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

D01433

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.76/1
11 August 1970

ORIGINAL: ENGLISH

Working Group Meeting on Economics of Scale
in the Latin American Automotive Industry [1]

Santiago, Chile, 21 - 30 September 1970

THE ECONOMICS OF SCALE IN THE MANUFACTURE OF SELECTED AUTOMOTIVE PARTS [2]

by

Emil F. Gibian
Consultant
Cleveland, Ohio
United States of America

---

[1] Organized jointly by the Economic Commission for Latin America (ECLA), the Inter-American Development Bank (IDB) and UNIDO.

[2] 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.

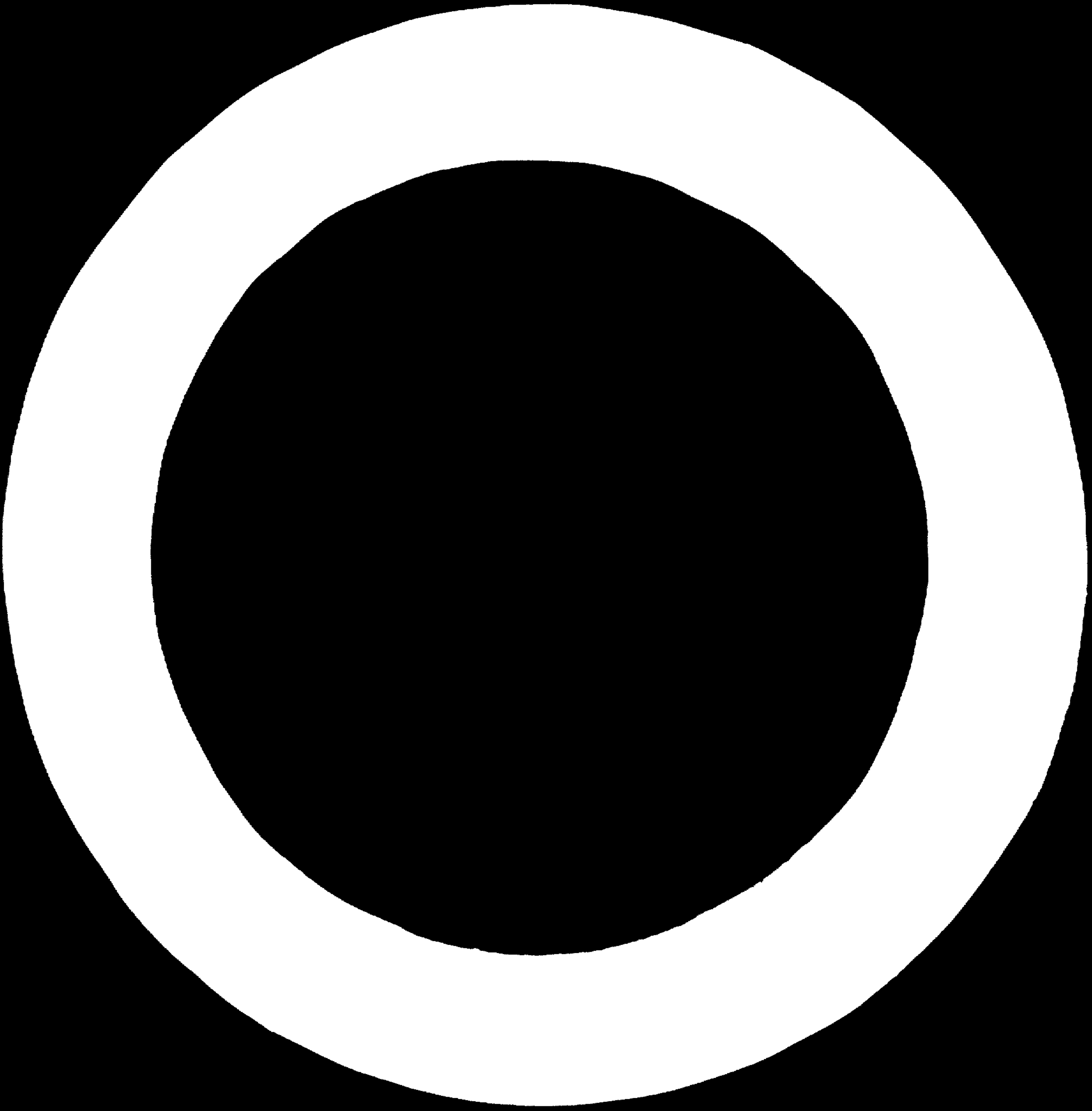


TABLE OF CONTENTS

ILLUSTRATIONS

TABLE OF CONTENTS

(Continued)

I. Influence of Production Volume on Technology and Economics

1. The economics of scale deserve prime consideration when introducing new manufacturing plants into developing countries or when readjusting and reequipping manufacturing facilities to best serve a specific market according to its present and forecast demands. The automotive industry of Latin America offers numerous cases where the economics of scale need to be taken into account. Some of these cases demonstrate proper solutions of the problem of dealing with the anticipated volume of production; one also finds cases where disregard of economics of scale led to difficulties or even outright failures.

2. The problems posed by the economics of scale are often complex, because of the many elements that have to be considered and because of their intertwined relation in the areas of technology, financial arrangement, personnel integration, government regulations, utilities, plant location, etc. This paper examines these various elements and their interaction, suggests a method of assembling and analyzing the significant data, and arrives at a method of cost analysis and cost comparisons for various volumes of production. Cases drawn from the manufacture of automotive parts are used to illustrate the recommended techniques.

II. Factors Influencing Economics of Production

3. To arrive at the most economical conditions for the manufacture of a product or products, at various levels of production volume, it is of course important to aim at the lowest possible manufacturing cost. Many items enter into the computation of the manufacturing cost and their influence on direct labor costs as well as on indirect labor cost and overhead costs may vary with the varying scale of production. The determination of these elements directly affecting manufacturing cost is discussed in the next chapter. But there are many factors besides manufacturing cost that must be considered, because they too affect the economics of scale in varying degrees.

