OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

05282

Distr.
LIMITED

ID/WG.146/116
18 September 1973

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Third Interregional Symposium
on the Iron and Steel Industry

Brasilia, Brazil, 14 - 21 October 1973

Agenda item 7

AUTOMATION OF SMALL ROLLING MILLS[1]

by

Hans H. Rohde
Korf Engineering GmbH
Federal Republic of Germany

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.73-[illegible]

Small rolling mills can be defined either by their products or by their rolling capacity. Typical products for small rolling mills are

- rebars
- wire rods
- small sections
- medium sections

Less frequent is the application of small rolling mills for

- narrow strips
- plates
- heavy sections

Wide strip is, because of the equipment costs and the very high capacity of a wide strip mill, not a typical product for small rolling mills.

Combinations between different products on the same mill are frequent, i. e. between reinforcing bars and wire rods or reinforcing bars and small sections.

Typical capacities for small rolling mills range between 30.000 and 100.000 tons/year for older mills and between 80.000 and 300.000 tons/year for newer mills.

Automation of existing mills can be aimed towards a number of different problems in the mill. It is usually intended to improve the operation of a mill without changing the basic features, i. e. the mill arrangement.

For new mills, considerations for automation are basically concerned with all the questions of lay-out.

The automation in rolling mill operation can have a number of different aims (see Fig. 1).

1.	increase of production by being able to pass more billets per hour through the mill
2.	increase of yield, coil weight, and production by being able to handle heavier billets
3.	avoiding manual work, which is potentially hazardous or dangerous
4.	reducing man-power
5.	(reducing of non-production time)

Fig. 1 - Objectives of automation in rolling-mill operation

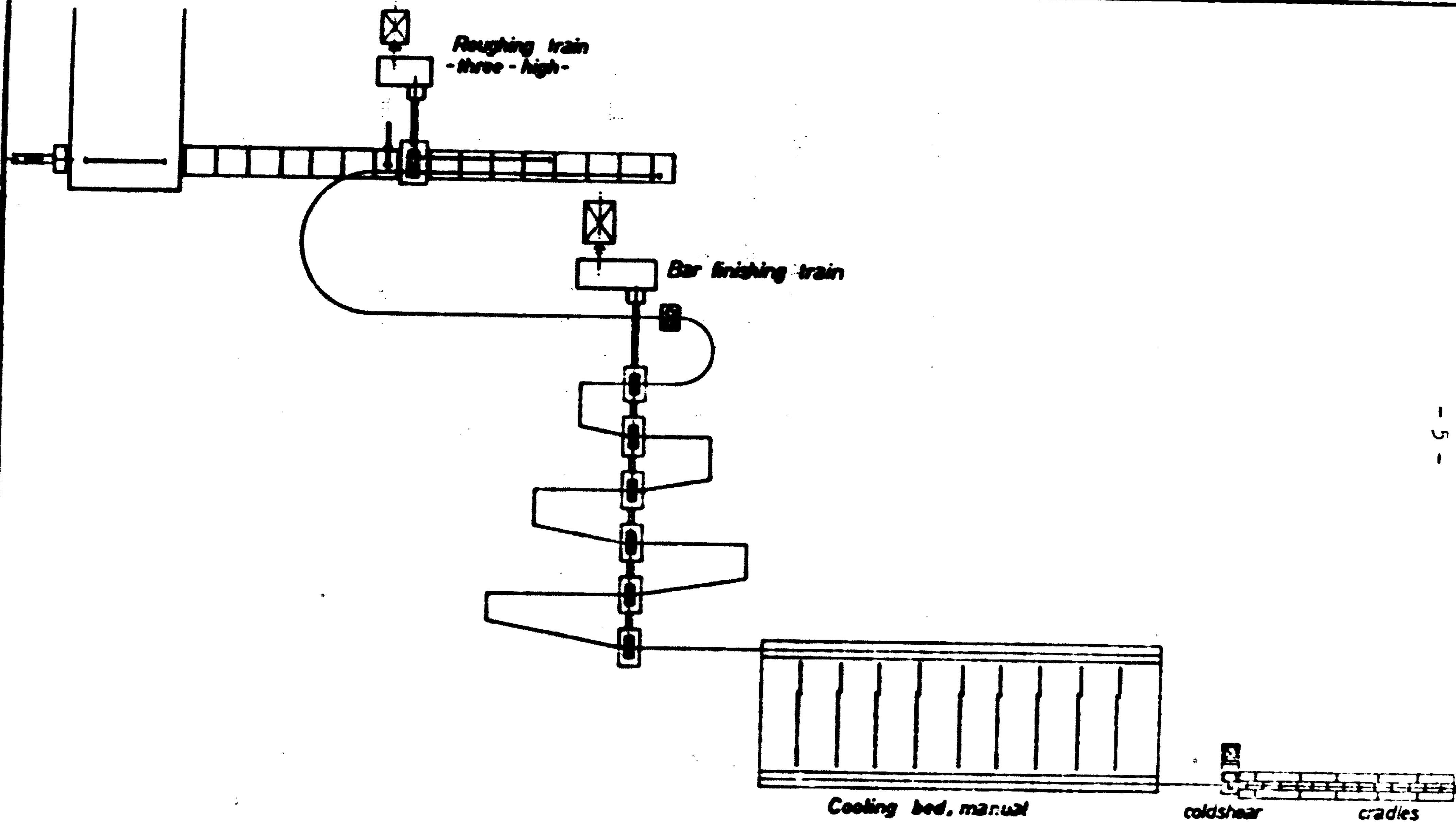
I willstate in advance that I shall not discuss the item 5, namely reducing of non-production time, since it is more of a factor for high-production mills, which have to attempt to squeeze non-production time to a minimum level when all other means of raising production have been exhausted and, for instance, speed increases are not possible.

