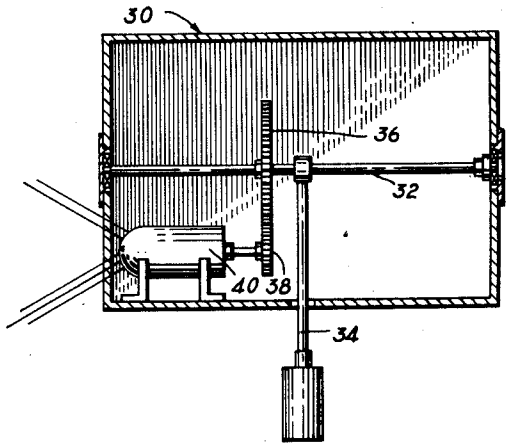
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CONTROL AND INDICATING MEANS

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Fig. 2



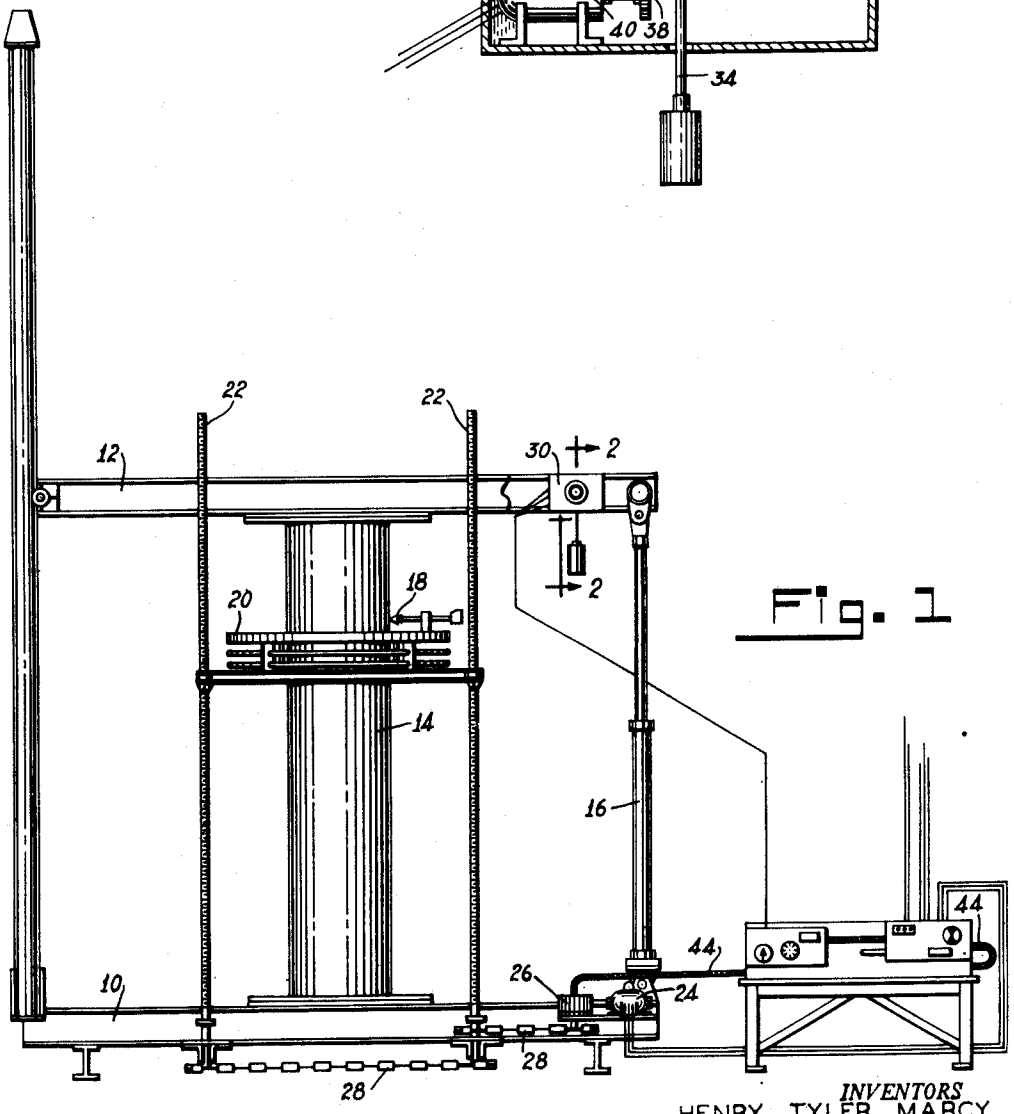


Fig. 1

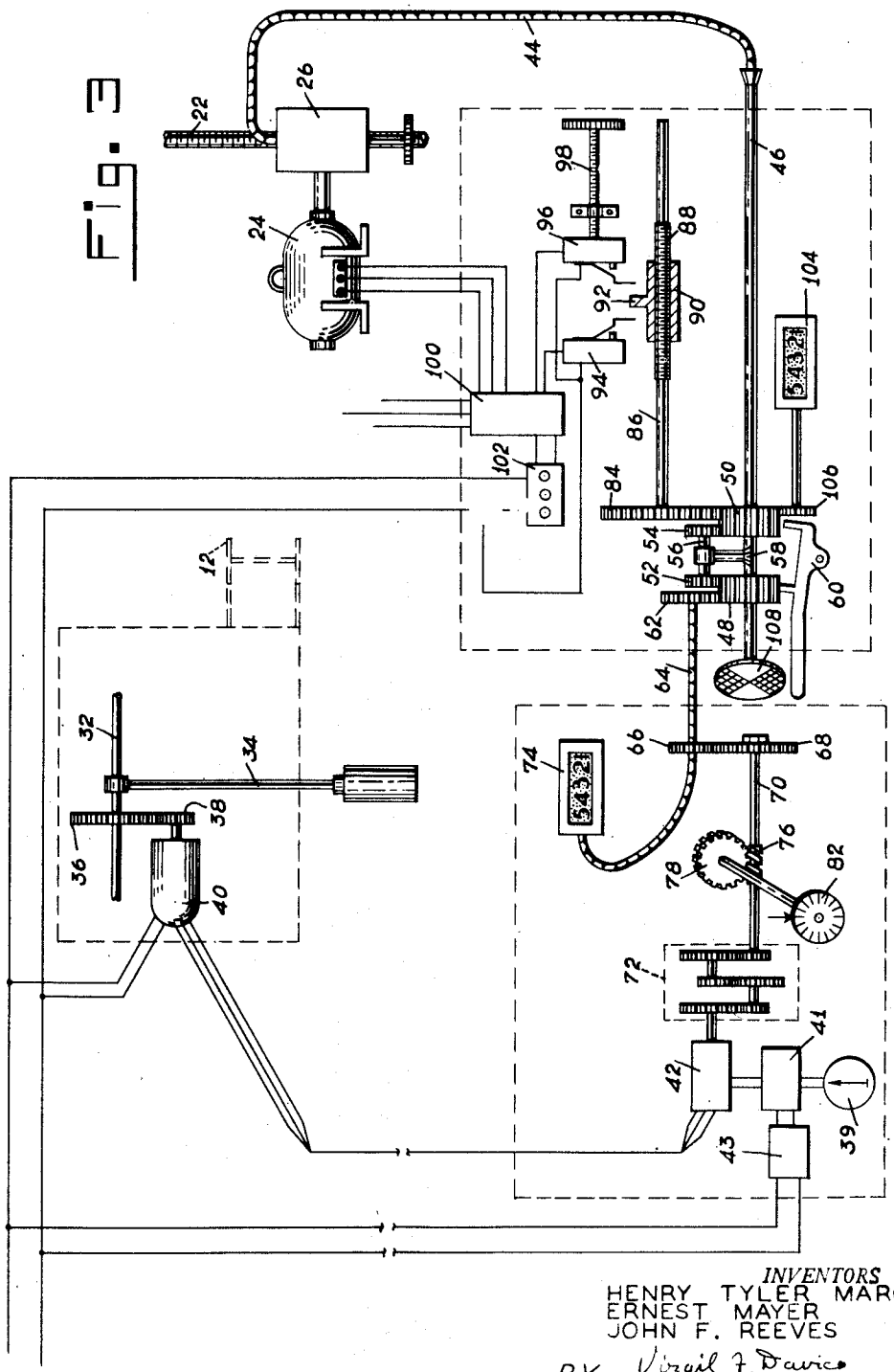
INVENTORS
HENRY TYLER MARCY
ERNEST MAYER
JOHN F. REEVES
BY Virgil F. Harris
Joseph Dalida
ATTORNEYS

