United States Patent

Peddinghaus

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[54] BENDING MACHINE

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[30] **Foreign Application Priority Data**

April 22, 1969 Germany ..... P 19 20 265.4

[52] **U.S. Cl.** **72/8,** 72/19, 72/28, 72/DIG. 4

[51] **Int. Cl.** **B21b 37/12**

[58] **Field of Search** ..... 72/6, 8, 19, 22, 28, 29, 149, 72/217, DIG. 4, DIG. 22

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[57] **ABSTRACT**

A bending machine for bars, wires and sections of steel and like materials having a bending plate which supports a pair of bending tools and which is rotatable and drivable in controlled directions, there being also provided a setting member connected to the bending plate for setting various principal bending angles. At least one of the bending tools is provided with switch means which are sensitive to the load applied at the beginning of bending and after reaching the pre-determined principal bending angle keep the drive to the bending plate switched on until the bending plate has achieved an additional bending angle which corresponds to the angle of rotation of the bending plate from the beginning of switching-on until the response of the switch means.

17 Claims, 7 Drawing Figures

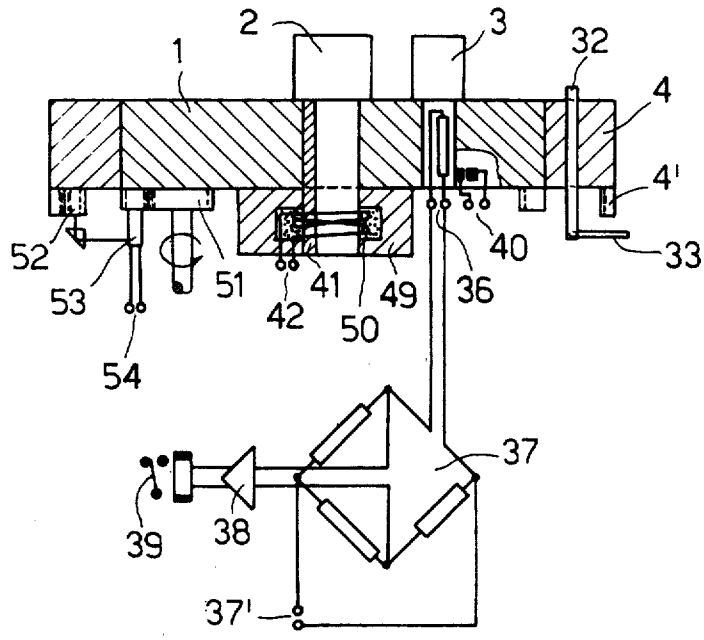


Fig. 1

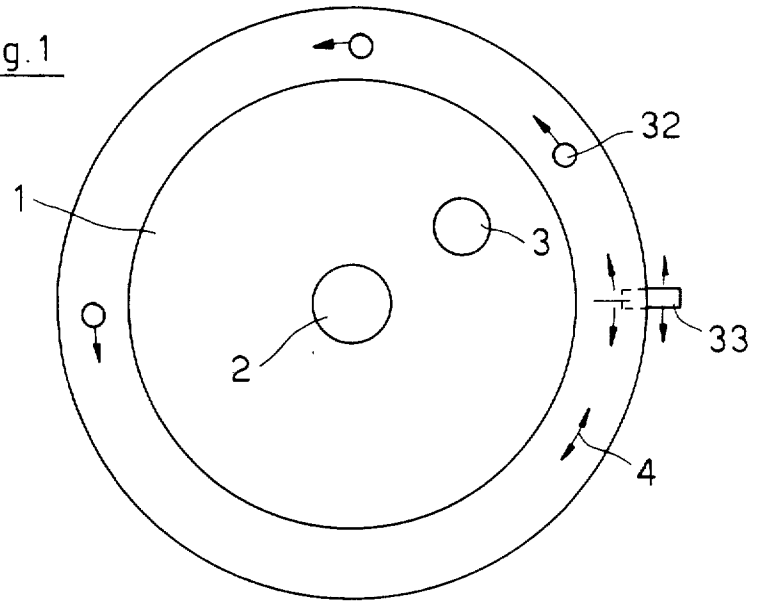
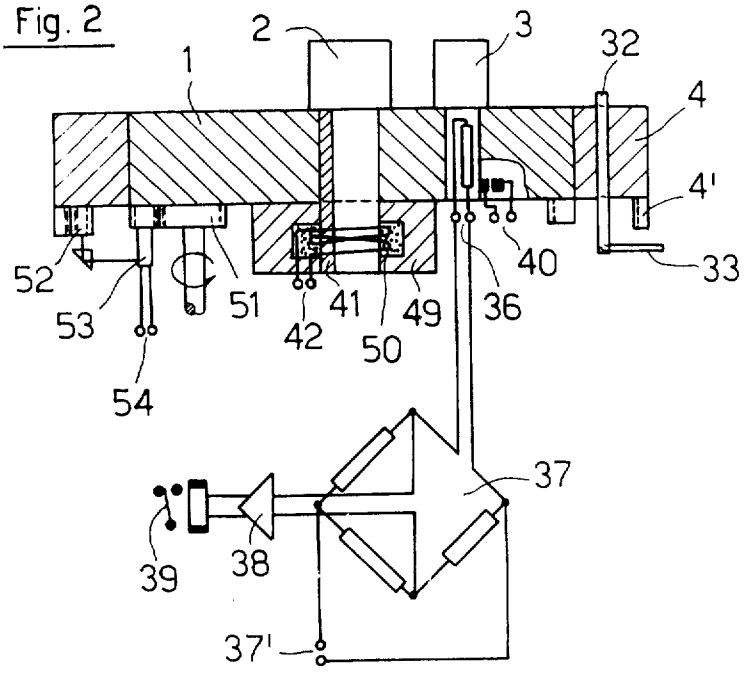


Fig. 2



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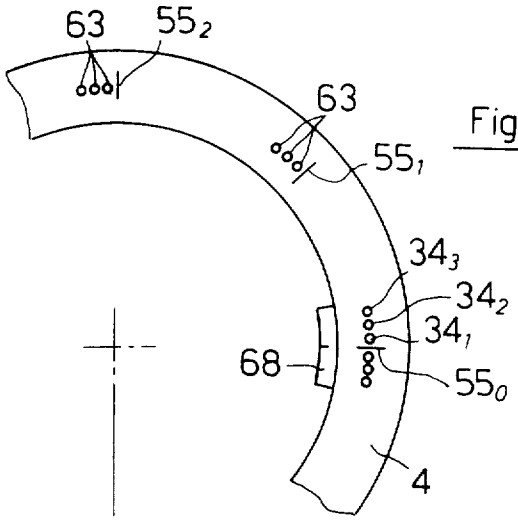

