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Hartkopf

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[45] **Sept. 18, 1973**

[54] **METHOD AND APPARATUS FOR FEEDING ELONGATED ROTARY WORKPIECES IN STRAIGHTENING MACHINES OR THE LIKE**

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[52] **U.S. Cl.** **72/99**, 72/133

[51] **Int. Cl.** **B21d 3/02**

[58] **Field of Search** 72/99, 133; 198/76

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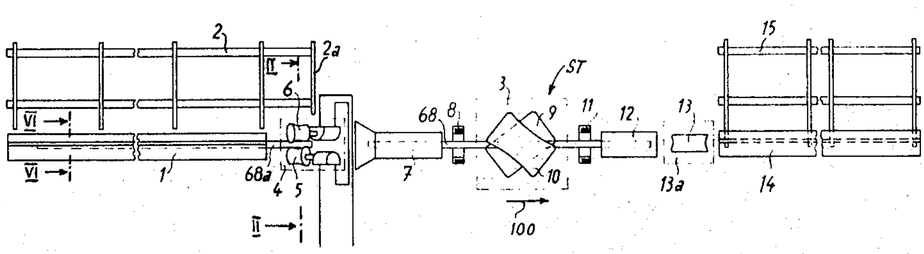
Primary Examiner—Richard J. Herbst
Attorney—Michael S. Striker

[57] **ABSTRACT**

A straightening machine for tubular or rod-like workpieces has concave straightening rolls which treat successive workpieces while such workpieces move lengthwise and rotate about their own axes. The feeding unit which advances workpieces into the range of the straightening rolls employs a pair of driven concave advancing rollers whose axes are inclined with reference to the axis of a workpiece between their concave surfaces. The advancing rollers can move successive workpieces at a higher speed so that the leading end of the workpiece between the advancing rollers catches up with the trailing end of the preceding workpiece which is being treated by the straightening rolls, and thereupon at a lower speed which corresponds to the speed of lengthwise transport of the workpiece at the straightening station. The speed of workpieces which are being transported by the advancing rollers can be varied by changing the inclination of the axes of rollers with reference to the axis of the advanced workpiece or by changing the operating speeds of series-connected hydraulic motors which rotate the advancing rollers.

20 Claims, 7 Drawing Figures



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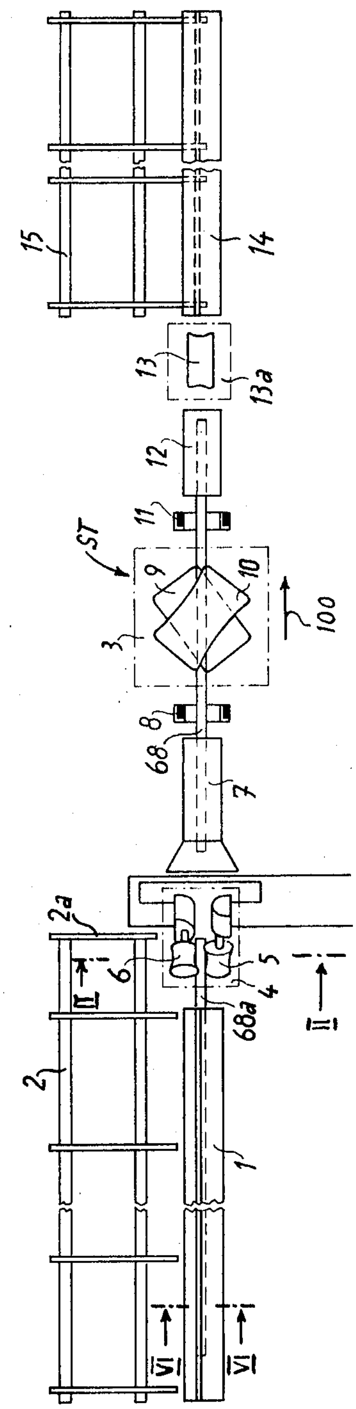


FIG. 1

FIG. 2

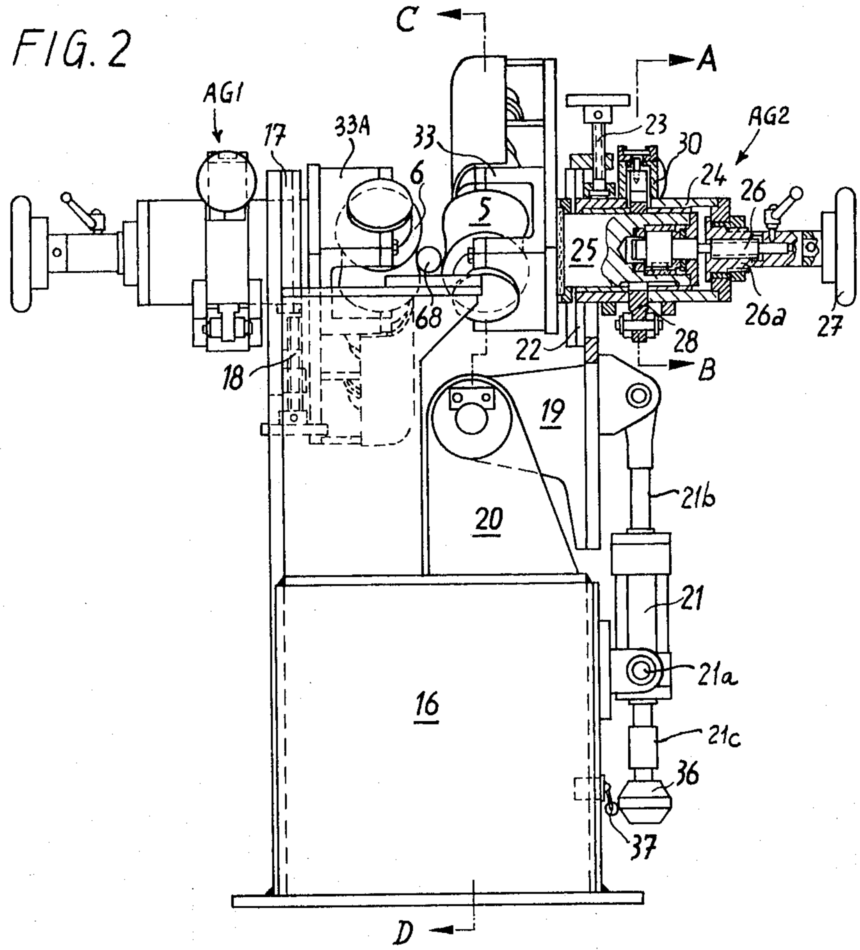
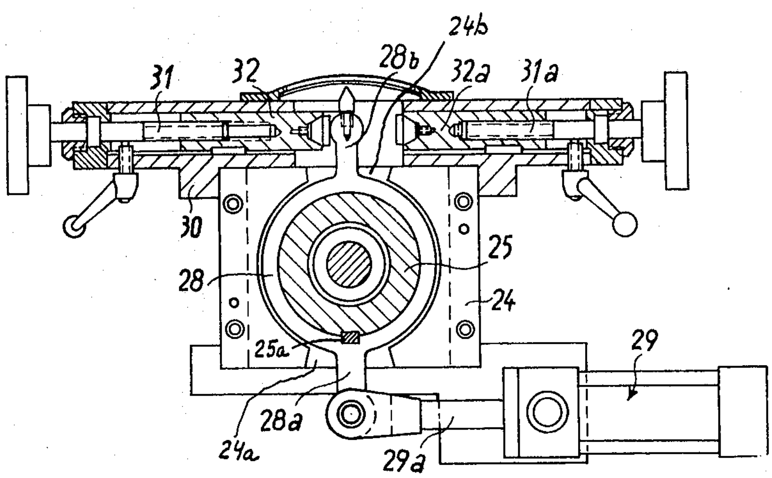

C
A
AG1
17
33A
33
6
5
23
30
AG2
24
26
25
68
22
28
26a
27
18
B
19
20
21b
21
21a
16
21c
36
37
D