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Fig. 3



INVENTORS
HENRY TYLER MARCY
ERNEST MAYER
JOHN F. REEVES

BY Virgil T. Davis
Joseph Daleda
ATTORNEYS

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CONTROL AND INDICATING MEANS

Henry Tyler Marcy, Staten Island, N. Y., Ernest Mayer, Jersey City, N. J., and John F. Reeves, Staten Island, N. Y., assignors to The M. W. Kellogg Co., Jersey City, N. J., a corporation of Delaware

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6 Claims. (Cl. 153—32)

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The present invention relates to control and indicating means and specifically pertains to control and indicating means particularly adapted for use with an apparatus for bending thermoplastic bodies in predetermined increments.

In application Serial No. 27,978, filed May 19, 1948, by Frederick A. Fitchmueller, for "Method and Apparatus for Bending Pipe," there is disclosed an apparatus capable of bending pipe in predetermined increments to a predetermined curvature. The apparatus disclosed in the above cited application comprises means for holding a length of pipe in a substantially vertical position, a stress applying beam member adapted to be attached to the upper end of the pipe, means for applying a bending force to the stress applying beam member, and a plurality of burners adapted to oscillate up and down along the pipe to heat predetermined increments of relatively narrow circumferential bands thereon to a predetermined temperature. When a circumferential band has been heated to a temperature such that the material thereof is capable of substantially uniform plastic flow, bending forces are applied thereto by means of the stress applying beam member to cause the heated band to be bent a predetermined amount.

It is desirable to have some means for controlling the oscillation of the burners to insure that the width of the bands is accurately maintained, that they are accurately located along the length of pipe, and that the material of said bands is heated uniformly throughout their widths.

It is also desirable that means be provided to indicate when the stress applying beam member has moved through a distance sufficient to impart a desired predetermined bend to the increment being shaped.

Accordingly it is one object of the present invention to provide an apparatus capable of indicating the degree of bend that has been applied to a section of material being shaped incrementally.

It is another object of the present invention to provide a control apparatus for aiding the incremental shaping of thermoplastic bodies by regulating the width of band heated and by measuring the angle to which each incremental band is bent.

It is still another object of the present invention to provide a control and indicating means suitable for use with an apparatus of the type disclosed in application Serial No. 27,978, wherein said means regulates the width of increment heated and indicates when a predetermined degree of shaping has been applied to said increment.

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It is a further object of the present invention to provide a control and indicating means suitable for use with an apparatus of the type disclosed in application Serial No. 27,978, wherein positioning the burners of said apparatus sets the control and indicating means to indicate continuously or selectively the desired angle of bend which must be imparted to the new increment.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings, wherein,

Fig. 1 is a somewhat diagrammatic elevation of an apparatus of the type disclosed in application Serial No. 27,978 and showing the control and indicating means of the present invention, operatively connected thereto;

Fig. 2 is a similar diagrammatic elevation partly in section taken along the line 2—2 of Fig. 1 and looking in the direction of the arrows; and

Fig. 3 is a diagrammatic view of the control and indicating means of the present invention.