Fig. 3

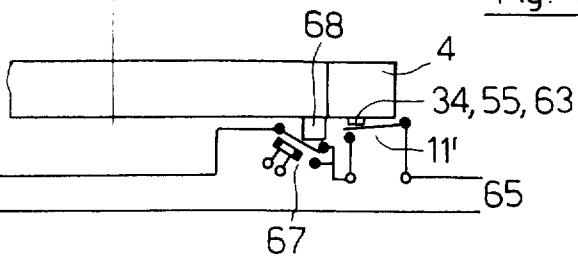

Fig. 4

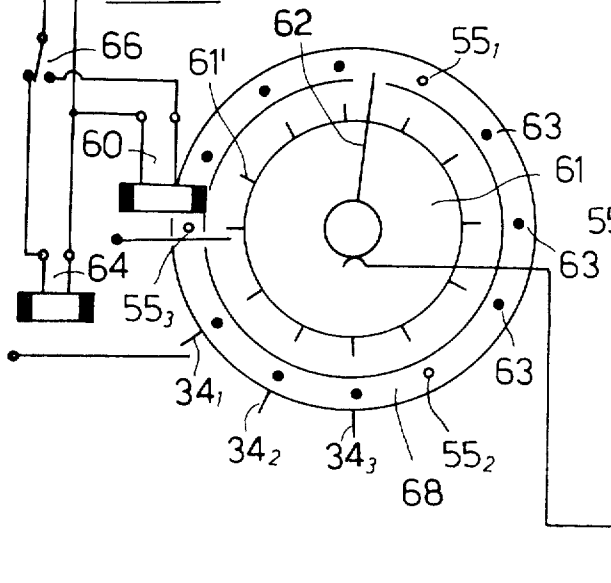

Fig. 5

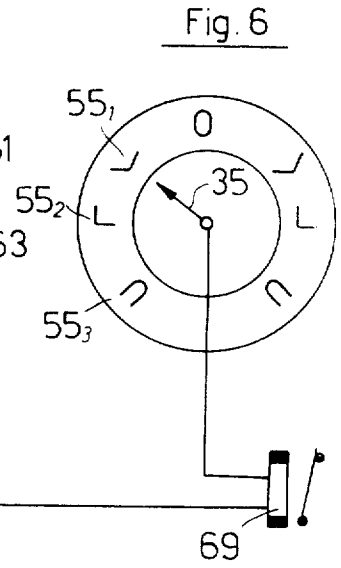

Fig. 6

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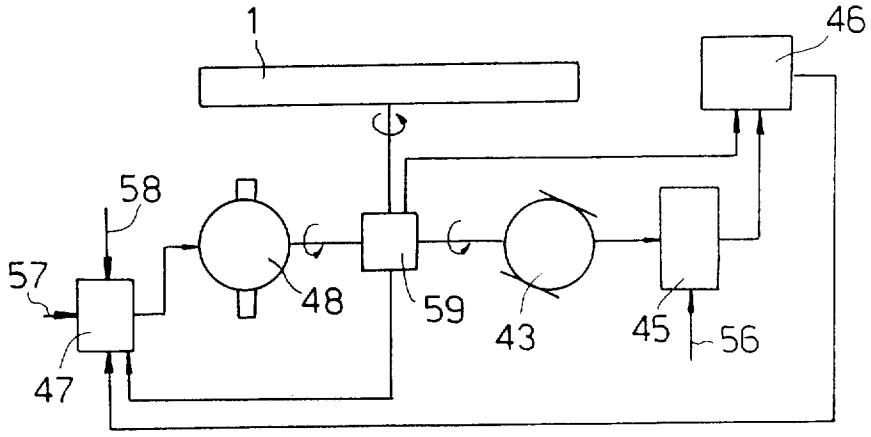
Fig. 7



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BENDING MACHINE

The invention relates to a bending machine for bars, wires and sections of steel and like materials, and having a bending plate, which supports the bending tools, and which is rotatable and drivable in controlled directions, there being also provided a setting means connected to the bending plate for setting the various principal bending angles.

Bending machines of this type are used above all as reinforcing-steel bar bending machines, the bar being guided between the bending tools of the bending plate so as at pre-determined positions (due to the rotation of the bending plate) the bar will be bent at a respectively pre-determined angle. The bending plate is controllably driven such that after the bending is completed it returns to its initial position in order, after an appropriate forwards movement of the bar, to begin the next bending operating, the drive operating in clockwise or in anti-clockwise direction according to the direction of the angle.

It has already been proposed, after any desired pre-determined principal bending angle has been reached, to continue the bending operation automatically by means of an electrical control, after which the directionally controlled drive returns the bending plate to its initial position so that a bending sequency program can be obtained, it being understood that immediately after each individual principal bending operation an additional bending angle can follow which takes into account the thickness and elasticity of the material so that the intended bending angle is in fact attained.

