element 11 of the character shown in Fig. 20.

The machine further comprises a relatively fixed rail 12 which is arranged in spaced relation to the form 1 and which bears with respect to the said form a specific fixed relation, as hereinafter set forth. As shown in Figs. 1 and 2, the rail 12 extends in parallel relation to the rotary axis of the form 1, and that end of the rail which more closely adjoins the form and which is indicated by the reference numeral 13 is rounded off more or less in conformity to the curving contour of the

inner end of the form, and is provided also with an upstanding cam-like projection 14 which, as shown in Fig. 4, projects from the upper face of the rail and centrally of the latter.

Fitted to the rail 12 and adapted to travel longitudinally thereon is a carriage, designated generally by the reference numeral 15. This carriage comprises two articulated elements 16 and 17 respectively. The carriage element 16 comprises a body member 18 shaped generally in the form of an inverted U and which straddles the rail 12, as best shown in Fig. 1. Journaled in the top of this body are two sets of rollers 19, 19 which engage the upper surface of the rail 12 and which support the body member upon the latter. The depending portions 21, 21 of the body 18 at the opposite sides of the rail each has journaled therein a pair of vertically arranged rollers 22, 22 which, as shown in Fig. 1, engage the opposite side faces of the rail. The sole contact of the carriage element 16 with the rail, therefore, is through the rollers 19 and 22, and these rollers function to support and guide the carriage element accurately on the rail.

Projecting from the opposite sides of the body member 18 of the carriage element 16 are two bosses 23 and 24 which are tapped for reception of screws 25, these screws functioning to secure to the carriage element 16 tie rods 26 and 27 by means of which the carriage element 16 is connected with the carriage element 17. The body member 18 of the carriage element 16 also comprises at one side a vertical boss 28 in which is journaled one end of a rod 29, the other end of which is connected, as hereinafter described, to a member of the carriage element 17. The upper end of that portion of the rod 29 which is journaled in the boss 28 is threaded for reception of a nut 31, this nut bearing upon the top of a collar 32 which, as shown in Fig. 2, embraces the upper extremity of the rod 29 and which at its under side is formed to constitute the upper race of an anti-friction bearing 33. The journaled portion of the rod 29 is thus supported for rotation about its longitudinal axis within the boss 28. It is to be noted that the travel of the carriage element 16 described above is confined entirely to the rectilinear portion of the rail 12.

The carriage element 17 is formed generally in the same manner as the carriage element 16, but differs from the latter in that the rear end thereof, namely, that end which adjoins the carriage element 16, is supported by a single roller 34 which engages the central portion of the upper surface of the rail 12, as shown in Fig. 3, and which when this carriage element has advanced to a given extent on the rail 12 will ride upon the cam extension 14 of the rail previously described. At the forward end, the carriage element 17 is supported, after the manner of the carriage element 16, by two rollers 35, 35 which, as shown in Fig. 4, engage the side portions of the upper surface of the rail at opposite sides of the cam extension 14. It will be noted also by reference to Fig. 4 that each of the rollers 35 is supported in anti-friction bearings 36 in the body member 37 of the carriage element 17, a similar anti-friction bearing being provided in the body member 18 of the carriage element 16, previously described, for the rollers 19, 19.

The depending side portions of the body member 37, which member corresponds substantially to the body member 18 of the carriage element 16 previously described, carry vertical rollers 38, see Figs. 4 and 6, which correspond to the rollers 22, 22 of the carriage element 16, and like the latter engage the opposite side faces of the rail 12. The body member 37 of the carriage element 17 has, one at each side, a boss, 39 and 41, see Fig. 3, which are tapped for reception of screws 42 and 43 which secure the connecting rods 26 and 27 to the carriage element 17.