FIG. 3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32a
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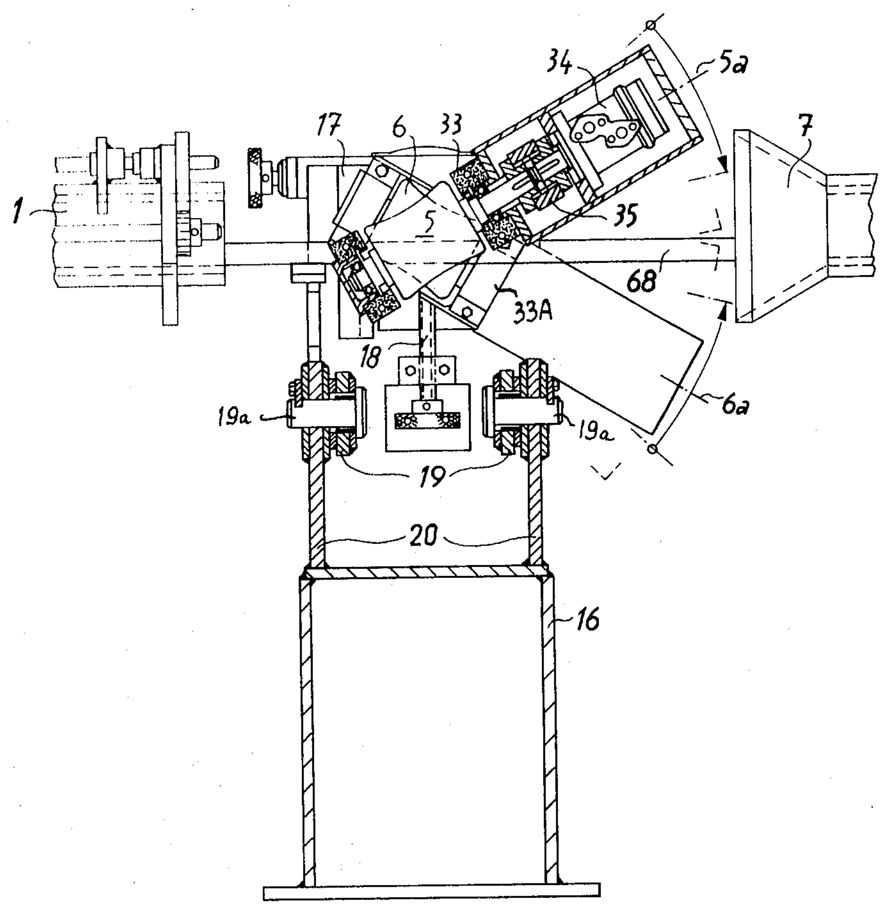
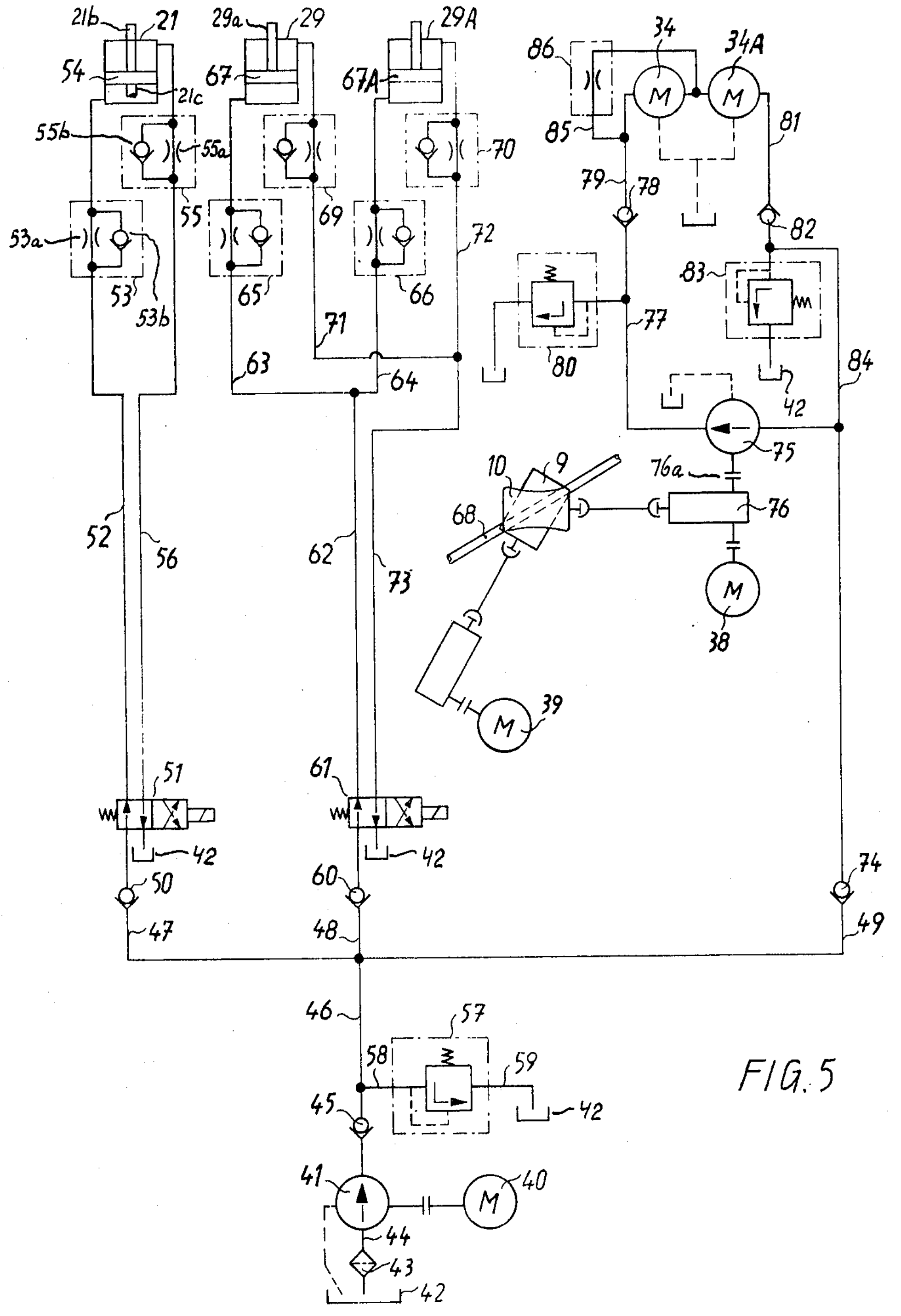
29
28a
24a
29a

FIG. 4

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54
21c
55b
55a
53a
53
53b
55
29a
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65
69
29A
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66
72
71
63
64
52
56
62
73
51
42
50
47
61
60
48
74
49
46
57
58
59
45
41
40
44
43
86
34
34A
85
81
79
78
82
83
80
77
84
75
76a
76
10
9
68
38
39