This reduction of non-productive time normally requires considerable equipment and is connected with high capital investment. It is therefore not typical for the small mill practice which we discuss here.

If we first take up the automation of existing mills we will use as an example a simple bar mill as shown in Fig. 2.

This mill consists of one three-high roughing stand, being supplied with billets from a pusher-type furnace, and an open finishing train with, for instance, 6 passes. After the finishing stand the bars are guided to a cooling bed which could be a grid-type manually operated bed.

The billet weight is limited by the length of the run-outs, particularly before the last pass, and by the maximum bar length that the cooling bed can accept. If the smallest rod size is 14 mm Ø the billet weight is limited to 80 kg.



Hand mill

Rehde	Automation small mills	2

If the mill is to be automated for higher weights the following steps are necessary (Fig. 3) :

a) Install a flying dividing shear after the last stand and equip the cooling bed run-in table in such a way that it can accept a number of consecutive bars directly after shearing.

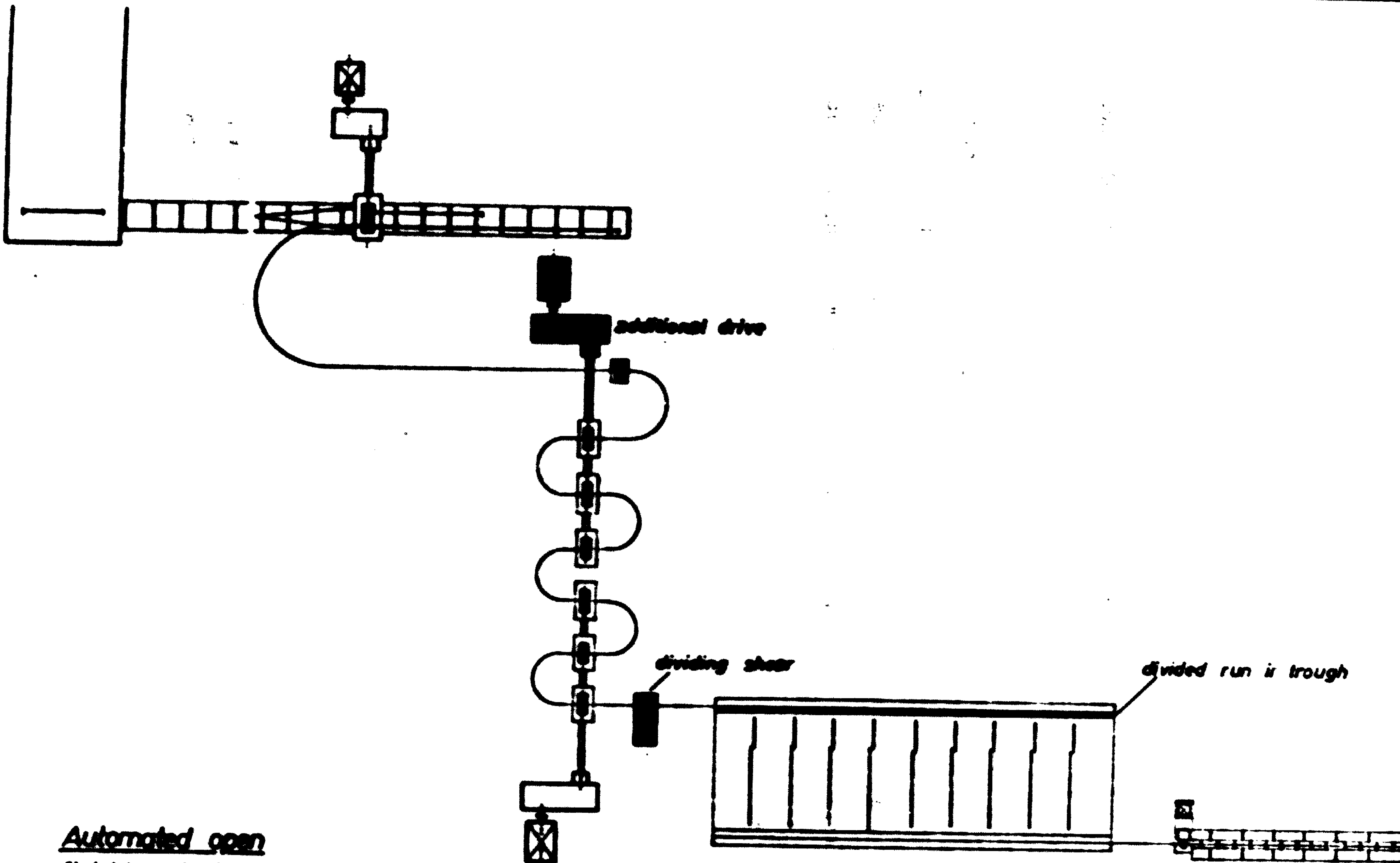
b) Intall repeaters between the stands of the finishing train.

The same effect can, of course, also be obtained by manual repeating which, however, is a hazardous operation and requires considerable skill.

c) Split the drive of the finishing train to limit loop lengths and give a higher exit speed.