Travel of the carriage element 17 is not confined entirely to the rectilinear portion of the rail 12, it being noted by reference to Fig. 5 that the rollers 35 are adapted to travel on the curved forward portion of the rail at opposite sides of the projecting cam 14, and that the roller 34 is adapted similarly to travel upon the upper surface of the said cam 14. The form of the curved forward end 13 of the rail 12 and of the cam 14 is such as to maintain the same relative position of the carriage 17 with respect to the curved rear portion of the form 1 that exists between the carriage and the cylindrical forward or outer end of the form when the carriage 17 is traveling in a straight path upon the rectilinear portion of the rail 12. To more adequately describe this relation of the carriage element 17 to the surface contour of the form 1, it will be noted by reference to Figs. 2 and 4 that this carriage is provided at the top with two upstanding arcuate extensions, 44 and 45, and that these extensions form a support, as indicated at 46, for a pin 47 which extends between the extensions and forms a journal for two rotary elements 48 and 49. The element 48 takes the form of a disk the peripheral portion of which is adapted to fit neatly within the convolute recess 3 of the form 1. The disk 48, therefore, constitutes in effect a coupling between the carriage element 17 and the form 1, so that as the form is rotated, the disk 48, traveling in the convolute recess 38, motivates the carriage element 17 and causes the latter to move longitudinally of the rail.

It is apparent that the plane of the disk 48, in order to mate accurately with the convolute groove 3 of the form, must be normal to the peripheral surface of the form at the point where the disk engages with the latter, and the forward end 13 of the rail, including the cam 14, is formed so that the carriage element 17 in traveling on this portion of the rail shall move angularly to an extent maintaining this normal relation of the disk 48 with the form. The end portion 13 of the rail and the cam 14 furthermore are so formed that the rotational center of the disk 48 shall remain in any position of the carriage element equidistant from the peripheral surface of the form and shall travel in a line which corresponds accurately to the curving contour of the latter. With this arrangement, it will be apparent also that a corresponding positional relation will maintain throughout the movement of the carriage element 17 between the rotary element 49 and the surface of the form 1, the space between this element 49 and the adjoining surface of the form remaining constant, as indicated in Fig. 2 by the broken line 51.

It has been noted previously that the rail 12 lies in parallel alignment with the rotary axis of the form 1. It will be noted further by reference to Fig. 1 that in the present instance the rail lies, in effect, in a vertical plane, which also includes the said rotary axis of the form. As shown in Figs. 1 and 3, the rotary axis of the elements 48 and 49 is also included in this same vertical plane,

and remains in this plane irrespective of the position of the carriage element 17 on the rail.

Pivotally supported on the pin 47 through the medium of upstanding apertured lugs 52, 52 is a bracket 53, this bracket extending transversely from the body member 37 of the carriage element 17 and away from the form 1, as shown in Figs. 1 and 3. In the inner end of the bracket 53 is a screw 54, this screw having an unthreaded portion which passes neatly through an aperture in the bracket 53 and a threaded terminal portion which enters a correspondingly threaded hole in the forward extremity of an elongated bracket member or arm 55. The bracket arm 55 may move angularly with respect to the supporting bracket 53 through the medium of the pivot constituted by the screw 54. The outer end of the bracket 53 contains a slot 56, and a screw 57 similar to the screw 54 passes upwardly through this slot and is threaded into the under side of the bracket arm 55. The slot 56 is formed on the arc of a circle centering in the pivot pin 54, and the screw 57 is free to move in the slot to permit the angular movement of the bracket arm 55 with respect to the bracket 53. The slot 56 is positioned so that when the pin 57 occupies one end of the slot, as shown in Fig. 3, the bracket arm 55 will extend at right angles to the pin 47, which as previously described forms the rotary axis for the elements 48 and 49. From this position, the slot 56 and the pivoted connection between the bracket arm 55 and the bracket 53 permit the arm 55 to swing through a maximum angle determined by the length of the slot 56 in the general direction of the carriage element 16.

As shown in Figs. 1 and 8, the bracket arm 55 is also supported on the outer upstanding portion 29a of the rod 29 previously referred to, the connection between the said rod and the bracket arm 55 being in the nature of a universal joint, as shown in Fig. 8. The end of the rod 29 is connected through the medium of a wrist pin 58 in a cylindrical member 59, this latter member being supported in anti-friction bearings 61 at the under side of the bracket arm. With this arrangement, the bracket arm 55 is capable of universal movement with respect to the upstanding end portion 29a of the rod 29.

