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ROLLING MILL POSITION CONTROL

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2 Sheets-Sheet 1

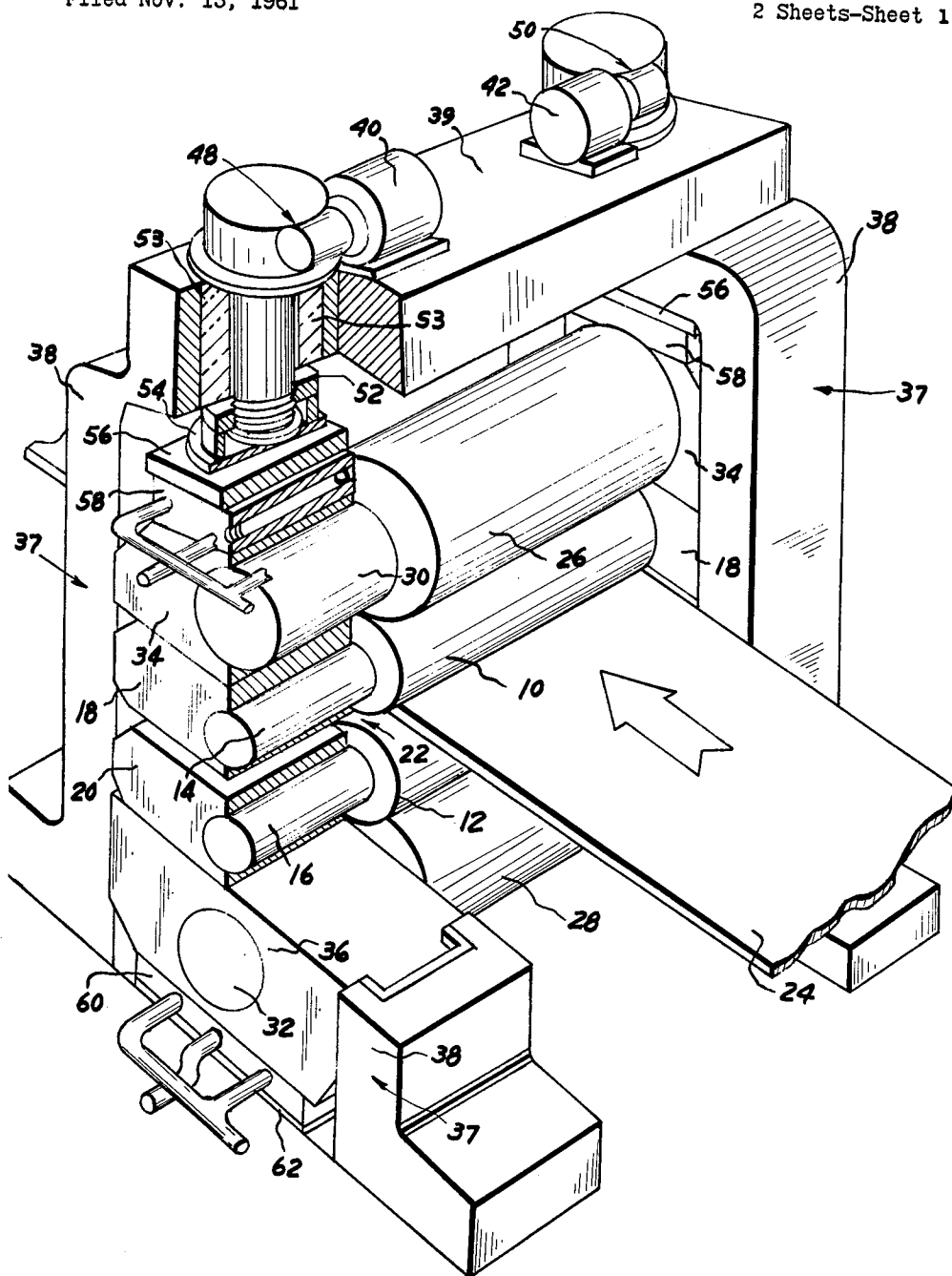


Fig. 1

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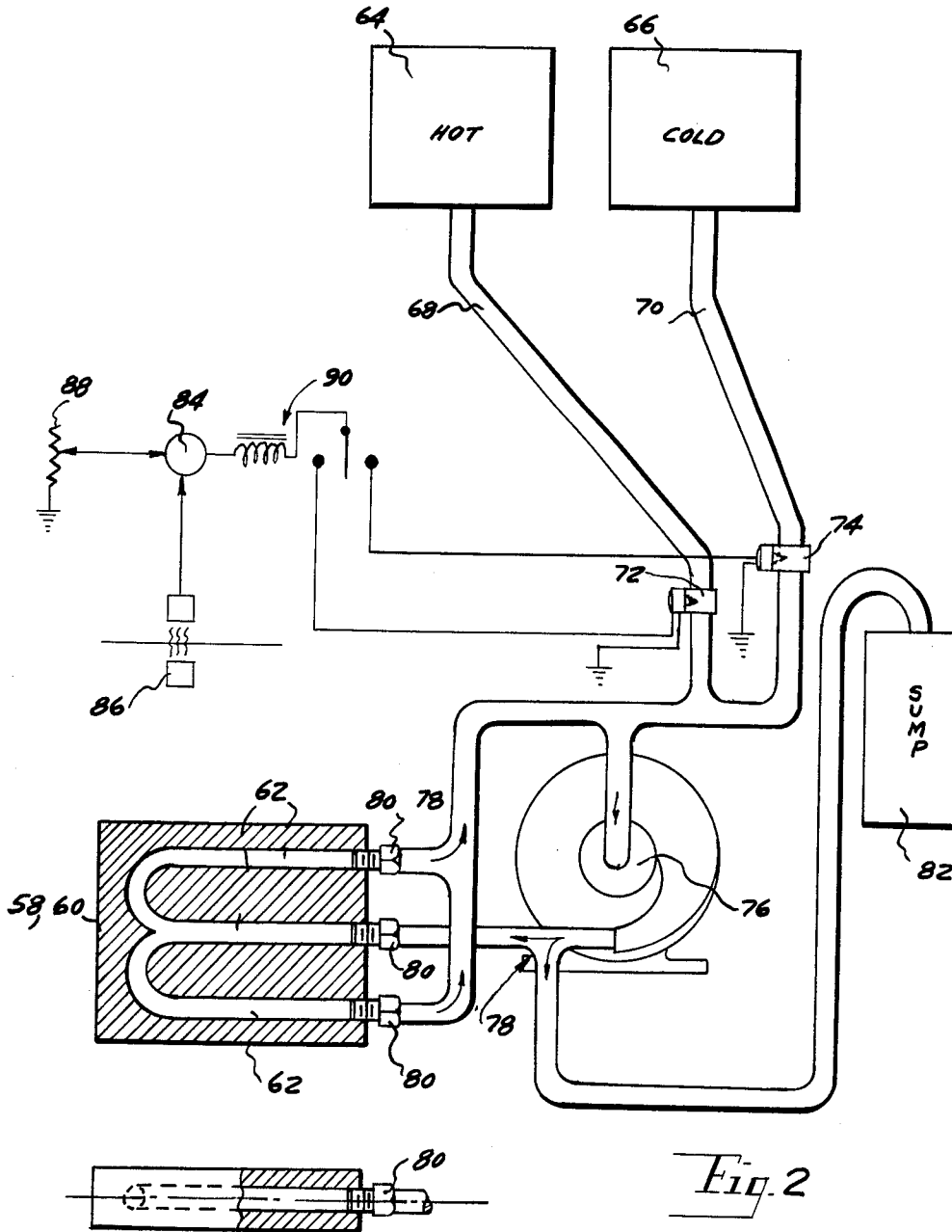


Fig. 3

Fig. 2

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1

2

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ROLLING MILL POSITION CONTROL
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7 Claims. (Cl. 72-9)

This invention relates to apparatus for adjusting the product thickness in rolling mills, and more particularly to apparatus for thermally controlling the roll spacing in such mills.

