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Large et al.

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[54] **PROCESSING OF WIRES**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 92,795, Nov. 25, 1970, abandoned.

[52] **U.S. Cl.** **72/286,** 72/289

[51] **Int. Cl.** **B21c 9/00**

[58] **Field of Search** 72/274, 278, 279, 286, 72/288, 289, 46, 47, 443

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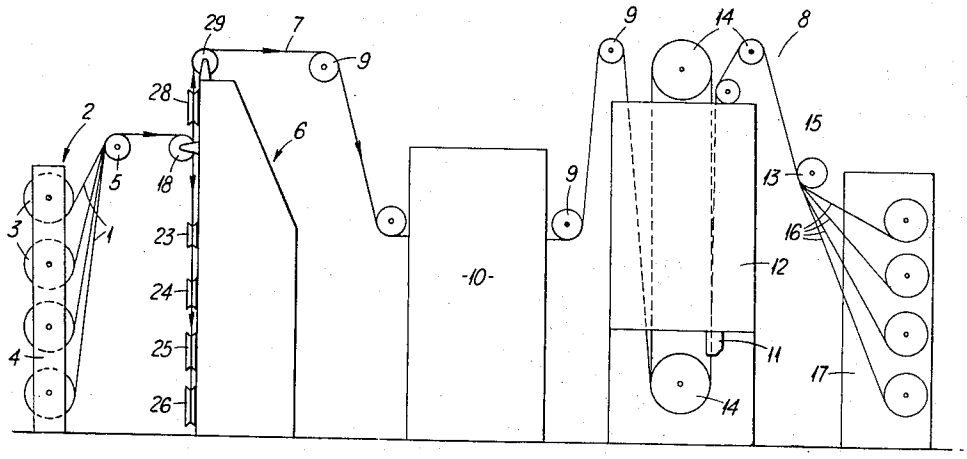
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[57] **ABSTRACT**

A method of processing wire comprises drawing it by at least one capstan through at least two dies to produce a reduction in area of at least 30 percent and passing through the or each wire directly (i.e. without an intermediate accumulator) into subsequent processing apparatus.

The or each drawing capstan is driven at a peripheral speed greater than the speed of the wire engaged thereby, and the subsequent processing apparatus includes means determining the speed of the wire, during drawing as well as during subsequent processing, at such a value that its speed through each die through which it passes is so related to the reduction in cross-section effected at that die that the wire is not significantly heated. In the case of copper or aluminium wires, the wire temperature should not exceed 150°C during drawing.

