(12) UK Patent Application (19) GB (11) 2 254 025 (13) A

(43) Date of A publication 30.09.1992

(21) Application No 9204191.2

(22) Date of filing 27.02.1992

(30) Priority data
(31) 4106178 (32) 27.02.1991 (33) DE

(71) Applicants
Erhard Hentzschel
Krankenhausstr 5, D-5608 Radevormwald,
Federal Republic of Germany

Matthäus Ulrich
Dischingerstr 7, D-6900 Heidelberg,
Federal Republic of Germany

(72) Inventors
Erhard Hentzschel
Matthäus Ulrich

(74) Agent and/or Address for Service
Brookes & Martin
High Holborn House, 52-54 High Holborn, London
WC1V 6SE, United Kingdom

(51) INT CL[5]
B21C 37/09

(52) UK CL (Edition K)
B3A A122J A78B A78W

(56) Documents cited
GB 2039808 A EP 0036968 A

(58) Field of search
UK CL (Edition K) B3A
INT CL[5] B21C
On line databases WPI, CLAIMS

(54) Method of, and apparatus for, producing double wall tubes

(57) A double walled tube (8) is made from steel strip (2) coated with copper by subjecting the strip to the action of rolls (4, 5) pre-calibre rolls (6) and finishing calibre rolls (7) and brazing the wound strip. The calibres employ outer roll sets (6, 7) and an inside tool (9). Various parameters are monitored and controlled to cause the tube winding to be subjected to two-stage cold forming and elongation by applying tractive power, to the tube winding by rotating the strip forming and the pre-calibre rolls (4, 5, 6) and the finishing calibre rolls (7) at different speeds whilst the position of the inside tool (9) is adjusted.