The conventional rolling mill consists of a pair of rotatable cylindrical rolls disposed with their axes in parallel relation and their ends journaled in bearings. At least one of the rolls and its bearings are movable in a plane passing through the axes of both rolls. The rolling operation is accomplished by passing metal sheets or strips between the rolls, the roll spacing having been preset to a value less than the thickness of the metal. As the metal is passed through the gap between the rolls, it is squeezed to a reduced thickness corresponding roughly to the size of the roll gap.

Adjustment of the roll spacing is normally achieved by rotation of large power-activated screws. The axes of the screws lie in the plane passing through the axes of both rolls and extend perpendicularly to the axes of the rolls. The screws are attached to adjusting blocks or pads which in turn are fixed to the bearings of the adjacent roll so that rotation of the screws causes movement of the roll and a change in the size of the gap between the rolls.

The forces exerted on the rolls by the metal sheet or strip during the rolling operation are often substantial and since the rolls are supported only at their ends, bowing of the rolls may occur. To prevent such distortion of the rolls, back-up rolls, consisting of larger diameter journaled rolls disposed with their axes parallel to the axes of the standard rolls and situated immediately adjacent the standard rolls, are frequently employed to provide additional support.

Although the roll spacing may be adjusted by rotation of the screws to produce a desired product thickness at a given moment, constant variations in the hardness and thickness of the incoming metal will result in an uneven product thickness unless means are provided to continually measure the product thickness and utilize such information to adjust the roll spacing. Precise-thickness gages are available which convert the product thickness readings into electrical signals. The output from these gages may be fed back to the screws in order to adjust the roll gap. Due to the size and inherent inaccuracy of these screws, however, small controlled increments of adjustment are unattainable in practice. The lack of precision typical of this conventional adjusting means is especially critical in the rolling of very thin stock such as foil. Although precise-thickness gages may be accurate in measuring the product thickness within millionths of an inch, such gaging information is of no value unless means are available for utilizing that information to make incremental adjustments of the roll gap.

The present invention contemplates a system in which precise gaging information is utilized to control thermal expansion and contraction of blocks of steel or other suitable material located immediately adjacent the rolls in such manner that expansion or contraction of the blocks induces a corresponding decrease or increase in the size of the gap between the rolls.

In a preferred embodiment of the present invention which will be subsequently described in detail, the blocks are interposed between the adjusting pads and the journaled ends and bearings of the back-up rolls in a conventional four-high rolling mill. The screws are rotated so

as to adjust the rolls roughly to the desired spacing. A temperature controlled fluent is arranged to circulate through channels in the blocks causing thermal expansion and contraction of the blocks. As the dimensions of the blocks vary, the working rolls are moved, altering the size of the roll gap; expansion of the blocks moves the working rolls closer together, reducing the roll spacing, while contraction of the blocks increases the separation or gap between the rolls.

A precise-thickness gage, positioned immediately after the rolls, measures the thickness of the metal as it issues from the rolls and transmits this information in the form of electrical signals to an error detector circuit. The desired thickness is similarly transmitted to this circuit which derives the algebraic difference between the two signals to regulate the flow of hot and cold fluent through servo valves into the block. A pump circulates the fluent through the blocks and maintains the pressure in the system. As the servo valves are opened and additional fluent introduced to the blocks, the excess fluent overflows into a sump. This arrangement allows fluent to be continuously circulated until a roll gap adjustment is required and a servo valve opened.

An alternative method of supplying temperature controlled fluent to the blocks consists of utilizing continuously flowing streams of hot and cold fluent as a fluent source. The two streams pass through a mixing valve which is actuated by the output signal from the error detector circuit so as to allow the correct mixture of hot and cold fluent to pass through to the blocks. This mixture will have a temperature suitable to vary the size of the roll gap so as to result in a product thickness equal to the desired thickness.

It is therefore an object of the present invention to provide in a rolling mill, a positioning system for controlling the roll spacing consisting of expansible blocks situated between the screws and the rolls, having interior channels into which is introduced fluent that is maintained at a temperature suitable to expand or contract the blocks in such fashion that the roll gap is increased or decreased to vary the desired thickness.