When thermoplastic bodies are bent or shaped by incremental bending, a plurality of increments are each bent or shaped through a predetermined angle, and the total bending or shaping of the body is the sum of the bending or shaping that is applied to, or imposed upon, each of the plurality of increments. When an apparatus of the type disclosed in application Serial No. 27,978 is employed to incrementally bend or shape a thermoplastic body, the stress applying beam member will have a predetermined slope prior to shaping or bending each increment, and will have a different slope or angle when the increment has been bent or shaped as desired. It is, therefore, possible to control the bending or shaping of a thermoplastic body in an aparatus of this type by comparing its slope with the slope it must assume when the particular increment being operated upon has been bent the desired amount.

The indicating and control means of the present invention is capable of comparing the slope of the stress applying beam with the predetermined slope that it must assume when the increment is bent as desired and indicating when said predetermined slope has been attained. The in-

dicating and control means is also capable of automatically resetting itself, when the bending or shaping apparatus is reset to bend or shape subsequent increments, to indicate the slope that the stress applying beam must assume to correctly shape the new increment. The indicating and control means of the present invention is also capable of controlling the movement of the means employed to heat each incremental band to insure that each band is heated uniformly throughout its width and to also insure that each increment is the desired predetermined width.

Fig. 1 is a diagrammatic elevational view of an apparatus for incrementally bending thermoplastic bodies. The bending apparatus disclosed in Fig. 1 is generally similar to the apparatus disclosed in the above mentioned application Serial No. 27, 978, and comprises a base member 10 and a stress applying beam 12 adapted to engage and be fastened respectively to the opposite ends of a thermoplastic body 14 that is to be bent or shaped. Means are provided, such as hydraulic cylinder 16, for applying a bending force to stress applying beam 12 which in turn applies a bending force to thermoplastic body 14. A plurality of high temperature burners 18 (only one being shown for purposes of clarity) are adjustably carried by frame member 20 for movement longitudinally along thermoplastic body 14. Burners 18 and frame 20 are moved up and down along thermoplastic body 14 by means of screw threaded rods 22 which are rotated by means of a reversible motor 24 acting through a reduction gear 26 and sprocket chains 28.

Burners 18 can be raised or lowered along thermoplastic body 14 by controlling the direction of rotation of motor 24. When the apparatus is in operation, burners 18 are oscillated up and down along thermoplastic body 14 a distance equal to the width of the increment or unit band that is being bent, to insure said increment or unit band being heated evenly throughout its width. Each increment or band that is bent or shaped will cause stress applying beam 12 to assume a different slope. If the slope that said stress applying beam 12 will assume is known, the radius of curvature that is applied to thermoplastic body 14 can be accurately controlled by bending each increment or band until stress applying beam 12 assumes the predetermined slope.

Fig. 2 is an elevational view partly in section of a slope measuring and indicating means 30 which is mounted on stress applying beam 12. Slope measuring and indicating means 30 is comprised of shaft 32 which carries and is rotated by a derangeable or balancing means such as pendulum 34. Gear 36 is carried by shaft 32 and is enmeshed with gear 38 which is connected to the rotor of synchro transmitter 40, so that the rotation of shaft 32 causes rotation in synchro transmitter 40. The ratio of gear 36 to gear 38 is such that the rotation of shaft 32 is magnified in the order of about 6 to 1 so that a slight rotation of shaft 32 produces an appreciable rotation in synchro transmitter 40 and thus increases the accuracy of slope measuring and indicating means 30.

It will be seen that as stress applying beam 12 rotates through a predetermined angle of arc as a given increment of thermoplastic body 14 is bent or shaped, pendulum 34 will cause rotation in synchro transmitter 40, causing transmission of a signal that can be calibrated in terms of the slope or angle of stress applying beam 12. The signal transmitted by synchro transmitter 40 is fed to the stator of control transformer 42 which is located remote from slope measuring and indicating means 30, preferably adjacent the manual controls for the bending apparatus. (See Fig. 3.)

It can be appreciated by those skilled in the art that pendulum 34 can be mounted in a gimbal and with the same basic instrumentation, the control and indicating means can be used for 3-dimensional bends. Moreover, other derangeable or balancing means such as a gyroscope assembly can be substituted for the pendulum to cause rotation of shaft 32.