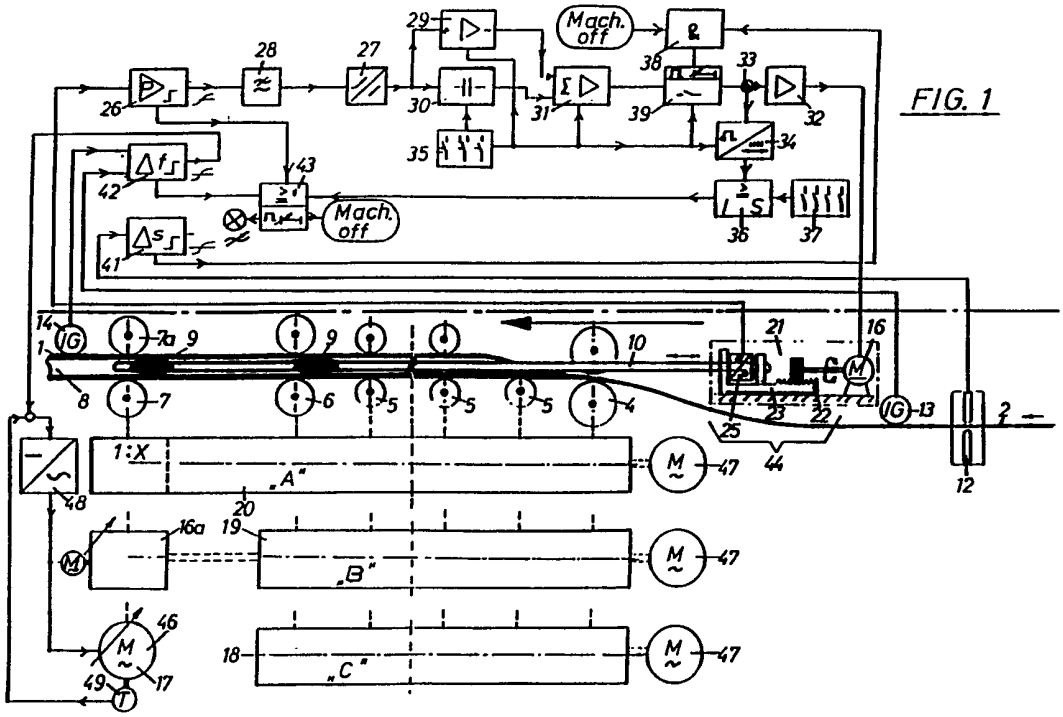
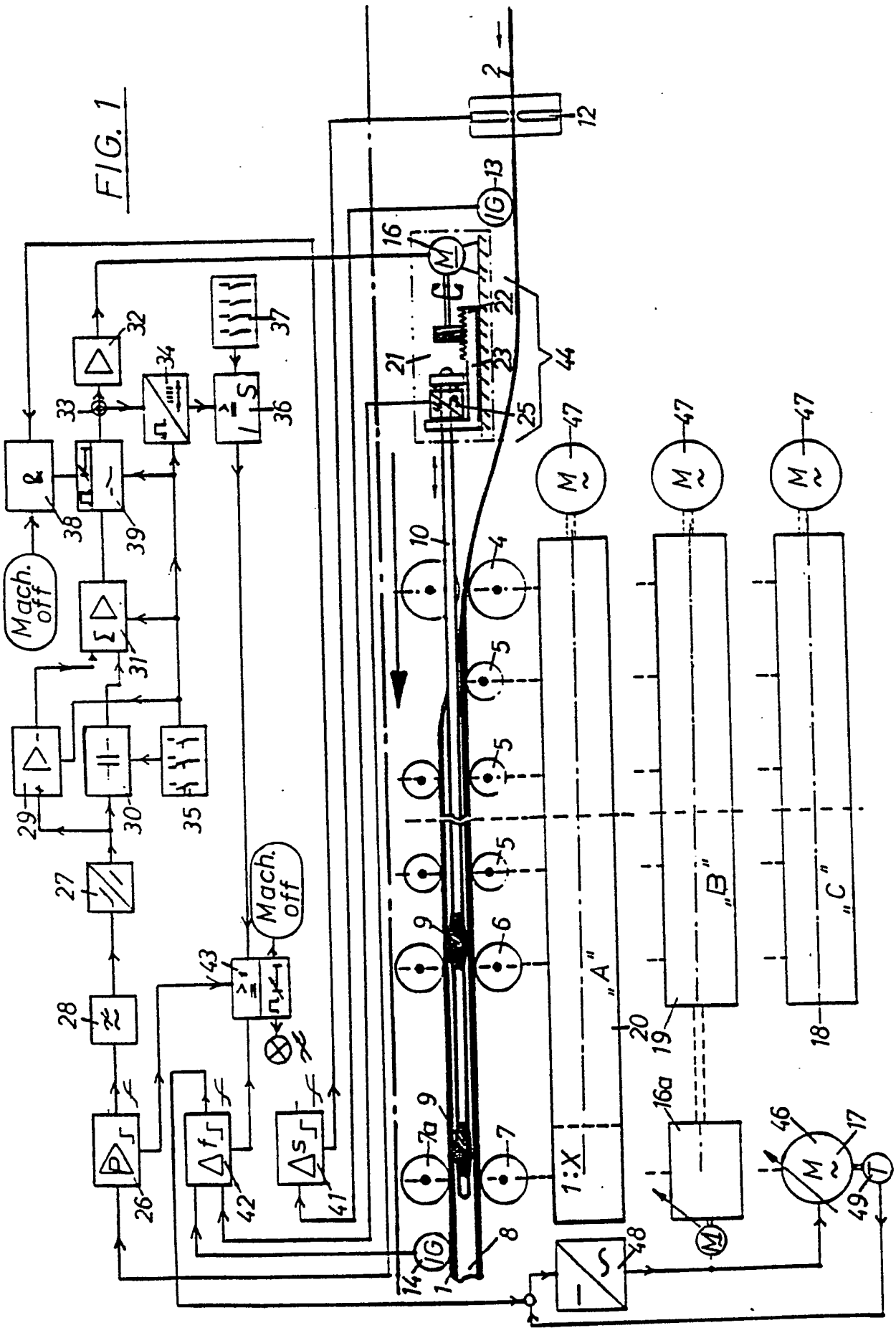


FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 254 025 A

FIG. 1



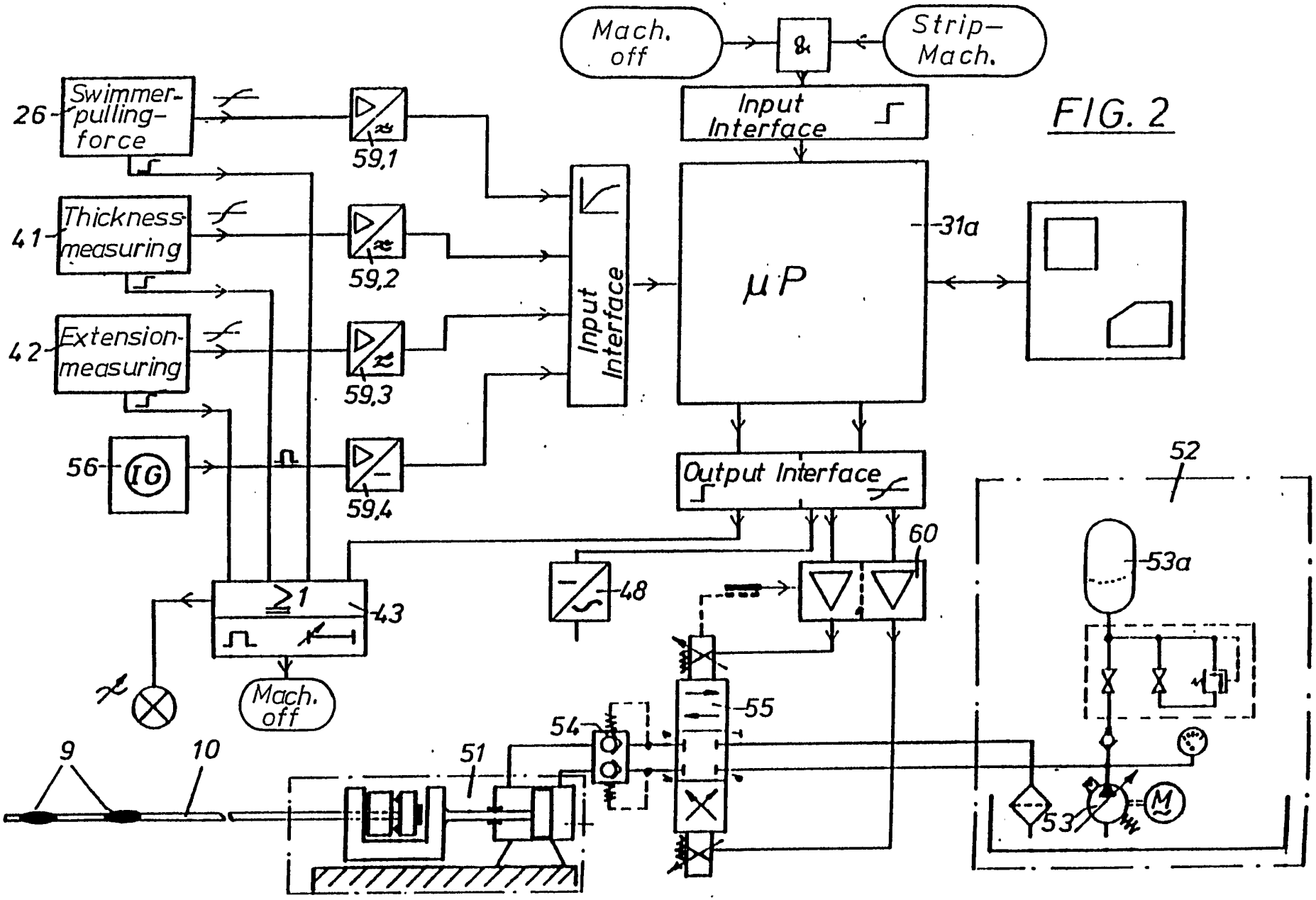

Mach. off
&
Strip– Mach.
Input Interface
26
Swimmer-pulling-force
59,1
41
Thickness-measuring
59,2
42
Extension-measuring
59,3
56
IG
59,4
Input Interface
µP
31a
Output Interface
52
60
53a
48
≥1
43
Mach. off
55
54
51
9
10
53
M

