July 19, 1955 C. J. BATH 2,713,376

METAL-FORMING MACHINE

Filed Dec. 17, 1951 6 Sheets-Sheet 1

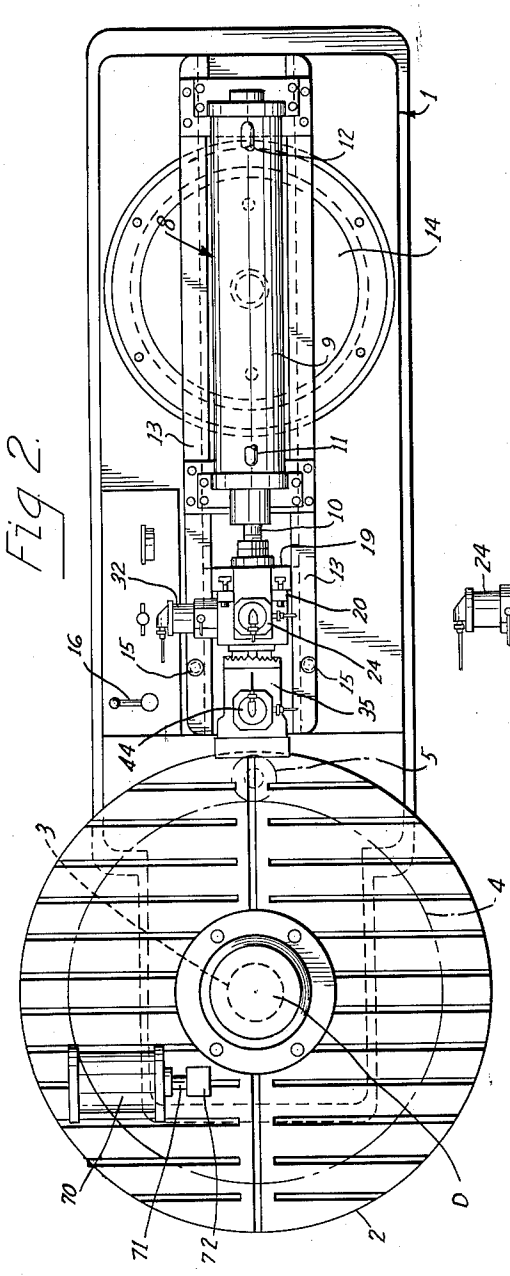


Fig 2.

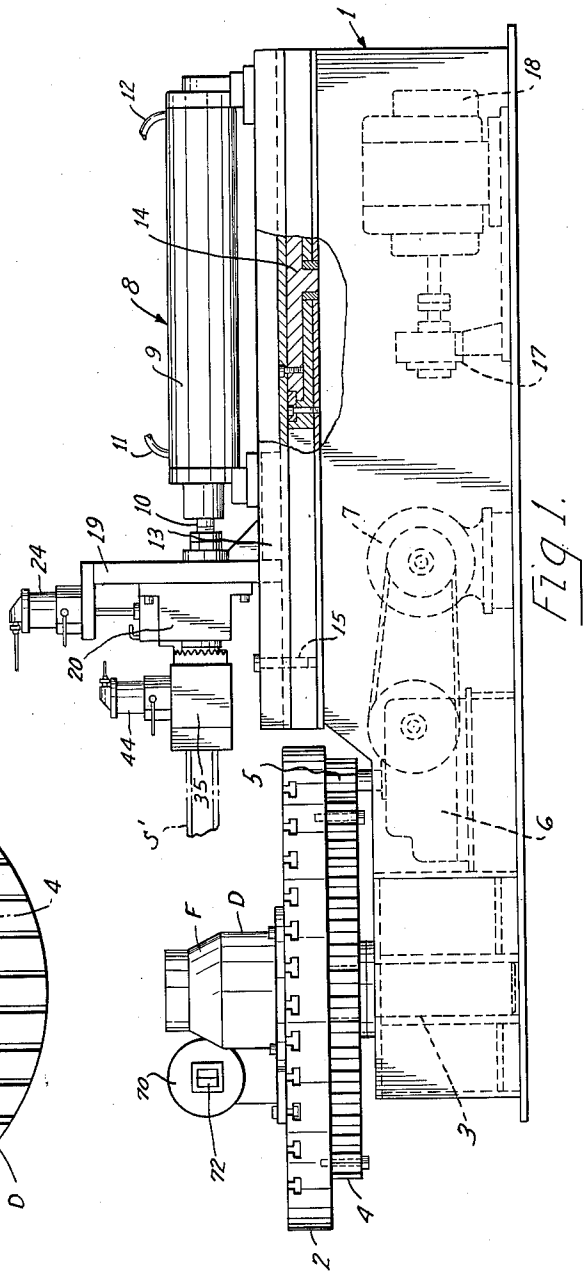


Fig 1.

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METAL-FORMING MACHINE

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Fig. 3.

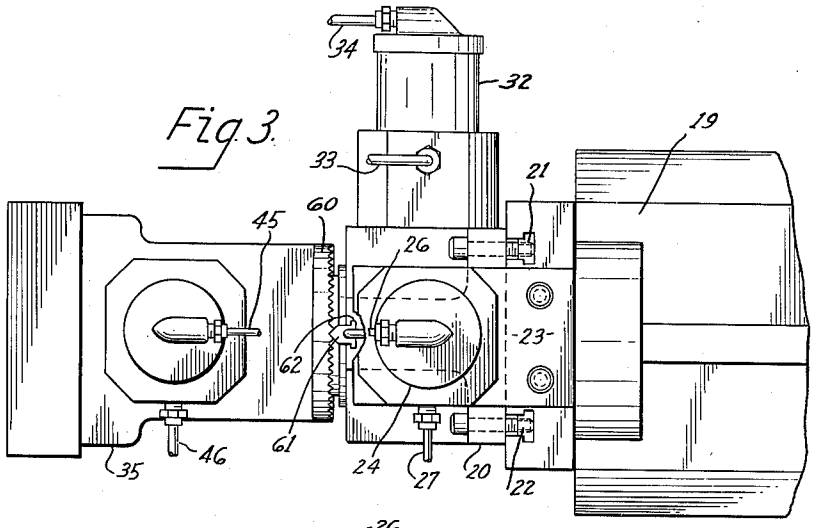


Fig 4.

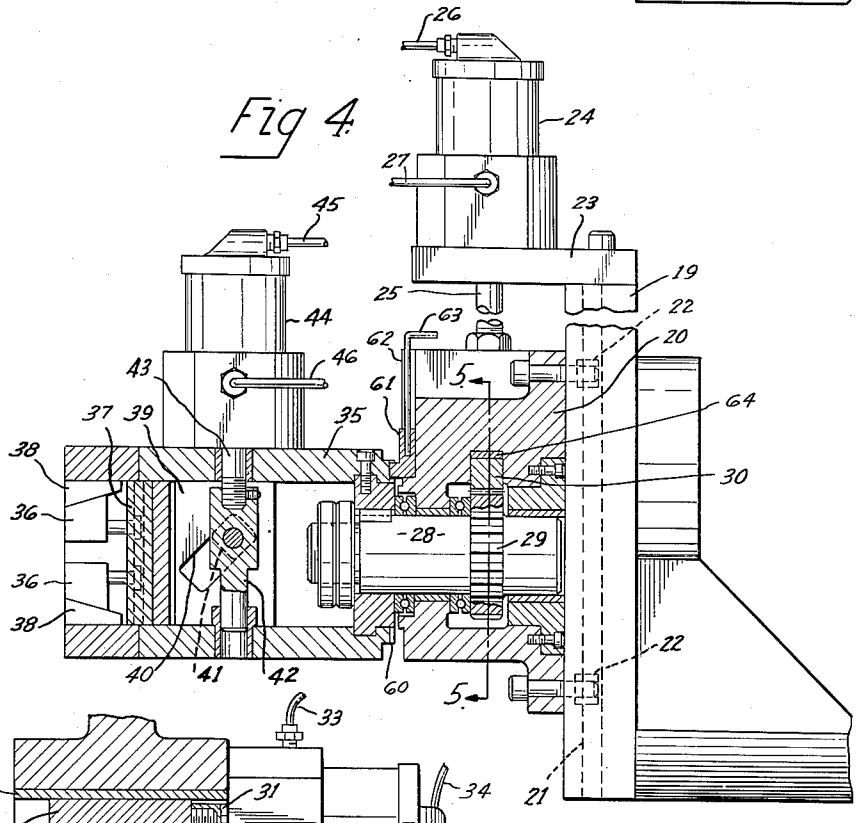


Fig. 5.