6 Claims, 3 Drawing Figures



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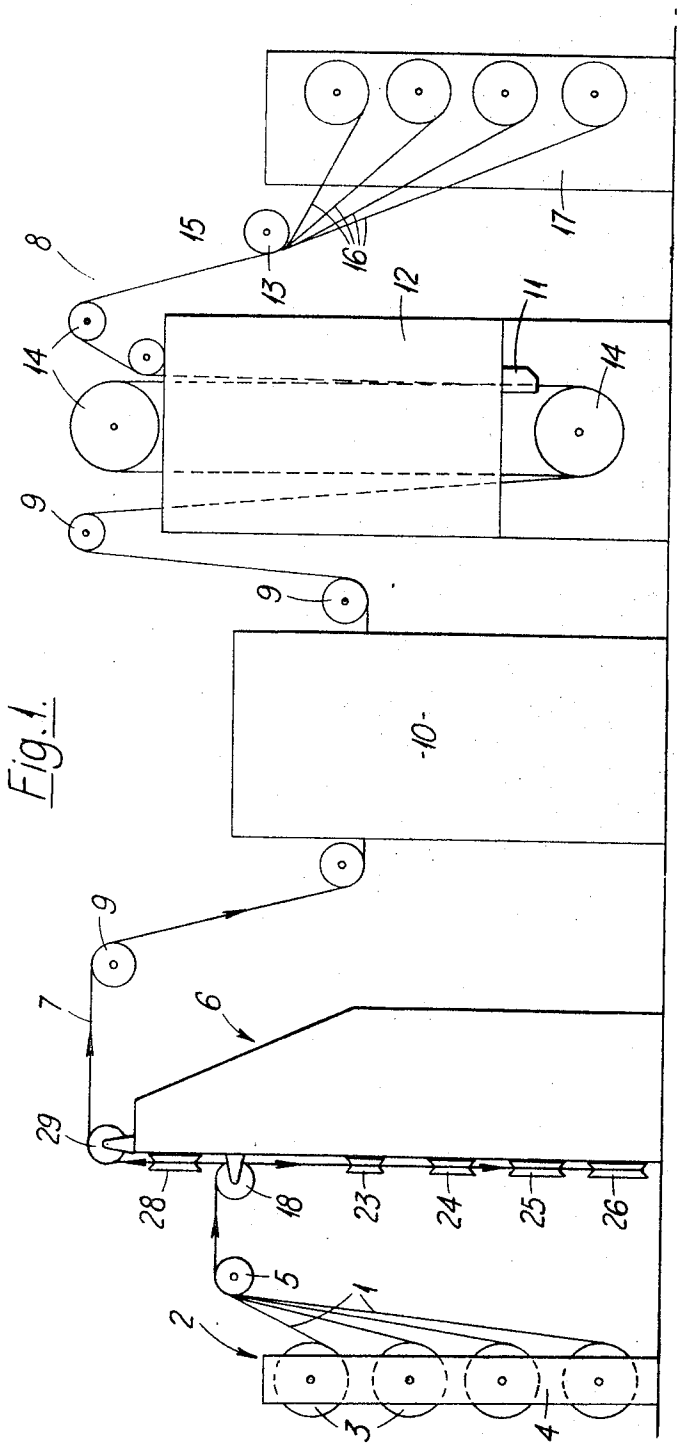
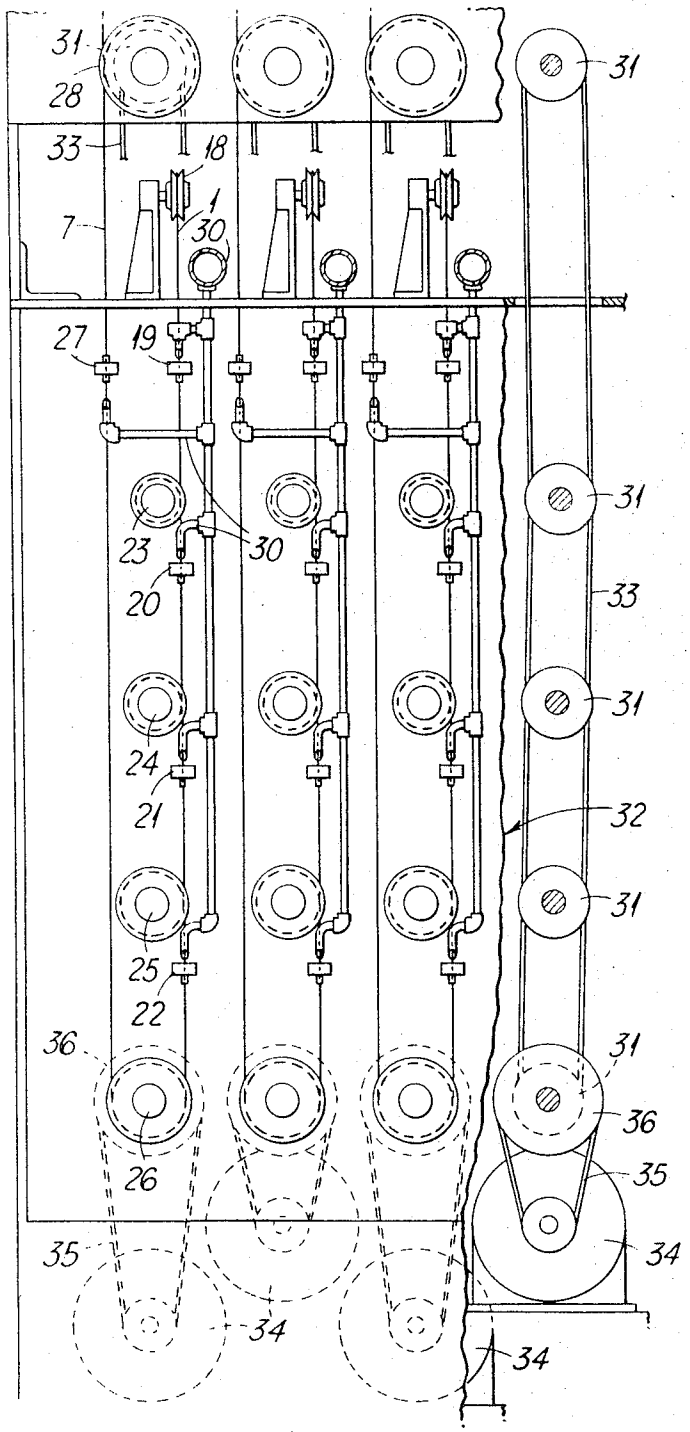