FIG. 5

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FIG. 6

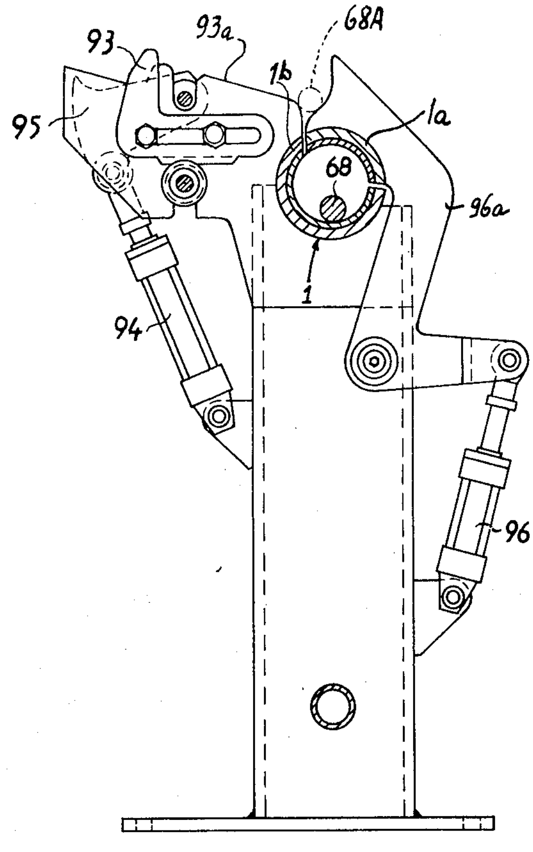
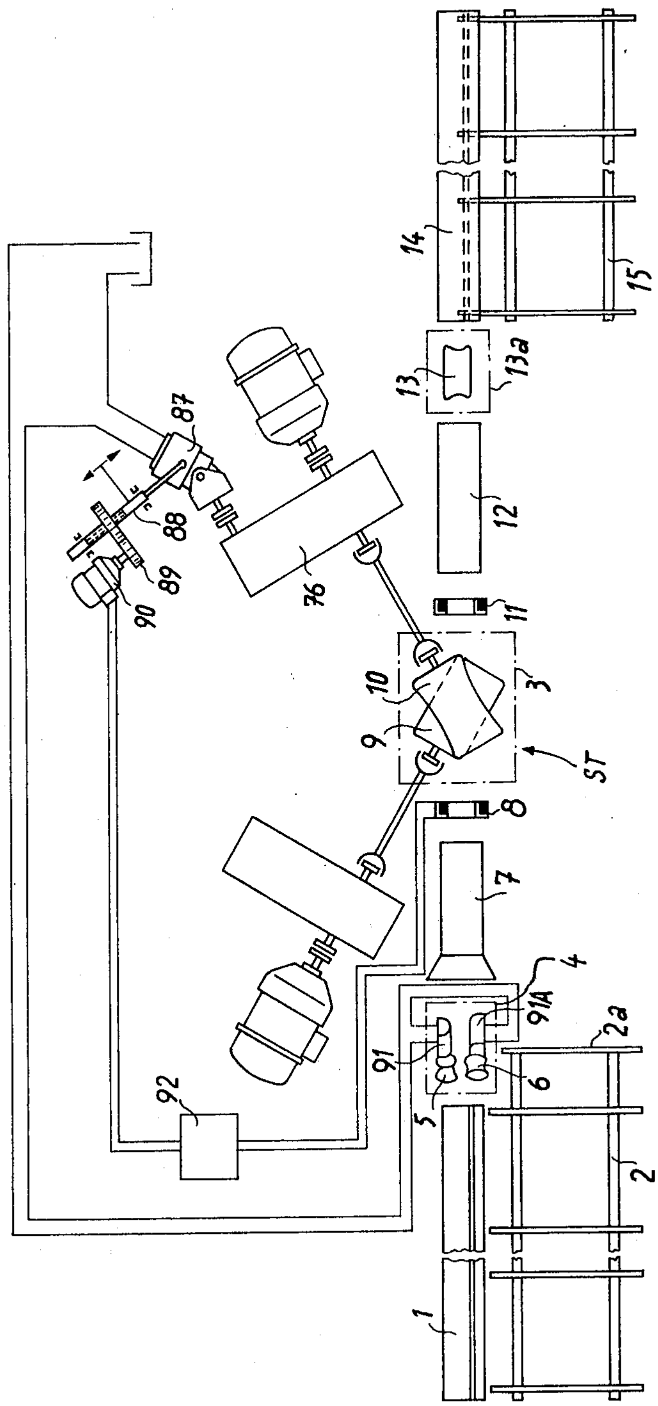


FIG.7



METHOD AND APPARATUS FOR FEEDING ELONGATED ROTARY WORKPIECES IN STRAIGHTENING MACHINES OR THE LIKE

BACKGROUND OF THE INVENTION

The present invention relates to a method and machine for treating elongated workpieces, such as metallic rods or tubes. More particularly, the invention relates to improvements in a method and machine for treating elongated workpieces which rotate about their own axes during lengthwise transport through a treating station. Still more particularly, the invention relates to improvements in a method and apparatus for feeding elongated tubular or rod-shaped workpieces to a treating station at which successive workpieces undergo a straightening or analogous treatment.

It is well known to employ in a straightening machine for tubular or rod-shaped metallic stock pairs of mutually inclined hyperbolical rolls whose concave peripheral surfaces engage and treat successive increments of workpieces while such workpieces move lengthwise and rotate about their own axes. A drawback of such straightening machines is that the trailing end of a freshly treated workpiece is subjected to substantial bending stresses and is deformed so that its axis is inclined with reference to the axis of the major portion of the respective workpiece. Such stresses develop as a result of the release of substantial amounts of energy which are stored in the machine frame and in the tensioning anchors when the trailing end of a workpiece moves beyond the straightening rolls. It was found that the deformation of the trailing end of a freshly straightened workpiece is due to such feeding of workpieces that the distance between the trailing end of a preceding workpiece and the leading end of the next-following workpiece exceeds the length of that portion of a workpiece which is being engaged by the straightening rolls. Thus, the energy which is released when the trailing end of a workpiece leaves the straightening rolls can deform the trailing end so that the workpiece must be subjected to a secondary treatment or the deformed trailing end must be separated from the major portion of such workpiece.

It was further found that, when an elongated tubular or rod-like workpiece is treated in a straightening machine and the trailing end of such workpiece is spaced from the leading end of the next-following workpiece, and when the workpiece which is being engaged by the mutually inclined straightening rolls rotates during straightening, its trailing portion swivals to travel along a conical path and strikes with a great force against the guide means wherein the workpiece is led during treatment. Such swiveling of the trailing portions of workpieces which advance through the straightening station is due to rotation of the workpieces about their own axes and can cause considerable damage to a tubular workpiece as well as to the guide means. At any rate, the wear on the guide means is considerable, especially if the workpieces are metallic tubes or rods of large diameter.

Attempts to avoid excessive damage to the guide means include the replacement of tubular guides with several pairs of conical (hyperbolic) rollers which form two rows. The rollers of one row are adjustable toward and away from the rollers of the other row. To this end, one roller of each pair is mounted in a holder and all such holders are pivotable about an axis which is parallel to the axis of the workpiece between the two rows of rollers. The means for pivoting the holders comprises a double-acting cylinder which can move the holders away from the path of workpieces so that a fresh workpiece can be introduced from above and is properly engaged by the two rows of rollers when the holders are returned to their operative positions. The cylinder is preferably designed to yieldably urge the rollers which are mounted in the holders against the workpiece between the two rows of rollers. The rollers are adjustable to allow for proper guidance of workpieces having larger or smaller diameters. Such guide means reduces the likelihood of swiveling of the trailing ends of workpieces which are being fed lengthwise and rotate about their own axes. However, a straightening machine which embodies such guide means is still incapable of preventing deformation of the trailing end of a workpiece which has been advanced beyond the straightening rolls. A machine of the just outlined character is disclosed in German Pat. No. 725,630.

It is further known to feed successive workpieces end-to-end in machines wherein the workpieces need not rotate about their axes. For example, it is known to employ in a shaving machine for metallic tubes or rods a system of feeding or advancing rollers which transport successive workpieces lengthwise while the workpieces perform no angular movement about their own axes. When a preceding workpiece reaches the shaving station and is treated by one or more orbiting knives, the speed of its lengthwise movement is reduced and the thus decelerated workpiece decelerates the next-following workpiece whereby the advancing rollers slip with reference to the peripheral surface of the next-following workpiece. The resulting scoring of the peripheral surface by the rollers presents no problems because the workpiece is about to enter the shaving station.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved method of feeding elongated tubular or rod-like workpieces toward a straightening or a like treating station (at which the workpieces rotate about their own axes during treatment) in such a way that the feeding action reduces the likelihood of deformation of the trailing ends of freshly treated workpieces and also reduces the likelihood of damage to the guide means and/or other component parts of the treating machine.

Another object of the invention is to provide a novel and improved apparatus for feeding successive elongated rod-shaped or tubular metallic workpieces into a straightening or analogous treating station.

A further object of the invention is to provide the feeding apparatus with novel and improved means for driving and otherwise moving the advancing elements for a succession of elongated rod-shaped or tubular workpieces which are caused to move lengthwise and to simultaneously rotate about their own axes.

An additional object of the invention is to provide a novel and improved straightening machine for tubular or rod-shaped workpieces which embodies the above outlined feeding apparatus.

Still another object of the invention is to provide a novel and improved method of controlling the speed of elongated workpieces which are fed toward, through and beyond a straightening station.