FIG. 2

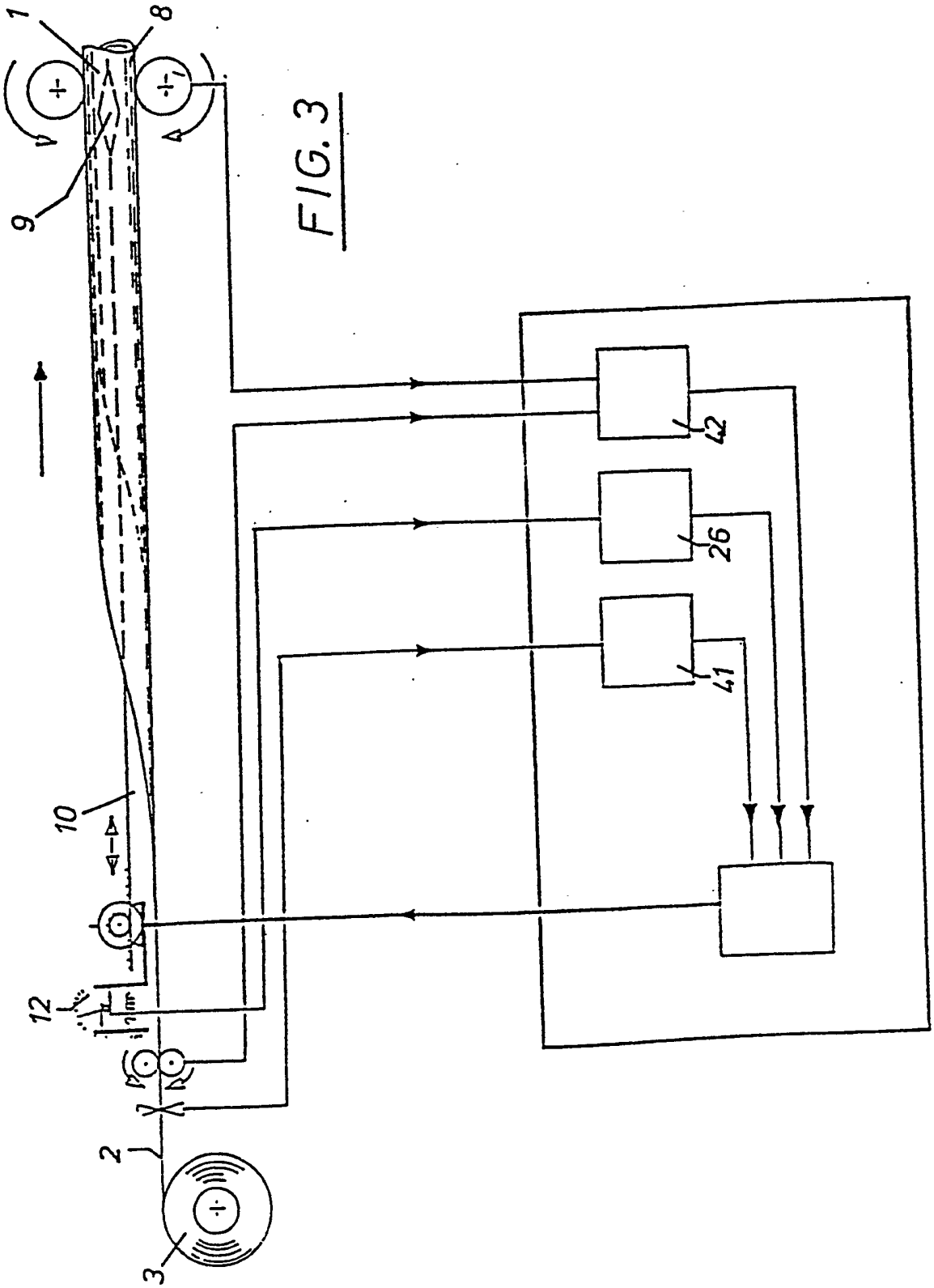
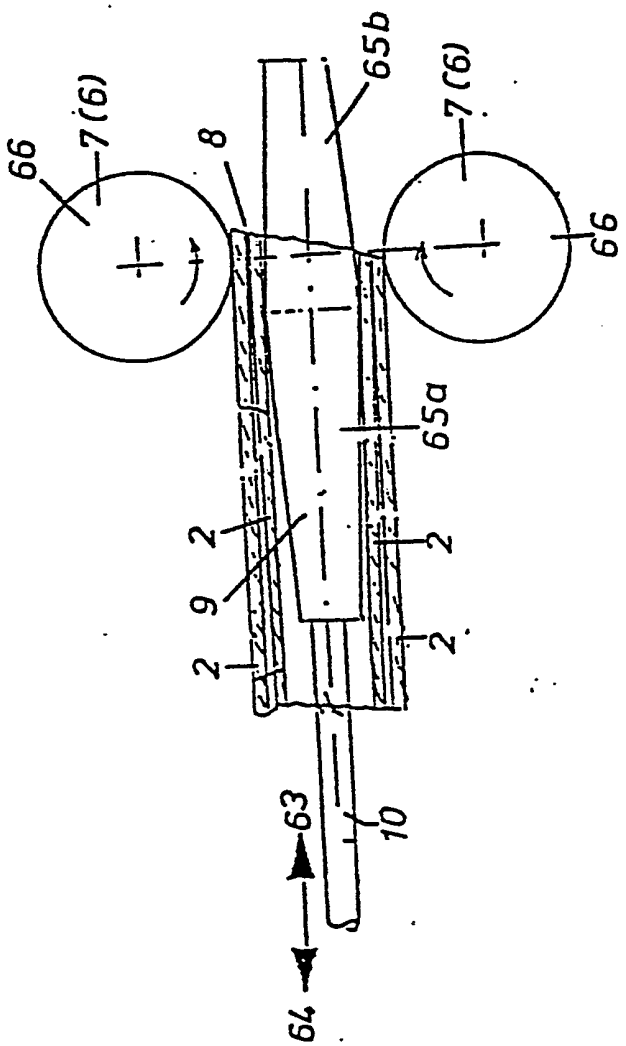


FIG. 3

FIG. 4



METHOD OF, AND APPARATUS FOR, PRODUCING DOUBLE WALL TUBES

The invention relates to a method of and an apparatus for producing double wall tubes, especially brake lines, fuel lines or hydraulic lines using the so-called "Bundy" R.T.M. method and a control system usable in such a method and apparatus.

As is known from DE-PS-813839 immediately after winding steel strips, coated on one or both sides with copper, are formed on a pre - and a finishing calibre to a compact tube winding. The calibres consist of an inside tool (swimmer) and an outside pair of forming rolls. The tube winding is then brazed under the influence of protective gas at a temperature above the melting temperature of copper.

Tubes of this nature are safety parts because of their special quality, so that following legal regulations or instructions or governmental directions their use as brake lines, fuel lines or hydraulic line are allowed. This means the conditions under which the tubes are made must be of extremely high quality. In practice, that means various parameters have to be monitored and controlled. For instance, the strip thickness influences the inside diameter and in keeping

the outside diameter constant. The dimensional tolerances and the stability of the tube winding are influenced by the inside tool, the so-called swimmer, especially by its diameter, by the tractive power, by the swimmer position, etc.