When synchro transmitter 40 and control transformer 42 are in balance, the voltage across the rotor of control transformer 42 is zero; when they are not in balance, there is a voltage across the rotor of control transformer 42. It will therefore be seen that if the rotor of control transformer 42 is rotated to place control transformer 42 out of balance with synchro transmitter 40, the rotor of synchro transmitter 40 can be rotated to bring synchro transmitter 40 back in balance with control transformer 42. Therefore, if the rotor of control transformer 42 is rotated an amount corresponding to the angle that it is necessary for stress applying beam 12 to pass through, to bend one increment a predetermined amount, the increment of thermoplastic body 14 being shaped has been bent the predetermined desired amount when synchro transmitter 40, is brought back into balance with control transformer 42, by the rotation of stress applying beam 12.

The signal voltage generated by the rotor of control transformer 42 is fed to galvanometer 39 through phase sensitive rectifier 41. An alternating reference voltage is supplied to phase sensitive rectifier 41 by tapping the same power line that provides an alternating voltage to excite the rotor of synchro transmitter 40, and passing the voltage thus obtained through a phase shift network 43 prior to feeding it into said rectifier 41. The phase shift network 43 operates on the voltage and compensates for the phase shift that occurs in synchro transmitter 40 and control transformer 42 to place it in phase with the signal voltage from the rotor of control transformer 42. Phase sensitive rectifier 41 supplies galvanometer 39 with a D. C. voltage that is proportional to the signal voltage from control transformer 42 and which has a polarity determined by the phase of the signal voltage with respect to the phase of the reference voltage. It will therefore be seen that it is possible to tell from the position of the needle of galvanometer 39 whether synchro transmitter 40 and control transformer 42 are in balance, or if the rotor of synchro transmitter has not rotated far enough to bring them in balance, or if it has rotated past the balance point. Since phase sensitive rectifier 41 and phase shift network 43 do not, per se, comprise the present invention, and inasmuch as there are several prior art circuits capable of functioning in the above described manner, they are not described in detail.

The control and indicating means of the present invention is connected to reduction gear 26 by means of flexible shaft 44, and means, to be explained more in detail hereinafter, are provided whereby lowering burners 18 to a new unit increment or band on thermoplastic body 14 causes the rotor of control transformer 42 to be rotated a predetermined amount so that it will indicate the angle or slope, stress applying beam 12 must assume when the new increment or band has been bent the correct amount.

Flexible shaft 44 is coupled directly to shaft 46 which carries a differential, comprising gears 48

and 50, which are mounted for rotation on shaft 46, and spider gears 52 and 54 meshed with gears 48 and 50, respectively, and fixedly mounted on shaft 56 which in turn is rotatably mounted in arm 58 rigidly attached to shaft 46. Locking means 60 is pivotally mounted adjacent gears 48 and 50 for selectively locking either gear 48 or gear 50. When locking means 60 is rocked to engage and lock gear 50, spider gear 54 is forced to roll around gear 50. This causes gear 52 to rotate, and gear 52 in turn rotates gear 48. Gear 48 drives gear 62 which, through flexible shaft 64, rotates gear 66 and 68 and shaft 70. Shaft 70, operating through a series of reduction gears 72, rotates the rotor of control transformer 42. Gears 66 and 68 are made readily interchangeable with others so that the amount the rotor of control transformer 42 is rotated for each rotation of flexible shaft 44 can be set at any predetermined amount. This makes it possible to set the control and indicating means of the present invention to control any predetermined radius of bend in thermoplastic body 14. It is a natural extension of this that a continuously variable ratio could be used and so programmed as to introduce any desired single plane shape to the thermoplastic body.

Flexible shaft 64 extends through gear 66 and is connected to a counter 74 that is calibrated to give the total number of increments that have been bent or shaped along body 14. Shaft 70 carries worm gear 76 which drives pinion gear 78 to rotate dial 82. Dial 82 is calibrated to give the total angle in the case of a circular bend or arc that has been bent or shaped.