With these measures the piece weight can be increased from, say, 80 kg to 150 kg, and the corresponding increase production is from 5 tons/hour to 7.5 tons/hour.

The bottle-neck for a further increase in billet weight and production is the one-stand non-automated roughing train.



Automated open finishing train

Rehde	Automation sm3!l mills	3

A second roughing stand has to be installed, the 10 passes have to be shared between the two stands, and bars have to be guided from one stand to the other by the use of repeaters.

With this a piece weight of 300 kg becomes possible and the production can be increased to approx. 12 tons/hour.

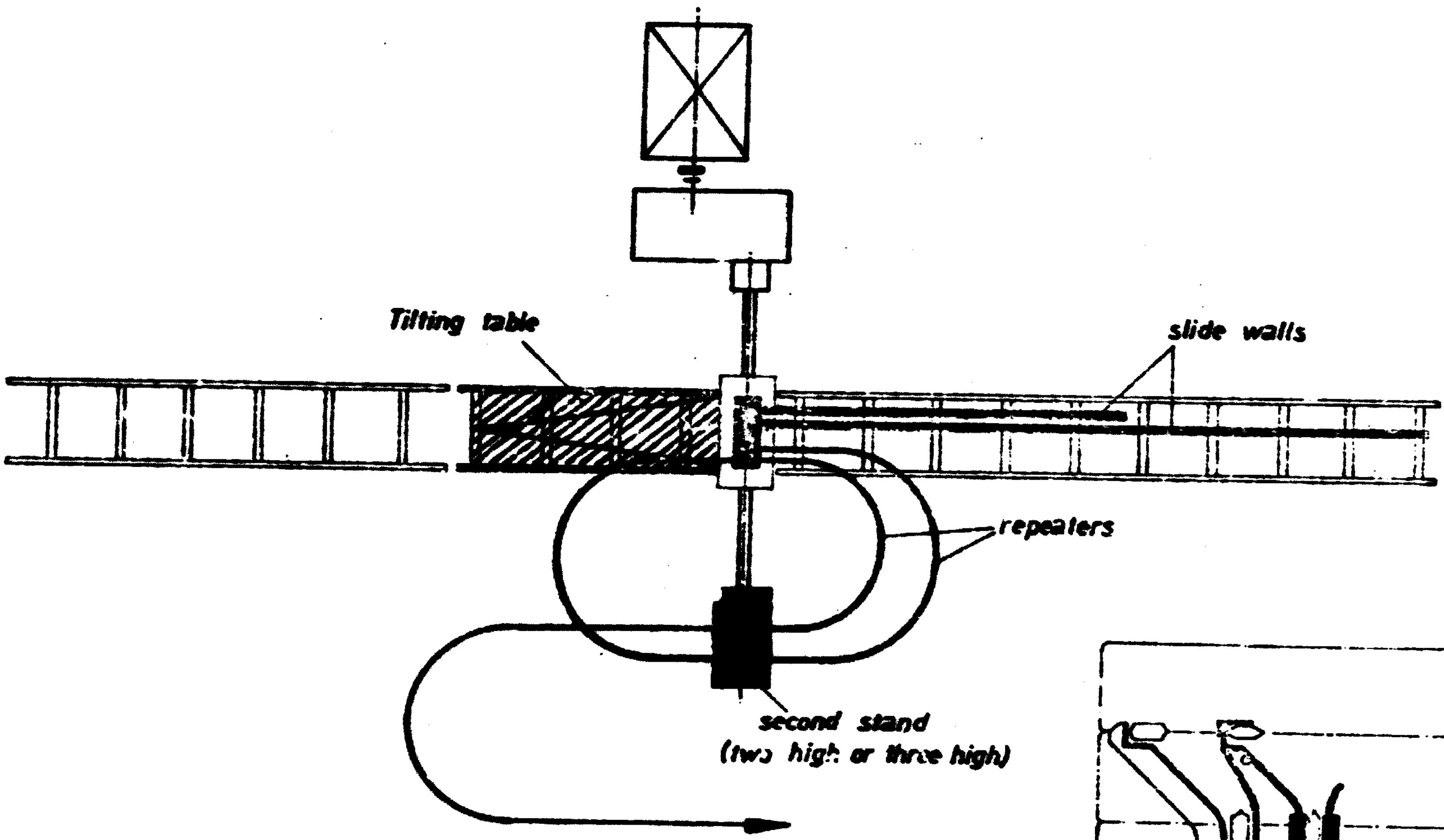
Since the production now depends very much on the exact and accurate work of the roughing stand for different passes, it is highly desirable at this stage to automate the pass sequence of the first stand. The normal means of automation of the first stand are (Fig. 4) :

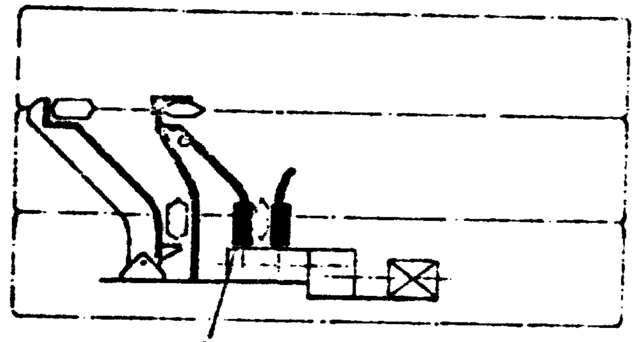
tilting table on either the entry or the exit side, depending on the pass design

and

slide walls on the opposite side to tilt the rectangular oval bars up when running out between top and midle rolls and re-enter in the upright position between bottom and intermediate roll.