4. The choice of technology to be used for the indicated production volume has, of course, a bearing on the manufacturing cost. But that choice also determines the type and size of plant required, the raw material to be used, the type and amount of various utilities, what type of tooling will be called for, and what skills will be needed to operate the equipment. The size of investment in plant and equipment has to be weighed against potential manufacturing cost advantages. The choice of technology also affects the amount of work in process and

inventories, items which will demand a substantial share of the required working capital.

III. Manufacturing Cost Elements

5. It may be useful to list those cost elements which will have a significant influence on the economics of manufacturing at varying production levels or when analyzing costs for alternate manufacturing methods. These cost elements fall into two classes, namely, variable costs and fixed costs; in a few instances, cost elements may be partly fixed and partly variable. The variable costs are directly proportionate to the production volume, that is, to the number of pieces produced or to the number of hours of direct labor. The fixed costs, as the name implies, remain essentially unchanged for a specific manufacturing method regardless of the production level.

6. Two major variable cost items are direct materials and direct labor. As long as the manufacturing method does not change, the cost per piece for material and direct labor remains fairly constant and is not affected by volume. An exception may occur for some materials, when increased volume may reduce cost because of quantity discounts from the supplier or because of lower transportation cost. But very significant cost differences may appear in these two items with changes

in manufacturing methods, particularly when higher volumes allow the adoption of semiautomated or fully automated production methods. Examples described in the later section of this paper will give specific data, like a changeover from a method using bar stock on automatic bar machines to a method using round wire on cold-headers. Similarly the content of direct labor cost may change dramatically with a change of methods. In fact, in cases of full automation the direct labor content may virtually shrink to zero.

7. A number of overhead cost elements are variable. These elements do not alter the unit cost at varying volumes and do not enter into the economics of scale, unless a method change also is involved. They are such items as maintenance of setup, perishable tools, electric power, etc. Then there are semivariable cost elements which are composed of both fixed and variable expenses. If the fixed portion of such cost elements is relatively large, it may have a significant influence on the unit cost at various production volumes. Examples of semivariable cost items are supervision and clerical salaries, general indirect labor. Fixed cost elements may play an important role in the economics of scale, since they remain constant at all production volume, although some may change with changes in manufacturing methods. Examples of fixed cost items are property taxes, depreciation charges, certain insurance items, and administrative expenses.

IV. Cost Analysis and Cost Comparisons

8. To complete the more or less theoretical and very elementary part of this paper, it seems appropriate to recommend a method which will lend itself to a reliable cost analysis and cost comparison, when considering the economics of scale from the viewpoint of varying production volumes and alternate technologies. It must also be assumed that adequate cost data and standards are available for a current operation, when an investment involving a new technology or a different scale of production is being contemplated. The method recommended for this purpose is based on budgetary control procedures. Such control is based on standards, applied to direct labor, material, indirect labor, and all overhead expenses with due regard to the nature of the costs, whether they are variable, fixed or semivariable.

9. The budget standards for overhead expenses of a department are recorded on a budget standard rate sheet. An example of such a two page document is shown in Figures 1 and 2. Note that the standards are expressed in dollars, the variable costs in dollars per standard productive labor hour, the fixed costs in dollars per month (21.25 working days). The total budgeted manufacturing expense is $6,271 of fixed expenses and $1.5499 per standard productive labor hour. The normal activity

of their department is 5,814 standard productive labor hours per month, resulting in a variable expense of $9,011. Adding to this $6,271 of fixed expenses, we arrive at a budgeted expense of $15,282 at high task. The adjusted budgeted expense takes into account that the efficiency of productive labor is expected at 83-1/3% of high task, which will result in $10,813 of variable expense plus $6,271 fixed expense, or an adjusted budgeted expense of $17,084. This amount divided by 5,814 results in a departmental burden rate of $2.94 per standard productive labor hour.

10. The primary purpose of the budget standard rate sheet is to form a base for the budgetary control of the plant operations and for the establishment of a standard cost system. But a budget standard rate sheet is also useful when examing the economics of scale under various conditions and assumptions. For a projected operation, it is necessary to construct a rate sheet based on estimated standards. This is not as formidable a task as appears at first glance, because experience and past history will allow fairly accurate estimates of the expected costs. The virtue of the rate sheet lies also in the fact that it facilitates a systematic analysis of the problem and that no significant factors will be omitted. The author has used this method, when working on a project for a new plant to manufacture automotive steering linkage components.

The old plant was to be abandoned, modern technology introduced. The question was how much will it cost and will the increased efficiency justify the cost? To answer these questions, a complete synthetic budget was constructed, department by department, and applied to an anticipated production volume. The project was approved on the basis of this analysis and the subsequent operation results closely approached the forecast budgeted estimates.

11. After a budget standard rate sheet is completed, the analysis of the effect of scale of production and the comparison between alternate methods can be advantageously presented in graphical form. A simple case will illustrate the usefulness of this graphical presentation. Let us assume a product with a present demand of 4,000 pieces per month. Budget standard rate sheets have been prepared for methods A and B. Manufacturing method A will require an investment of $100,000. A more sophisticated method B will require an investment of $200,000, reduce direct material cost, direct labor cost and the variable overhead rate, but increase the fixed overhead, mainly because of the higher depreciation. The totals for the two methods are:

Cost Item	Method A	Method B
Material cost per piece	$ .75	$ .50
Direct labor cost per piece	$1.50	$1.00
Variable overhead cost per piece	$1.50	$ .75
Fixed overhead cost per month	$6,000.00	$10,000.00

The conditions with method A are graphically represented in Figure 3, those with method B in Figure 4. At the expected normal volume of 4,000 pieces per month, the total budgeted manufacturing cost is $21,000 with method A and the standard cost per piece is $5.25. With method B, the total cost is $19,000 and the standard cost per piece is $4.75.