An ancillary object of the invention is to provide a novel and improved hydraulic system for a straightening machine which is used to treat elongated tubular or rod-like workpieces.

The method of the present invention is employed for the feeding of elongated workpieces, such as metallic tubes or rods, toward and through a treating station, especially a straightening station. The method comprises the steps of rotating a first workpiece about its own axis and simultaneously conveying the workpiece lengthwise along a predetermined path toward and through a treating station so that the workpiece moves through the treating station at a first speed (which may but need not be constant), introducing into the path a second workpiece so that the leading end of the second workpiece is spaced from the trailing end of the first workpiece while the trailing end of the first workpiece is still located upstream of the treating station, conveying the second workpiece lengthwise toward the treating station at a second speed which exceeds the first speed so that the leading end of the second workpiece at least closely approaches but preferably moves into abutment with the trailing end of the first workpiece upstream of the treating station, and thereupon conveying the second workpiece toward the treating station at the first speed, i.e., so that the leading end of the second workpiece enters the treating station at the same time when the trailing end of the first workpiece leaves such station. The third, fourth and further workpieces are thereupon manipulated in the same way as the second workpiece.

If the (first) speed of the workpiece which passes through the treating station varies, the second speed is preferably changed as a function of variations in the first speed so that the location where the leading end of a next-following workpiece catches up with the trailing end of the preceding workpiece need not change due to eventual variations in the first speed. The second workpiece preferably rotates about its own axis during lengthwise movement at the second speed and thereupon at the first speed, and the speed of such rotary movement during lengthwise transport at the first speed preferably equals the speed of rotary movement of the first workpiece.

The method may further comprise the steps of producing a signal in response to movement of the leading end of the second workpiece (and/or the trailing end of the first workpiece) beyond a predetermined portion of the path between the introducing and treating stations, and utilizing such signal to decelerate the second workpiece from the second speed to the first speed.

The workpieces are preferably accelerated upon completed transport beyond the treating station for the purpose of separating the trailing end of each preceding workpiece from the leading end of the next-following workpiece. This allows for unimpeded sidewise removal of treated workpieces from the path downstream of the treating station. The introduction of successive workpieces into the path upstream of the treating station preferably takes place by moving the workpieces sideways.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved feeding apparatus itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic plan view of a straightening machine for tubular or rod-shaped workpieces including a feeding apparatus which is constructed and assembled in accordance with a first embodiment of the invention;

FIG. 2 is an enlarged transverse vertical sectional view of the feeding apparatus, substantially as seen in the direction of arrows from the line II—II of FIG. 1;

FIG. 3 is a sectional view as seen in the direction of arrows from the line A-B of FIG. 2;

FIG. 4 is a sectional view as seen in the direction of arrows from the line C–D of FIG. 2;

FIG. 5 illustrates a portion of the hydraulic circuit of the machine shown in FIG. 1;

FIG. 6 is an enlarged fragmentary sectional view as seen in the direction of arrows from the line VI—VI of FIG. 1; and

FIG. 7 is a diagrammatic plan view of a straightening machine including a feeding apparatus which is constructed and assembled in accordance with a second embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, there are illustrated certain components of a straightening machine for elongated solid rod-shaped or tubular metallic workpieces. For the sake of convenience, the workpieces will be called rods with the understanding, however, that the machine can be used with equal advantage for the straightening or analogous treatment of tubes or the like. The rods are stored in a magazine in the form of a rack **2** which includes a front stop **2*a*** and a lateral stop **93** (see FIG. **6**) and serves to feed successive rods **68**, **68*a***, . . . sideways into a tubular guide or channel member **1** having a pivotable section **1a** which can be moved to and from the closed position of FIG. **6** by a hydraulic or pneumatic motor here shown as a cylinder and piston unit **96**. When the motor **96** moves the section **1*a*** to its open position, the foremost rod **68** can be transferred from the rack **2** into the stationary section **1*b*** of the guide **1** and is then ready to be rotated about its own axis as well as to be transported lengthwise so that its leading end enters a straightening station ST which accommodates a straightening unit **3** shown in FIG. **1** by broken lines and including two mutually inclined concave (hyperbolical) straightening rolls **9, 10.** Prior to entry into the stationary section **1b** of the guide **1**, the foremost rod **68** abuts against the lateral stop **93** and rests on a pivotable transfer member **95** which is actuatable by a hydraulic or pneumatic motor in the form of a cylinder and piston unit **94** shown in FIG. **6.** When the motor **94** pivots the transfer member **95** in a clockwise direction, as viewed in FIG. **6**, the member **95** lifs the foremost rod **68** over the lateral stop **93** and causes it to roll sideways along a suitably inclined guide surface **93*a*** so as to descend (either immediately or with a certain delay) into the section **1*b***. The motor **96** thereupon returns the section **1*a*** to the closed position of FIG. **6** and the rod **68** in the guide **1** is ready to start its lengthwise movement (accompanied by rotary movement about its own axis) in order to advance the leading end into the straightening unit **3** at the station ST. The rods **68**, **68*a***, . . . are placed onto the rack **2** in such a way that their front end faces abut against the stop **2*a***.

The space between the front end of the guide **1** and the straightening station ST accommodates a feeding apparatus **4** which includes two mutually inclined concave (hyperbolical) feeding or advancing rollers **5**, **6** serving to engage the leading end of that rod (**68**) which is received in the guide **1**. To this end, the advancing rollers **5**, **6** are mounted rearwardly of the front stop 2a, as considered in the direction (arrow **100**) of lengthwise movement of rods toward the straightening station ST. At least one of the advancing rollers **5**, **6** (namely, at least the advancing roller **5**) is movable to and from a retracted position in which it allows for unimpeded entry of the foremost rod into the guide **1**. The movable advancing roller (**5**) is thereupon returned to the operative position shown in FIG. **1** in which the two advancing rollers cooperate to rotate the foremost rod about its own axis and to simultaneously move the rod lengthwise toward the straightening station ST. The feeding apparatus **4** is followed by an auxiliary tubular guide **7** which may but need not have a movable section and is disposed between the feeding apparatus **4** and a ring-shaped signal generating device **8** here shown as an inductance which can produce signals in response to entry of the leading end as well as in response to passage of the trailing end of a rod through and beyond its interior. A similar ring-shaped signal generating device **11** is disposed downstream of the straightening unit **3** and upstream of a second auxiliary tubular guide **12**. The latter is followed by an accelerating unit **13a** which includes cooperating upper and lower accelerating rollers **13** (only one shown) and is followed by a tubular guide or channel member **14** which is adjacent to one side of a second magazine or rack **15** serving to receive and store straightened rods. The construction of the guide **14** is preferably somewhat similar to that of the guide **1**, i.e., the guide **14** may also comprise a stationary section and a pivotable section which must be moved to an open position in order to allow for evacuation of a freshly straightened rod onto the rack **15** whereon the rod rolls sideways into abutment with a lateral stop or into abutment with the previously straightened rod.

The length of the auxiliary guide **7** is selected in such a way that the leading of a next-following rod (e.g., the rod **68*a***) can catch up with the trailing end of that rod (e.g., **68**) which is being caused to pass through the straightening station ST. The arrangement is preferably such that the leading end of the next-following rod catches up with the trailing end of the preceding rod in the space between the straightening rolls **9**, **10** and the signal generating device **8**. The length of the auxiliary guide **12** is such that it can properly guide the leading end of a rod which is being advanced through the straightening station ST while the trailing end of the preceding (freshly straightened) rod is being moved away from the treated rod by the rollers **13** of the accelerating unit **13*a***. This is desirable in order to insure that the sidewise transport of the preceding rod from the guide **14** onto the rack **15** cannot be impeded by the rod which is being moved through the straightening station ST. The leading end of a next-following rod preferably reaches the accelerating rollers **13** at a time when the transfer of the preceding rod from the guide **14** is already completed. The guide **14** can be designed to allow for evacuation and transfer of straightened rods onto the rack **15** under the action of gravity.