The purpose of the tilting table is to allow to run a number of bars simultaniously towards the rolls and at the same time eliminate the manual lifting and guiding of the bars on this side.





Automated three-high roughing train

Rohde	Automation small mills	4

The slide walls eliminate the manual work of turning.

The obvious short-coming of the slide walls is that, if the bars are not perfectly straight, difficulties may arise due to the bars sticking between the slide walls.

Therefore the bar length to be used on the slide walls is limited, especially if the bars become thinner. The practical limit is in the order of 12 m.

If for some applications longer slide walls are required, it is recommendable to install a vertical pinch-roll set at the bottom of the walls to ensure that the bars are, if necessary, forced up and guided into the next pass.

A 10 pass roughing train, fully automated, consisting of two stands will be able to handle up to 20 tons/hour.

Still higher tonnages require a reduction of the number of passes in the roughing train.

If two passes are transferred to the finishing train by adding two additional continuous stands at the end, two objectives are achieved, namely the roughing-train capacity is increased and the finishing-train capacity is also increased due to a higher finishing speed of the bars by the addition of the two continuous stands.

Such a mill will be capable of piece weights of 300 to 350 kgs (based on 100 mm square entry) and production rates of approx. 25 tons/hour.

A still further increase can be achieved by limiting the number of passes in the roughing train to 6 and increasing the number of finishing stands to 4 continuous-arranged finishing stands. This arrangement will be capable of productions in the order of 35/40 tons/hour.

In summary, it can be said that for existing mills the following tools of automation are applicable and give the best results

- repeaters on finishing train
- dividing shear in front of cooling bed
- cooling bed entry trough for close sequence of bars
- automation of roughing train with repeater, tilting tables, and slide walls
- addition of continous finishing stands for speed increase

In many cases the possible increases are limited by the entry piece available, particularly if this is an ingot. Small ingot practice is usually limited to ingot weights of approx. 100 to 120 kg. For heavier ingots the cross-section is such that additional passes are needed in the roughing train, which defeats the purpose of a production increase.

However, when continuously cast or bought billets are available, one should utilize the possibility of increased lengths and therefore increased weights.

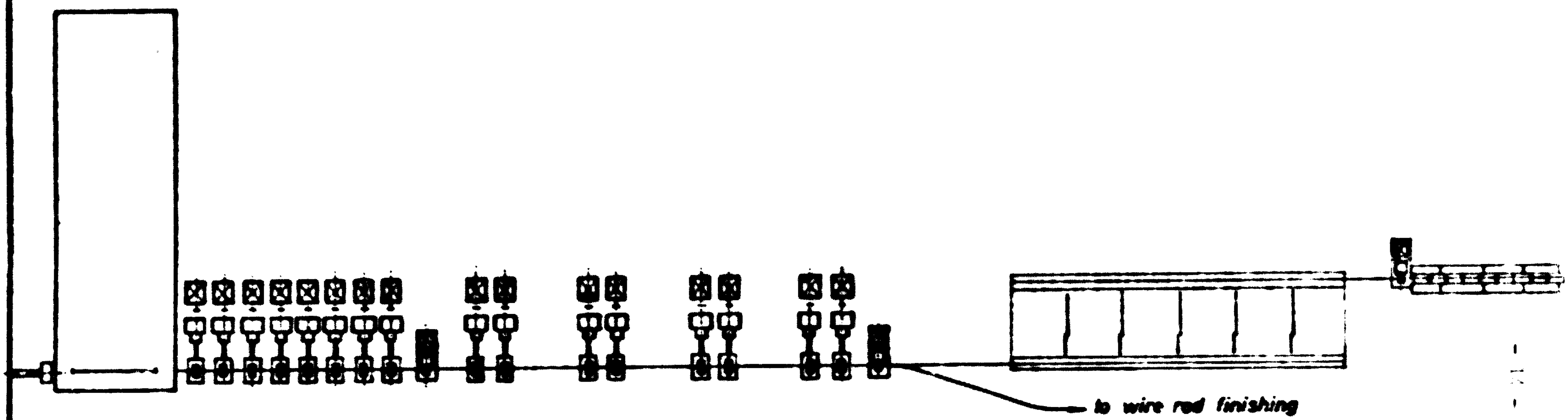
In generally it can be stated that the success of the automation of existing mills is dependent on a high degree of operational and maintenance skill. This explains why the reported successes of such automation vary considerably, even though the same elements are used.

May I mention that attempts have been made to automate the roughing trains even further by eliminating the tilting table and replacing it by a number of independent narrow tables. With this measure the time interdependence between the individual passes can be completely eliminated. On the other hand, very complex controls are necessary. This solution has only found a very limited application with special steel makers.

In recent years it has been realized that an automated rolling process is easier to operate if the mill used is a continuous mill. Therefore, for new mills an investigation should be made to which extent continuous operation is feasible. In many cases it has been decided to install continuous arrangements in spite of the fact that the full production capacity of continuous mills was not required in the particular case.