12. To appraise the merit of these two methods and to select the most economical one for the prevailing market conditions, it is suggested to draw up the chart, Figure 5, which superimposes the total budgeted manufacturing cost picture of method B over that of method A. This graphical representation is revealing and gives management a reliable tool to compare costs over a wide range of production volume. Cost of method B are obviously higher than method A until we reach a monthly volume of 2,667 pieces, at which point the cost of both methods are equal. At the normal volume of 4,000 pieces per month, method B shows a gain of $2,000 per month over method A. The decision has to be made whether the additional investment of $100,000 is justified by a yearly saving of $24,000 in manufacturing costs. A decision for the costlier method B would be greatly favored, if there were a reasonable expectation that a volume higher than 4,000 pieces per month might

be expected, because the gain of method B over method A increases in direct proportion to the production volume beyond the break-even point of 2,667 pieces. For instance, at 5,333 pieces per month, method B has double the advantage over the 4,000 piece level, showing a gain of $48,000 a year, which certainly would justify the additional investment needed for method B.

13. Our findings so far may be summarized as follows: A reliable procedure for the study of economics of scale in the production of automotive components - or for that matter of any product - should have for its basis an adequate cost accounting system. A flexible budgetary control technique is recommended. The use of the most economical technology has to be weighed against the investment needed, available funds, flexibility to changeover to other designs, depreciation policies. Labor skills, available utilities, sources of prime material, tools and manufacturing supplies and their prices play a role in decisions concerning the economics of scale. A forecast of the market demands, number of designs and types, lot sizes to be processed are factors to be considered. The relation between costs of materials, labor, and equipment often varies significantly from country to country and will affect the decision as to which manufacturing method is the most economical for a particular situation. Finally, there will be cases

where an analysis will show that the establishment of a production facility is economically not feasible because the volume is insufficient to justify the cost of investment or the operating costs with any of the available technologies; such cases prompt the adoption of regional understandings to create a market of sufficient magnitude for an economical production unit.

14. Some aspects of this complex interplay of many factors will be brought out in greater detail by cases involving the manufacture of automotive components in small and large volumes. These cases are cited primarily to illustrate how the economics of scale and the technology of production interrelate.

V. Automotive Steering Pump

15. The machining of the pump housing, the bulkiest and also costliest part of the pump assembly, is the subject of this study. An estimated 3,000 pieces per month will be required in the foreign subsidiary. Another plan for a monthly capacity of 50,000 per month follows somewhat the setup of a U.S.A. plant, which is geared for a production of around 80,000 pieces per month. The estimating parameters for the smaller plants are:

a. Required rate of production

3,000 pieces per month

50 weeks per year, 5 days per week, one 7 hour shift

80 percent machine utilization

Required rate of production 21 pieces per hour

b. Equipment cost is based on U.S. prices; shipping costs and export duties are not included.

c. In addition to the equipment cost shown in the tabulation, it is estimated that a sum of $75,350 will be expended for starting costs, which include engineering services, vendor tooling, handling equipment, training, etc.

The equipment cost breakdown for this operation is shown in the following tabulation, which gives a list of operations, the hourly production rate for each operation and the costs of equipment including permanent tooling.

EQUIPMENT COST BREAKDOWN FOR 3,000 PER MONTH

Pcs/Hr	Hrs/C	Oper# & Description	Capital	Durable Tlg.	Gages	Groom	Total
-	-	10 Rec. Inspection	90	-	1,150	200	1,440
40	2.500	20 Bore Face Turn	77,250	12,500	900	640	91,290
30	3.333	30 Mill Bosses	4,000	1,660	250	100	6,010
38	2.630	40 Drill & Chmfr 4 Lug Holes	3,500	1,600	350	125	5,575
		50 Tap 4 Lug Holes	3,500	1,400	80	125	5,105
30	3.333	60 Face, Chmfr, Drill & Tap	11,300	1,100	125	110	12,635
		70 Face, Chmfr, Drill & Tap	10,000	1,800	300	250	12,350
		80 Same as above	10,000	1,800	300	250	12,350
		90 Drill	10,000	1,800	150	50	12,000
		100 Drill	10,000	1,800	150	50	12,000
40	2.500	110 Finish & Semi-Finish Bore	35,000	10,000	1,800	1,600	48,400
		120 Bore Ring Grooves	8,300	2,300	500	150	11,250
38	2.630	130 Press in Bushing	5,000	900	250	300	6,450
		140 Finish Bore	30,000	3,200	3,500	1,000	37,700
32	3.125	150 Drill Ream and Burr	36,000	14,900	4,000	1,976	56,876
80	1.250	160 Burr	1,000	500	-	-	1,500
		170 Wash	3,000	-	-	-	3,000
	21.301		$257,940	$57,260	$13,805	$6,926	$335,931

16. The machine tools are modern general purpose tools. As indicated in the tabulation, one operator will be able to run, in some instances, more than one machine tool simultaneously, the total direct labor time being 21.301 hours per 100 pieces. The capital investment is $315,200 in local U.S. prices.

17. The larger plant for 50,000 pieces per month employed a more sophisticated technology with special purpose machine tools, a large amount of automation and automatic gaging. The direct labor cost is reduced to 3,931 hours per 100 pieces and the capital investment amounts to $792,000. The tabulation for the large capacity plant is as follows on the next page.