The bracket arm 55 carries at its outer end an upright bracket 62 in which is rotatably mounted a roll 63 of sheet metal in the form of a strip 64. The upper surface of the outer end portion of the bracket arm 55 is channeled, as indicated at 65, for reception of the strip of metal 64. This channel acts as a guide for the strip extending longitudinally of the bracket arm 55 toward the rotary form 1. Mounted at the inner end of the bracket arm 55 and secured to said arm by means of a U-clamp 66 is a forming die 67, this die having a longitudinal slot 68 through which the metal strip 64 passes. The slot 68 at the rear end of the die 67 is straight, as shown in Fig. 8. The slot changes gradually in form toward the opposite end of the die and terminates in the S-shaped opening shown in Fig. 7. As the strip 64 of metal is drawn through the die, in a manner hereinafter described, its cross sectional shape is changed from the normal flat rectangular form in which it passes into the die to the S-like configuration, as shown in Fig. 9, wherein one longitudinal side edge is turned inwardly towards the one face of the strip, and the other longitudinal edge is turned over in the other direction towards the opposite face. The under side of the die, including its tapered extremity 69, is cylindrical in section, and this portion of the die seats in a correspondingly formed recess 71 in the upper surface of the bracket arm 55. As shown in Fig. 7, the outer or entrant end of the die is provided with transversely extending flanges 72, 72 which carry adjusting screws 73, 73, the lower ends of these screws, as shown in Fig. 8, bearing against the upper surface of the bracket arm 55 at opposite sides of the recess 71 in which the die is seated. With the clamp 66 slightly loose, the screws 73 may be adjusted to, in turn, accurately adjust the die on its seat about its longitudinal axis, bringing the die slot into proper positional relation to the rotary element 49 and to the form 1. It will be noted further by reference to Fig. 7 that the upper surface of the conical tip 69 of the die is flattened and shaped to provide an inturned portion 74, which functions in the operation of the device in a manner hereinafter set forth.

It will be noted by reference to Fig. 5 that the angular movement of the carriage element 17, which occurs when that element passes over the curved end 13 of the track 12, occurs about an axis or axes which pass approximately through the common center line of the screws 42 and 43 which secure the connecting rods 26 and 27 to the body member 37. The terminal end of the rod 29, however, which is connected to the bracket arm 55 by means of the universal joint previously described, lies well above this axis. It is apparent, therefore, that as the carriage element moves over the rounded end 13 of the track, the rod 29 must function to retard the movement of the free end of the bracket arm 55 with respect to the body member 37 of the carriage 17, with the result, in effect, that the said bracket arm 55 is adjusted on its pivot 54 with respect to the body member 37 to the right, as viewed in Fig. 5. The result of this relative movement between the bracket arm 55, which carries the forming die 67 as previously described, and the body member 37 of the carriage element 17, is illustrated in Fig. 11, wherein it will be noted that the longitudinal axis of the die 67 now extends at an angle to the rotary axis of the elements 48 and 49. Since the disk 48 acts to guide the formed strip to the form as it leaves the forming die 67, the strip where it leaves the die is bent transversely, with the result that the metal is drawn or stretched in the longitudinal portion of the strip at the outer side of the bend. This stretching of one side of the formed strip causes the strip to conform accurately to the curvature of the rotary form 1 so that it lies flatly and accurately against the form throughout the curved portion of the latter. The arrangement is such that as the angle of the curve increases toward the inner end of the form, the angularity of the bracket arm 55 and of the forming die 67 with respect to the axis of the elements 48 and 49 increases proportionately.

In operating the machine described above, one end of the metal strip 64 is passed through the forming die 67, and a short section of the formed strip is drawn from the die. This formed end is then slit longitudinally, as illustrated in Fig. 19, to provide a free end of approximately half the width of the normal formed strip, which may be passed into the slot 4, as shown in Fig. 1, the wedge element 5 being driven into the slot to lock the inserted end of the strip in the end of the form. At this point, the rotary disk 48 will occupy a position in the outer end of the convolute