If one looks at a fully continuous mill for rounds (Fig. 5), it becomes apparent that, in addition to the high mechanical equipment costs, the electrics play an important part. The costs of individual D.C. drives can easily amount to 3 - 4 Mio Dollars on such a mill, the costs not only stemming from the fact that direct current is used but also from necessity to establish a very close control of the speed ratios. It has therefore been normal to limit the number of drives by grouping a number of stands (2 to 10 stands) and connecting them with fixed gear ratios. Of course, this requires a very good prediction on the pass design and speed ratios to be used and is less flexible if product changes are considered.

Also the roll costs are higher since the sets of rolls have to be kept matched in diameter.



fully continuous mill

Rehde	Automation small smill	5

For small mill operation this arrangement is still a relatively expensive proposition and is normally used if production rates of, say, 200.000 tons or more are considered.

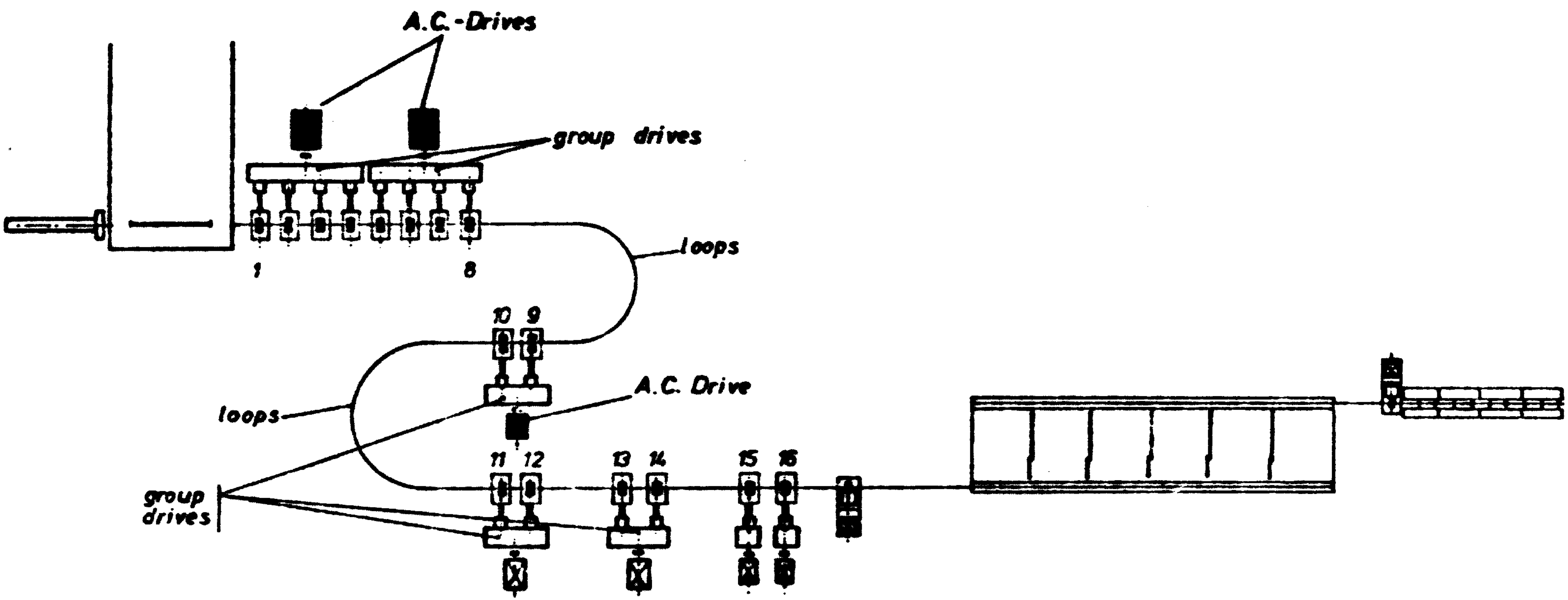
For smaller tonnages a combination in the form of a semi-continuous or hybrid mill is quite adequate (Fig. 6). This hybrid mill is characterized by the use of group drives, A.C. drives with loops inbetween to take up the variations in roll diameter and the potential speed drops of the A.C. drive on load.

This type of mill is capable of billet weights of 500 to 600 kg, and is possible if one is prepared to sacrifice somewhat in flexibility.

It can be used for mills producing rebars and rounds and for combination mills with rebars, rounds, and wire rods.

It normally does not lend itself for section-mill applications.

The hybrid mill can normally be laid out in such a manner that by exchange of motors and splitting of drives the mill can be converted into a fully continuous mill, accepting much higher entry weights (1.000 to 1.500 kg), and operating at production levels in the order 300.00 tons/year.


A.C.-Drives
group drives
loops
1
8
10 9
A.C. Drive
loops
11 12
13 14
15 16
group drives