EQUIPMENT COST BREAKDOWN AT 50,000 PCS PER MONTH

Pcs/Hr	Hrs/C	Oper# & Description	Capital	Durable Tlg.	Gages	Groom	Total
-	-	10 Rec. Inspection	90	-	1,150	200	1,440
220	.445	20 Bore, Drill & Ream	154,500	33,000	1,100	750	189,350
400	.250	30 Turn, C'Bore & Face	76,250	4,000	1,000	400	81,650
300	.333	40 Mill	42,000	12,000	500	1,000	55,000
220	.455	50 Drill	154,000	35,000	1,325	2,400	192,725
220	.455	60 Drill 3 Holes	76,000	21,000	500	240	97,740
180	.555	70 Press in Bushing	5,000	2,500	250	160	7,910
		80 Finish Bore	45,000	24,000	2,100	760	71,860
210	.476	90 Groove	25,000	6,500	2,200	300	34,000
210	.476	100 Drill Dowel Pin Hls	33,000	11,000	4,000	1,000	49,000
210	.476	110 Wash	26,000	6,000	-	760	32,760
	3.931		$636,840	$155,000	$14,125	$7,970	$813,935

18. To study the economics of scale for this particular subject, it is assumed that the material cost, namely, the cost of the housing casting, is constant and equal in any situation. The average direct labor rate in the subsidiary plant will be $1.50 per hour, in the U.S.A. plant is $4.00 per hour. The capital investment will be amortized over a period of 10 years (120 months), so that the depreciation charge per month will be 1/120 of the capital investment. Employing the budgeting control technique, the analysis, given here in a somewhat abbreviated form, can be conducted as follows:

19. A. Subsidiary plant for 3,000 pieces per month

.213 hours per piece at direct labor cost of $1.50 per hour	$ .32/pc.
Variable overhead at 250% of direct labor	$ .80/pc.
Total variable cost per piece	$1.12
Fixed overhead (not including depreciation	$2,400 per month
Depreciation on $315,000	$2,620 per month
Total monthly fixed overhead	$5,020

B. Plant for 50,000 pieces per month in U.S.A.

.03931 hours per piece at direct labor cost of $4.00 per hour	$ .16/pc.
Variable overhead at 300%	$ .48/pc.
Total variable cost per piece	$ .64

Fixed overhead (not including depreciation)	$3,200 per month
Depreciation on $792,000	$6,600 per month
Total monthly fixed overhead	$9,800

C. Plant for 50,000 pieces per month in same Country as A

.03931 hours per piece at direct labor cost of $1.50 per hour	$ .06/pc.
Variable overhead at 450%	$ .27/pc.
Total variable cost per piece	$ .33
Fixed overhead (not including depreciation)	$3,200 per month
Depreciation on $950,000 (20% over local U.S. prices)	$7,900 per month
Total monthly fixed overhead	$11,000

20. With the above data on hand, the economics of alternatives can be ascertained. For alternative A, assuming the modest requirement of 3,000 pieces per month, the manufacturing costs, not including the cost of the casting, figures $\$1.12 + \frac{5020}{3000} = \$2.79$. If the same piece is manufactured in U.S.A. as per B, at a rate of 50,000/month, the manufacturing cost amounts to $\$\ .64 + \frac{9800}{50000} = \$\ .64 + .196 =$ $\$\ .836$. If the same sophisticated technology were transplanted to the

subsidiary as per C and could attain a production volume of 50,000 pieces/month, the manufacturing cost per piece would amount to $\$ .33 + \frac{11100}{50000} = \$ .55$ per piece. If, however, the volume were 3,000 pieces/month, the cost of one piece goes up to $\$ .33 + \frac{11100}{3000} = \$4.03$!

21. Break-even charts described in paragraph 11, if constructed for the plans A, B and C, would clearly show the interrelation of these alternatives, and would suggest the best solution. It is quite evident that the cost for method A, even if volume could be doubled to 6,000 pieces/month, is still relatively high, namely $1.96. Importing the parts from U.S.A, where their cost is $ .84 appears feasible, if we assume that the imported cost were about double due to customs duties and freight charges, that is, $1.68, and if the U.S.A. plant has the capacity for this relatively modest increase of its production volume. In fact, the avoidance of the $315,000 investment makes this alternative preferable, even if the subsidiary plant could increase its volume to 9,000 pieces/month in a 3 shift/day operation, where the cost would happen to come down to $1.68, the same cost as the imported part. The most economically attractive alternative could be brought about if the scale of production could be increased by enlarging the market through a regional agreement. The question is, at what volume could

the cost of $1.68 be reached under plan C and at the same time allow to repay the $950,000 over a period of 5 years instead of 10 years. A simple equation gives the solution

$$.33 + \frac{11100 + 7900}{X} = 1.68$$

$$X = 14,000 \text{ pieces per month}$$

The final conclusion then is: Do not consider plan A, but rather plan on importing the finished pump housing for a monthly consumption of 3,000 pieces. If, however, the market can be expanded to reach a demand of 14,000 pieces/month or more, then it would be economically justified to make the investment for plan C. If importing were prohibited and the market was limited and is not expected to ever reach 14,000 pieces/month, then a plant equipped with conventional machine tools per plan A is recommended notwithstanding the penalty of a very high product cost associated with such a plan.

VI. Automotive Valve Manufacture

22. The manufacture of automotive engine valves is an excellent example of the influence of production volume and lot sizes on the manufacturing methods chosen. The economics of scale become

very involved because of the proportions in the value of cost elements vary so much from country to country. In a U.S. valve manufacturing plant, the average labor rate increased each year by 10 cents/hour from 1960 to 1966 and 20 cents/hour each year from 1966 to 1970. The rate in 1960 was $2.30, in the beginning of 1970 it was $3.80. Compare this with average labor rates in Argentina or Brazil and the rate of Latin American labor is close to 1/3 of U.S. labor. The opposite relation occurs in the cost of a typical exhaust valve steel 21-4N. The Brazilian price for this material, produced domestically, is 42% higher than the cost in U.S.A. The Argentine price for this steel, imported from France and burdened with high import duty and shipping cost, is 140% higher than the U.S. cost.