The present invention has the aim to control the production parameters with greater accuracy than before and to compensate for variations rapidly and automatically so that the tube winding can be produced in a constant high quality.

In accordance with one aspect of the invention there is provided a method of producing double wall tubes, especially brake lines, fuel lines or hydraulic lines using the so-called "Bundy" method, in which immediately after forming or winding steel strips coated on one or both sides with copper are formed on a pre - and a finished calibre to a compact tube winding, each of which calibres consists of an inside tool (swimmer) and an outside set of forming rolls and the tube winding is brazed under influence of protective gas using a temperature above the melting temperature of copper, wherein the tube walls are pressed together by a first cold forming, caused by the calibres, whilst the tube

walls are supported and then a second cold forming, which is caused by tractive power put on the compact tube winding by different rotating speeds of strip forming rolls and the pre-calibre on the one hand and the finishing calibre on the other hand to produce elongation or extension of the tube.

In another aspect the invention provides apparatus for producing double wall tubes, especially brake lines, fuel lines or hydraulic lines using the so-called "Bundy" method, said apparatus comprising strip forming rolls for treating steel strip coated on one or both sides with copper, pre - and finishing calibres for forming the strip into a tube, each calibre comprising an inside tool (swimmer) and an outside set of forming rolls, means for brazing the wound tube after forming under protective gas using a temperature above that of the melting temperature of copper and a control system for controlling the operation of the calibres to subject the tube walls to a two stage cold forming treatment, the second stage involving different rotating speeds of strip forming rolls and the pre-calibre on the one hand and the finishing calibre on the other hand to produce an extension of the tube.

In accordance with the invention, the tube walls

are pressed together by a first cold forming caused by calibres (the working together of the inside tool and the outside set of forming rolls), and that this pressing together of the tube walls is supported and increased by a second cold forming, which is caused by tractive power put on the compact tube winding by different rotating speeds of the strip forming rolls and the pre-calibre on the one hand and the finishing calibre on the other hand.

By this a better quality of tubes up to now and a constant quality during production can be achieved.

However, the stability of the tube winding has a special importance. The double wall tube, which is called tube winding before brazing, would spring back and open if there would be only an elastic forming. A usual plastic forming, realized by hard pressing of both wound tube walls would not be sufficient to keep the orderly overlapped double wall tube form, as manufactured in the finishing calibre. Only by "overforming" in accordance with the invention by the two stage cold forming can bring the wanted result.

Advantageously is a tube winding elongation of 4-8%. On average an elongation of 5-6% is sufficient for a cold strengthening.

A preferred way for the elongation to be adjusted is controlled tractive power on a pulling bar.

The desired high quality constant product achieved during manufacturing can be achieved by the invention so that the extension (stretching) is measurable between an in- running steel strip and an out-running tube winding by means of measurement sensors and an instantaneous value is lodged into a memory as a reference input while tool setting occurs and can be used as a basic value of a microprocessor in an automatic control operation. A hydraulic or electrical linear drive can control or automatically control the change of the position of the inside tool or the tractive power of the inside tool can be measured by a load cell in an automatic control system. The instantaneous value during tool setting can be loaded into the memory as a reference input and is available for a variance comparison at an attitude control and by this control the linear drive can be switched for changing the position of the inside tool.

Thereby all existing parameters can be covered. Besides this such an equipment has a special advantage for automatic control.

In accordance with a further feature of the invention an adjustable separate drive for a finishing

calibre rolling set ensures a higher automatically controlled rotary speed to the other connected forming roll drives. Thereby the tractive power put on the tube winding can be controlled easily.

Alternatively, instead of separate drives for the finishing rolling set there can be an adjustable mechanism. A further drive variation is that instead of a separate drive for the finishing rolling set there a rigid mechanism or gear for driving this and the other form rolling drives with a fixed rotary speed for each drive.

The linear drive for changing the position of the inside tool may consist of an hydraulic or mechanical linear drive, which is connected to a support for the inside tool respectively connected to a load cell.

A control system usable in the invention may have the following features.

(a) a load cell which is impinged by a pulling bar of the inside tool,

(b) a load amplifier, which is assigned to an electromechanical servomotor,

(c) a first module for the adjustment of a signal level,

(d) an average value former with a filter for the measuring signal,

(e) an inverter and a parallel connected memory for reference input,

(f) a position control and

(g) a final signal amplifier influencing the servomotor.

Such a control systems fulfils all conditions for obtaining and controlling the named parameters.

A further preferred feature of the invention is the provision of a counter and a reference input corrector, which are joined by a feed back connection before entering the signal amplifier. It is advisable that via the counter a comparator and an adjusting device establish positive or negative limiting values of the position adjustment of the inside tools. An AND-gate connected between the position control and a first signal amplifier, and a second module can be provided for adjusting the signal level in the conditions "machine stop" or "strip end". Thereby the last instantaneous value can be registered as a new start.