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METAL-FORMING MACHINE

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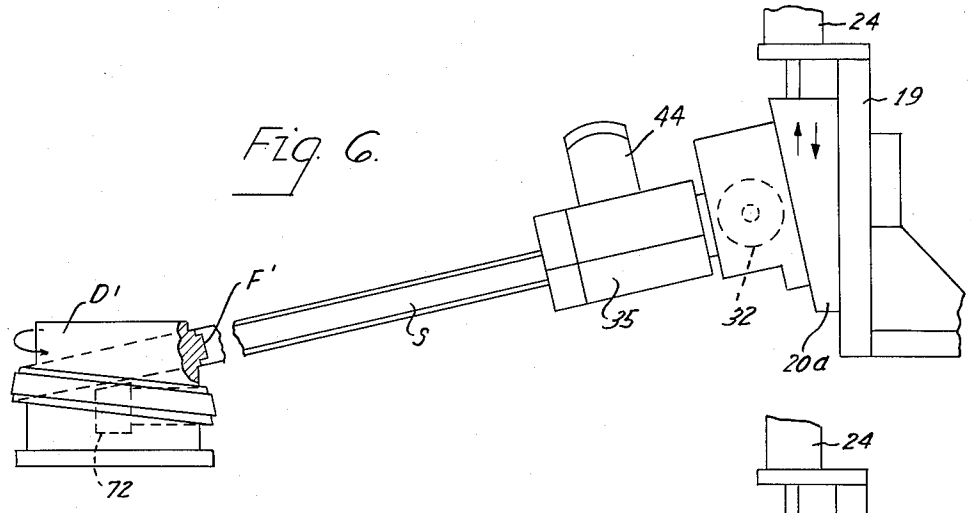


Fig. 6.

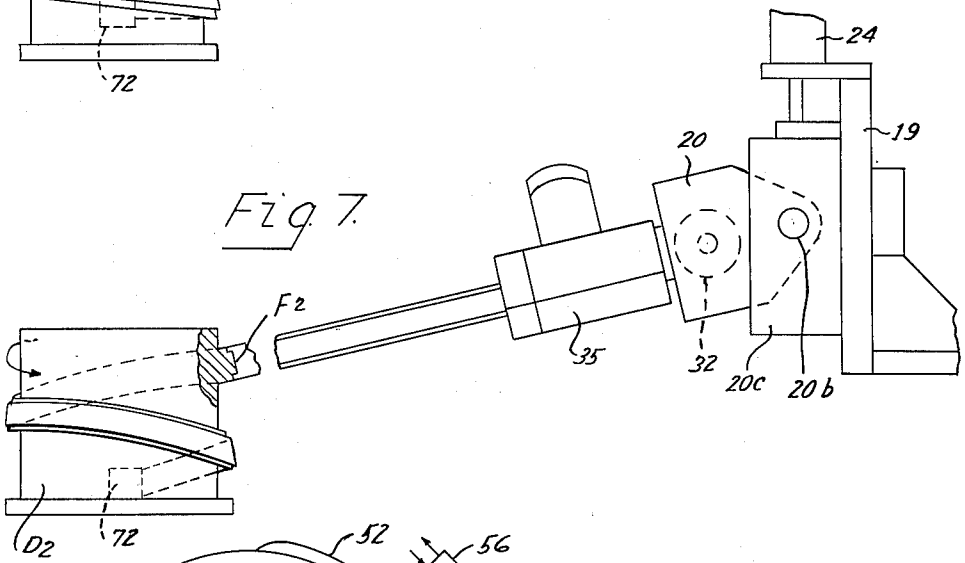


Fig. 7.

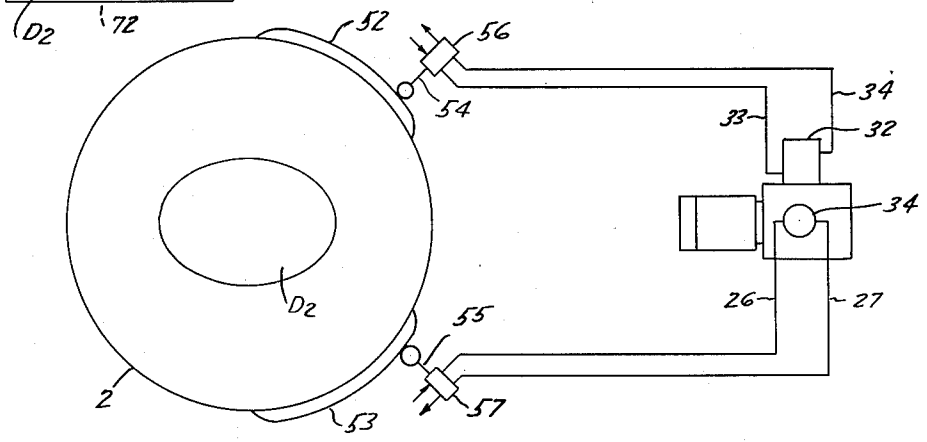


Fig. 8.

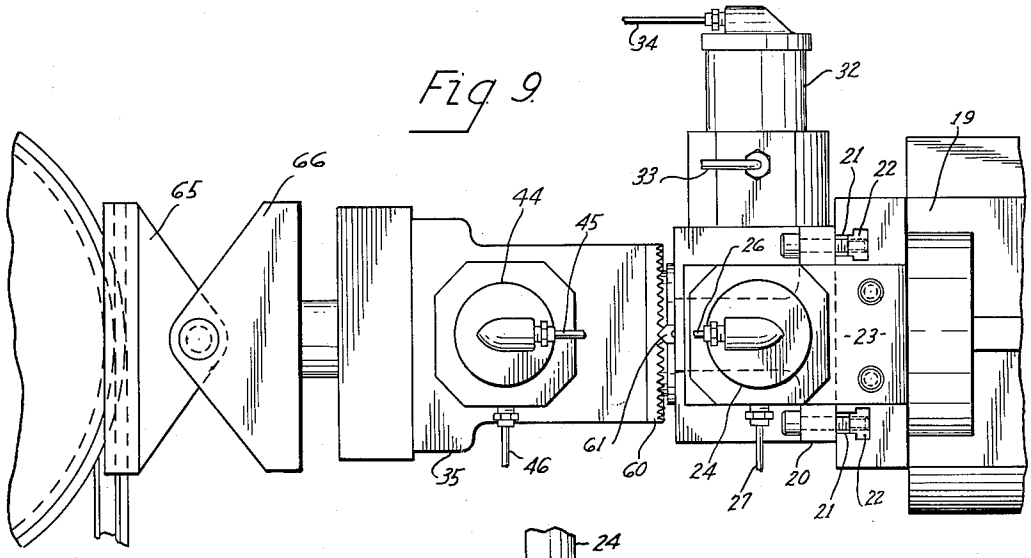
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July 19, 1955 C. J. BATH 2,713,376

METAL-FORMING MACHINE

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Fig 9



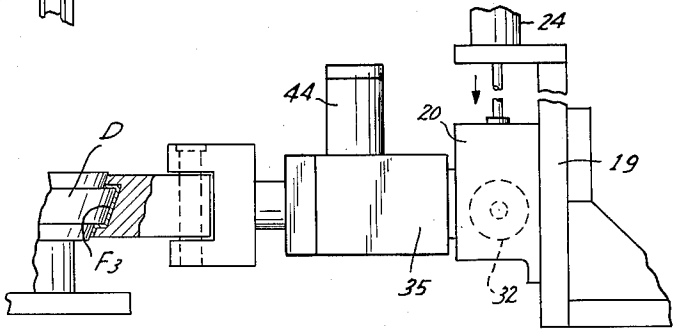


Fig 10.