Another object of the present invention is to provide in a conventional rolling mill, apparatus for controlling the roll spacing consisting of a precise-thickness gage which measures the product thickness, and an electrical circuit which utilizes the gage information as to departures from the desired product thickness to control the entry of temperature controlled fluent into channels in an expansible block situated between the screws and the journaled end of the rolls.

Other objects and advantages will be more readily apparent from the following detailed description of a preferred embodiment of the present invention. The description makes reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a preferred embodiment of the present invention, with parts broken away.

FIG. 2 is a schematic view of the hydraulic and electrical systems employed with the structure of FIG. 1.

FIG. 3 is a detailed side view of the expansible metal block shown in FIG. 2, with parts broken away.

The invention is illustrated as employed in a conventional four-high rolling mill. Two cylindrical rolls 10 and 12 having ends 14 and 16 journaled in bearings 18 and 20 are disposed with their axes in horizontal parallel relation. The rolls 10 and 12 are situated adjacent one another defining a rectangular gap or space 22 through which the metal sheet or strip 24 is passed. Back-up rolls 26 and 28, of larger diameter than the working rolls 10 and 12, are disposed with their axes parallel to the axes of the working rolls and are in contact with them. The back-up rolls 26 and 28 have ends 30 and 32 journaled in bear-

ings 34 and 36 which are fixed to the bearings 18 and 20 of the working rolls 10 and 12.

A frame 37 having vertical members 38 and a horizontal deck 39 supports two motors 40 and 42, each having output through a right-angle drive 48 and 50 situated on the surface of the deck 39. The bearings 18, 20, 34 and 36 are supported between the vertical members 38 so as to be free for vertical movement. Screws 52, fixed at their upper ends to the deck 39 and journaled along their upper length in bearings 53 in the deck, terminate at their lower ends in nuts 54 which are fixedly attached to distributing or adjusting pads 56 which distribute the force exerted by the screws over a larger area.

Expansible blocks 58 of steel or other suitable material are interposed between and permanently affixed to the bearings 34 of the upper back-up roll 26 and the distributing pads 56. Similar expansible blocks 60 are situated between the bearings 36 of the lower back-up roll 28 and a support pad 62. The blocks 58 and 60 are fitted with channels 62 through which a fluent is arranged to circulate. All four of the blocks 58 and 60 are connected to a single hydraulic and electrical system. Fluent is supplied from hot and cold reservoirs 64 and 66 where the fluent is maintained at a fixed, known temperature and is transferred under pressure through hot and cold inlet lines 68 and 70, each having a servo valve 72 and 74, to a pump 76. The pump 76 forces the fluent through the channels 62 in the blocks 58 and 60 and maintains a constant pressure in the system. The fluent is moved through the system between the pump 76 and the blocks 58 and 60 through a network of tubing 78 which is connected to the block by nozzles 80. A sump 82 is positioned sufficiently higher in elevation than the blocks 58 and 60 and pump 76 so that the sump receives fluent from the system only when one of the servo valves 72, 74 is opened and hot or cold fluent allowed to enter.

The electrical system is comprised of an error detector circuit or analog subtracter 84 which determines the algebraic differences of two input signals. One input signal is produced by a precise-thickness gage 86 which is located immediately after the rolls 10 and 12 so as to measure the product thickness as the metal issues from the rolls. The gage 86, which may be an X-ray or nuclear thickness gage or may consist of a precision micrometer device, transmits to the detector circuit 84 a signal which is proportional to the thickness reading of the gage. The second input signal is supplied by a potentiometer 88 which is preset to transmit a signal equal in magnitude to that transmitted by the gage 86 when metal of the desired thickness is passed through the gage.

The detector circuit 84 produces a signal which is the algebraic difference of the two input signals and transmits it to a single-pole double-throw polarized relay 90 which is connected to each of the servo valves 72 and 74. As the signal reaches the relay 90, the relay will close the circuit leading to one of the servo valves 72 and 74 and a signal equal to the algebraic difference of the two input signals will be transmitted to the servo valves 72 and 74; the algebraic sign of the output signal from the error detector 84 determines which of the servo valves 72, 74 will be activated. The magnitude of the output signal transmitted to the valves 72 and 74 controls the extent to which the valve is opened, thus determining the rate of flow of fluent through the valves 72 and 74.