Fig. 1.

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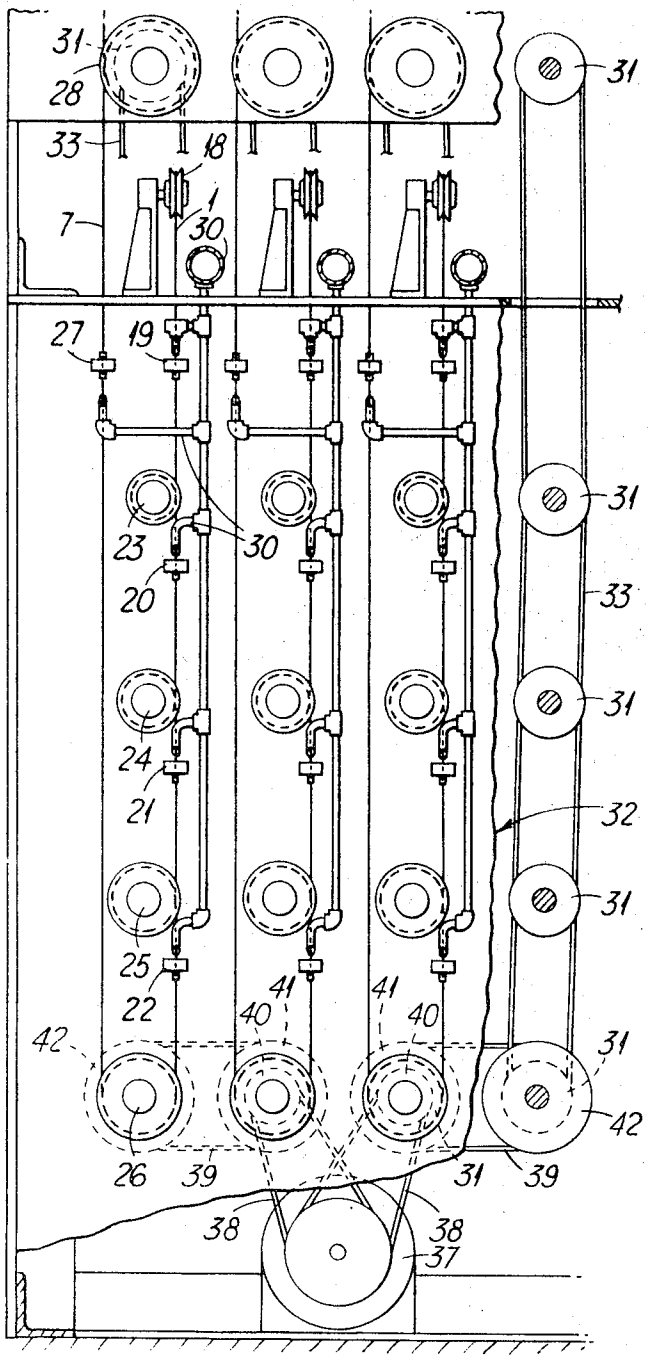
Fig. 2.



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Fig. 3.



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PROCESSING OF WIRES

This application is a continuation-in-part of our application Ser. No. 92,795 filed Nov. 25, 1970, now abandoned.