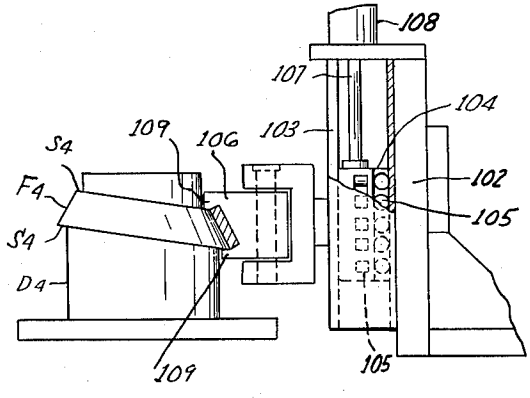


Fig. 14.

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METAL-FORMING MACHINE

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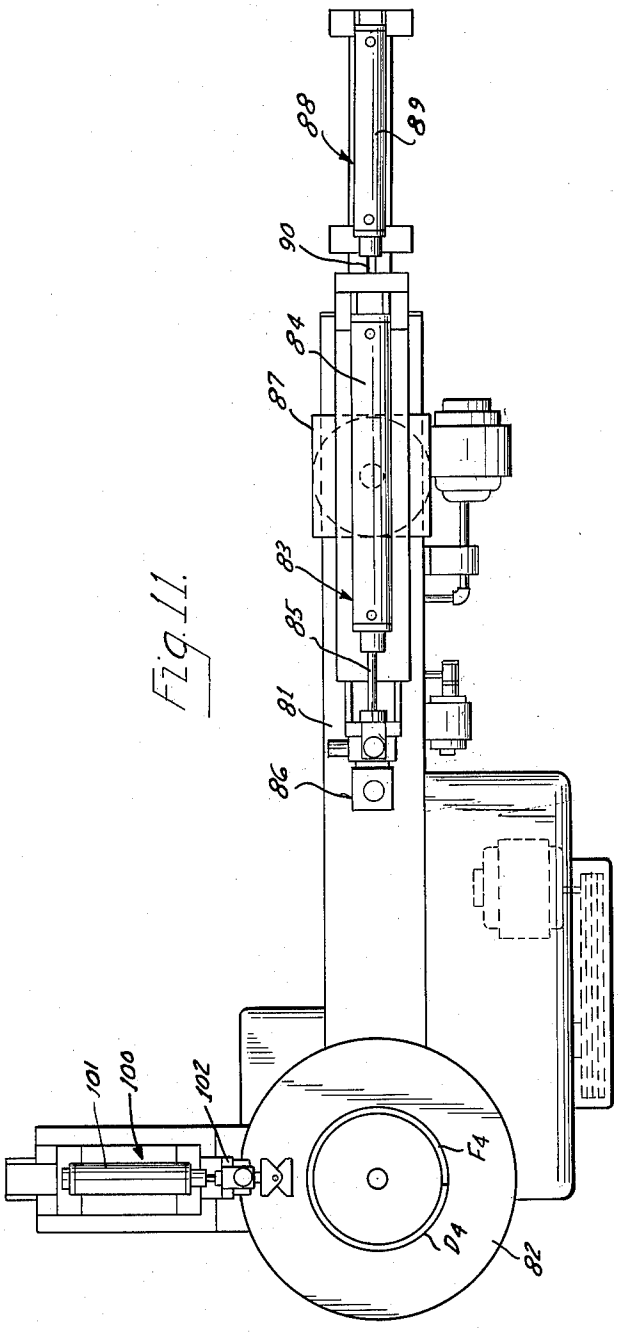


Fig. 11.

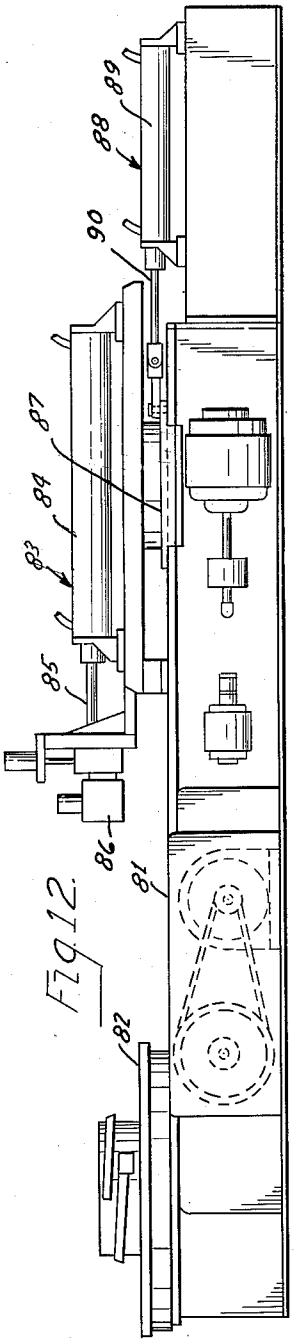


Fig. 12.

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METAL-FORMING MACHINE

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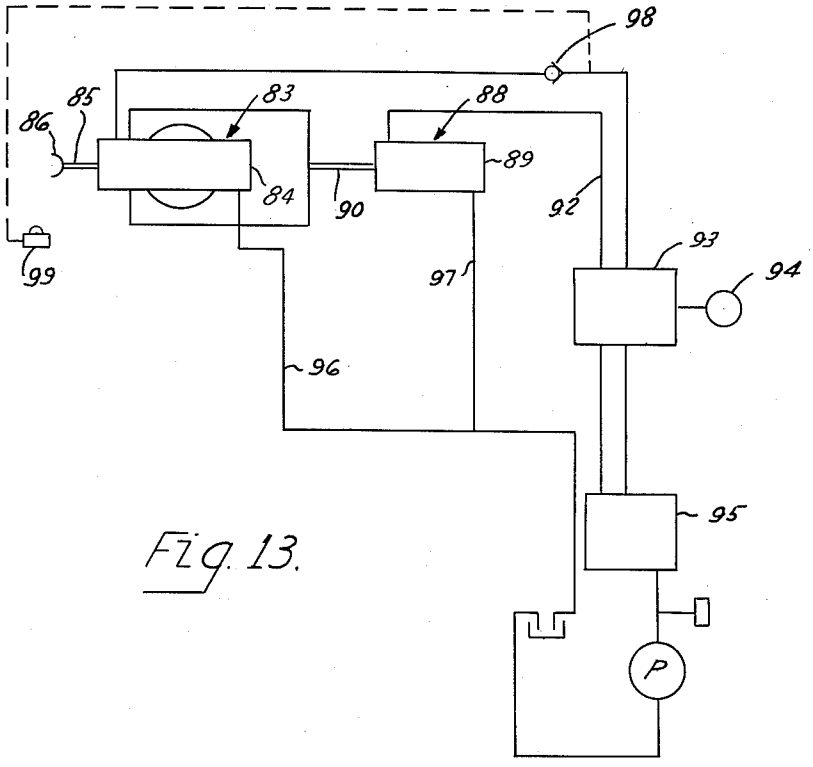


Fig. 13.