While the control system may be made on an electric or electronic basis, another alternative is a hydraulic linear drive for positioning the inside tool

which is connected to a pressure pump via a pilot controlled check valve and a proportional valve, co-operating with amplifier modules which are coordinated to the single tube making parameters e.g. strip thickness measuring amplifier and an elongation measuring device, aswell as the signal adjusting modules. The corresponding signals are fed to a microprocessor as reference inputs or correction values, by which differences of control values are noticed and compensated via the signal amplifier and the proportional valve.

The invention may be understood more readily and various other aspects and features of the invention may become apparent from consideration of the following description.

Embodiments of the invention will now be described by way of examples only, with reference to the accompanying drawings wherein:

Figure 1 is a block diagram of apparatus in accordance with the invention utilizing a first control system in an electromechanical design;

Figure 2 is a block diagram of apparatus in accordance with the invention utilizing a second control system with a microprocessor based control system, but in

a hydraulic design;

Figure 3 is a block diagram for supplementing Figure 1; and

Figure 4 is a partial section of a tube winding mechanism of the apparatus with an inside tool and sets of rolls constituting a calibre.

According to Figure 1 in the central region of the block diagram the devices for making double wall tubes as per the so-called "Bundy" method are shown. For the tube making method one sided or double sided copper coated strip 2 is pulled off a coiler 3 and via scarfing rolls 4, forming rolls 5 pre-calibre rolls 6 and finishing calibre rolls 7 formed to a completed tube winding 8.

In a first phase the steel strip 2 is scarfed at the edges and then wound. A second phase follows the stabilisation of the tube winding 8 and after that the brazing (this step is not to be seen on the drawing). The second phase requires an inside tool 9, that is a so-called "swimmer", which shows its function. The double wall tube 1 after manufacturing shows at least the double wall thickness of the steel strip 2.

The inventive process is based on the fact, that the tube walls (both surfaces of the steel strip 2) are pressed together by a first cold forming made by the

inside tool 9 working together with the scarfing rolls 4, the forming rolls 5, the pre-calibre rolls 6 and the finishing calibre rolls 7 and that this pressing together of the tube walls is increased by a second cold forming, that is put on the tube winding 8 by tractive power caused by different rotary speeds of the forming rolls 5 and pre-calibre rolls 6 on one hand and the finishing calibre rolls 7 on the other hand.

The resultant elongation of the tube winding should be 4-8%, preferably on average 5-6%. The elongation can be brought to the tube winding by a controlled tractive power on a pulling bar 10 connected with the inside tool 9.

In Figure 4 the double step cold forming operation is represented. The pre-calibre rolls 6 and the finishing calibre rolls 7 press the tube winding 8 radially together whereby the second step of the cold forming is caused by pulling of the inside tool 9 axially in (direction 63) or out (direction 64). The inside tool 9 is obviously constructed as double cones 65a and 65b. In order to transfer the tractive power from the finishing calibre rolls 7 to the tube winding 8 these rolls 7 have a roughened surface preferably a surface

with a wearing coat on its calibre form 66. At the same time it is essential, that the inside tool 9 prevents the tube winding 8 from escaping into the inside of the tube. The inside tool 9 forms together with the pre-calibre rolls 6 and the finishing calibre rolls 7 a roll gap, between which the winded double wall tube 1 is pulled out by means of the roughened calibre form 66.

A control system for the apparatus is shown in two alternatives. The alternative according to Figure 1 shows an electromechanical solution. This control system is composed of a load cell 25 impinged by the pulling bar 10, a load measuring amplifier 26, a first module 27 an average value former 28 with a filter for the measuring signal, an inverter 28 and a parallel connected memory for reference input 30 and a position control 31. An instantaneous value, put in normally, is stored as a reference input and is used for the variance comparison in automatic conditions at the position control 31.

According to the upper region of the block diagram of Figure 1 a counter 34 and a reference input corrector 35 are joined by a feed back connector before entering a final signal amplifier 32. Via the counter 34, a comparator 36 and an adjusting device 37 positive or

negative limiting values of the position adjustment of the inside tools 9 are set.

An AND-gate 38 is connected between the position control 31 and the final signal amplifier 32 and a second module 39 for adjusting the signal level in the conditions "machine stop" or "strip end" whereby the last instantaneous value can be registered as a new start.

A strip thickness measuring sensor 12 gives a signal to an amplifier 41, which is connected to the AND-gate 38. The strip thickness is thus monitored and indicated. The strip thickness measuring can take place continuously with the strip thickness sensor 12.

By means of an incremental pulse generator 13 as a pick up sensor (strip inlet) and an incremental pulse generator 14 (tube winding outlet) there will be measured in an elongation measuring device 42 the difference speed, thereby the elongation can be monitored and indicated.