The object of the present invention is to improve still further the above-mentioned arrangement. We will proceed from the fact that the principal bending angles actually obtained in bars, wires or sections with a bending machine of the type described above will deviate substantially from the pre-set main bending angles due to the different strengths of material being bent. However, it is possible with the present invention, to compensate for the error in the principal bending angle actually obtained and which results resulting from the elastic deformation of the material. According to the invention, this is achieved in that at least one of the bending tools is provided with switch means which are sensitive to the load applied at the beginning of bending and which are arranged after the pre-determined principal bending angle is reached to keep the drive of the bending plate switched on until the bending plate has achieved an additional bending angle which corresponds to the angle of rotation of the bending plate from the beginning of switching on until the response of the switch means. In this way it can safely be ensured that the idling of the bending plate, which takes place until positive engagement of the bending tools with the material to be bent, does not result in any reduction of the principal bending angle actually obtained. This is particularly important if the operating program of the bending machine provides a change from one dimension to another. As a further embodiment of the proposal, the switch means are chosen such that a response of the switch means only occurs when a pre-determined minimum bending stress of the bending tools is exceeded. By this means the proportion of elastic deformation of the material to be bent can likewise be completely or partially determined and the bending angle corresponding to this acts at the same time on the previously determined principal bending angle, so that the principal bending angle does not turn out to be too small owing to the elastic deformation.

The extension of the switching-on of the drive of the bending plate can be realized in varying ways. Thus, the setting elements of the setting member can themselves have a variable position, whose change of the angle of rotation of the bending plate is controlled from the beginning of switching-on until the response of the switch means. In addition, a switch feeler arranged to co-act with the setting elements of the setting member can have a variable position, whose change can be controlled in the same way. Finally, the setting member can also have a variable position in relation to the bending plate, the change of angle of which can be controlled as stated.

The elements of the setting member are appropriately impulse transmitters. These impulse transmitters can be co-ordinated in multiple sequences with a principal bending angle and with the initial position of the bending plate, where they follow each other sufficiently closely in order to be able to suppress the deviations of the bending angle over the required tolerance. The principal bending angle is thus pre-set by means of an electric switch feeler to an impulse number corresponding to the principal bending angle to be controlled and in addition by means of the impulses transmitted from the beginning of switching-on until the response of the switch means is automatically switched to a greater impulse number, this further switching finally being interrupted by the response of the switch means to the beginning of bending. Thus, at the switch feeler there is undertaken an automatic angle addition, which, however, can also take place at a step-by-step switch which can be set and which counts the impulses.

In order to be able to form the circuit economically, the impulse transmitters are advantageously arranged only in immediate connection with one principal bending angle as well as in the immediate vicinity of the initial position of the setting member, on both sides of the initial position of the setting member, no more impulse transmitters being provided than in connection with this one principal bending angle. The last-named condition makes it possible to prevent wrong additions of impulses and thus the amounts of angles as a previously controlled principal bending angle.

The switch means connected with the bending tools can be formed in many ways. It is always essential that in some form or other they respond to the load of the bending tool occurring at the beginning of bending.

The said switch means can therefore be strain resistors, which are connected to the bending tools and are components of resistance bridges, whose diagonal voltage is supplied to an amplifier and from there to a switch relay. The switch relay is connected in a circuit, which interrupts a basic, pre-determined extension of the switching-on of the drive beyond the pre-set principal bending angle.

The switch means can also be contacts, which with compressive loading of the bending tools switch on a relay circuit of known type.

The registering of the compressive or bending loading of the bending tools can likewise take place by piezoelectric materials connected to it. In consideration of the relatively rough operating conditions, those switch means which facilitate switching without contact are of particular significance. Amongst other things, this is possible with the use of magnetostrictive material, which forms the bending tools or is contained in them. There can also be provided in the region of the support for the bending tools a coil, which is connected in the relay circuit and which as a result of the alterations of the value of the magnetic property occurring with a compressive or bending load, brings about an actuation of the switch relay.