Hybrid mill

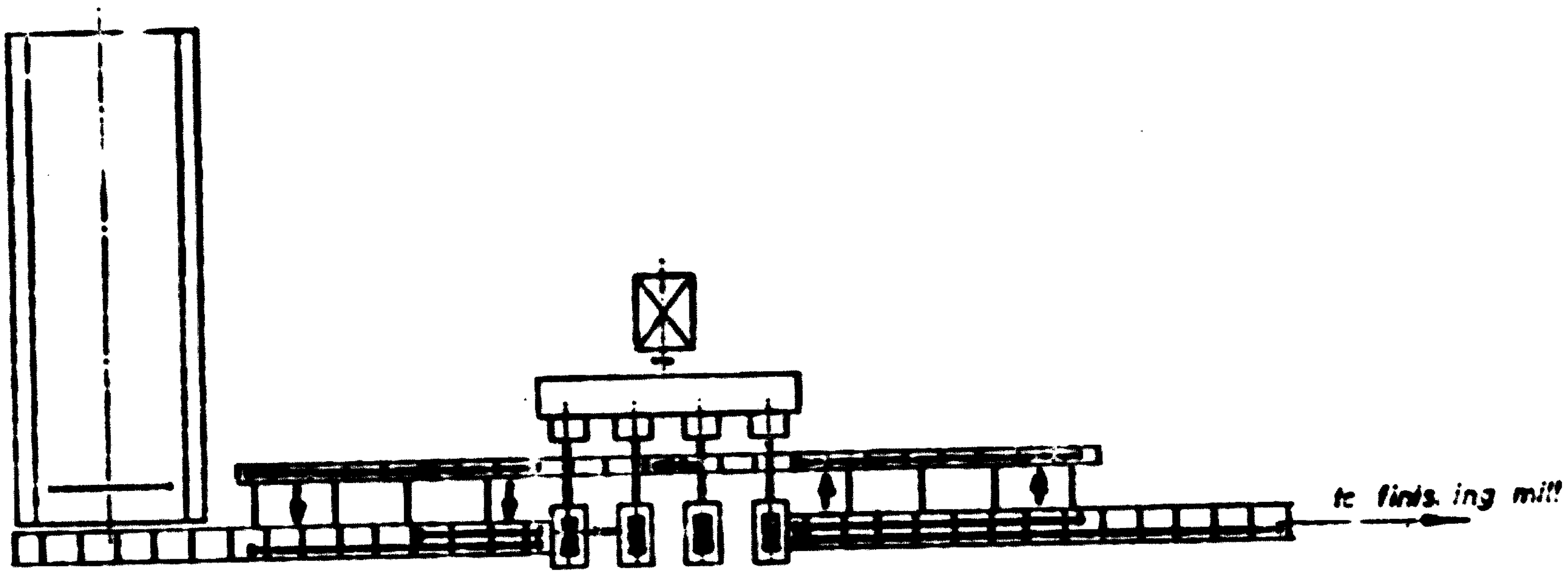
In this case, however, capacity and arrangement of furnace and arrangement of the cooling bed have to take into account this later addition.

The mechanical costs of such a mill are relatively high since one stand has to be used for every pass required.

An interesting possibility to save on the mechanical side as well is to arrange the roughing train as a twice-through mill (Fig. 7). This arrangement uses, for example, four stands for 8 passes. The bar is returned to the first stand after passing through No. 4 and only after all 8 passes have been completed the bar will be guided to the intermediate train.

This arrangement needs some additional space and mechanical handling gear for the return of the bars but is still cheaper then an 8-stand roughing train.

Furthermore, it can be extended at any time in future by adding another 4 stands, thus making it a completely continuous roughing train.



Twice through roughing train

Rohde	Automation small mills	7

The billet weight is somewhat restricted in this case and should, with a 100 mm square entry, not exceed 450 to 500 kg. Otherwise the space in front and behind the twice-through roughing train becomes excessive.

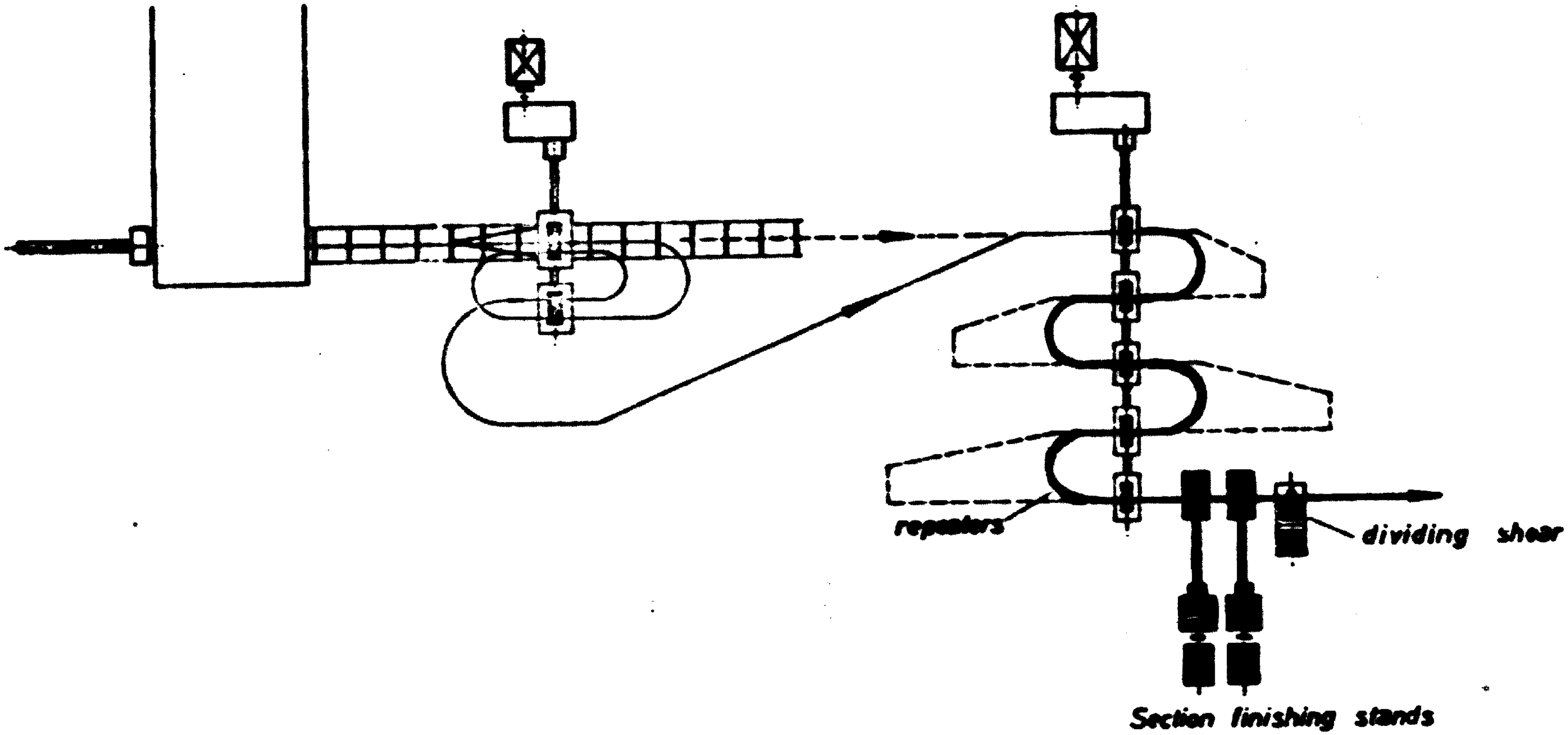
In the layout of mills producing sections a fully continuous mill is normally not compatible with the needs of a small rolling mill. The reason is that a continuous section mill can normally not employ group drives and has to have a number of vertical stands in order to have the necessary edging passes.