This invention relates to a method of and apparatus for the processing of wires, and more particularly to the operation of wire-drawing machinery in line with machinery for performing a subsequent operation on the drawn wire.

In the method in accordance with the invention a wire is drawn by at least one capstan through two or more dies to produce a total reduction in area of at least 30 percent. The or each drawing capstan is driven at a respective peripheral speed which is greater than the speed of the wire engaged thereby. After drawing, the wire is passed directly (by which is meant without first passing through an accumulator) into subsequent processing apparatus including means, such as a takeup capstan, which determines the speed of the or each wire during drawing as well as during the subsequent processing at such a value that the speed of the or each wire through each die through which it passes is so related to the reduction in cross-section effected at that die that the wire is not significantly heated; that is so that its temperature does not exceed 150°C (and preferably not 50°C) when the wire is of copper or of aluminium.

The actual limiting value of the wire speed set by this criterion will depend upon the initial diameter and the reduction at each die and on the initial temper of the wire (though normally fully-soft wire would be used), but typically it would be in the range from 0.1 to 1 m s^{-1}, i.e. a hundredth to a tenth of the speed at present generally used in wire drawing. Because of the low speed, the slip of the wire on the drawing capstans results neither in damage to the wire nor in excessive wear of the capstans or dies, and the presence of slip allows the wire speed to be determined by the subsequent processing apparatus without the need for any means at all for varying during running the ratio of the speed of the final capstan to the takeup speed, or only simple means. Preferably the amount by which the peripheral speed of each capstan exceeds the speed of the wire engaged thereby is from 1 percent to about 10 percent, the upper limit being set by the amount of wear that is tolerable.

In most cases economic considerations will make it desirable to process at least two wires and preferably more, e.g. about 8, simultaneously in order to economise on space and to allow one operator to supervise the processing of all the wires; certain parts of the apparatus, for example an enamelling oven, may serve for processing all the wires. In such cases the drawing capstan or capstans for each wire may be driven independently, which gives maximum flexibility of operation in view of the greater control available permitting, if desired, the processing of different wire sizes at the same time; alternatively all the capstans may be driven from a common source, which is more economical in terms of the initial cost of the machine. If this alternative is adopted, it may under certain circumstances be necessary to thread up a wire on a rotating capstan, but because of the low speed of operation this is neither difficult or dangerous.

The invention is especially useful where the subsequent processing apparatus is enamelling apparatus,

but it may also, for example, be tinning apparatus, a wire covering extruder, a paper covering apparatus, or twinning, quadding or bunching apparatus of the rotating-takeup type or the reverse lay type. In cases where the drawing capstans for each wire are controlled separately from the capstans for each of the other wires or where changes in the speeds of all the wires are expected to occur always substantially at the same time, the drive of this subsequent apparatus is preferably coupled, for example electrically, to the drive for the drawing capstans to allow a constant speed ratio to be obtained automatically both during running and during acceleration and deceleration.

Preferably the total reduction in area should not exceed 80 percent, and for such reduction up to about eight dies would be used, the drawing capstans may be of steel but are preferably of ceramic material, and the degree of overdrive is preferably about 10 percent.

Wire produced by the method in accordance with the invention is readily annealed, and after annealing exhibits an excellent combination of flexibility with high tensile strength. Where the subsequent processing apparatus is enamelling apparatus a separate annealing step may prove unnecessary; in other cases a simple in-line annealer can be operated very easily (because of the low wire speed). If a large reduction is used, an in-line annealer can be readily interposed between drawing stages, and in such case it may be preferable for the instantaneous wire speed in the early drawing stages to be positively controlled using a separate drive and an intermediate accumulator, rather than to rely throughout on control by the speed of the subsequent processing apparatus.

The apparatus in accordance with the invention comprises means for carrying out the method, as already described.

The apparatus in accordance with the invention may be compactly designed and requires little attention from the operative; it requires unreeling of relatively stout wire at a relatively low speed and consequently reduces risk of breakage and facilitates jointing "on the run"; the wire tension can be very low and constant in its passage though the subsequent processing apparatus, reducing the effects of varying tension on the wire diameter; and by changing one or more of the drawing dies many sizes of finished wire can be produced from only a few stock sizes.