By passing over the upper or under limiting value adjusted in the before mentioned measuring device a signal will be given to an OR-time-gate 43, which gives at first a warning. After the time x is over, the whole production line will be stopped.

The inside tool positioning device 44 is shown besides a linear drive 21, a support 22, an inside tool power sensor 23, the tool pulling bar 10, the load cell 25 and this is a subassembly of the control system.

A servomotor 16 for positioning of the inside tool 9 is connected to the mechanical linear drive 21.

There is also the possibility to adjust by a separate drive 17 the finishing calibre roll stand 7, 7a to a higher controlled rotary speed than it is on the other forming roll stand drives 18.

On the other hand it is possible that instead of a separate drive 17 for the finishing calibre roll stand 7, 7a an adjustable mechanism 19 is used.

In another modification, instead of the separate drive 17 for the finishing calibre rolls 7 or 7a a rigid mechanism 20 with fixed rotary speeds for the rolls 7 or 7a and the other forming rolls 18 is used.

There are three variants to obtain the wanted elongation in the tube winding 8:

1) A solution C (Figure 1) in form of a separate drive 17.

2) A solution B in form of an adjustable mechanism 19 and

3) A solution in the form of a rigid mechanism

20 with fixed rotary speeds.

An AC-motor 48 is provided for the separate drive 17, an AC-motor 47 for driving of the forming roll stands 18 as well as and the adjustable mechanism 19 and the rigid drive 20.

The AC-motor 46 is fed by an inverted rectifier 48. The instantaneous value of the rotary speed is picked up by a tachogenerator 49, which gives inputs to the inverted rectifier 48.

According to Figure 2 a hydraulic linear drive 51 for positioning the inside tool 9 can be seen; it is a part of an electrohydraulic inside tool positioning device.

In Figure 2 on the right side can be seen in a dot-and-dash outline a frame 52 a complete hydraulic pressure fluid equipment with a pump 53 and a hydraulic diaphragm storage 53a as a pressure source. The hydraulic linear drive 51 is connected to the pressure source by a dislockable non-return valve (pilot controlled check valve) 54 and a proportional valve 55.

The parameters of elongation and tractive power of the inside tool 9, empirically found out, and coordinated with the single tube dimensions, will be stored in a

microprocessor 31a as reference input. According to these reference inputs the position of the existing inside tools 9 is established fully automatically. As soon as the front end of the tube winding leaves the production machine the incremental pulse generator 13 as measuring sensor of the strip inlet and the generator 14 as a measuring sensor of the tube winding outlet will be activated and, after a short delay, also the control device for the inside tool 9. The value of the elongation is passed to the microprocessor 31a via the elongation measuring device and a signal modification module 59.3. This value is the basic instantaneous value of the controlling device.

Both correction instantaneous values will be added to that basic instantaneous value or subtracted and as a control deviation passed to a proportional valve amplifier 60 as a signal amplifier. In the proportional valve 55, which is fed by the amplifier 60, the electrical signal is converted into an hydraulic signal, which gives a mechanical movement to the hydraulic cylinder 62, by way of the proportional valve 55.

The measuring amplifier of the inside tool tractive power measuring device, the amplifier of the strip thickness measuring and that of the elongation

measuring are provided with adjustable limiting value indicators, which will give at first a fault signal and, after quite a while, the total production line will be stopped.

By different surface conditions of the steel strip 2 the friction factor between the strip 2 and the inside tool 9 can be changed and with it the tractive power of the inside tool 9. Here the power measuring amplifier 28 influences the procedure. The measuring signal of the amplifier 26 during tube forming will be passed as a correction value to the microprocessor 31a via the amplifier 26 and a signal forming module 59.1.

Deviations of the stored reference input will be computed with the elongation control value and the resulting control deviation is passed to the proportional amplifier 60. This control deviation will be balanced by the proportional valve 55 and the hydraulic linear drive 57.

The measured signal for the sensor 12 as a further correction value is passed to the microprocessor 31a via the strip thickness measuring amplifier 41 and a signal modification module 59.2. An incremental pulse generator 56 measures the distance between the strip thickness

sensor 12 and the reference position of the inside tool 9. After a delay time, which is dependent on the production speed, the difference between the reference strip thickness and the effective strip thickness is passed as a correction value to the microprocessor 31a via a signal modification module 59.4.

CLAIMS

1. A method of producing double wall tubes, especially brake lines, fuel lines or hydraulic lines using the so-called "Bundy" method, in which immediately after forming steel strip coated on one or both sides with copper is formed on a pre- and a finishing calibre to a compact tube winding, each of which calibres consist of an inside tool (swimmer) and an outside set of forming rolls and the tube winding is brazed under influence of protective gas using a temperature above the melting temperature of copper, wherein the tube walls are pressed together by a first cold forming, caused by the calibres whilst the tube walls are supported and then by a second cold forming, which is caused by tractive power put on the compact tube winding by different rotating speeds of strip forming rolls and the pre-calibre on the one hand and the finishing calibre on the other hand to produce extension of the tube.