groove 3 of the form, and the outer edge of the formed strip of metal will be confined between the grooved portion 49a of the rotary element 49 and the form, after the manner illustrated in Fig. 3. At this point, also as shown in Fig. 3, the bracket arm 55 will extend transversely at right angles to the track 12. The form 1 is now set in motion, with the result that the strip 64 of metal will be drawn through the forming die and will be wound upon the surface of the form 1. At the end of one full revolution of the form 1, the outer turned-in edge of the strip as it leaves the forming die will engage in the outturned edge of the strip forming the first convolution on the form 1, this outturned edge of the initial convolution embracing the turned-over flange 74 of the die, as shown in Fig. 9a. These overlapped and interengaged edges of the strip are immediately confined between the surface of the form and the grooved portion 49a of the element 49, and at the same time the carriage has advanced to the point where the adjoining elevated portion 49b of the said element engages and begins to compress the initial convolution of the formed strip to the shape indicated in Fig. 2. The interengaged edges of each adjoining pair of adjoining convolutions are thus subjected first to a partial compression against the form by the grooved portion 49a of the element 49, and a subsequent further compression by the portion 49b of said element.

The manner in which the overlapped and interengaged edges of the strip are worked into place and flattened against the form by action of the element 49 to securely interlock the convolutions is best illustrated in Figs. 12 to 16, inclusive. In these drawings, the portion of the strip 64 leaving the forming die is shown in full lines. Fig. 12 shows the turned-in edge 64a of this portion of the formed strip overlapping and interengaged with the outturned edge of previously laid convolution as these interengaged edges pass to the grooved portion 49a of the roller 49. Figs. 13 and 14 illustrate the manner in which the grooved portion 49a of the roller functions to partially compress the interengaged and overlapped edges against the surface of the form and to relatively position the said edges in preparation for the subsequent compression by the portion 49b of the roller which completes the interlock and produces the solid laminated joint as shown in Fig. 16.

This action continues until the forward carriage element 17 passes onto the rounded end 13 of the track 12, at which time, as previously described, the direction of movement of this forward carriage element changes to conform to the curvature of the form 1. In this tilting of the forward carriage element 17 and also as previously described, the position of the bracket arm 55 with respect to the rail 12 changes as a result of the retarding action of the rod 29, with the result that the forming die 67 changes its angular relation with respect to the elements 48 and 49, as shown in Fig. 11. The resulting stretching or drawing of the one side edge of the strip causes the strip to conform to the changing contour of the form and to lie flatly upon the latter. In this part of the operation of the machine, the interengagement and compacting of the edges of the adjoining convolutions continues as before until the inner edge of the form is reached and the fabricating operation is completed. As a result of this operation, a fabricated sheet metal tube of the form shown in Fig. 17 is produced, the structure of the interlocked joints being illustrated in Fig. 18. It is to be noted particularly that the adjoining convolutions of metal are in the aforedescribed operation interlocked together in a manner precluding relative movement therebetween, the fabricated or laminated structure having a substantial degree of rigidity, strength and stability. The end edges of the tube may be trimmed and finished by crimping, knurling or other suitable means.

It will be noted by reference to Fig. 22 that in the fabricated sheet material produced as described above, the turned-over edge portions 64a and 64b of the individual strips are relatively offset with respect to the normal plane or lateral center line of the strip indicated by the broken line X—X, and that the said edge portions are connected by a web 75 of the metal which extends transversely to and intersects said plane. In the structure, the extreme edge portion 76 of each strip is confined closely within the loop and is held immovably in place by the abutting transverse web of the adjoining strip. Each longitudinal joint is thus effectively sealed and there is no articulation between the adjoining strips or convolutions. In effect, the sheet material is a four-ply laminated structure and possesses the inherent strength, stability and relative stiffness of structures of that character.

It will be apparent that by utilizing the principles set forth above tubular forms other than that illustrated, and of various and varying shapes, may be fabricated. Where tubular forms which are not symmetrical with respect to a single rotary axis are required, provision may be made for moving the die and associated parts with respect to the non-symmetrical form which receives the strip material, to thereby obtain the essential relative movement between the die and the form. By the same process, it is possible also to form a metallic fabricated shell or covering in situ upon a framework of desired shape. It is possible also, by forming a straight cylindrical tube and subsequently slitting the tube longitudinally, to produce a flat sheet of the fabricated structure. Obviously, flat fabricated sheets of this character may also be produced by using a plurality of closely and properly spaced dies with provision for a straight draw therethrough of the metal strips and subsequent working together of the interengaged edges against a suitable base. Also, if desired, provision may be made for introducing packing at the terminal ends of the individual strips, as shown in Fig. 23, although for most purposes, the normal tight seal provided by the interlocked edges of the strip or strips will be found adequate. Furthermore, as shown in Fig. 24 and where additional rigidity is required, the individual interlocked joints may be cambered transversely, this being readily accomplished by suitably shaping the surfaces of the form and of the pressure roller 49.