A further advantage of the method and apparatus in accordance with the invention is that the capstans may be driven at normal running speed during the threading up of the drawing apparatus and/or of the subsequent processing apparatus.

The invention will be further described, by way of example, with reference to the accompanying drawings in which:

FIG. **1** is a diagrammatic drawing of apparatus in accordance with the invention, and

FIGS. **2** and **3** are cut-away drawings of alternative forms of wire-drawing machine suitable for use in the apparatus of FIG. **1**.

As shown in FIG. **1**, relatively large diameter wires **1** are taken from any suitable source **2** such as reels **3** mounted in a stand **4** and pass by way of suitable guides **5** (if necessary) to a wire-drawing machine **6** more fully described below. The relatively fine wires **7** emerging from the drawing machine pass to subsequent processing apparatus **8**. There is no accumulator between the

drawing machine **6** and the subsequent processing apparatus **8**, but the use of intermediate guides **9** is not excluded, and an annealer **10** may be interposed if required.

The subsequent processing apparatus **8** is enamelling apparatus consisting essentially of an applicator **11**, an oven **12** and a positively driven capstan **13**, together with the necessary wire guides **14**. For convenience of illustration, a conventional vertical enamelling apparatus is shown, but it is to be understood that horizontal enamelling apparatus is equally suitable. The capstan **13** is positively driven by a motor **15** under conditions such that there is no slip between the capstan and the enamelled wires (magnet wires) **16**, so that the speed of the capstan **13** determines the speed of the wires throughout the apparatus; after passing through the last drawing die the speed of the wire is equal to the effective peripheral speed of the capstan **13**, whereas upstream of that die it will be less to an extent determined by the reduction at each drawing die.

Take-up means for the enamelled wire produced is indicated at **17**.

The two forms of wire-drawing machine shown in FIGS. **2** and **3** are identical apart from the drive arrangements described below. The machine is laid out vertically with a separate capstan for each die, which has been found to make the machine particularly easy to thread up. The drawings show four units for drawing four wires in parallel, but it will be understood that there may be more than four units.

Each wire **1** enters the drawing machine from above the plane of the paper and is deflected into a vertical path by a pulley **18** (also shown in FIG. **1**) which should be positioned above head height. It is then drawn through four dies **19, 20, 21, 22**, which are all vertically aligned, by respective capstans **23, 24, 25, 26.** From the capstan **26** each wire passes upwards to a final drawing die **27** and an output capstan **28.** The drawn wire passes over a pulley **29** to the subsequent processing apparatus. Lubricant is supplied to all the drawing dies by ducts **30.** Preferably the final drawing die **27** is lubricated by a jet directed on its input side since this makes it possible in most cases (at the low speeds utilised in accordance with the invention) for the drawn wire **7** to emerge from this die carrying no appreciable amount of lubricant. If necessary, however, carefully maintained felt wipers can be provided or the wire can be washed with clean water and dried by evaporation before it reaches the enamelling apparatus.

As indicated above, the speed of the wire at each stage of drawing is determined by the speed of the capstan **13** in the enamelling apparatus and the reduction at each drawing die. The peripheral speed of each of the capstans **23, 24, 25, 26, 28** exceeds the speed of the wire where it contacts them by about 10 percent. It is convenient to drive all the capstans at the same angular velocity and to chose the diameters to obtain the peripheral speed required. In this case each of the capstans is coupled directly to a drive pulley **31** behind the front plate **32** of the machine and all of these pulleys for one wire are coupled by a transmission belt **33.**

In the machine shown in FIG. **2**, each of the belts **33** is driven from an individual motor **34** by a drive belt **35** acting on a further pulley **36** mounted on the shaft of capstan **26.**

In the machine shown in FIG. **3**, on the other hand, a single motor **37** drives all the belts **33** through belts **38, 39,** and pulleys **40, 41, 42.**

The following tables show two examples of the manufacture of specific sizes of enamelled wire by the method of the invention and using either of the forms of apparatus shown in the accompanying drawings.