2. A method according to Claim 1 wherein the extension of the tube winding is adjustable in the range of 4 - 8%.

3. A method according to Claim 1 or 2 wherein the extension of the tube is adjusted by a controlled tractive power working on a draw bar connected with the

inside tool of one or more of the calibres.

4. A method of producing double wall tubes substantially as described herein with reference to, and as illustrated in any one or more of the Figures of the accompanying drawings.

5. Apparatus for producing double wall tubes especially brake lines, fuel lines or hydraulic lines using the so-called "Bundy" method, said apparatus comprising strip forming rolls for treating steel strip coated on one or both sides with copper, pre and finishing calibres for forming the strip into a tube, each calibre comprising an inside tool (swimmer) and an outside set of forming rolls, means for brazing the wound tube after forming under protective gas using a temperature above that of the melting temperature of copper and a control system for controlling the operation of the calibres to subject the tube walls to a two stage cold forming treatment the second stage involving different rotating speeds of the strip forming rolls and the pre-calibre on the one hand and the finish calibre on the other hand to produce an extension of the tube.

6. Apparatus according to Claim 5 and further comprising sensors for measuring the extension between

the in-running steel strip and the out-running tube winding, a microprocessor with a memory for storing an instantaneous value as a reference input while tool setting occurs and a hydraulic linear drive for controlling the change of the position of the inside tool.

7. An apparatus according to Claim 5 and further comprising sensors for measuring the extension between the in-running steel strip and the out-running tube winding, a microprocessor with a memory for storing an instantaneous value as a reference input while tool setting occurs, means for measuring tractive power of the inside tool and control means to control an electrical linear drive for changing the position of the inside tool.

8. Apparatus according to Claim 6 wherein the linear drive for changing the position of the inside tool consists of a hydraulic or mechanical linear drive, which is connected to a support for the inside tool.

9. Apparatus according to Claim 6, 7 or 8 wherein there is a separate drive providing an automatically higher controlled rotary speed to the finishing calibre than the other connected forming roll drives.

10. Apparatus according to Claim 6, 7 or 8 and further

comprising an adjustable mechanism for adjusting the rotational speed of the finishing calibre.

11. Apparatus according to Claim 6, 7 or 8 wherein a mechanism is provided for driving the finishing calibre and the other form rolling drives with a fixed rotary speed different to one another.

12. Apparatus according to any one of Claims 5 to 11 and further comprising a load cell which subjected to force by a pulling bar acting on the inside tool;

a load amplifier which is assigned to an electromechemical servomotor;

a first module for the adjustment of a signal level;

an average value former with a filter for a measuring signal;

an inverter and a parallel connected memory for reference input;

a position control; and

a final signal amplifier influencing the servomotor.

13. Apparatus according to Claim 12 wherein there is further provided a counter and a reference input corrector joined by a feed back connection before

entering the final signal amplifier.

14. Apparatus according to Claim 12 or 13 wherein there is provided a counter, a comparator and adjusting device with which positive or negative limiting values of the position adjustment of the inside tool is established.

15. Apparatus according to any one of Claims 12 to 14 wherein an AND-gate is connected between the position control and the final signal amplifier, and a second module serves for adjusting the signal level in the conditions "machine stop" or "strip end" whereby the last instantaneous value can be registered as to a new start.

16. Apparatus according to Claim 5, wherein an hydraulic linear drive for positioning the inside tool is connected to a pressure pump via a pilot controlled check valve and a proportional valve, signal amplifier modules are provided which are coordinated to the tube making parameters, e.g. strip thickness and elongation and measuring and signal adjusting modules provide corresponding signals to a microprocessor as reference inputs or correction values, by which differences of control values are noticed and compensated via the signal amplifier and the proportional valve.

17. Apparatus for making tubes or a control system

therefor substantially as described with reference to, and as illustrated in, any one or more of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
9204191.2

Relevant Technical fields

(i) UK Cl (Edition K) B3A

(ii) Int CL (Edition 5) B21C

Search Examiner
A R MARTIN

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI, CLAIMS

Date of Search
18 MAY 1992

Documents considered relevant following a search in respect of claims ALL CLAIMS

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	EP 0036968 (WEISS) See Claim 1	Claims 1 and 5 at least
A	GB 2039808 (MILANO-BUNDY) See Claim 1	Claims 1 and 5 at least

HCS - c:\wp51\doc99\fil000266

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Published 1992 at The Patent Office, Concept House, Cardiff Road, Newport, Gwent NP9 1RH. Further copies may be obtained from Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, NP1 7HZ. Printed by Multiplex techniques ltd, St Mary Cray, Kent.