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United States Patent Office

2,713,376

Patented July 19, 1955

2,713,376

METAL-FORMING MACHINE

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Application December 17, 1951, Serial No. 262,016

19 Claims. (Cl. 153—40)

This invention relates to a metal-forming machine for forming lengths of metal stock, such as planar and flanged strips, rods, bars, tubes, and the like, into regularly or irregularly curved or contoured shapes and is an improvement on the machine disclosed in U. S. Letters Patent 2,514,830, issued July 11, 1950.

For the purpose of illustration the machine is described hereinafter as applied to stretch-forming, wipe-forming, and combined stretch and wipe forming.

In the stretch-forming of metals by the machine described in the above identified patent, a side face die is mounted on a turntable for rotation therewith, one end of a length of stock is anchored in fixed position relative to the side face die, and the opposite end of the length of stock is gripped by a suitable tool which is mounted on a piston of a piston and cylinder assemblage. The assemblage is operable to exert and maintain a predetermined tension on the stock as the stock is wrapped about the side-face die by rotation of the turntable. As a result of this operation, particularly if the stock is stressed close to the elastic limit during wrapping, the stock is made to conform to the side face of the die with little or no springback.

Generally, during forming of a relatively wide strip of sheet metal stock by such a machine, the strip of stock is disposed horizontally endwise with its transverse dimension upright and is bent or curved mostly flatwise of the strip. More complicated forms, however, often are required, particularly in airplane structures and the like. Many of these more complicated forms require that the stock be curved not only flatwise of the stock but also somewhat edgewise. Further, many forms require that the stock be twisted about its longitudinal axis in addition to being curved flatwise and edgewise. In such instances it is necessary that the stock be formed about a side face die of which the forming face not only slopes lengthwise at various angles to the plane of the turntable, but also slopes transversely at various angles to the axis of rotation. Thus during forming of stock about such a die, the stock may have its transverse dimension upright at all times, or at a fixed angle to the axis of rotation, or at various angles to the axis of rotation as forming progresses. Likewise, some shapes require that the stock extend lengthwise parallel to the plane of the turntable, or slope lengthwise relative thereto at a uniform angle or slope at progressively changing angles as the work progresses.

One feature of the present invention is the provision in a metal-forming machine, such as described in the above patent, of a header assembly connected to the piston of the metal stressing piston and cylinder assemblage and adapted for operative connection with the stock and so arranged that the tool carried thereby can be moved vertically to cause the stock to follow the longitudinal line of slope of the forming face of the die and also can be rotated or rocked about axes generally parallel to the axis of the piston in its various vertical positions to cause the

stock to twist and conform with the transverse line of slope of the forming face.

Another feature resides in the arrangement of a stretch-forming header assembly and wipe-forming header assembly whereby the stock can be subjected concurrently to stretch and wipe forming operations even when the piece to be formed necessitates that the stock slope lengthwise relative to the horizontal, or plane of the turntable, and also transversely relative to the axis of rotation of the turntable.

Another feature relates to the provision of means for greatly increasing the effective range of travel of the gripping head of the stretch-forming header assembly so that a very long length of stock can be formed effectively in a continuous operation while the pull applied thereto is maintained substantially uniform throughout the entire forming operation.

More specific objects and advantages of the invention will become apparent from the following description, wherein reference is made to the drawings in which:

Fig. 1 is a side elevation of a preferred form of metal-forming machine and header assembly combination of the present invention, part of the machine being shown in section for clearness in illustration;

Fig. 2 is a top plan view of the machine illustrated in Fig. 1;

Fig. 3 is an enlarged fragmentary top plan view of a preferred header assembly of the present invention;

Fig. 4 is a side elevation of the structure illustrated in Fig. 3, part thereof being shown in section for clearness in illustration;

Fig. 5 is a fragmentary vertical sectional view of the header assembly and is taken on the line 5—5 in Fig. 4;

Figs. 6 and 7 are diagrammatic side elevations, respectively, showing mountings and operating positions of the header assembly during the stretch forming of strip stock spirally into a spiral of uniform pitch and of variable pitch, respectively;

Fig. 8 is a diagrammatic top plan view of the machine illustrating a pressure fluid circuit and control means for controlling the operation of the stretch-forming header assembly automatically;

Fig. 9 is a fragmentary top plan view of a header assembly, such as illustrated in Fig. 3, and cooperating die showing the assembly arranged for wipe-forming instead of stretch-forming;

Fig. 10 is a diagrammatic side elevation, partly in section and on a reduced scale, of the structure illustrated in Fig. 9;

Figs. 11 and 12 are respectively a top plan view and front elevation of a modified form of the machine illustrated in Fig. 1 and showing the extension means for increasing the range of travel of the gripping head of the stretch-forming header assembly;

Fig. 13 is a hydraulic flow diagram illustrating the control for coordinating the wipe-forming piston and cylinder assemblage and the extension means of the machine illustrated in Figs. 11 and 12; and

Fig. 14 is a fragmentary side elevation of the wipe-forming header assembly of the machine illustrated in Figs. 11 and 12.

As more fully described in the above identified U. S. Letters Patent, the machine comprises essentially a base 1 on which is mounted a turntable 2 adapted to carry a side face die. The turntable 2 is supported for rotation on the base 1 by means of a vertical shaft 3 and is driven by means of a ring gear 4 which is fixedly secured to the turntable. A driving gear 5 is drivingly connected to the gear 4 and is rotatably driven, through a speed reducer 6, by means of a reversible electric motor 7.

For applying tension on a length of stock which is to be stretch-formed about a side face die on the turntable

2, a piston and cylinder assemblage, indicated generally at 8, is provided. This assemblage comprises essentially a cylinder 9 and a piston 10. Pressure fluid, which may be either compressed air or hydraulic fluid, is supplied to the assemblage at opposite sides of the piston, selectively, by means of flexible hoses 11 and 12, respectively, which may be connected, selectively, one to a source of pressure and the other to a sump. Such a connection may be through any suitable reversing control valve (not shown) arranged to connect the cylinder concurrently at one side of the piston to the pressure source and at the other side to the sump.

The assemblage 8 includes a guideway 13 which is in fixed position relative the cylinder 9. The assemblage 8 and the guideway 13 are mounted on a plate 14 which is rotatably mounted on the base 1 so that the assemblage and guideway can swing as a unit about an upright axis. Suitable shear pins 15 engaging bores in the base 1 are provided for locking the assemblage and guideway against swinging movement about the upright axis when the machine is to be used for wipe-forming, these pins being removed and permitting the assemblage to swing freely about the upright axis for stretch-forming.

The operation of the reversible control valve is effected by means of a lever 16. The pressure fluid is supplied by means of a suitable pump 17 driven by a motor 18.

Mounted in the guideway 13 is an L-shaped carriage 19 which is connected to the piston 10 and is reciprocable thereby along, and is guided by, the guideway 13 in a direction generally toward and away from the table 2.

The structure thus far described is described more fully in the above mentioned U. S. Letters Patent 2,514,830.

In order to embody the principles of the present invention, a header assembly, one preferred form of which is illustrated in Figs. 3 through 5, is provided.