One peculiar and useful property of the fabricated structure described is its complete lack of resonance. By reason of this property, it is useful in the tubular form as a duct for air where the conditions of use are such as to tend to create undesirable vibration noises, and also for sound amplifiers where extraneous noises arising from resonance is to be avoided. This applies also to the fabricated material in sheet form which may be used to advantage for various purposes where the property of non-resonance is desirable.

I claim:

1. In a machine for forming fabricated metallic tubular structures, the combination with a form of longitudinally curving contour, of a carriage, a guide for sheet metal strip material of substantially S-shaped cross section supported on said carriage, said guide embracing and closely fitting said strip, means for relatively traversing said carriage and form so as to wind the strip material upon said form in contiguous convolutions, means on said carriage for continuously interengaging the reversely curved edges of the strip material in the adjoining convolutions, means on said carriage for collapsing the interengaged edges of said strip material upon the form to produce an interlocked joint uniting the convolutions, and means for automatically adjusting said guide in accordance with the changing contour of the surface of said form so as to effect a modification of said strip conforming the latter to said changing contour.

2. In a machine for forming fabricated metallic tubular structures, the combination with a form of longitudinally curving contour, of a carriage, a die on said carriage for shaping sheet metal strip material to a substantially S-shaped cross section, means for relatively traversing said carriage and form so as to wind the strip material on the latter in contiguous convolutions and with the reversely curved edges of said material interengaged in said adjoining convolutions, means on said carriage for progressively collapsing the interengaged edges against the form to produce an interlocked joint uniting the convolutions, and means for automatically adjusting said forming die in accordance with the changing contour of said form to produce a relative stretching of one side of said formed strip conforming the strip to said changing contour.

3. In a machine for forming fabricated metallic tubular structures, the combination with a rotary form of curving contour, of means for convolutely winding preformed sheet metal strip material of substantially S-shaped cross section upon said form, said means comprising a relatively fixed rail in spaced relation to said form and having one end curved to conform substantially to the curvature of the form, an articulated carriage movably supported on said rail and comprising two flexibly connected carriage elements arranged in series longitudinally of the rail, a forming die for said strip material mounted on the leading carriage element, together with other means for guiding said formed strip to the form, means for attaching one end of said formed strip to the form, means for rotating the form and for synchronously advancing the carriage on the rail so as to wind said strip in contiguous convolutions upon the form with the reversely turned edges of the material interengaged in the adjoining convolutions, a universally suspended bracket carried by said leading carriage element and constituting a support for said die, and a link connecting said bracket to the trailing carriage element whereby movement of the forward carriage element on the curved portion of said rail will effect an angular adjustment of the bracket and of said die on the forward carriage element in accordance with the changing contour of the form.

4. In a machine for forming fabricated metallic tubular structures, the combination with a rotary form having a convolute groove and means for rotating said form, a rail extending in spaced relation to said form and shaped to conform substantially to the axial surface contour of the latter, a carriage movable on said rail and having an element engaging with the groove of said form whereby rotation of the form effects a synchronized movement of the carriage on the rail, a guide for sheet metal strip material of substantially S-shaped cross section mounted on the carriage, means for securing one end of said strip to the form whereby subsequent rotation of the form results in the winding of said strip in contiguous convolutions on the form, means on said carriage for progressively interengaging the reversely curved edges of the strip material in the adjoining convolutions, and means also carried by the carriage for progressively collapsing the said interengaged edges against the form to produce an interlocked joint uniting the convolutions.