Alternatively, the drive to the bending plate may be connected to a tacho-generator, the potential of which is fed to a comparator circuit, which on failing to reach a pre-determined reference potential actuates a switch, which in turn switches off a storing circuit, into which a value was fed which corresponds to the angle of rotation of the bending plate from the switching-on of the drive until the loading of the drive at the beginning of bending or in the region of the elastic deformation of the material to be bent, the value fed in corresponding to the amount of the angle delaying the switching-off of the drive. With this embodiment it is assumed that the tacho-generator firstly during the idling of the bending plate produces a constant potential. As it becomes loaded, the speed reduces the potential generated by the tacho-generator. This reduction of potential can be determined in a known comparator circuit, which then, as already described effects a switching-off of the basic pre-determined extension of the switching-on phase of the drive.

The value fed into the storing circuit can again consist of a number of impulses, which is proportional to the angle of rota-

tion on idling. However, the value fed in can also be formed from a potential which is proportional to the angle of rotation. Thus, for example, in known manner, the time constants of an RC-circuit can be influenced, for example the resistance of the RC-circuit can be increased by means of a motor potentiometer, the motor then being switched off by a switch signal transmitted by the comparator circuit. The idling time determined by this can easily by changed by an empirical factor, which takes into consideration the angular velocity reduced on bending in relation to idling, and depend on the switch-on phase of the drive.

The storage member can in addition be a switch feeler of the drive starting-switch, which can be operated by means of the impulses or the potential, which then switches on the drive beyond the pre-set principal bending angle until an additional bending angle has been achieved which corresponds to the value of the angle of rotation fed-in at the beginning of the drive. In this case, even the switch feeler, which was previously pre-set to a specific principal bending angle, is changed.

When using the proposed tacho-generator also, because of the value fed-in, the position of the setting elements on the setting member or the position of the setting member in relation to the bending plate are changed by a value of the same angle. Finally, due to the stored value, the position of a mechanical switch feeler which can be directly co-ordinated on the setting means, can be altered by an amount of the same angle.

The invention is illustrated by the drawings relating to the embodiments.

FIG. 1 is a plan view of a bending plate constructed as an example,

FIG. 2 is a sectional view of a bending plate constructed according to several embodiments,

FIG. 3 is a plan view of an annular setting member with impulse transmitters,

FIG. 4 is a side view of the setting member shown in FIG. 3,

FIG. 5 is an impulse-operated step-by-step switch,

FIG. 6 is a starting-switch and

FIG. 7 is a block diagram of a further embodiment.

According to FIG. 1 there is shown a bending plate 1, of the bending machine, which can be constructed in a known manner, and which supports the central bending tool 2 and the eccentric bending tool 3. The bending plate 1 is surrounded by an annular setting member 4, in which setting means 32 corresponding to the principal bending angles are inserted and which can be controlled with the assistance of the switch feeler 33. The setting means 32 can be varied in position according to the arrow, likewise their switch feeler 33 and also, in a manner still to be described, the annular setting member 4 in relation to the bending plate 1.

FIG. 2 shows various embodiments of how the bending tools can be equipped with the switch means. The bending tools 2 and 3 with their shafts penetrate the bending plate 1 or are inserted in it. Compressive and bending strains are taken positively in the respective shafts of the bending tools. Since the sections of the shafts of the bending tools in the plate 1 always have little play with respect to the openings provided for them in the bending plate 1, there is provided in the bending plate, for example, a micro-switch, whose terminals are shown in FIG. 2 at 40. There is connected to these terminals a flexible cable, it being understood that the bending plate 1 constantly returns from its operating position to its initial position. The contacts of the micro-switch can be constructed with very little separation, so that compressive and bending stresses of the shaft of the bending tool 3 will close the contacts of the micro-switch.

In addition FIG. 2 shows that the shaft of the bending tool 3 can also be provided with a strain resistor, whose terminals have the reference 36. A strain resistor of this type alters its resistance value when the tool shaft undergoes bending strain. If this resistor is included in a known bridge circuit 37, which is supplied with potential at 37'then firstly the bridge is so equalized that in an unloaded condition, no diagonal voltage occurs. When there is a loading there occurs a diagonal voltage, which is then appropriately amplified in an amplifier 38 and then actuates the relay 39, which in turn is connected in the control circuit as later described.