Mounted on the carriage 19 for sliding movement in a direction transversely of the path of movement of the carriage, and preferably vertically, is a tool support 20. The tool support 20 is mounted for such vertical sliding movement by means of guideways 21 on the carriage engaged by suitable dogs 22 carried by the support 20. Mounted on top of the carriage 19, in fixed position relative thereto, is a platform 23 on which is mounted a reversible double-acting piston and cylinder assembly 24 having a piston 25 which is connected to the upper end of the support 20. Operating fluid is supplied to opposite sides of the piston through a suitable control valve by means of hoses or other flexible connections 26 and 27, respectively, for operating the piston to raise and lower the support 20, selectively, and to lock the support 20 hydraulically in any selected vertical position.

Rotatably mounted in the support 20 is a pinion shaft 28 which extends forwardly beyond the forward face of the support 20 in a direction toward the table 2. Mounted on the shaft 28 for rotation therewith is a pinion gear 29 which in turn is engaged by a suitable reciprocable rack 30 so that upon the movement of the rack endwise in opposite directions the shaft 28 is caused to rotate in corresponding opposite directions. The rack 30 is connected to a piston 31 of a reversible double-acting piston cylinder assembly 32. The assembly 32 is provided with flexible hoses 33 and 34 for admitting pressure fluid to opposite sides of the piston 31 for operating the piston 31 in opposite directions, selectively, and for locking the piston hydraulically in any predetermined rotated position. Thus by operation of the assembly 32, the shaft 28 is caused to oscillate or rotate about a horizontal axis extending generally toward and away from the table and parallel to the axis of the piston 10 regardless of the vertical position of the support 20.

Mounted on the forwardly extending end of the pinion shaft 28, for rotation therewith, is a tool holder 35. When used for stretch-forming, the tool holder 35 is provided with gripping jaws 36 which are mounted on a suitable carrier 37 for movement therewith and for movement relatively toward and away from each other. The gripping jaws 36 are in engagement with cam surfaces 38 so that when the carrier 37 is moved in one direction the jaws 36 are moved relatively toward each other, and when the carrier is moved in the opposite direction the jaws are released for movement away from each other.

The carrier 37 is provided with a rearward extension 39 having therein a diagonal slot 40. A suitable dog 41 extends transversely of the extension 39 through the slot 40 and is connected with a plunger 42 which, in turn, is connected to the piston 43 of a reversible double-acting piston and cylinder assembly 44. Operating pressure fluid is admitted to the assembly by flexible couplings 45 and 46 at opposite sides of the piston, respectively, for moving the piston in opposite directions, selectively. Thus, upon movement of the plunger 42 downwardly in Fig. 4, the jaws 36 are released and upon movement of the plunger 42 upwardly the carrier 37 is moved to the left, thus moving the jaws 36 to the left along the cams 38 and moving the jaws relatively toward each other.

When the machine is to be used for stretch-forming, no tool other than the jaws 36 are mounted in the tool holder as the jaws 36 directly grip an end of the stock to be formed, and are themselves the tool. When, however, the machine is to be used for wipe-forming, then a suitable wiping tool is secured in the tool holder 35 by means of jaws 36 and is pressed against the workpiece, as will be more fully described in connection with the Figs. 9 and 10.

As mentioned hereinbefore, the machine has a wide field of application. One use thereof is the stretch-forming of strip stock into elements which are generally circumferentially incomplete right angular frusto-conical shapes. In such instances the stock may extend lengthwise parallel to the plane of the turntable 2, but must be disposed with its transverse dimension at an angle to the axis of the turntable.

In order to illustrate this use of the present invention, the table 2 is shown as equipped with a side face die D having a frusto-conical forming face F. Thus the face F does not slope downwardly circumferentially of the die but only slopes outwardly from its upper edge to its lower edge, thus being disposed at an angle to an upright axis through the die.

In order to form a strip of stock about such a die face, the tool support 20 is raised to the proper level so that the stock will extend horizontally from the face F. The tool holder 35 is oscillated or rotated about a horizontal axis parallel to the axis of the piston 10 so as to hold one end of the stock with its transverse dimension parallel to the face F. The other end of the stock is secured in fixed position relative to the die D.

Thereupon pressure fluid is admitted in front of the piston 10 and the turntable 2 is rotated to stretch form the stock, the holder 35 being held in the proper rotated position by the hydraulically locked piston and cylinder assembly 32.

In some instances the slope of the transverse dimension of the face F relative to the axis of the turntable is not uniform. In such instances, the holder 35 may be rotated by the assembly 32 concurrently with its movement toward the die so as to maintain the stock in parallelism at all times with the face F from the instantaneous point of contact of the stock and face to the holder 35.

Another use of the machine in which advantage is taken of the various features hereinbefore described is in the formation into circumferentially closed shapes, such as circumferentially closed and complete generally frusto-conical annuli and the like, from transversely contoured lengths of stock. The shapes designated as "frusto-conical" may be truly frusto-conical or approximations thereof in overall appearance in that part or all of the transverse dimension slopes relative to the axis. For example, a piece approximately in the shape of a segment of a sphere, except for the intermediate contouring in its transverse dimension, for use as a cowl for radial engines,

illustrates the problems involved and the application of the present machine to their solutions.

Such a finished piece is to be circumferentially closed and with its bases parallel to each other. However, due to the interference of the clamping means for securing an end of the stock for rotation with the die D and to other structural requirements, it is impractical to make such an article and maintain a uniform diameter by stretching it entirely around a die face which, lengthwise, extends parallel to the plane of the turntable.

However, a practical method of forming such articles is to stretch form the stock spirally for a length slightly more than that required for a complete annulus, cut off the excess length, and then spring the severed ends into aligment and butt weld them together. Proper allowance in the die face for transverse springing results in a true annulus of accurate dimension and of which the cross-section at each plane parallel to its bases is circular. Referring to Fig. 6, the die for performing this method has its side face F_1 extending at a uniform pitch axially of the spiral and just sufficient pitch so that the clamping means for the die end of the stock, the holder **35**, and the leading end of the stock do not interfere with each other as a full turn of the spiral is completed.

Since the pitch of the spiral is constant, it is unnecessary to move the support to different elevations as the work progresses. Instead, the holder **20** is elevated, or depressed, as the case may be, to a position such that the stock will extend in a straight line tangent from the line of instantaneous contact with the die face F_1 entirely to the holder **35** in the initial or final rotated position of the die D_1. The stock S necessarily will slope from the holder **35** to the die D_1. A filler block, or auxiliary slide, **20***a* which is slidable vertically on the carriage **19** by the assembly **24** is connected in fixed position to the support **20** so that the holder **35** is disposed at an angle to the horizontal equal to the angle made by the length of the stock S with the horizontal.

Since the lengthwise slope of the spiral face F_1 is constant, the level of the holder **35**, when once set as above pointed out, remains the same throughout the forming operation and also, with no change in the level, the stock remains tangent to the instantaneous line of contact with the forming face F_1.

If desired, however, the block **20***a* may be dispensed with and instead the holder **35** may be mounted on the support **20** in the manner described in connection with Fig. 7.

The slope of the transverse dimension of the stock relative to the axis of the die D_1 is controlled by the assemblage **32** as hereinbefore described.

In Fig. 7 is illustrated another example of the use of the machine in the solution of problems of this general nature.

Often it is necessary to provide circumferentially closed frame members or annuli which overall are of oval, elliptical or like shapes. A typical example of such an article is the frame for the loading door of a cargo plane. Such frames are somewhat elliptical, and accordingly, if they are to be formed as generally spiral lengths of which the ends are sprung into alignment and welded as above described, provision must be made for the change in pitch required in the side face of the die at different points along its length. This is particularly true if the frame, in addition to being elliptical parallel to its general plane, also as a whole is curved or bowed somewhat normal to its general plane.

To form such articles in accordance with the above method, a die D_2 having a side face F_2 is mounted on the turntable **2**, the face F_2 having a pitch which varies at different points along its length.