It will thus be seen that moving burners 18 along thermoplastic body 14 the predetermined distance for the new incremental bend causes the indicating and control means of the present invention to set control transformer 42 for the new incremental bend and to record on counter 74 and dial 82 respectively the total number of increments that will have been bent or shaped, and the total angle of arc through which those increments will have been bent, the differences in the readings on the counter and dial being determined by prior calculation.

When locking means 60 is rocked so that it locks gear 48 and releases gear 50, spider gears 52 and 54 then cause gear 50 to rotate. Gear 50 drives gear 84 which is fixedly mounted on and rotates shaft 86. A portion of shaft 86 is threaded to form lead screw 88 which engages nut 90. A lug 92 is formed on nut 90 and is adapted to engage and actuate electrical switches 94 and 96. Switch 94 is fixedly mounted, while switch 96 is adjustably carried by adjusting screw 98 for movement towards or away from switch 94. Switches 94 and 96 are connected to motor control relays located in motor control box 100.

After control transformer 42 has been set in the above described manner and locking means 60 has been rocked to lock gear 48 and release gear 50, motor 24 is started by means of manual switches 102, and burners 18 are ignited. Motor 24 through reduction gears 26 and sprocket chains 28 cause burners 18 to travel either up or down along thermoplastic body 14. At the same time flexible shaft 44, transmitting power through shaft 46 and gears 50 and 84, causes lead screw 88 to rotate and move nut 90. When lug 92 engages one of the electrical switches 94 or 96, motor 24 is caused to reverse by reason of switch 94 or 96 actuating motor control relays. The reversal of motor 24 causes burners 18 to travel along thermoplastic body 14 in the opposite direction, and also causes lead screw 88 to rotate in the opposite direction causing nut 90 to reverse its direction until it contacts and actuates the other of switches 94 or 96, causing motor 24 to again reverse. This oscillation of burners 18 along thermoplastic body 14 is permitted to continue until the increment of thermoplastic body 14 under burners 18 has been heated to the predetermined degree, and bent through the predetermined angle or arc as indicated by control transformer 42 and galvanometer 39.

In one form of manual operation, when galvanometer 39 indicates that the increment has been bent through the desired angle of arc, burners 18 are shut off, motor 24 is stopped by manual switch 102, locking means 60 is rocked to lock gear 50 and release gear 48, and motor 24 is started by means of manual switches 102 to lower burners 18 the predetermined desired amount, indicated on dial 82 or counter 74, and to set control transformer 42. The above described cycle is repeated until thermoplastic body 14 has been bent or shaped the desired total amount.

The width of the incremental band on thermoplastic body 14 that is bent or shaped in each cycle is controlled by the spacing between electrical switches 94 and 96. If it is desired to increase the width of band being heated, switch 96 is moved away from switch 94 by means of adjusting screw 98. If it is desired to decrease the width of band being heated, switch 96 is moved toward switch 94 by means of adjusting screw 98.

A second counter 104 is coupled to gear 50 by means of gear 106 and is calibrated to give the number of inches that burners 18 oscillate up and down along thermoplastic body 14. A disc or target 108 is carried by an extension of shaft 46 and serves as an indicating means to notify the operator of the apparatus whether or not motor 24 is running.

The structure as disclosed herein can be modified readily to obtain automatic operation of the machine: e. g. suitable connections can be made between rectifier 41 and either pressure or temperature control means in place of galvanometer 39. If so operated, the pressure would be applied continuously, sufficient in magnitude, to attain the desired bend for the instantaneous position of the heated increments. Likewise the temperature of the heated increment may be used to control the amount of heat released by the burners which are moved at a constant rate; or alternately the heat released by the burners may be constant and the rate of travel of the burners be controlled by the temperature of the heated increment.

Since certain changes may be made without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not limitative.