Finally, there can also be used magnetostrictive materials, in order to determine the beginning of a loading. Thus, in the embodiment shown the bending tool 2 is provided with a shaft passing centrally through the bending plate 1 and into a bearing 49. In its region 41 the shaft is made of magnetostrictive material, thus, for example, from an appropriate nickel or cobalt alloy. The bearing 49 has an inner recess, in which rests a coil indicated at its terminals at 42, the coil being embedded in a suitable insulation material 50. In known manner, the deviations of the value of the magnetic property can be determined at the point 42, in order in likewise known manner to actuate a switch relay which also lies in the control circuit. A driven pinion 51, which meshes with an inner toothed rim, serves for the drive of the bending plate.

The position of the switch feeler 33 or of the setting means 32 can be altered by the idling angle of rotation before the beginning of applying the load, so that this angle is added to the actual bending process. For example, the variability of the setting member 4 in relation to the bending plate 1 is shown in the left-hand part of FIG. 2. In this case, the setting member 4 is provided with a toothed rim 4'which meshes with a pinion 52, which is in turn driven by means of an adjusting motor 53 attached to the bending plate 1 and having terminals 54. Terminals 54 lie in a circuit, which at the beginning of switching on is also switched on and can be interrupted by the relay 39.

As seen in FIG. 3 the annular setting member 4, shown fragmentarily, is provided with impulse transmitters 34,63, of which, for reasons of clarity, only three are shown there being in the immediate vicinity of the initial position $55_0$and at positions corresponding to the principal bending angles 55, 55_2. A further principal bending angle 55_3indicated in FIG. 5 and here there would also be another impulse transmitter. Due to a limitation of the impulse transmitters to the immediate vicinity of the points 55_0, 55_1 . . . etc., the electrical circuit can be formed particularly economically and reliably. Apart from the impulse transmitters 34 and 63, impulses are also transmitted from impulse transmitters at the points 55_1, $55_2$and 55_3. As shown in FIG. 4, an impulse transmitter 34, (at whose position, however, one of the other impulse transmitters can work) co-operates with an impulse contact 11'which in turn is connected in a control circuit 65. In the control circuit 65 there is also connected a relay-switch combination 67 in which a switch lever is mounted such that on the inner side of the annular setting member 4 it can be actuated on the one hand by the excited relay and on the other hand by a trip cam 68. This trip cam extends in the shape of a sector over an angular region, which is somewhat greater than the angular region in which the impulse transmitters 34_1, 34_2 and 34_3 provided on both sides of the initial position 55_0, lie.

In the position shown in FIG. 4 the switch feeler lies against the trip cam 68 and stands in the center between two contacts connected to each other and which are connected in the control circuit 65. Thus the relay 67 is not excited. In this position, according to the angular extent of the trip cam 68, contacts can only be closed at the impulse contact 11' by the impulse transmitters 34_1, 34_2 and 34_3. However, these contacts do not generate any pulses of current, because the control circuit 65 is interrupted by the relay switch combination. However, if the annular setting member 4, coupled in known manner to the bending plate, is rotated further, the trip cam 68 is brought out of engagement and the resulting contacts, closed by the impulse transmitters 55 and 63, are inserted in the control circuit 65, because the switch feeler of the relay switch combination 67 lies against one of the two contacts. The coil of the said relay switch combination is excited immediately after the switching-on of the drive motor of the bending machine and remains in an excited condition until the switch means connected to the bending tools respond to the mechanical loading of the bending tools. Due to this, the con-

trol circuit 65 is then kept closed when the bending machine turns through the initial idling angle of rotation. In this case, the contacts actuated by the impulse transmitters 34 are likewise registered as impulses in the control circuit 65.