5. In a machine for forming fabricated metallic tubular structures, the combination with a rotary form of curving contour, of a carriage traversible axially of said form in substantially constant spaced relation to the surface of the latter, means for traversing said carriage in timed relation with the rotary movement of said form, means on said carriage for guiding preformed sheet metal strip material of substantially S-shaped cross section to the form in contiguous convolute windings, said guide means including a die for preforming said strip to the S-shaped cross section, means associated with the guide for continuously interengaging the reversely curved edges of the strip material in the adjoining convolutions, means on said carriage for collapsing the interengaged edges of said strip material upon the form to produce an interlocked joint uniting the convolutions, and means operatively associated with the carriage for adjusting the die angularly with respect to said form in accordance with the changing contour of the surface of the latter so as to effect a relative stretching of one side of the formed strip conforming the strip to said changing contour.

6. In a machine for forming fabricated metallic tubular structures, the combination with a form of varying diameter, and means for convolutely winding preformed sheet metal strip material of substantially S-shaped cross section upon said form with the reversely curved edges of the strip material interengaged in the adjoining convolutions, said means comprising a guide for said strip, and mechanism for relatively traversing said guide and form both circumferentially and longitudinally of the latter, means similarly relatively traversible with respect to the form and operative substantially in a common plane paralleling the longitudinal axis of the form for confining and subsequently collapsing said interengaged edges against the form to thereby produce an interlocked joint securely uniting the convolutions, and means for automatically relatively moving said guide, confining and collapsing means and the form radially of and in accordance with the changing diameter of the latter.

7. In a machine for forming fabricated metallic tubular structures, the combination with a form of varying diameter, and means for convolutely winding preformed sheet metal strip material of substantially S-shaped cross section upon said form with the reversely curved edges of the strip material interengaged in the adjoining convolutions, said means comprising a guide

for said strip, and mechanism for relatively traversing said guide and form both circumferentially and longitudinally of the latter, means similarly relatively traversible with respect to the form and operative substantially in a common plane paralleling the longitudinal axis of the form for confining and subsequently collapsing said interengaged edges against the form to thereby produce an interlocked joint securely uniting the convolutions, and means for automatically relatively moving said guide, confining and collapsing means and the form radially of and in accordance with the changing diameter of the latter and for automatically angularly adjusting said guide, confining and collapsing means with respect to the axis of the form in accordance with the changing contour of the latter.

8. In a machine for forming fabricated metallic tubular structures, the combination with a form of longitudinally curving contour, of means for convolutely winding preformed sheet metal strip material of substantially S-shaped cross section upon said form with the reversely curved edges of the strip material interengaged in the adjoining convolutions, said means comprising a die for shaping the strip material to the S-shaped cross sectional form and for guiding the formed strip to the latter, together with mechanism for relatively traversing said die and form both circumferentially and longitudinally of the latter, means for confining and subsequently collapsing said interengaged edges against the form to produce an interlocked joint securely uniting the convolutions, and means for automatically adjusting said die and said confining and collapsing means angularly with respect to the axis of the form in accordance with the changing contour of the latter.

9. In a machine for forming fabricated metallic tubular structures, the combination with a form of longitudinally curving contour, of a relatively fixed rail spaced from the surface of said form and conforming substantially to the curving contour of the latter, a carriage movable on said rail, means on said carriage for guiding preformed sheet metal strip material of substantially S-shaped cross section to the form with the reversely curved edges thereof interengaged in adjoining convolutions, and means on said carriage and operative in succession and substantially along a common line at one side of the form for confining and subsequently collapsing said interengaged edges against the form to produce an interlocked joint securely uniting the convolutions.

10. In a machine for forming fabricated metallic tubular structures, the combination with a rotary form of longitudinally curving contour, of a carriage movable longitudinally of the form, means on said carriage and including a die for shaping sheet metal strip material to substantially S-shaped cross section for guiding said strip material to the form with the reversely curved edges of the material interengaged in adjoining convolutions, means on said carriage for confining and subsequently collapsing said interengaged edges against the form to produce an interlocked joint securely uniting the convolutions, means for adjusting the carriage during its movement so as to maintain an approximately constant angular relation between the carriage and the adjoining part of the form surface and means operatively connected with said carriage for automatically adjusting the said die angularly with respect to the axis of the form in accordance with the curving contour of the latter.

RALPH K. ODOR.