What is claimed is:

1. Indicating and control means in combination with an apparatus adapted to incrementally shape thermoplastic bodies and including a stress applying member adapted to rotate through a predetermined angle of arc to shape an increment of a thermoplastic body a predetermined amount and means adapted to move along said body to heat the material thereof to a temperature whereat it can be shaped by the force exerted by said stress applying member, comprising signal generating means carried by said stress applying member, a signal receiving means electrically

connected to said signal generating means, and means connected to said heating means for predeterminedly displacing components of said last mentioned means in accordance with the movement of said heating means to thereby indicate the angular disposition of said stress applying member at the end of the shaping increment corresponding to a respective position of said heating means.

2. In combination with an apparatus adapted to incrementally shape thermoplastic bodies and having a stress applying member adapted to rotate through a predetermined angle of arc to successively shape a plurality of increments of a thermoplastic body a predetermined amount and means adapted to move along said body to heat the material thereof to a temperature whereat it can be shaped by the force exerted by said stress applying member, indicating and control means comprising derangeable means carried by said stress applying member, signal generating means also carried by said member and adapted to be actuated by said derangeable means as said member is rotated, control means connected to said signal generating means, and means connected to said heating means for indicating a control quantity on said control means.

3. Indicating and control means for an apparatus adapted to incrementally shape thermoplastic bodies, and including a stress applying member adapted to rotate through a predetermined angle of arc to shape an increment of a thermoplastic body a predetermined amount, and means adapted to move along said body to heat the material thereof to a temperature whereat it can be shaped by the force exerted by said stress applying member, comprising, a derangeable means carried by said stress applying member, a transmitting mechanism also carried by said stress applying member and adapted to be actuated by said derangeable means as said member is rotated, control means electrically connected to said mechanism, and means connected to said heating means for affecting said control means prior to the rotation of said stress applying member.

4. In combination with an apparatus adapted to incrementally shape thermoplastic bodies and having a stress applying member adapted to rotate through a predetermined angle of arc to successively shape a plurality of increments of a thermoplastic body a predetermined amount, heating means, and means adapted to move said heating means along said body to successively heat said plurality of increments substantially uniformly throughout their widths and to move said heating means along said body to successive increments, indicating and control means comprising, a balancing means carried by said stress applying member, signalling means also carried by said stress applying member and adapted to be affected by said balancing means as said member is rotated, a control mechanism connected electrically to said signalling means, and means coupled to said means for moving said heating means for actuating said control mechanism prior to the rotation of said stress applying member.

5. Indicating and control means for an apparatus adapted to incrementally shape thermoplastic bodies and having a stress applying member adapted to rotate through a predetermined angle of arc to successively shape a plurality of increments of a thermoplastic body a predetermined amount, heating means, and means adapted to move said heating means along said body to successively heat said plurality of increments substantially uniformly throughout their widths and to move said heating means along said body to successive increments, the combination including a pendulum carried by said stress applying member, a synchro transmitter also carried by said stress applying member and adapted to be actuated by said pendulum as said member is rotated, a control mechanism, said synchro transmitter being connected electrically to said control mechanism, and means adapted to couple said control mechanism to said means for moving said heating means whereby said means for moving said heating means is capable of rotating said mechanism through a predetermined angle while moving said heating means to a succeeding increment of said body.

6. Indicating and control means for an apparatus adapted to incrementally shape thermoplastic bodies and having a stress applying member adapted to rotate through a predetermined angle of arc to successively shape a plurality of increments of a thermoplastic body a predetermined amount, heating means, and means adapted to move said heating means along said body to successively heat said plurality of increments substantially uniformly throughout their widths and to move said heating means along said body to successive increments, comprising signal generating means carried by said stress applying member capable of transmitting a signal indicative of the slope of said stress applying member, means, actuated by said means adapted to move said heating means, for setting a signal to a value indicative of the angle of arc said stress applying means must pass through in shaping an increment of said body, and means for comparing said last mentioned signal with said signal indicative of the slope of said stress applying member.

HENRY TYLER MARCY.
ERNEST MAYER.
JOHN F. REEVES.

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