In the control circuit 65 there is also connected a change-over switch 66, which is appropriately a relay actuated by the switch means connected to the bending tools. This change-over switch switches the impulses of the control circuit 65, before the response of the said switch means, to the relay 64 and after the response of the said switch means, to the relay 60. The two said relays are provided with ratchets, the ratchet of the relay 60 switching on the switch disk 61 provided with switch teeth 61' in stages with each pulse, whereas the ratchet of the relay 64 switches on the contact ring 68 arranged concentrically to the switch disk 61 in stages which are equally spaced with the stages of the switch disk 61. The contact ring 68 thus moves forwards due to the impulses generated by the impulse generator 34 in relation to the switch feeler 62 connected to the switch disk 61, by an angular distance corresponding to the number of impulses. Due to this, the contact ring 68 moves forwards by a corresponding number of the pulse steps 63. In addition, the contact ring is connected to the contacts 55_1, 55_2 and 55_3, which are in turn connected to a setting button with the assistance of the switch feeler 35 shown in FIG. 6 and are thus able to be pre-selected. These three contacts correspond to the principal bending angles 45°90° and 180°as is indicated by symbols on the switch button in FIG. 6. In order to ensure adequate rotation of the contact ring 68, easily flexible cables serve for the connection between the corresponding contacts on the contact disk and the setting button. Finally, the contact feeler 62 is connected by means of a contact spring in the control circuit of a switch relay 69, in which there is also connected the switch feeler 35 of the setting button. Thus the relay 69 is energized whenever one of the pre-determined contacts 55_1, 55_2 and 55_3 corresponding to the principal bending angles are contacted by the switch feeler 62. The relay 69 then switches off the drive of the bending plate which returns in known manner to its initial position. The step-by-step switch seen in FIG. 5 and the starting switch of FIG. 6 also return to their initial positions.

In the embodiment shown in FIG. 7 the bending plate 1 is driven by a motor 48 through gears 59. From the gears 59 there is a drive to the tacho-generator 43 which generates a potential corresponding to its number of revolutions, such potential being fed to the comparator circuit 45. In the comparator circuit 45 there is also provided a set potential 56, which can, for example, be pre-selected for specific bending loads, As the potential of the tacho-generator 43 falls, the comparator circuit 45 transmits a control signal, which brings a switching-off in the memory 46. The memory is in addition connected by means of a drive to the gears 59 of the bending plate 1 or is at least electrically coupled and stores a value, which corresponds to the idling angle of rotation of the bending plate 1. When loading of the bending tools occurs a reduction of the number of revolutions of the tacho-generator 43 occurs and the control circuit transmits the switch signal for the store 46 and storage of the value corresponding to the idling angle of rotation is interrupted.

The store 46 is in turn connected to the cut-out switch 47 and there occurs a switch delay corresponding to its stored value. It is particularly appropriate if this adjustment of the switch delay in the cut-out switch 47 takes place at the same time as the storage in the store 46. The delay of the cut-out in the cut-out switch 47 corresponds to the idling angle of rotation. The cut-out switch 47 contains, in addition, a value 58 which can be pre-controlled by hand or by a perforated card or perforated strip program, which value corresponds to the desired main bending angle. The supply of current 57 to the motor 48 is therefore not interrupted after the controlled value for the main bending angle has been reached, but only after the delay, which is taken into consideration in the manner described. A connection between the gears 59 and the cut-out switch 47 thus guarantees that a cut-out occurs corresponding to the actual angle of rotation or bending angle.

In addition, in place of the store 46 or the cut-out switch 47 there can be provided the means illustrated in connection with the previous embodiments.