Also continuous section mills require complex mechanical and electrical equipment for quick pass and stand changes to maintain the required flexibility with frequent section changes.

For small rolling mills therefore the following solution for section rolling is preferable (Fig. 8):

- roughing train:

  continuous, possibly as twice-through train or arranged as a automated three-high mill



Small section mill automated

- intermediate train: open
  with repeaters for the lighter sections, such
  as angles

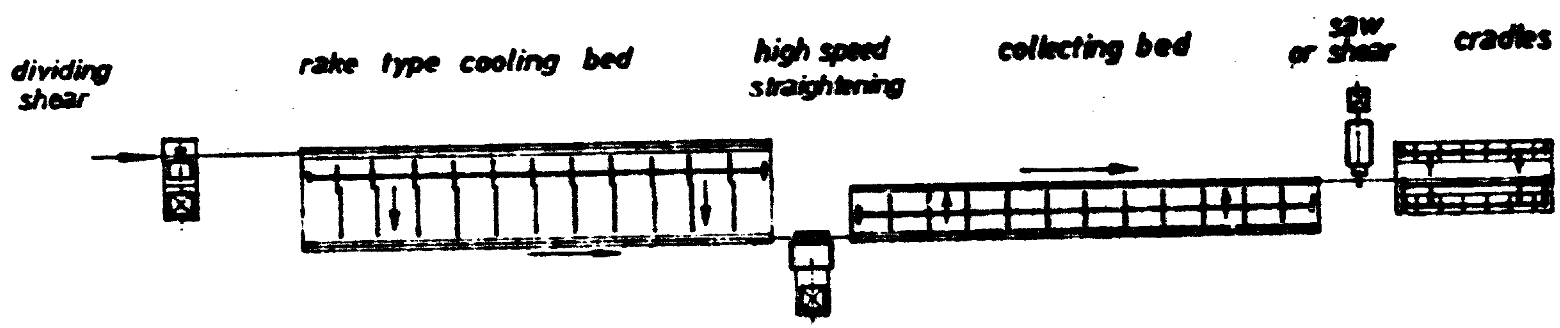
- finishing train
  consisting of one to three continuous individually
  driven stands behind the last stand of the open train

This will limit the length of the free run-outs or the loops and permit rolling of a precise product. Also the finishing speed can be higher than normal with open trains.

The main tasks for automation of small-tonnage section mills lie in the finishing end (Fig. 9).

Instead of the conventional double-handling by cutting to finished length first, storing, untangling, straightening, and stacking, it is definitely preferable to do all this in one production flow.

This, however, requires an increased cooling-bed size, cooling the bars down to a temperature acceptable for straightening (for instance 100 °C), and straightening with



Automated small section mill finishing end a high-speed straightener directly off the cooling bed in full cooling-bed bar length.