Referring now to FIGS. **2** to **4**, there is illustrated the manner in which the advancing roller **5** of the feeding apparatus **4** can be moved to and from its operative position, i.e., from and to an inoperative or retracted position in which the member **95** of FIG. **6** is free to effect the transfer of a fresh rod into the guide **1**. The advancing roller **6** is mounted at that side of the path for a rod (**68**) in the guide **1** which is adjacent to the rack **2**, and the advancing roller **5** is mounted at the opposite side of such path. The feeding apparatus **4** comprises a stationary frame **16** having an upwardly extending portion or extension **17** which constitutes a vertical guide member for an aggregate AG1 which carries the advancing roller **6**. The level of the aggregate AG1 can be adjusted by a feed screw **18**. The aggregate AG1 comprises means for pivoting the axis **6a** of the roller **6** with reference to the axis of a rod (**68**) in the guide **1**. A second aggregate AG2 serves to support the advancing roller **5** for pivotal movement between operative and inoperative positions. Since the two aggregates are similar (and preferably nearly identical), only the details of the aggregate AG2 are fully illustrated in the drawing because the mounting of the aggregate AG2 is more complex due to the fact that the roller **5** is pivotable toward and away from the guide **1**. FIGS. **2** and **4** show that the frame **16** is provided with two spaced upwardly extending supporting brackets **20** for plate-like arms or cheeks **19** which are turnable about the common axis of two horizontal shafts **19a** in response to actuation of a hydraulic or pneumatic motor here shown as a double-acting cylinder and piston unit **21**. The cylinder of the motor **21** is pivotably secured to the frame **16**, as at **21*a***, and the piston rod **21*b*** of this motor is articulately connected with the arms **19**. The arms **19** are rigidly connected with a plate-like carrier **22** which normally assumes an upright position (in a substantially vertical plane) as shown in FIG. **2**. The carrier **22** forms a vertical guide member for the parts which support the advancing roller **5**. Such parts can be adjusted with reference to the carrier **22** (i.e., up or down, as viewed in FIG. **2**) by a feed screw **23** which can be rotated by a hand wheel or the like.

The parts which support the advancing roller **5** include a two-piece casing **24** for a shaft **25** which is mounted in the casing **24** for movement radially of the path for the rod **68** and can be moved toward and away from the rod **68** shown in FIG. **2** by a threaded sleeve **26** which is rotatable in a nut **26*a*** of the casing **24** by a hand wheel **27**. The axis of the shaft **25** in operative position of the aggregate AG2 is at least substantially normal to the axis of a rod in the guide **1** and is preferably located in a horizontal plane. The portions of the casing **24** define a pair of vertically aligned slots **24*a***, **24*b*** (see FIG. **2**) for a device which can turn the shaft **25** and hence the advancing roller **5** about the axis of the shaft **25**. Such turning device comprises a sleeve or hub **28** which is fixed to the shaft **25** by a key **25*a*** and has two radial projections or extensions **28*a***, **28*b*** which respectively extend through the slots **24*a***, **24*b*** of the casing **24**. The extension **28*a*** is articulately connected with the piston rod **29*a*** of a hydraulic or pneumatic cylinder **29** which is mounted on the casing **24**. The piston **67** of the cylinder **29** is shown in FIG. **5**. The extension **28*b*** passes through the slot **24*b*** and into a housing **30** which is mounted on the casing **24**. The housing **30** accommodates two stops **32, 32***a* which are disposed at the opposite sides of the extension **28***b* and are adjustable axially toward and away from each other by two feed screws **31, 31***a*. The cylinder **29** for the hub **28** is a double-acting cylinder and the extent of strokes of the piston **67** in this cylinder is determined by the selected axial positions of stops **32, 32***a* in the housing **30**. This is clearly shown in FIG. **3**. In other words, the axial positions of the stops **32, 32***a* in the housing **30** determine the extent to which the shaft **25** can turn the advancing roller **5** about the axis of the hub **28**. The roller **5** is rotatably mounted in a bifurcated holder **33** which is rigidly connected with the inner end portion of the shaft **25**, namely, with that end portion which is nearer to the path for the rod **68** shown in FIGS. **2** and **4**. The holder **33** further serves to support a hydraulic motor **34** which serves to rotate the advancing roller **5**. The motor **34** can rotate the roller **5** by way of a clutch **35**.

The aggregate AG1 comprises a second holder **33A** (FIG. **4**) which accommodates the motor **34A** (FIG. **5**) for the advancing roller **6**. The shaft which supports the holder **33A** is analogous to the shaft **25** for the holder **33** and is mounted in a casing similar to the member **24**.

The piston **54** (FIG. **5**) in the cylinder of the motor **21** for the arms **19** shown in FIG. **2** has a downwardly extending rod **21***c* which carries a conical acutating member or trip **36** for an electric limit switch **37**. The switch **37** and the aforementioned signal generating devices **8, 11** constitute component parts of a programming system which serves to operate various movable parts of the machine in a predetermined sequence. The operation of the machine which includes the parts shown in FIGS. **1** to **4** and **6** will be described with reference to FIG. **5** which shows additional parts of the programming system. FIG. **5** further shows two electric or fluid-operated motors **38, 39** which respectively serve to rotate the straightening rolls **10** and **9**. The motor **38** drives the straightening roll **10** by way of a transmission **76** which has a take-off **76***a* serving to drive a variable-delivery pump **75**. The pump **75** serves to supply pressurized fluid (e.g., oil) for the aforementioned motors **34, 34A** which respectively drive the advancing rollers **5** and **6**. It will be seen that the rotational speed of the advancing rollers **5, 6** can be varied as a function of changes in rotational speed of the straightening roll **10** which is preferably driven at the same speed as the straightening roll **9**.

FIG. **5** further shows a main pump **41** which is driven by an electric motor **40** and serves to draw oil from a tank or fluid source **42** through a supply conduit **44** containing an oil filter **44**. The outlet of the pump **41** is connected with a conduit **46** which contains a one-way ball check valve **45** and is connected with an adjustable pressure relief valve **57** by way of a conduit **58**. When the oil pressure in the conduit **46** exceeds a predetermined value which is selected by appropriate adjustment of the valve **57**, the conduit **58** is free to admit oil into a return conduit **59** which conveys the oil into the tank **42**. The conduit **46** serves to deliver pressurized oil to three conduits **47, 48, 49** which respectively serve to supply pressurized oil to the motor **21**, cylinders **24, 24A** and pump **75** for the motors **34, 34A**. The conduit **47** delivers pressurized oil to an electromagnetically operated valve **51** by way of a ball check valve **50**. The valve **51** is connected with the upper and lower chambers of the cylinder of the motor **21** by conduits **52, 56** which respectively contain flow regulating devices **53, 55**. The devices **53, 55** respectively comprise flow restrictors **53***a*, **55***a* and ball check valves **53***b*, **55***b*.

The conduit **48** serves to supply pressurized oil to a second electromagnetically operated valve **61** by way of a ball check valve **60**. The valve **61** delivers pressurized oil into one of two conduits **62, 73**. The conduit **62** is respectively connected with the lower chambers of the cylinders **29, 29A** (below the pistons **67, 67A** by conduits **63, 64** which respectively contain flow regulating devices **65, 66**. The conduit **73** communicates with conduits **71, 72** which are respectively connected with the upper chambers of cylinders **29, 29A** and respectively contain flow regulating devices **69, 70**. Each of the flow regulating devices **65, 66, 69, 70** is identical with the device **53** or **55**.

The conduit **49** contains a ball check valve **74** and is connected with the inlet of the pump **75** as well as with a conduit **84** which is connected with the motor **34A** by way of a further conduit **81** containing a check valve **82**. The conduit **81** further contains an adjustable pressure relief valve **83**. The outlet of the pump **75** is connected with a conduit **77** which is connected with an adjustable pressure relief valve **80** and contains a ball check valve **78**. A conduit **79** which is connected with the conduit **77** downstream of the check valve **78** is connected with the motor **34** and with a conduit **85** which by-passes the motor **34** and contains a flow restrictor **86**.