The support **20** is pivotally secured by a pivot **20***b* to a filler block or auxiliary slide **20***c*, which is slidable on the support **19** by the assembly **24**, so that the support **20**, and with it the holder **35**, can rock about a horizontal axis and thus accommodate itself for alignment endwise with the stock S regardless of the endwise slope of the stock S.

The length of stock S is then connected at one of its ends for rotation with the die D_2 and at the other of its ends with the jaws of the holder **35**. Tension is exerted endwise of the strip of stock S by the piston and cylinder assemblage **8** through the medium of the carriage **19**, auxiliary slide **20***c*, pivot **20***b*, support **20**, and holder **35**. Assuming that the die D_2 is rotated in a direction indicated by the arrow in Fig. 7, the support **20** is moved upwardly progressively so that the line of pull on the strip S is maintained substantially parellel to the endwise slope of the surface F_2 at the instantaneous point of contact at all times. At the same time, the holder **35** is turned progressively about its longitudinal axis so that the strip S is twisted about its own longitudinal axis and is maintained substantially parallel to the transverse line of slope of the surface F_2 at the instantaneous point of contact of the strip and surface F_2. As the die D_2 continues to rotate, the support **20** is moved and the holder **35** is turned to whatever degrees are necessary so that the strip lies flat against and tangent lengthwise to the surface F_2 at the instantaneous point of contact at all times during the forming operation.

In many instances where it is desired to make a large number of duplicate pieces, the piston and cylinder assemblages **24** and **32** can be operated in predetermined fixed relation to the rotated position of the die D_2. A convenient manner of accomplishing this result is by the provision of cams **52** and **53** in fixed relation to the die D_2, preferably on the turntable **2**. These cams operate the plungers **54** and **55**, respectively, of reversible control valves **56** and **57**, respectively. The control valve **56** may be connected to the piston and cylinder assemblage **32** and the control valve **57** to the piston and cylinder assemblage **24**. Thus vertical movement of the support **20** and the oscillation of the tool holder **35** can be so controlled as to maintain the strip in the most advantageous position for forming on the particular die.

It sometimes happens that a strip, during forming, must be twisted to a degree greater than can be accomplished by the rack **30** in a single stroke of the rack. For these extreme cases provision is made for locking the tool holder **35** in a fixed rotated position, for releasing the rack, for moving the rack to its starting position while out of its engagement with the pinion **29**, and for re-engaging the rack for continuing the rotation of the holder **35** farther in the same direction. For this operation the holder **35** is provided at the end adjacent the support **20** with a circumferentially extending row of teeth **60** and a detent **61** is mounted on the support **20** in suitable slideways **62** for movement radially of the shaft **28**. A handle **63** is connected to the detent for effecting radial movement thereof. The detent preferably fits relatively tightly in the slideway **62** so that when moved radially outwardly from the row of teeth **60** it will remain in such position. When it is desired to disengage the rack **30**, the detent **61** is engaged with the teeth **60**, thus locking the holder **35** in its rotated position. A removable backing plate **64** is provided in the support **20** and provides the slideway for the rack **30**. With the tool holder **35** locked against rotation by the detent **61**, the plate **64** is removed whereupon the rack **30** can be moved radially of the shaft **28** and gear **29** to disengage it from the gear **29**. While disengaged, the rack **30** is returned to its starting position and then re-engaged with the gear **29**, after which the plate **64** is replaced and the rack **30** can again be operated to rotate the shaft **28** and the holder **35** farther in the same direction as that in which it had been originally rotated.

Referring to Figs. 9 and 10, when it is desired to use the machine as a wipe former, the piston and cylin-

der assemblage 8 and the guideway 9 are swung about their upright axis into a position in which the axis of the piston intersects the axis of the table 2. By means of the pins 15, the assemblage 8 and guideway 9 are then locked in this position. A wipe-shoe 65, pivotally mounted on its holder 66, is then installed in the tool holder 35, being held in a fixed position therein by means of the jaws 36. When one end of the strip of stock has been anchored for rotation with a die D_3, the piston and cylinder assemblage 8 is operated to force the shoe 65 firmly against the stock so as to press the stock against the forming face F_3 of the die. Starting in this position the assembly 24 is released so that the tool holder 35 can float vertically, and the assembly 32 is released so that the holder 35 can rotate or oscillate about its longitudinal axis thus permitting the wipe-shoe 65 at all times to follow along the forming face F_3 of the die D_3.

In some instances where abrupt curvature occurs in the die face, it is desirable at times during, and preferably at the end of, the forming operation to give a substantial and sudden pull on the end of the stock which is anchored for movement with the table and die so as to assure that the stock will be stressed firmly against the die face on the leading side of the peak of the abrupt curvature. For this purpose there is provided on the table, instead of the ordinary stationary anchor, an anchoring piston and cylinder assemblage 70, the piston 71 of which is provided with a suitable gripping head 72. The assemblage 70 is mounted in fixed position on the turntable 2, and the end of the stock to be secured for rotation with the turntable 2 and die D is gripped by the gripping head 72.

Fluid pressure is admitted to the assemblage 70 so as to hold the piston stationary, the assemblage being one of the double-acting, reversible type. Thus the leading end of the stock is held in fixed position during forming. After the forming operation and before releasing the stock from the tool, fluid pressure is admitted to the assemblage 70 so as to exert on the end of the stock gripped thereby sudden and sufficient tension to stress the stock at the leading side of the peak of abrupt curvature into conformance with the face of the die.

It is apparent from the foregoing description that the tool holder may be rocked about horizontal axes and concurrently moved vertically to different positions so as to to maintain the line of pull, or the line of applied pressure in the case of wipe-forming, in the proper relation to the face of the die to assure better conformance of the stock therewith and to eliminate or reduce the tendency of the stock to creep or slide off of the forming face.

The length of stroke of the piston of the swinging stretching assemblage is limited by a number of practical considerations. Yet it is not feasible in many instances, when forming the stock spirally, to set the die in eccentric relation to the turntable so as to reduce the travel of the holder compared to the travel that would be required if the die were centered, and thus make possible the formation of lengths of stock considerably longer than the travel permitted the holder by the stretching assemblage.

To overcome these problems, an extension means for the stretch-forming piston and cylinder assemblage is provided, as illustrated in Figs. 11 and 12.

Furthermore, in some instances it is necessary to form stock having an accurately contoured cross-section presenting abrupt bends, depressions, flanges, and the like, which must be held accurately to shape and dimension. Frequently also considerable thrust axially of the die develops when spiral faced dies are employed. Such thrusts cause the stock to creep off of the die axially during stretch forming. Likewise, some of the generally frusto-conical shapes are such that the metal of the stock must be stretched at some portions across its width and stretched much less or even upset at other portions across its width. In order to assure the retention, or formation, of the transverse contour and proper relative position of the stock at the instantaneous line of contact with the die, and the proper conformance of the finished workpiece with the die face, concurrent stretch-forming and wipe-forming are employed.

The machine illustrated in Figs. 11 and 12 is one, such as generally described in U. S. Letters Patent 2,514,830, which is adapted for concurrent stretch-forming and wipe-forming as well as for providing greater travel for the holder 35, thus meeting all requirements for large irregular annuli and the like.

Referring to Figs. 11 and 12, the machine comprises a base 81 on which is mounted a power driven turntable 82.

A metal forming piston and cylinder assemblage 83 having a cylinder 84 and a piston 85 with a tool holder 86, corresponding to the assemblage 8 and its holder 35, is provided. The assemblage 83, instead of being mounted for swinging movement on the base 81, is mounted for swinging movement about an upright axis on a supporting carriage 87 which, in turn, is mounted on the base 81 for guided movement endwise therealong generally toward and away from the turntable 82. Except for being mounted on the carriage 87, the assemblage 83, and all associated parts, is the same as the assemblage 8 and associated parts, heretofore described.