23. A valve finishing line set up in 1960 in the U.S. consisted of various turning and grinding machine tools totaling 36 and performing 12 distinct operations. The machine tools are located along a roller conveyer line, work in process is handled in tote pans, the operators load and unload manually, the wheel dressing and size control are done manually by the operators, floor inspection insures proper quality control. There are 27 operators per shift. A complete change of setup for a new valve performed by the operators, takes approximately four hours. The minimum lot size is approximately

4,000. The manufacturing cost per unit produced on this line has risen in the last ten years approximately by 35%, primarily because of the above given increase in wages. This is also the type of line installed in that company's plants in Argentina and Brazil. A substantial amount of work in process has to be on the line at each work station, so that a stoppage of one machine would not idle all the following operations.

24. A completely automated line has been installed in 1962 and another one, of updated technology, in 1968. All finishing is done by grinding, the handling is mechanized with automatic loading and unloading, post process gage machine control provides automatic dressing and compensation. The number of operations is essentially the same as on the manual line (11 against 12), the number of individual machine tools is 18 against 36, and the number of men per shift is 9 against 27. The tooling cost of such an automated line is relatively low, but a change-over to a different valve is costly and causes the loss of approximately two shifts. Therefore, the minimum economic lot size is approximately 200,000 pieces, the line has to operate on a two shift, 5 or 6 day schedule (the third shift is set aside for maintenance of setup), and the production volume must be 400,000 or more per month. Under such conditions, the unit cost is 46% of the unit cost for the same valve finished on the manual line. The labor cost in the automated

line is 22% of the unit manufacturing cost against 35% on the manual line, the depreciation share 30% against 18%.

25. The economics of such an automated line in Argentina or Brazil would be disastrous under present conditions. The savings in labor cost would be insignificant, there is no saving in material costs and the depreciation rate on the costly equipment also has an adverse effect. But the greatest drawback is the present insufficient volume and the absence of large runs. However, with the growth of the Latin American automobile industry and also the prospect of regional agreements which would reduce the number of types and increase the volume, it may be feasible in the not too distant future to find an economic approach to a partial automation of valve machining lines. Several European valve plants have such modified lines or are in the process of installing them. Figure 6 shows the end of a fully automated valve finishing line. In the foreground are two female inspectors who check the finished valves coming off the line for visual defects only. They are the only inspectors on the line, because dimensional accuracy is 100% insured by the automatic gaging and compensating devices. In the background are various grinding machines with their electronic control boards and automatic material handling devices. When this

picture was taken, the line was running, but note that none of the machine tools is manned, the entire operation being automatic.

VII. Steering Linkage Manufacture

26. Steering linkage parts offer good examples of how the manufacturing technology and also a design are modified to suit products or volumes. Two components have been selected for that purpose; the ball stud and the centerlink. For those readers not entirely familiar with steering linkage parts and their English nomenclature, the illustrations, Figures 7, 8, and 9 will help to visualize these components. Figure 7 shows a centerlink with the ball studs assembled to the two socket ends. Figure 8 shows in detail a solid ball stud assembled to a socket, Figure 9 is a photograph of a hollow head ball stud that is being manufactured in very high volume.

A. Ball Stud

27. A high production manufacturing process to produce hollow ball studs as illustrated in Figure 9 is described in the following tabulation:

Major Operations	Pcs/hr	Equipment	Capital Investment
Cold-head	2,000	3/4" Coldheader	$300,000
Drill and Countersink Cotter Hole	1,000	Davis-Thompson Cotter Drill	$ 75,000

Major Operations	Pcs/Hr	Equipment	Capital Investment
Roll Thread	1,250	Roll Threader	$ 50,000
Burnish Ball	333	Roll Threader	$ 50,000
Heat Treat	1,000	Automatic Pass Through Atmosphere Hardening Furnace	$100,000

The total labor time for above operations is .63 hours/100 pieces which at an average rate of $3.80/hour amounts to $2.40/100 pieces. The total investment in machine tools and equipment is $575,000. The material used is .905" round coldheading wire, 3.3" length per piece. It should be noted that the coldheading method allows to produce a hollow head, a very advantageous design; except for the thread and cotter pin hole, coldheading produces a finished stud of excellent physical properties and finish and constant dimensional accuracy. It is also interesting, that the design of the header tools and gages, the inventory of available tools and gages, the die dimensions for each gather die blow, the volume of metal and length of wire required to make a particular design of a hollow ball stud, all these tasks are programmed to a computer. The computer output gives the designer all the dimensions for dies and gages. The design time has been reduced by approximately 40 hours per job. Also all duplications of tooling and gaging has been eliminated. Such advanced procedures further enhance the profitability of an expensive, but high performance manufacturing setup for large volume production. Production lots for this setup are in the range of 100,000 pieces and over.

28. Smaller lots which also are the rule in Latin America usually start out with a solid ball stud blank produced on automatic bar machines or on hot forging machines. An automatic bar machine will represent a capital investment of $70,000 and turn out approximately 100 pieces/hour. The same stud, specified for the above high production line would require on the automatic, 1-5/16" round bar stock with a cut length of 3.08". That is double the weight of the coldheaded stock and means that 50% of the material goes into chips! The subsequent steps in the ball stud manufacturing process also can be simplified for the smaller lots, particularly the heat treating, in order to reduce the capital investment. The special purpose drilling and countersinking machine can be replaced by inexpensive standard machine tools and the loading and unloading can be done by the operators, thereby saving the costly automated loading equipment. Thus a line for the volume of 100 pieces/hour can be set up with an investment of approximately $165,000, or $350,000 less than the high production line. The cost comparison for the three cost items and for U.S. wage and material cost levels is

given in this tabulation, expressed in dollars per piece.