The operation of the machine shown in FIGS. **1** to **6** is as follows:

Several untreated rods **68, 68***a*, . . . are placed onto the rack **2** in such a way that their leading ends abut or nearly abut against the front stop **2***a* and that the rightmost rod, as viewed in FIG. **6**, abuts against the lateral stop **93**. The stop **93** is adjustable substantially radially of the tubular guide **1**. The machine is thereupon set in operation by starting the motors **38, 39** for the straightening rolls **10, 9** and the motor **40** for the main pump **41**. The latter draws oil from the tank **42** by way of the supply conduit **44** and through the oil filter **43** and forces pressurized oil through the ball check valve **45** and into the conduits **46, 47, 48** and **49**. The pressurized oil opens the ball check valve **50** in the conduit **47** and passes through the valve **51** into the conduit **52** or **56**. FIG. **5** shows the valve member of the valve **51** in that position in which the conduit **47** is free to communicate with the conduit **52** while the conduit **56** communicates with the tank **42**. The pressurized oil then flows through the flow regulating device **53** and enters the lower chamber of the cylinder in the motor **21** to move the piston **54** upwardly, as viewed in FIG. **5**. This causes the piston rod **21b** to pivot the aggregate AG2 to the operative position shown in FIG. **2**. If the tubular guide **1** does not accommodate a rod when the aggregate AG2 is moved to the operative position of FIG. **2**, the arms **19** are caused to come into abutment with a suitable stop, not shown. As the piston **54** moves upwardly, it expels oil from the upper chamber of the cylinder in the motor **21**, and such oil is returned into the tank **42** by way of the flow regulating device **55** in the conduit **56** and valve **51**. The fluid pressure in the conduit **47** begins to rise when the aggregate AG2 reaches the operative position of FIG. **2** but such pressure cannot exceed a predetermined value because the relief valve **57** then opens and connects the conduit **58** (and hence the conduits **46, 47**) with the return conduit **59** which delivers oil back into the tank **42.**

The oil which enters the conduit **48** opens the ball check valve **60** and flows into the conduits **62, 63, 64** or **73, 71, 72.** If the valve **61** connects the conduit **48** with the conduit **62,** pressurized oil flows through the flow regulating devices **65, 66** to enter the corresponding chambers of the cylinders **29, 29A.** This causes the shafts (see the shaft **25** of FIGS. **2–3**) for the advancing rollers **5, 6** to move the corresponding holders **33, 33A** to such angular positions (see FIG. **4**) which are determined by the positioning of the respective stops (see the stop **32***a* for the sleeve **28** on the shaft **25** of FIG. **3**) so that the angle between the axes **5***a*, **6***a* of the rollers **5, 6** is best suited to insure the lengthwise movement of a rod in the guide **1** at a speed which suffices to enable the leading end of such rod to catch up with the trailing end of the preceding rod while the preceding rod is being moved through the straightening station ST. The oil which is expelled from the cylinders **29, 29A** by the pistons **67, 67A** flows back into the tank **42** by way of the conduits **71, 72,** flow regulating devices **69, 70,** conduit **73** and valve **61.** When the extension **28***b* of the hub **28** shown in FIG. **3** already abuts against the stop **32***a* but the conduit **63** continues to admit pressurized oil into the corresponding chamber of the cylinder in the motor **29,** the relief valve **57** opens and allows the conduit **59** to return surplus oil into the tank **42.** The same holds true for the aggregate AG1, i.e., the buildup of oil pressure in the conduit **64** after the axis **6***a* of the roller **6** has reached the position shown in FIG. **4** will also cause the relief valve **57** to open so as to prevent excessive stressing of the machine by pressurized oil.

The pressurized oil which enters the conduit **49** opens the ball check valve **74** and flows into the pump **75** which is driven by the take-off **76***a* of the transmission **76** between the motor **38** and the straightening roll **10.** The pump **75** conveys oil into the conduit **77** so that the ball check valve **78** opens and admits oil into the conduits **79** and **85.** The motors **34, 34A** are connected in series and the adjustment of the relief valve **80** is such that the pressure of oil at the downstream side of the pump **75** cannot exceed a preselected value. The flow restrictor **86** in the bypass conduit **85** insures that the RPM of the motor **34** equals the RPM of the motor **34A.** The suction side of the pump **75** draws oil from the conduit **84** which receives oil from the motor **34A** by way of the conduit **81** and ball check valve **82.** Thus, the pump **75** recirculates oil which flows from the conduit **77,** through conduits **79, 85, 81** and back through the conduit **84.** The relief valve **83** controls the oil pressure in the conduits **81** and **84.**

It will be seen that, shortly after the pump **41** is started, the arms **19** move the aggregate AG2 to the operative position of FIG. **2** and that the axes **5***a*, **6***a* of the advancing rollers **5, 6** are caused to make with the axis of the rod **68** in the guide **1** a predetermined angle which is best suited to insure accelerated transport of a rod from the guide **1** toward the straightening station ST. The rotational speed of the advancing rollers **5, 6** is determined by the motors **34, 34A** and is a function of the speed of the straighteing roll **10** because the pump **75** which supplies oil to the motors **34, 34A** is driven by the transmission **76** which rotates the roll **10.**

The straightening operation is regulated by a programming system which includes the aforementioned detectors **8, 11** and the limit switch **37.** The treatment of a first rod **68** and the transport of the second rod **68** are carried out as follows: In the first step, the programming system causes the motor **94** of FIG. **6** to pivot the transfer member **95** in a clockwise direction so that the foremost or rightmost rod **68** which abuts against the lateral stop **93** is transferred onto the guide surface **93***a* and is ready to be introduced into the guide **1.** If desired, the rod **68** which is transferred onto the guide surface **93***a* can come to rest in the broken-line position **68A** of FIG. **6** in which it abuts against a portion of the carriage **96***a* for the movable section **1***a* of the guide **1.** The programming system then comprises a suitable time delay relay or the like which causes the motor **96** to move the pivotable section **1***a* to its open position with a predetermined delay following actuation of the transfer member **95** by the motor **94.** As the section **1***a* pivots in a clockwsie direction (reference being had to FIG. **6**), the rod **68** leaves the position **68A** and descends into the section **1***b* to assume the full-line position of FIG. **6.** The same time delay device can serve to reset the electromagnetically operated valve **51** of FIG. **5** so that the valve **51** connects the conduit **47** with the conduit **56** and the conduit **52** with the tank **42.** The pressurized oil furnished by the pump **41** and conduit **46** is then free to flow through the conduit **56** and flow regulating device **55** to enter the upper chamber of the cylinder in the motor **21** whereby the arms **19** move the aggregate AG2 with the advancing roller **5** to the retracted position. The oil which is expelled from the lower chamber of the cylinder in the motor **21** can flow through the regulating device **53,** conduit **52,** valve **51** and back into the tank **42.** Thus, the roller **5** is retracted and allows the leading portion of the rod **68** which descends into the guide **1** to enter the space between the rollers **5** and **6.** The programming system resets the valve **51** to the condition shown in FIG. **5** after the elapse of a predetermined interval (for example, after the elapse of an interval determined by the delay device which actuates the motor **96** for the guide section **1***a*) so that the lower chamber of the cylinder in the motor **21** is again connected with the conduit **47** and the motor **21** returns the aggregate AG2 to the operative position shown in FIG. **2.** The return movement of the aggregate AG2 to the operative position of FIG. **2** can take place simultaneously with return movement of the guide section **1a** to the closed position shown in FIG. **6.** As the motor **21** returns the aggregate AG2 to the operative position of FIG. **2,** its piston rod **21***c* causes the trip **36** to actuate the limit switch **37** which causes the motor **94** to again pivot the transfer member **95** in a clockwise direction, as viewed in FIG. **6,** so that the member **95** transfers the next-following rod **68***a* from the rack **2** onto the surface **93***a* whereby such rod rolls against the carriage **96***a* to assume the broken-position **68A** of FIG. **7** above the closed guide **1.** Thus, the engagement of a preceding rod **68** by the advancing rollers **5, 6** automatically entails the transfer of the next-following rod **68** into a position of readiness above the guide **1.**

The rollers **5, 6** are respectively driven by the motors **34, 34A** and cause the rod **68** to perform a lengthwise movement accompanied by a rotary movement along its own axis so that any selected point on the periphery of the rod **68** travels along a helical path. Such composite movement of the rod **68** is due to mutual inclination of the axes **5***a*, **6***a* of advancing rollers **5, 6** as shown in

FIG. 4. The large angle between the axes 5*a*, 6*a* of the advancing rollers 5, 6 insures that the rotational speed of the rod 68 about its own axis is relatively small but that the rod 68 advances lengthwise at a substantial speed.