In order to provide an extension means for affording greater travel of the holder 86, there is mounted on the base 1 a piston and cylinder assemblage 88. The assemblage 88 comprises a cylinder 89 arranged in fixed position on the base 81 with its axis extending endwise of the path of travel of the carriage 84, and a piston 90 which is connected to the carriage 87.

The assemblages 83 and 88 are operated in such relation to each other that, as the stock is wound about a die D_4 on the turntable 82, the assemblage 88 first operates and permits the carriage 87 to move toward the turntable 2, against the resistance of piston 90, to or almost to, the end of its run. Thereupon, without any noticeable change in the force opposing movement of the holder 86 toward the table, the assemblage 83 operates and permits the holder 86 to continue its resisted movement toward the table without any hesitation. Such continuous movement of the holder 86 against constant pressure is necessary if uniform stretching is to be obtained.

For example, should the total pressure resisting travel of the holder 86 be changed suddenly, or should the machine be stopped after the piston 85 has been extended, the carriage 87 then advanced to a new position, the piston being correspondingly retracted in its cylinder, and the carriage 87 secured in its new position and the operation continued, there would be a pronounced change in thickness or cross section of the metal stock beginning at or near that line of instantaneous contact with the die at which stretch-forming was interrupted.

To provide for continuity in operation of the holder 86 under uniform resistance to movement, the system illustrated diagrammatically in Fig. 13 may be used. In this system, since the pistons 85 and 90 are of different diameter, any well known type of equalizer with the usual safety releases and remote pressure control valves may be used.

The cylinders have their forward or piston ends connected respectively to the source of pressure fluid through lines 91 and 92, an equalizer 93, with a remote pressure control valve 94, and a manual control valve 95 being interposed in both lines 91 and 92 between the source and the cylinders. Lines 96 and 97 are connected to the opposite ends of the cylinders 84 and 89, respectively, and connect with a sump through the valve 94. Interposed in the line 91, preferably between the cylinder 84

and the equalizer, is a pilot operated check valve **98** which is normally seated and, when seated, prevents the discharge of pressure fluid from the piston end of the cylinder **84**.

A pilot valve **99** is mounted on the base **81** in a position in which it can be engaged and operated by a suitable abutment on the carriage **87** so as to open the check valve **98**.

The position of the pilot valve **99** preferably is such that it opens the valve **98** when the piston **90** has reached, or almost reached, its maximum extended position, whereupon the piston **85** continues the application of the yieldable resisting force on the stock. As a result the stock is subjected to the same pull continuously during the forming operation.

It is apparent from the foregoing description that the field of applicability of the machine is greatly expanded by the present improvements.

The machine of Figs. 11 and 12 also is arranged for concurrent stretch-forming and wipe-forming operations.

The wipe-forming assemblage thereof comprises a piston and cylinder assemblage **100** including a cylinder **101** and piston **102**. The cylinder is mounted on the base **81** with its axis offset circumferentially of the turntable **82** from the axis of the cylinder **84** extending generally toward and away from the rotational axis of the turntable **82**. The cylinder **101** is constrained from swinging movement. The assemblage is provided with a reciprocable guided carriage **102** similar to the carriage **19** heretofore described. Mounted on the carriage **102** is a vertical guideway **103** on which a tool holder **104** is mounted on rollers **105** for vertical reciprocation. A suitable wipe-forming shoe **106** is carried by the holder **104**.

The holder is connected to a piston **107** operating in a cylinder **108** which is mounted on the carriage **19**.

The assemblage comprising the piston **107** and cylinder **108** may be merely a dash pot in which instance the holder **104** is free to float vertically but is cushioned in its movements. On the other hand, the assemblage may be a reversible double acting piston and cylinder. In the latter case, the holder **104** may be rendered free floating vertically by fully venting both ends of the cylinder, or if cushioned floating is desired, by partially venting both ends of the cylinder **108**.

The wipe-shoe **106** generally has a transversely contoured face with some portion, or portions engaging with the metal on the die face, or with some shoulder adjacent the die face, so as to prevent the shoe from creeping or kicking axially of the die off of the die face. Under such circumstances free floating movement is all that is necessary to enable the shoe to move vertically so as to follow a spiral die face, as heretofore described, and retain the stock thereon. Thus the transverse contour of the die face or the shoulders provide means for constraining the wipe shoe to move vertically for providing the vertical component of movement for following the spiral face of the die.

For example, in Fig. 14, a die D_4 having a spiral face F_4 with its width sloping relative to the die axis is shown. In this illustration the die D_4 is provided with slide shoulders S_4 at the upper edge and lower edge, respectively, of the face F_4 and the shoe **106** is provided with upper and lower guide lips **109** engageable therewith, respectively. The lips **109** and shoulders S_4 cooperate to prevent movement of the shoe vertically out of proper contact with the face F_4, thus assuring that the stock is held in proper relation on the die.

However it sometimes happens that the spiral is not of constant pitch and the shoe cannot be guided by such lips engaging shoulders on the die. In such cases, a swivelled roller type shoe, or a shoe having a contact face which is narrow lengthwise of the die face, may be required for following the variable pitch face of the die. In any event, if the vertical position of the shoe cannot be obtained by the cooperating lips and shoulders described, they are dispensed with and the shoe is moved positively vertically by operation of the cylinder **108** and piston **107** by positive fluid pressure so as to cause the shoe to rise or fall in proper alignment with the die face and to hold the shoe in proper instantaneous alignment vertically.

Having thus described my invention, I claim:

1. In a machine of the character described and comprising a base, a power driven rotatable turntable on the base and adapted to support a side face die, a metal-forming piston and cylinder assemblage mounted on the base with the piston axis extending generally toward and away from the turntable in a plane generally normal to the turntable axis, said assembly including a tool supporting member adapted to support a tool for operatively connecting the piston to the stock, a supplemental metal-forming piston and cylinder assemblage rotatable with the turntable, clamping jaws carried by the piston of the supplemental assembly and adapted to grip an end of a length of stock for exerting metal-forming tension thereon, by the piston of the supplemental assembly, control means for controlling the admission of fluid pressure to the supplemental assemblage so as to operate the supplemental assemblage selectively for moving the end of the stock under said tension relative to the turntable and for holding the end of the stock in fixed position relative to the turntable and independent control means for controlling the admission of pressure fluid to the other assemblage independently of the supplemental assemblage.

2. In a machine of the character described and comprising a base, a power driven rotatable turntable on the base and adapted to support a side face die, and clamping means for connecting one end of a length of stock for rotation with the turntable, a carriage mounted on the base for movement lineally toward and away from the turntable, a stretch-forming piston and cylinder assemblage, means mounting the assembly on the carriage with the piston axis extending generally toward and away from the turntable in a plane generally normal to the turntable axis and for swinging movement about an upright axis parallel to and offset from the axis of the turntable, a header assembly connected to the piston for movement therewith as the piston is moved axially, said assembly including a tool supporting member adapted to support a tool for operatively connecting the piston to said stock, a second stretch-forming piston and cylinder assemblage mounted on the base with its piston axis extending lengthwise of the path of travel of the carriage, means operatively connecting the piston of the second assemblage to the carriage for yieldably resisting movement of the carriage toward the turntable.

3. The structure according to claim 2 characterized in that control means are provided for rendering the assemblages operative in succession for yieldably resisting movement of the tool supporting member toward the turntable.