TABLE I

Initial wire 1: Fully annealed copper wire of approximately 0.15 mm diameter. Speed of wire taken from supply 0.84 m s^{-1}

Die reference	19	20	21	22	27
Die diameter (mm)	0.140	0.125	0.112	0.100	0.090
Reduction in cross-section (%)	less than 20	21	20	20	19
Temperature rise (approx) (deg.C)	less than 60	60	60	60	60
Diameter of wire leaving die (mm)	0.140	0.125	0.112	0.100	0.090
Speed of wire leaving die (m s^{-1})	0.96	1.20	1.50	1.88	2.33
Speed of corresponding capstan (m s^{-1})	1.05	1.31	1.64	2.05	2.56
Capstan reference	23	24	25	26	28
Degree of overdrive (%)	9	9	9	9	10

TABLE II

Initial wire 1: Fully annealed copper wire of approximately 0.60 mm diameter. Speed of wire taken from supply: 0.23 m s^{-1}

Die reference	19	20	21	22	27
Die diameter (mm)	0.560	0.500	0.450	0.400	0.355
Reduction in cross-section (%)	less than 20	20.0	19.0	20.6	21.2
Temperature rise (approx) (deg.C)	less than 60	60	60	60	60

TABLE II – Continued

Initial wire 1: Fully annealed copper wire of approximately 0.60 mm diameter. Speed of wire taken from supply: 0.23 m s^{-1}

Diameter of wire leaving die (mm)	0.560	0.500	0.450	0.400	0.355
Speed of wire leaving die m s^{-1}	0.27	0.34	0.42	0.53	0.67
Speed of corresponding capstan m s^{-1}	0.30	0.38	0.47	0.59	0.73
Capstan reference	23	24	25	26	28
Degree of overdrive (%)	11	12	12	11	10

The enamel applied may be any wire enamel that can be applied at the output wire speed (boxed in the right hand column of the tables) with the available enamelling apparatus. In both the examples described the enamel was in fact the polyvinyl acetal enamel sold under the trade mark "Formvar". A total radial thickness of enamel of 8.5μm in the example of Table I or 18μm in the example of Table II was obtained in 6 passes (coats). The oven used was an electrically heated horizontal oven 3 m long maintained at a substantially uniform temperature of 450°C.

What we claim as our invention is:

1. A method of manufacturing enamelled wire comprising:

a. drawing a bare copper wire by at least one capstan through a series of dies to reduce its area by from 30 percent to 80 percent;

b. passing the wire directly into enamelling apparatus including means determining the speed of the wire, during drawing as well as during subsequent processing, at so low a value that the speed of the wire through each one of said dies is so related to the reduction in cross-section effected at that die that solely as a consequence of the low speed the wire is not heated above 150°C during drawing, and

c. driving said drawing capstan at a peripheral speed greater than the speed of the wire engaged thereby.

2. A method of manufacturing a plurality of enamelled wires comprising:

a. drawing each of a plurality of bare copper wires by at least one capstan through a series of dies to reduce its area by from 30 percent to 80 percent;

b. passing each wire directly into enamelling apparatus including means determining the speed of the wires, during drawing as well as during subsequent processing, at so low a value that the speed of each wire through each one of said dies is so related to the reduction in cross-section effected at that die that solely as a consequence of the low speed the wire is not heated above 150°C during drawing; and

c. driving all of the drawing capstans for all of the wires from a common source at respective peripheral speeds greater than the speeds of the wires engaged thereby.

3. A method as claimed in claim **1** in which the speed of the or each wire at least in part of its path is in the range from 0.1 to 1 m s^{-1}.

4. A method as claimed in claim **1** comprising coupling the drive of said subsequent processing apparatus to the drive for the drawing capstans to obtain a constant speed ratio.

5. A method as claimed in claim **2** in which the speed of each wire at least in part of its path is in the range from 0.1 to 1 m s^{-1}.

6. A method as claimed in claim **2** comprising coupling the drive of the said subsequent processing apparatus to the drive for the drawing capstans to obtain a constant speed ratio.

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