Cost Item	Manual Line	High Production Line	Difference
Direct Labor	.090	.024	+ .066
Depreciation	.040	.014	+ .026
Material	.104	.052	+ .052
Totals	$ .234	$ .090	+ $ .144

The ball stud produced on the manual line for a volume of 100 pieces/hour costs 14.4 cents more than the stud produced on the high production line for 1,000 pieces/hour. While this applies for U.S. conditions, the cost difference would be higher in Latin America, where the labor rates are lower, but the material costs are higher. Steel prices in Brazil at present are 50% higher, in Argentina 75 to 100% higher.

29. Two illustrations of the equipment from the high production ball stud line are shown. Figure 10 is a 3/4" five station coldheader with wire coil in place. Figure 11 shows the thread roller with the associated material handling equipment for automated operation. In the foreground is the device for loading the feeding hopper and at the machine is the chute for the automatic feeding of the studs to the rollers.

B. Centerlink

30. The high production line for the centerlink made from bar stock is described in the following tabulation:

Major Operation	Pcs/hour	Equipment	Capital Investment
Cut to length	1,000	Cut Off Shear	$ 10,000
Upset one end and bore	167	3" Upsetter with Indicator on Heating Unit	$170,000
Upset other end and bore	167	3" Upsetter with Indicator on Heating Unit	$170,000
Shot blast	1,000	Tumbler shot blast	$ 45,000
Drill and ream two end holes and two center holes complete	250	Davis-Thompson special 6 station rotary drill	$430,000

31. The total investment for the major machine tools is $825,000. The Davis-Thompson rotary drill will produce 3,750 pieces in two shifts; to match this output, the upsetters have to be run on three shifts.

32. In manufacturing centerlinks, it is necessary to control the dimensional relationships between the two end and center holes. The first upset operation establishes the locations of one end and center hole. The second upset operation uses these locations to obtain the necessary dimensional relationships between all four holes.

33. Different tooling is ordinarily required to upset each end of a centerlink. If only one upsetter were used to produce the entire centerlink on high volume production runs, cycling would be required in order to maintain a balance between work in process inventory costs and setup costs. Therefore, on high volume runs, upsetters are normally paired - each upsetter produces one end of the centerlink. This eliminates the cycling problem, also provides the opportunity for improved material handling systems, and reduces the amount of work in process.

34. After the upset operations, a centerlink is shotblasted to remove the scale and the necessary holes are machined. On the Davis-Thompson special 6 station rotary drill, two revolutions are required to drill and ream all four holes. Four centerlinks are machined at each station (excluding the load/unload station). The operator's work cycle consists of the following:

- Unload two centerlinks that are machined complete.

- Move other two centerlinks to have center holes machined.
- Load two centerlinks to have end holes machined.
- (Next station).

35. For low volume runs, four 2-spindle drill presses might be used to machine the four holes. The operation would consist of the following:

Operation	Pieces/hour	Equipment	Capital Investment
Drill 2 end holes	83 1 man	2 spindle drill press	$12,000
Ream 2 end holes	83	2 spindle drill press	$12,000
Drill 2 center holes	83 1 man	2 spindle drill press	$12,000
Ream 2 center holes	83	2 spindle drill press	$12,000

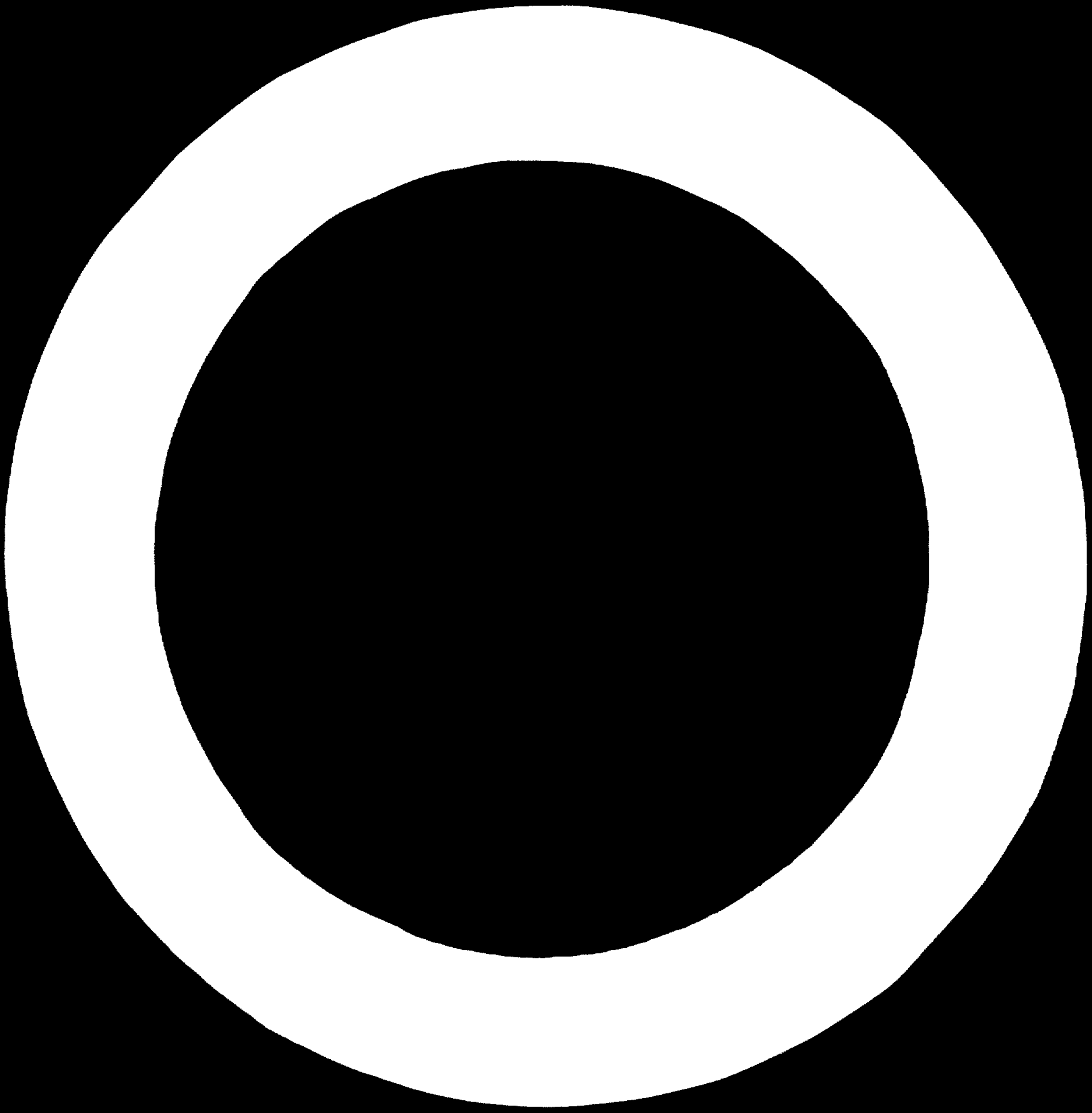
Twelve 2-spindle drill presses would be required to match the capacity of the Davis-Thompson special rotary drill. It would require a capital investment of $144,000. The direct labor would be 6 times higher, inasmuch as the 12 drill presses would be operated by 6 men as compared with the one operator on the special rotary drill.