The electrical system is arranged so that the output signal from the error detector circuit 84, which is transmitted when the product thickness exceeds the desired thickness, will open the servo valve 72 on the hot inlet line 68 sufficiently to allow hot fluent to enter the blocks 58, 60. The rate of flow at which the fluent enters the blocks 58, 60 must be sufficient to raise the temperature of the blocks 58, 60 and expand them only enough to reduce the roll gap 22 the amount necessary to produce a product thickness equal to the desired thickness.

Similarly, if the product thickness is less than the desired thickness, the flow of cold fluent must be sufficient

to result in a product thickness equal to the desired thickness. If the product thickness equals the desired thickness, no signal will be transmitted from the subtracter circuit 84 since the two input signals will be numerically equal. As a result, the relay 90 will not be activated and the servo valves will remain closed. The pump 76 will then recirculate the fluent already flowing in the system.

In operation, the motors 40 and 42 are activated to rotate the screws 52 until the roll gap 22 closely matches the thickness of the incoming metal 24. The potentiometer 88 is set to transmit a signal corresponding in magnitude to the signal emitted by the thickness gage 86 when metal of the desired thickness is passed through the gage 86.

The working rolls 10 and 12 are rotated by power means (not shown). The metal sheet 24 is passed through the roll gap 22 and the gage 86. Departures of the product thickness from the desired thickness are communicated to the appropriate servo valves 72 and 74; the flow of fluent at a new temperature through the blocks 58 and 60 causes a corresponding expansion or contraction of the blocks. This, in turn, causes a change in the spacing of the working rolls 10 and 12; expansion of the blocks 58 and 60 reduce the roll gap 22 while contraction of the blocks 58 and 60 increases the roll gap.

The effect of this expansion or contraction of the blocks 58, 60 on the product thickness will be noted by the thickness gage 86. The new signal emitted by the gage 86 will direct further opening or closing of the servo valves 72 and 74. This process is continued until the product thickness exactly equals the desired thickness, at which time the servo valves 72 and 74 will be closed and the fluent in the blocks 58 and 60 recirculated.

An alternative positioning system consists of two gages 86, each located at opposite edges of the metal as it issues from the rolls 10 and 12. Each gage is connected to an independent hydraulic and electric system of the type previously described in detail; each hydraulic system feeds fluent into the pair of blocks 58 and 60 located on the same edge of the metal sheet 24 as the gage. With this arrangement the present invention can be adapted to produce a product sheet having a thickness which varies uniformly from edge to edge; this may be accomplished simply by setting each of the potentiometers 88 at a different value.

An alternative method of transferring heat with respect to the expansible blocks or material consists of the use of electrical resistors as heating elements in conjunction with a suitable cooling process.

Although the present invention has been illustrated in conjunction with a four-high rolling mill, it may be employed in a similar manner in conventional rolling mills of any size, having any number of standard or back-up rolls.

Having described the invention in its simplest terms, it is to be understood that the features of construction may be changed and varied in greater or lesser degree without departing from the essence of the invention defined in the appended claims.

I claim:

1. In a rolling mill having a stationary frame, and cylindrical rolls disposed with their axes parallel to one another and journaled in bearings which are movable within said frame, a positioning system for controlling the spacing between said rolls, comprising:

55 gage means for measuring the thickness of the rolled product;

expansible material fixed to the bearings of said rolls; and means, under the control of the gage means, for maintaining said material at a temperature which is a function of the reading of said gage.

2. In a rolling mill having a stationary frame, and cylindrical rolls disposed with their axes parallel to one another and journaled in bearings which are movable within said frame, a positioning system for controlling the spacing between said rolls, comprising:

5

expansible metal blocks fixed to the bearings of said rolls, said blocks having interior channels adapted to receive fluid;

rotatable screw means each having one end attached to said frame and a second end attached to one of said blocks, the axes of said screw means lying in the plane of the axes of both of said rolls and extending perpendicularly to the axes of said rolls; means for rotating said screws so as to move said blocks and said bearings within said frame; and means for introducing fluid at controlled temperatures into said channels in said blocks.