When the leading end of the rod 68 reaches the space within the detector 8, the latter produces a signal which energizes the solenoid of the valve 61. The latter then connects the conduit 48 with the conduit 73 and the conduit 62 is connected with the tank 42. The oil is then free to flow from the conduit 48, via conduits 73, 71, 72 and flow regulating devices 69, 70 into the respective chambers of the cylinders 29, 29A. This causes the shafts 25 for the holders 33, 33A to turn about their own axes whereby the extension 28b of FIG. 3 returns into abutment with the stop 32 and the corresponding extension of the aggregate AG1 also returns into abutment with a stop corresponding to the stop 32 of FIG. 3. In other words, the angle between the axes 5*a*, 6*a* of the advancing rollers 5, 6 decreases to equal or approximate the angle between the axes of the straightening rolls 9, 10. Thus, the angle which the axis 5*a* makes with the axis of the rod 68 between the advancing rollers 5,6 equals the angle between the axis of the straightening roll 10 and the rod in the straightening station ST, and the angle between the axis 6a and the axis of the rod 68 between the rollers 5, 6 equals the angle between the axis of the roll 9 and the rod at the straightening station.

The diameters and rotational speeds of the advancing rollers 5, 6 are selected in such a way that the peripheral speed of the rollers 5, 6 equals the peripheral speed of the straightening rolls 9, 10 when the angle between the axes 5*a*, 6*a* is reduced. Consequently, once a trailing rod has caught up with the preceding rod (which passes through the straightening station ST), the speed of lengthwise movement of both rods is the same. The speed at which the two rods rotate about their own axes is also the same. The preceding rod enters the space between the straightening rolls 9, 10 and is subjected to a straightening operation. When the straightening operation upon the preceding rod progresses to such an extent that the trailing end of the rod which is being treated by the rolls 9, 10 leaves the space between the advancing rollers 5, 6, the programming system causes the valve 51 to connect the conduit 47 with the conduit 52 for a short interval of time so that the extension 28*b* of the holder 28 for the shaft 25 is returned into abutment with the stop 32*a* and the angle betwen the axes 5*a*, 6*a* of the rollers 5, 6 increases. The rod 21*c* moves the trip 36 upwardly so that the latter releases the limit switch 37 which causes the motor 96 to move the section 1*a* of FIG. 6 to the open position so that the rod 68*a* which was held in the position 68A is free to enter the stationary section 1*b* of the guide 1. The limit switch 37 also resets the valves 51 and 61 so that the aggregate AG2 is pivoted to its retracted position in order to allow the rod 68*a* which has left the position 68A to enter into the space between the advancing rollers 5, 6. The aggregate AG2 then returns to the operative position of FIG. 2. This is caused by the valve 51. The valve 61 thereupon causes the axes 5*a*, 6*a* of the rollers 5, 6 to assume the angular positions shown in FIG. 4. The limit switch 37 also energizes a time delay relay of the programming system which causes the motor 94 to return the section 1*a* of the guide 1 to the closed position of FIG. 6 with a predetermined delay and to reset the valve 51 so that the aggregate AG2 is moved to the operative position in order to allow the roller 5 to engage the leading portion of the rod 68*a* in the guide 1. When the guide 1 is closed again and the rollers 5, 6 engage the rod 68*a* in the guide 1, the trip 36 causes the limit switch 37 to actuate the motor 94 which transfers a further rod (not shown) into the position 68A of FIG. 6.

The rod 68*a* which is engaged by the advancing rollers 5, 6 is rapidly transported toward the straightening station ST so that its leading end catches up with the trailing end of the rod 68 which is being treated by the straightening rolls 9, 10. When the trailing end of the treated rod 68 moves beyond the detector 8, the latter produces a signal for actuation of a scanning device (not shown) which forms part of the programming system and monitors the movements of rods between the detector 8 and the center of the straightening station ST. The leading end of the next-following rod 68*a* (which is being advanced by the rollers 5, 6) reaches the detector 8 shortly after the latter detects the trailing end of the preceding rod 68. The detector 8 then actuates an adjustable time delay relay of the programming system which relay changes the condition of the valve 61 after the elapse of a predetermined interval of time. This causes the cylinders 29, 29A to reduce the angle between the axes 5*a*, 6*a* of the advancing rollers 5, 6 so that the rod 68*a* whose leading end has advanced beyond the detector 8 begins to move lengthwise at a reduced speed. The just mentioned delay is selected in such a way that the rod 68*a* which is being advanced by the rollers 5, 6 catched up with the rod 68 which is being treated by the straightening rolls 9, 10 while the leading end of the rod 68*a* travels between the straightening rolls 9, 10 and the detector 8. The aforementioned scanning device which monitors the rods between the detector 8 and the centers of the straightening rolls 9, 10 then produces a signal which causes the rollers 13 of the accelerating unit 13*a* to move into engagement with the uppermost and lowermost portions of the adjacent rod 68 and to rapidly introduce such rod into the guide 14. The accelerating rollers 13 are driven in opposite directions and are movable radially of the adjacent rod 68 by a mechanism which forms no part of the present invention. When the trailing end of the rod 68 which is being accelerated by the rollers 13 reaches the detector 11, the latter produces a signal which energizes a time delay relay of the programming system so that the relay produces a signal after elapse of a predetermined interval of time from the generation of signal by the detector 11. The signal from the relay triggers the following operations: The accelerating rollers 13 are moved away from the freshly treated rod 68 and are brought to a standstill. The movable section of the guide 14 is moved to the open position so that the rod 68 which has entered the guide 14 under the action of the accelerating rollers 13 is free to roll sideways onto the rack 15. A further time delay relay produces a signal when the rod 68 reaches the rack 15. Such signal is used to close the guide 14. In the meantime, the rod 68a which is being advanced by the rollers 5, 6 moves its leading end into the space between the straightening rolls 9, 10 (and its trailing end beyond the rollers 5, 6) and the treatment, acceleration and storage of such rod 68*a* are then carried out in the same way as described above for the preceding rod 68. The rods are treated one after the other as long as the rack

2 contains a supply of untreated rods and as long as the programming system for the straightening machine is on.

An important advantage of the improved advancing apparatus 4 is that the output of the straightening machine is increased because the straightening unit 3 operates at maximum capacity, i.e.., without any gaps between successive workpieces. Another advantage of the feeding apparatus 4 is that it prevents the straightening machine from deforming the trailing ends of those workpieces which move beyond the straightening rolls 9, 10 at the station ST. All this is achieved by the simple expedient of temporarily transporting a freshly introduced workpiece at a relatively high speed so that the thus accelerated workpiece catches up with the preceding workpiece before the trailing end of the preceding workpiece moves beyond the straightening rolls 9, 10.

The advancing rollers 5, 6 reduce the extent of (or completely prevent) the swinging movements of the trailing end of the workpiece in the guide 1 so that this guide can stand long periods of use. Also, when the leading end of a freshly introduced workpiece reaches the trailing end of the workpiece which is being treated by the rolls 9, 10 the trailing end of the preceding workpiece is held against excessive lateral movements. The frame of the straightening machine cannot release energy which would result in deformation of the trailing end of a freshly treated workpiece when such trailing end moves beyond the rolls 9, 10 because the leading end of the next-following workpiece enters the straightening station ST simultaneously with movement of the trailing end of the freshly treated workpiece beyond such station. This insures that each workpiece is properly treated from end to end and that the rack 15 receives workpieces with undeformed trailing ends.