35. The two key machines of the high production line are shown in Figures 12 and 13. Figure 12 shows one of the upsetters and the overhead chain conveyor for bringing the cut bars to the operator and conveying the links with the one upset end to the operator of the second

upsetter. Figure 13 is a picture of the 6 station rotary drill. It shows two centerlinks already unloaded. Note that each rotating platform holds two skids in order to eliminate machine downtime for material handling. Figure 14 is a picture of two 2-spindle drill presses on a low volume centerlink machining line.

VIII. What Next?

37. More cases could be described to illustrate the impact of scale on technology and costs in the manufacture of automotive components. The problem of Latin America is the same as the problem of the European countries, Japan, and the United States. How to consolidate the demand for automotive parts, eliminate duplication, splintering into small units, and how to adopt common designs in order to boost lot sizes and take advantage of the latest technology. Can this be done in Latin America without stifling healthy competition and to the benefit of all parties concerned? A rational approach to the economics of scale holds a key to that answer. Industry, governments, international agencies and professional societies need to be involved and share in this work.



ILLUSTRATIONS

BUDGET STANDARD RATE SHEET TPFC 506

Division	Foundry	Normal Activity -[redacted]/Man Hours	5814 SPLH
Department	Casting No. 4	Budgeted Expense @ Normal Act. - High Task.	$15,282
Foreman		Adjusted Budgeted Expense @ Normal Activity	$17,084
Effective	7-1-53 Supersedes None	Burden Rate	$2.94 per SPLH

ACCT. No.	ITEM	UNIT OF MEASURE	BUDGET STANDARDS		Dollar Conversion Factor		BUDGET STANDARDS	
			Fixed Hrs.	Vari'bleHs.	Fixed $	Variable $	Fixed $	Variable $
	PRODUCTIVE LABOR							
101	Direct Labor-Operating					2.03		
102	Direct Labor-Inspection							
	TOTAL PRODUCTIVE LABOR							
	MANUFACTURING EXPENSE Non-Operating Labor							
102	Inspection Labor			.0205		2.03		.0416
103	Set-up			.0256		2.03		.0520
104	Repairs to Products							
105	Reclassified Indirect Labor							
111	Idle Time							
112	Breaking in New Help			.0317		1.99		.0631
113	Maintenance of Set-up			.0119		1.99		.0237
114	Time Paid-Not Worked			.0017		1.99		.0034
115	Paid Holidays							.0685
	TOT. PROD. LABOR NON-OPER.			.0914				.2523
	Non-Productive Labor							
121	General Indirect Labor		24.0	.1460	1.75	1.75	893	.2555
122	Inventory Taking							
124	Inspection-Floor Checkers		16.0	.0584	2.05	2.05	697	.1197
125	Factory Super.							
126	Inspection Super.							
127	Cleaning Machines			.0070		2.03		.0142
128	Administrative & Clerical Sal.						700	.0662
130	Employee & Super. Training							
131	Employee Relations							
132	Overtime Premium-Hourly							
133	Night Shift Premium							
134	Vacation Expense						663	
135	Overtime-Salaries							
137	Payroll Adjustment							
	TOTAL NON-PROD. LABOR		40.0	.2114			2953	.4556
	TOTAL LABOR		40.0	.3028			2953	.7079
	Other Manufacturing Exp.							
200	Social Security Taxes						51	.0667
210	Workmen's Compensation Ins.						6	.0074
215	Pension Expense—Hourly						80	.1302
220	Travel & Other Business Exp.							
301	Project Cost-Direct							
304	Coal							
305	Oils and Lubricants							
306	General Supplies							.1032
307	Grind. Wheels & Abrasives							
308	Stationery & Office Supplies							.0034
310	Shipping Boxes & Supplies							
311	Cafeteria Expense							
313	Employee Welfare							.0086
315	Royal Expense							

Figure 1.