3. In a rolling mill having a stationary frame, and cylindrical rolls disposed with their axes parallel to one another and journaled in bearings which are movable within said frame, a positioning system for controlling the spacing between said rolls, comprising:

expansible metal blocks fixed to the bearings of said rolls, said blocks having interior channels adapted to receive fluid;

rotatable screw means each having one end attached to said frame and a second end attached to one of said blocks, the axes of said screw means lying in the plane of the axes of both of said rolls and extending perpendicularly to the axes of said rolls;

means for rotating said screws so as to move said blocks and said bearings within said frame;

gage means for measuring the thickness of the rolled product;

and means, under control of the gage means for maintaining the fluid introduced into said channels at a temperature which is a function of the product thickness.

4. In a rolling mill having a stationary frame, and cylindrical rolls disposed with their axes parallel to one another and journaled in bearings which are movable within said frame, a positioning system for controlling the spacing between said rolls, comprising:

a source of fluid;

expansible metal blocks fixed to the bearings of said rolls, said blocks having interior channels adapted to receive fluid from said source;

rotatable screw means each having one end attached to said frame and a second end attached to one of said blocks, the axes of said screw means lying in the plane of the axes of both of said rolls and extending perpendicularly to the axes of said rolls;

means for rotating said screws so as to move said blocks and said bearings within said frame;

gage means for measuring the thickness of the rolled product;

servo valves situated between said source of fluid and said blocks;

and means for actuating said servo valves as a function of said product thickness.

5. In a rolling mill having a stationary frame, and cylindrical rolls disposed with their axes parallel to one another and journaled in bearings which are movable within said frame, a positioning system for controlling the spacing between said rolls, comprising:

a reservoir of hot fluid;

a reservoir of cold fluid;

expansible metal blocks fixed to the bearings of said

6

rolls, said blocks having interior channels adapted to receive fluid from said reservoirs;

rotatable screw means each having one end attached to said frame and a second end attached to one of said blocks, the axes of said screw means lying in the plane of the axes of both of said rolls and extending perpendicularly to the axes of said rolls;

means for rotating said screws so as to move said blocks and said bearings within said frame;

gage means for measuring the thickness of the rolled product, said gage means being adapted to transmit a signal proportional in magnitude to the measured product thickness;

means for supplying a signal proportional in magnitude to the desired product thickness;

servo valves situated between each of said reservoirs and said blocks;

and means provided for receiving said signals and producing a signal which is a function of the difference between said desired and said measured thicknesses, said last signal being adapted to actuate said servo valves.

6. In a rolling mill having a stationary frame, and cylindrical rolls disposed with their axes parallel to one another and journaled in bearings which are movable within said frame, a positioning system for controlling the spacing between said rolls, comprising:

expansible material fixed to the bearings of said rolls;

means for measuring a dependent variable associated with the operation of the rolling mill;

and means, under control of the measuring means for maintaining said expansible material at a temperature which is a function of said dependent variable.

7. In a rolling mill having a stationary frame and cylindrical rolls disposed with their axes parallel to one another and journaled in bearings which are movable within said frame, a positioning system for controlling the spacing between said rolls, comprising:

expansible material fixed to the bearings of said rolls;

rotatable screw means each having one end attached to said frame and a second end attached to said expansible material, the axes of said screw means lying in the plane of the axes of both of said rolls and extending perpendicularly to the axes of said rolls;

means for rotating said screws so as to move said bearings within said frame;

means for measuring a dependent variable associated with the operation of the rolling mill;

and means, under control of said measuring means, for maintaining said expansible material at a temperature which is a function of said dependent variable.

References Cited by the Examiner

UNITED STATES PATENTS

1,112,269	9/14	Crellin	82—900
1,150,885	8/15	Rittenberger	80—55.1
2,128,826	8/38	Jung	80—55.1

FOREIGN PATENTS

137,260	9/52	Sweden.
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