4. The structure according to claim 3 characterized in that said control means admits fluid pressure to the cylinder of said assemblage so as to operate the said second assemblage by the fluid pressure to resist yieldably the movement of the carriage toward the table along the major portion of its path of travel while locking the piston of the first assemblage from movement in its cylinder, after which it admits fluid pressure to the cylinders so as to operate the piston of the first assemblage by fluid pressure to yieldably resist movement of the tool supporting member toward the table.

5. In a machine of the character described and comprising a base, a power driven rotatable horizontal turntable on the base and adapted to support a side face die, and clamping means for connecting one end of a length of stock for rotation with the turntable, a stretch-forming piston and cylinder assemblage mounted on the base for swinging movement about an upright axis offset from the axis of the turntable, and with the piston axis extending

generally toward and away from the turntable in a generally horizontal plane, a horizontal guideway fixed in position relative to the cylinder and extending parallel to the axis thereof, a carriage reciprocable along said guideway and guided thereby and connected to the piston for movement therewith, a clamping head, means connecting the clamping head to the carriage for movement therewith lengthwise of the guideway, for rotation about axes extending generally toward and away from the table, and for movement transversely of said last mentioned axes, concurrently, a wipe-forming piston and cylinder assemblage mounted on the base with the piston axis extending generally toward and away from the turntable in a generally horizontal plane, a second horizontal guideway fixed in position relative to the wipe-forming cylinder and extending parallel to the axis thereof, a second carriage reciprocable along, and guided by, the second guideway, a wipe-tool supporting member, mounting means mounting the member on the second carriage for movement therewith along the guideway and for free floating vertical movement relative to the carriage, means for supplying pressure fluid to the stretch-forming cylinder in front of the piston, and means for supplying pressure fluid to the wipe-forming cylinder in back of the piston while pressure fluid is being so supplied to the stretch-forming cylinder.

6. In a machine of the character described and comprising a base, a power driven rotatable turntable on the base and adapted to support a side face die, and clamping means for connecting one end of a length of stock for rotation with the turntable, a metal-forming piston and cylinder assemblage, means on the base supporting the assemblage with the piston axis extending generally toward and away from the turntable in a plane generally normal to the table axis, a guideway fixed in position relative to the cylinder and extending parallel to the axis thereof, a carriage reciprocable along, and guided by, the guideway, and connected to the piston for movement therewith, a tool supporting member, mounting means mounting the member on the carriage for movement therewith and for rotation in opposite directions about an axis extending generally toward the turntable, said member being adapted to support a tool for operatively connecting the piston to said stock, auxiliary power means drivingly connected to the member and operable to effect said rotation of the member, and control means for controlling the auxiliary power means for rotating said member in opposite directions, selectively.

7. The structure according to claim 6 characterized in that said auxiliary power means comprises an auxiliary reversible piston and cylinder assembly, a rack connected to the piston of the auxiliary assembly for reciprocation thereby, and a pinion coaxial with, and rotatable with, the member and in driving engagement with the rack.

8. The structure according to claim 6 characterized in that means are provided for operating the control means for the auxiliary power means in predetermined relations to the rotated position of the turntable for controlling the operation of the auxiliary power means in relation to the rotated position of the turntable.

9. In a machine of the character described and comprising a base, a power driven rotatable turntable on the base and adapted to support a side face die, and clamping means for connecting one end of a length of stock for rotation with the turntable, a metal-forming piston and cylinder assemblage, means on the base supporting the assemblage with the piston axis extending generally toward and away from the turntable in a plane generally normal to the table axis, a guideway fixed in position relative to the cylinder and extending parallel to the axis thereof, a carriage reciprocable along, and guided by, the guideway, and connected to the piston for movement therewith, a tool supporting member, mounting means mounting the member on the carriage for movement therewith and for rotation in opposite directions about an axis extending generally toward the turntable, said member being adapted to support a tool for operatively connecting the piston to said stock, and said mounting means including a support mounted on the carriage for movement transversely of the path of movement of the carriage and rotatably supporting the member for said rotation in a plurality of relative positions of the support and carriage.

10. The structure according to claim 9 characterized in that auxiliary power means are drivingly connected to said support and are operable to effect said transverse movement of the support.

11. The structure according to claim 10 characterized in that control means for the auxiliary power means are provided and are operative in predetermined relations to the rotated positions of the turntable for controlling the operation of the auxiliary power means in relation to rotated positions of the turntable.

12. The structure according to claim 9 characterized in that separate and independently operable auxiliary power means are provided for the support and member, respectively, for rotating the member and for moving the support transversely, respectively.

13. The structure according to claim 12 characterized in that the auxiliary power means for moving the support are mounted on the carriage and the auxiliary power means for rotating the member are mounted on the support.

14. The structure according to claim 9 characterized in that means connect the member to the support for relative rocking movement about an axis extending transversely of the axis of rotation of the member.

15. In a machine of the character described, a base, a horizontal power driven rotatable turntable on the base, a side face die mounted on the turntable for rotation therewith, clamping means for connecting one end of a length of stock for rotation with the turntable, a metal-forming piston and cylinder assemblage mounted on the base with the piston axis extending generally horizontally toward and away from the turntable, a guideway fixed in position relative to the cylinder and extending parallel to the axis thereof, a carriage reciprocable along, and guided by, the guideway, and connected to the piston for movement thereby, a tool supporting member, mounting means mounting the member on the carriage for movement therewith and for guided vertical bodily movement in opposite directions relative thereto parallel to its original position, a wipe forming shoe carried by and movable with the member and having a lateral wiping face complementary to and engageable with the side face of the die, the side face of the die sloping in a direction axially of the die whereby the instantaneous area of the side face of the die presented for engagement by the shoe is at different elevations relative to the plane of the turntable in different rotated positions of the side face die, guiding means rotatable with the die, cooperative means operatively connected to the shoe and in engagement with and operated by the guiding means of the die and constraining the shoe to move vertically in opposite directions in accordance with the elevation of the instantaneous area of the die engaged by the shoe.

16. A structure according to claim 15 characterized in that means are provided and connected to the member for yieldably resisting said vertical movement of the member.

17. A structure according to claim 15 characterized in that said shoe is supported by said supporting member and mounting means for rotation about an axis extending generally horizontally toward and way from the table.

18. In a machine of the character described, a base, a horizontal power driven turntable on the base, a side face die mounted on the turntable for rotation therewith, clamping means for connecting one end of a length

of stock for rotation with the turntable, a metal forming piston and cylinder assemblage mounted on the base with the piston axis extending generally horizontally toward and away from the turntable, a guideway fixed in position relative to the cylinder and extending parallel to the axis thereof, a carriage reciprocable along, and guided by, the guideway and connected to the piston for movement thereby, a tool supporting member, means mounting the member on the carriage for movement therewith and for guided vertical movement relative thereto, a wipe forming shoe mounted on the tool supporting member for vertical movement therewith, power means carried by the carriage and operatively connected to the tool supporting member and operable to move the tool supporting member vertically in opposite directions, and control means for controlling the operation of the power means for moving said member vertically in opposite directions selectively.

19. In a machine of the character described and comprising a base, a power driven rotatable turntable on the base and adapted to support a side face die, and clamping means for connecting one end of a length of stock for rotation with the turntable, a metal-forming piston and cylinder assemblage, means on the base supporting the assemblage with the piston axis extending generally toward and away from the turntable in a plane generally normal to the table axis, a guideway fixed in position relative to the cylinder and extending parallel to the axis thereof, a carriage reciprocable along, and guided by, the guideway, and connected to the piston

for movement therewith, a tool supporting member, including a support, means mounting the support on the carriage for movement transversely of the path of movement of the carriage, auxiliary power means carried by the carriage and connected to said support and operable to effect said transverse movement of said support in opposite directions, independently of the rotation of the turntable and control means for controlling the auxiliary power means so as to move the support in said opposite directions selectively.

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