Having thus described my invention, what I desire to claim by Letters Patent is:

1. A bending machine for bars, wires and sections of steel and like materials, having a bending plate which supports a pair of bending tools, and drive means for rotating said bending plate in either direction of rotation, there being also provided a setting member connected to the bending plate for setting various principal bending angles characterized in that at least one of said bending tools is provided with switch means which are sensitive to the load applied to said one bending tool at the beginning of a bend so as to be movable by such load from an initial, at rest, condition to a second condition, said switch means being connected to said drive means and being arranged to maintain said drive means in operation to continue rotation of said bending plate after the latter has reached a pre-set bending angle until said bending plate has rotated through an additional bending angle which corresponds to the angle it rotates through initially between the time said drive means is first actuated and the time when said switch means achieves said second condition consequent upon application of said load.

2. A bending machine according to claim 1 characterized in that said setting member has setting elements which have a variable position.

3. A bending machine according to claim 1 characterized in that the setting member has setting elements, there being also provided a switch feeler which coacts with said setting elements and which has a variable position.

4. A bending machine according to claim 1 characterized in that said setting member has a variable position relative to the bending plate.

5. A bending machine according to claim 1 characterized in that said setting member includes impulse transmitters arranged to coact with an electrical impulse contact, there being also provided further impulse transmitters which are respectively associated with principal bending angles and with the initial position of the bending plate, the principal bending angle required being pre-settable by means of an electrical switch feeler to a number of impulses corresponding to said required principal bending angle, said switch feeler or a step-by-step switch associated with it being automatically switched to a greater number of impulses during a period from the time when said drive means is first actuated to a time when said switch means achieves said second condition consequent upon application of said load.

6. A bending machine according to claim 5 characterized in that the impulse transmitters are arranged only in intermediate connection with one principal bending angle as well as in the intermediate vicinity of the initial position of the setting member on both sides of the initial position of the setting member, no more impulse transmitters being provided than in connection with one principal bending angle.

7. A bending machine according to claim 1 characterized in that said switch means only achieve said second condition when a pre-set minimum bending strain of the bending tools is exceeded.

8. A bending machine according to claim 7 characterized in that the switch means are strain resistors connected to the bending tools, said strain resistors being components of resistance bridges, whose diagonal voltage is supplied to an amplifier and from there to a switch relay.

9. A bending machine according to claim 7 characterized in that said switch means comprise contacts which switch on a relayed circuit when compressive-loading of the bending tools occurs.

10. A bending machine according to claim 7 characterized in that said switch means consist of a magnetostrictive material forming the bending tools or contained in them, and of a coil acting on a relay circuit provided in the region of the support of the bending tools, the alterations of the value of the magnetic property which occurs with a compressive or bending strain bringing about an actuation of the switch relay.

11. A bending machine for bars, wire and profiles of steel and like materials having a bending plate which supports a pair of bending tools and drive means for rotating said bending plate in either direction of rotation, there being also provided a setting member connected to the bending plate for setting various principal bending angles characterized in that said drive means is connected to a tacho-generator, the potential of which is fed to a comparator circuit, which on failing to reach a pre-determined reference potential actuates a switch which switches off a storing circuit in which a value is stored, said value corresponding to the angle of rotation of the bending plate from the switching-on of said drive means until the loading of said drive means at the beginning of bending, the value stored, corresponding to this angle, delaying the switching-off of the drive.

12. A bending machine according to claim 11 characterized in that the stored value consists of impulses, the number of which is proportional to the angle of rotation.

13. A bending machine according to claim 11 characterized in that the stored value consists of a potential, which is proportional to the angle of rotation.

14. A bending machine according to claim 11 characterized in that the storage member is a switch feeler of a drive starting-switch, actuated by means of impulses or the potential, which then switches on the drive beyond the pre-set principal bending angle until an additional bending angle has been achieved which corresponds to the value of the angle of rotation stored at the beginning of the drive.

15. A bending machine according to claim 11 characterized in that the value stored changes the position of the setting elements on the setting member by a value of the same angle.

16. A bending machine according to claim 11 characterized in that the stored value changes the position of the setting member in relation to the bending plate, by a value of the same angle.

17. A bending machine according to claim 11 characterized in that the stored value changes the position of a switch feeler which can be co-ordinated with the setting elements, by an amount of the same angle.

* * * * *