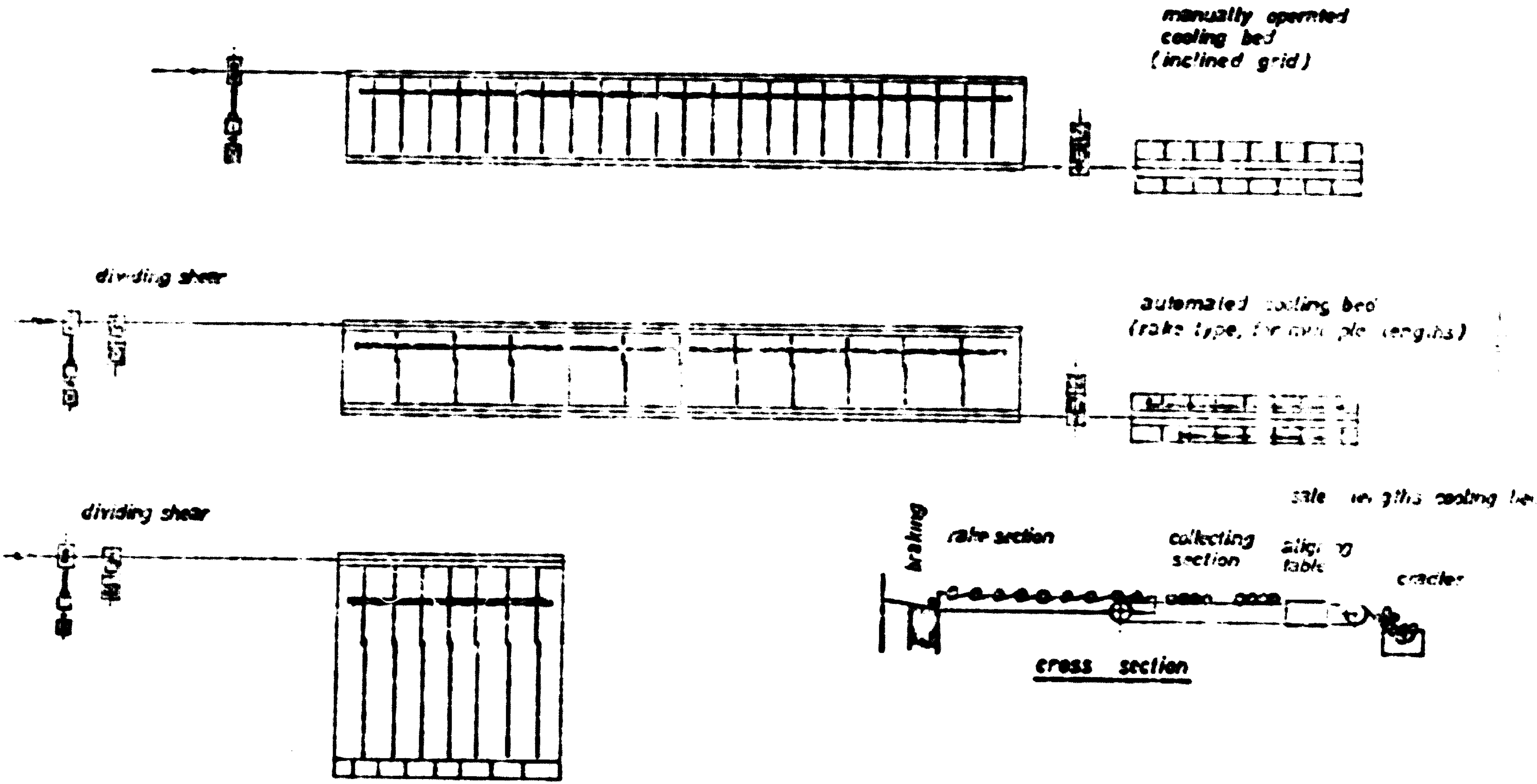
Only after this, the bars are collected to groups and cut and stacked.

It is realized that this requires heavy additional investments in the finishing end because of

- the larger size of the cooling beds
- the high-speed straightening
- the considerable mechanical equipment and space needed for collecting groups of bars and allowing cutting and stacking

However, this is more than balanced by the fact that far less manpower is needed, that the cut length can be easier varied for customer demands, and that no intermediate stockage is required, which otherwise would tie large amounts of operating capital.

Returning to bar mills (Fig. 10), it may be interesting to know the recent developments in the automation of cooling beds. The most simple cooling bed is normally a trough followed by a grid-type cooling bed, operated manually.



Cooling beds

Most newer mills have a cooling bed which can accept a sequence of bars, transfer them to a rake system, from where the bars are collected by shuffle-bars into groups and then cut on the cold shear. It is characteristic for this type of cooling bed that the bars entering the cooling bed are pre-cut into multiples of sales lengths, i. e. 60 m long to give 5 x 12 m on the cold shear.

A newer development is to cut directly to sales lengths at the shear behind the last stand, cooling the bars on a short fast-cycle cooling bed. After cooling, the bars can be directly collected into groups and, without further handling, bundled and shipped.

This type of cooling bed depends, of course, heavily on the shear in front of the cooling bed. From our own practice I can report that with such a shear, which is a start-stop shear, we are achieving an accuracy of plus/minus 2 cm when cutting at 11 m/sec.

The savings on manpower amount to at least 6 man per shift or on 3-shift operation 18 workers.

Also the space requirement is so much less that this in itself justifies the higher expenses for the rotary shear.

In summary, I would like to bring out the main points again:

The automation of existing mills is a complex task relying heavily on the operational and maintenance skill. This is true in spite of the fact that the individual elements of such automation, such as repeaters, slide walls, tilting table, continuous finishing stands, etc. are well known. In any case, such an automation requires a detailed study not only on the elements to be automated but also of the other parameters involved, such as furnace capacity, cooling bed performance, etc. Any such automation should only be done as a step-by-step approach.

For new mills, particularly mills rolling rebars and rounds, the automation should take into account the experience that continuous mills are more easy to operate than open trains. Any such automation should therefore use as many elements of continuous mills as possible. Good compromises have been obtained by using group drives driven by A.C. motors and by twice-through roughing mills.

For section mills, any automation should preferably start at the finishing end where most saving can be accomplished.

A notable development in the automation of mills is the introduction of sales-length cooling beds which have led to a considerable decrease in mill manpower.

3. 9. 74