Referring to FIg. 7, there is shown a modified straightening machine wherein the acceleration of workpieces (not shown) which are being transported toward the straightening station ST is not effected by pivoting the axes of the advancing rollers 5, 6 but rather by changing the speed of the motors 91, 91A for such advancing rollers. This results in substantial simplification of the aggregates for the advancing rollers 5, 6 because these rollers need not be pivoted with their holders. The change in speed of the motors 91, 91A for the advancing rollers 5, 6 is effected by changing the inclination of the customary tilting plate (not specifically shown) in an axial piston pump 87 which is driven by the transmission 76 for the straightening roll 10. The mechanism for changing the inclination of the tilting plate in the pump 87 comprises a feed screw 88, a gear train 89 which can move the feed screw 88 axially, and a servomotor 90 which rotates the first gear of the gear train 89. The feed screw 88 changes the inclination of the tilting plate in the pump 87. The servomotor 90 is controlled by a circuit 92 which receives signals from the detector 8. The circuit 92 further receives signals from the limit switch 37 (not shown in FIG. 7). The circuit 92 may comprise a time delay relay and an amplifier; such parts determine the length of intervals during which the motor 90 causes the feed screw 88 to increase the inclination of the tilting plate in the axial piston pump 87 so that the latter conveys more fluid through the series-connected motors 91, 91A whereby the advancing rollers 5, 6 drive the adjacent workpiece at a higher speed so that such workpiece can catch up with the workpiece which is being treated by the straightening rolls 9, 10.

Otherwise, the operation of the machine shown in FIG. 7 is identical with that of the machine shown in FIG. 6. The only important difference is that the advancing rollers 5, 6 of the machine shown in FIG. 7 need not be pivoted with their holders, i.e., it is merely necessary to move the roller 5 to and from a retracted position so as to permit the introduction of a fresh workpiece from the rack 2 into the guide 1. All other parts which are shown but not specifically mentioned in FIG. 7 are denoted by characters identical with those employed in FIGS. 1 to 6.

The straightening machine of FIG. 7 can be used with particular advantage for the treatment of large-diameter tubes or rods which are normally moved lengthwise at a relatively low speed. This renders it possible to temporarily increase the speed of lengthwise movement of a freshly introduced workpiece by increasing the operating speeds of the motors 91, 91A to such an extent that the leading end of the freshly introduced workpiece catches up with the trailing end of the workpiece which is being treated at the station ST before such trailing end moves beyond the rolls 9, 10. The temporary increase in rotational speed of the accelerated workpiece about its own axis during travel toward the workpiece which passes through the station ST is of no consequence because the difference between the normal rotational speed and the increased rotational speed about the axis of such workpiece is relatively small. However, when the diameters of the workpieces are relatively small (e.g., less than 100 millimeters), the difference between the rotational speeds while a workpiece moves lengthwise at a first and second speed is substantial so that such workpieces are preferably treated in machines of the type shown in FIGS. 1 to 6 wherein the rotational speed of a next-following workpiece is preferably caused to match that of the preceding workpiece immediately before or at the time the two workpieces meet upstream of the straightening station.

The machine of FIG. 7 can be modified by replacing the pump 87 with an adjustable electromagnetically operated valve which can temporarily change the rate of oil delivery to the motors 91, 91A in response to signals from the detector 8.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. A method of feeding elongated workpieces, such as tubes or rods, to and through a treating station, especially a straightening station, comprising the steps of rotating a first workpiece about its axis and simultaneously conveying the workpiece lengthwise along a predetermined path toward and through said treating station so that the workpiece moves through the treating station at a first speed; introducing into said path a second workpiece so that the leading end of said second workpiece is spaced from the trailing end of said

first workpiece while such trailing end is still located upstream of said treating station; conveying said second workpiece lengthwise at a second speed which exceeds said first speed so that the leading end of said second workpiece at least closely approaches the trailing end of said first workpiece upstream of said treating station; and reducing the speed of said second workpiece from said second to said first speed and thereafter conveying said second workpiece through said treating station at said first speed.

2. A method as defined in claim **1** wherein said first speed is variable and further comprising the step of changing said second speed as a function of variations of said first speed.

3. A method as defined in claim **1,** further comprising the step of rotating said second workpiece about its axis during lengthwise movement at said first and second speeds.

4. A method as defined in claim **1,** further comprising the steps of producing a signal in response to movement of the leading end of said second workpiece beyond a predetermined portion of said path, and utilizing such signal to decelerate said second workpiece from said second to said first speed.

5. A method as defined in claim **1,** further comprising the step of accelerating said first workpiece upon completed transport of the trailing end of said first workpiece beyond said treating station so that the trailing end of said first workpiece moves away from the leading end of said second workpiece.

6. A method as defined in claim **1,** wherein said second workpiece is introduced into said path by moving sideways.

7. In a machine for straightening or analogous treatment of elongated workpieces, such as metallic rods or tubes, a combination comprising a treating unit having means for rotating successive workpieces about their own axes and for advancing such workpieces lengthwise at a first speed; and a feeding apparatus for supplying successive workpieces to said treating unit, said apparatus comprising advancing means for advancing successive workpieces lengthwise along a predetermined path at a second speed exceeding said first speed so that the leading end of a next-following workpiece which is introduced into said path with a delay following the introduction of preceding workpiece catches up with the trailing end of the preceding workpiece, and for thereupon advancing such next-following workpiece at said first speed so that the next-following workpiece enters said treating unit at least substantially simultaneously with lengthwise movement of the preceding workpiece beyond said treating unit.

8. A combination as defined in claim **7,** wherein said advancing means comprises a pair of concave advancing rollers, motor means for rotating said rollers about their respective axes, holder means for maintaining said rollers in positions of contact with a workpiece therebetween so that the axes of said rollers are inclined with reference to the axis of such workpiece whereby the workpiece is caused to move lengthwise and to rotate about its own axis, and adjusting means for changing the inclination of the axes of said rollers to thereby change the speed of lengthwise movement of the workpiece which is engaged by said rollers.

9. A combination as defined in claim **8,** wherein said adjusting means comprises fluid-operated motor means for turning said holder means about axes which are at least substantially normal to the axes of workpieces in said path.

10. A combination as defined in claim **9,** wherein each of said fluid-operated motor means comprises a double-acting cylinder and piston unit actuatable to turn the respective holder means and the associated roller about the corresponding axis.

11. A combination as defined in claim **10,** further comprising signal generating detector means adjacent to said path between said unit and said apparatus and arranged to produce signals for actuation of said cylinder and piston units in response to detection of predetermined portions of successive workpieces.

12. A combination as defined in claim **11,** further comprising electromagnetically operated valve means arranged to control the actuation of said cylinder and piston units in response to signals from said detector means.

13. A combination as defined in claim **11,** wherein said detector means comprises at least one inductance.

14. A combination as defined in claim **7,** wherein said advancing means comprises a pair of conical rollers, holder means for maintaining said rollers in positions of contact with a workpiece therebetween so that the axes of said rollers are inclined with reference to the axis of the workpiece therebetween, motor means for rotating said rollers whereby the rotating rollers cause the workpiece therebetween to rotate about its own axis and to move lengthwise toward said treating unit, and adjusting means for changing the speed of said motor means to thereby change the speed of lengthwise movement of the workpiece which is engaged by said rollers.

15. A combination as defined in claim **14,** wherein said motor means comprises a discrete fluid-operated motor for each of said rollers, variable-delivery pump means for supplying a pressurized fluid to said motors, and means for changing the rate of fluid delivery by said pump means.

16. A combination as defined in claim **15,** wherein said means for rotating the workpieces in said treating unit comprises a plurality of straightening rolls and motor means for rotating at least one of said rolls, said pump means receiving motion from said last mentioned motor means.

17. A combination as defined in claim **7,** wherein said treating unit comprises a plurality of concave straightening rolls and first motor means for rotating at least one of said rolls, said advancing means comprising a pair of concave advancing rollers, second motor means for rotating said advancing rollers, and means for changing the speed of said second motor means as a function of changes in the speed of said first motor means.

18. A combination as defined in claim **7,** further comprising a source of workpieces and transfer means for delivering successive workpieces from said source into said path at predetermined intervals.

19. A combination as defined in claim **7,** wherein said advancing means comprises a pair of rotary concave advancing rollers located at the opposite sides of a predetermined portion of said path and means for moving at least one of said advancing rollers away from and toward said path to thus permit entry of a fresh workpiece into said path when said one roller is moved away from said path.

20. A combination as defined in claim **7,** further comprising means for accelerating successive workpieces downstream of said treating unit.

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