Budget Standard Rate Sheet, Page 1

BUDGET STANDARD RATE SHEET
TPPC 806 (2)

DEPT. Casting
DATE 7-1-53 No. 4

ACCT. No.	ITEM	UNIT OF MEASURE	BUDGET STANDARDS		Dollar Conversion Factor		BUDGET STANDARDS	
			Fixed Hrs.	Vari'ble Hrs.	Fixed $	Variable $	Fixed $	Variable $
316	Unexpended Supplies							
341	Rentals-Office Equipment							
342	Rentals-Govt. Property							
343	Rentals-Other							
410	Subscriptions and Dues							
501	Postage							
502	Telephone & Telegraph							
503	Water							.0024
504	Power and Light							.0034
505	Gas and Fuel Oil							.0688
530	Professional Services							.1118
580	Retirement Plan Premium							
600	Real Estate Taxes							
601	Personal Property Taxes						900	
610	Property & Liability Ins.						500	
620	Depreciation-Mach. & Equip.						120	
621	Depreciation-Buildings						200	
690	Revenue-Supplies & Serv.						525	
801	Maintenance-Mach. & Equip.							
802	Maintenance-Tools							.0731
803	Maintenance-Instruments							.0086
804	Maintenance-Buildings							.0258
805	Rearrang. Plant Facilities							.0172
807	Product Tooling Used							.0215
809	Perishable Tooling Used							
810	Experimental-Product							
811	Expermental-Plant & Equip.							
812	Experimental-Mfg. Methods							
								.0258
815	Material Trucking							
816	Cleaning & Sweeping							
819	Misc. Factory Expense							
								.0129
	TOT. MFG. EXP. BEFORE APP.							
	APPORTIONMENTS From Other Divisions						2382	.6908
	Division Non-Prod. Depts.						674	.1079
	Division Admin. Depts.						262	.0433
	TOTAL APPORTIONMENTS							
							936	.1512
	TOTAL MFG. EXPENSES							
							6271	1.5499
898	Expense Reclassified Credit							
899	Expense Recovery Credit							
	NET MFG. EXPENSE							

Division Industrial Engineer

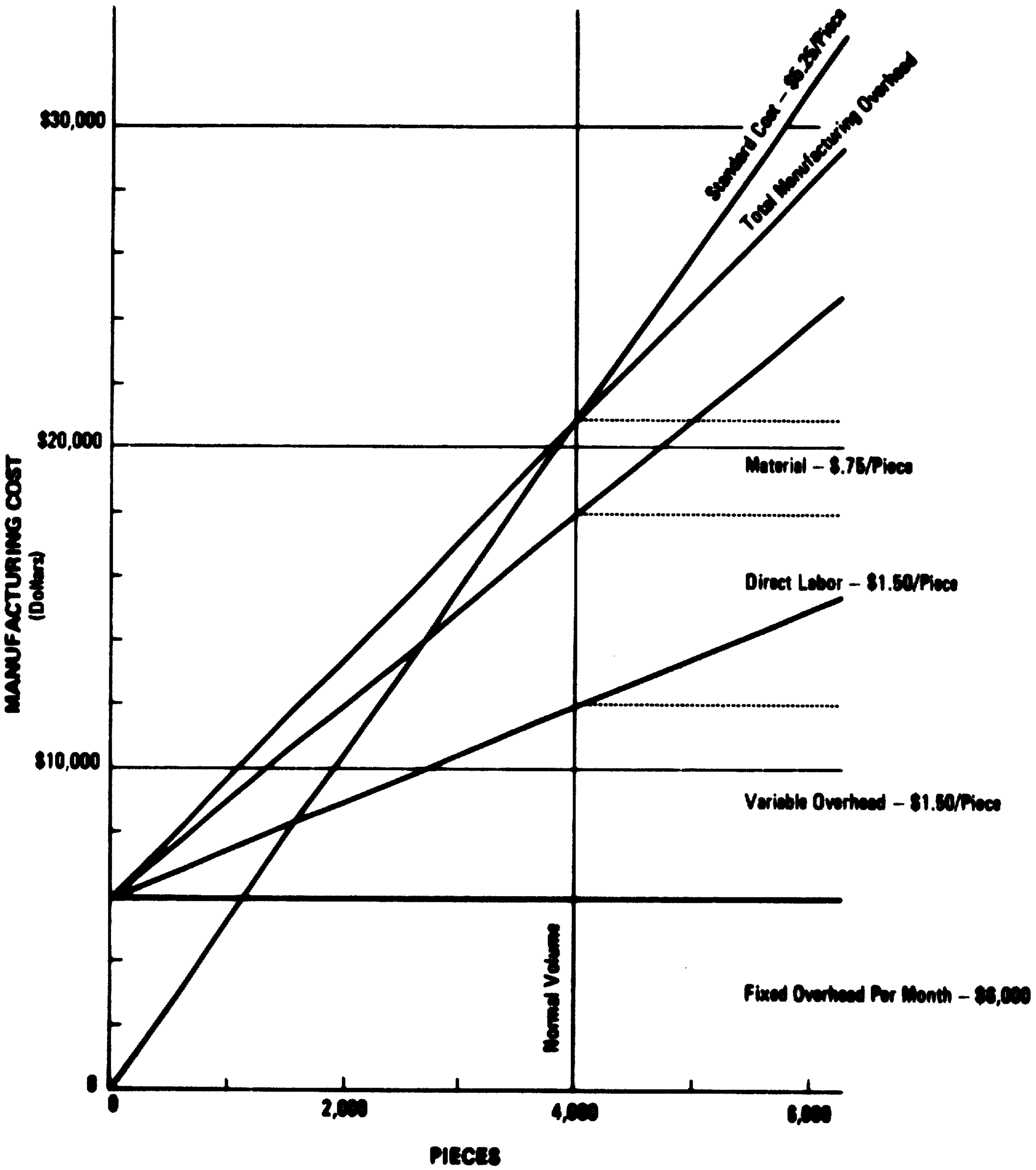
Division Manager

Department Manager

Factory Manager

Figure 2.

Budget Standard Rate Sheet, Page 2

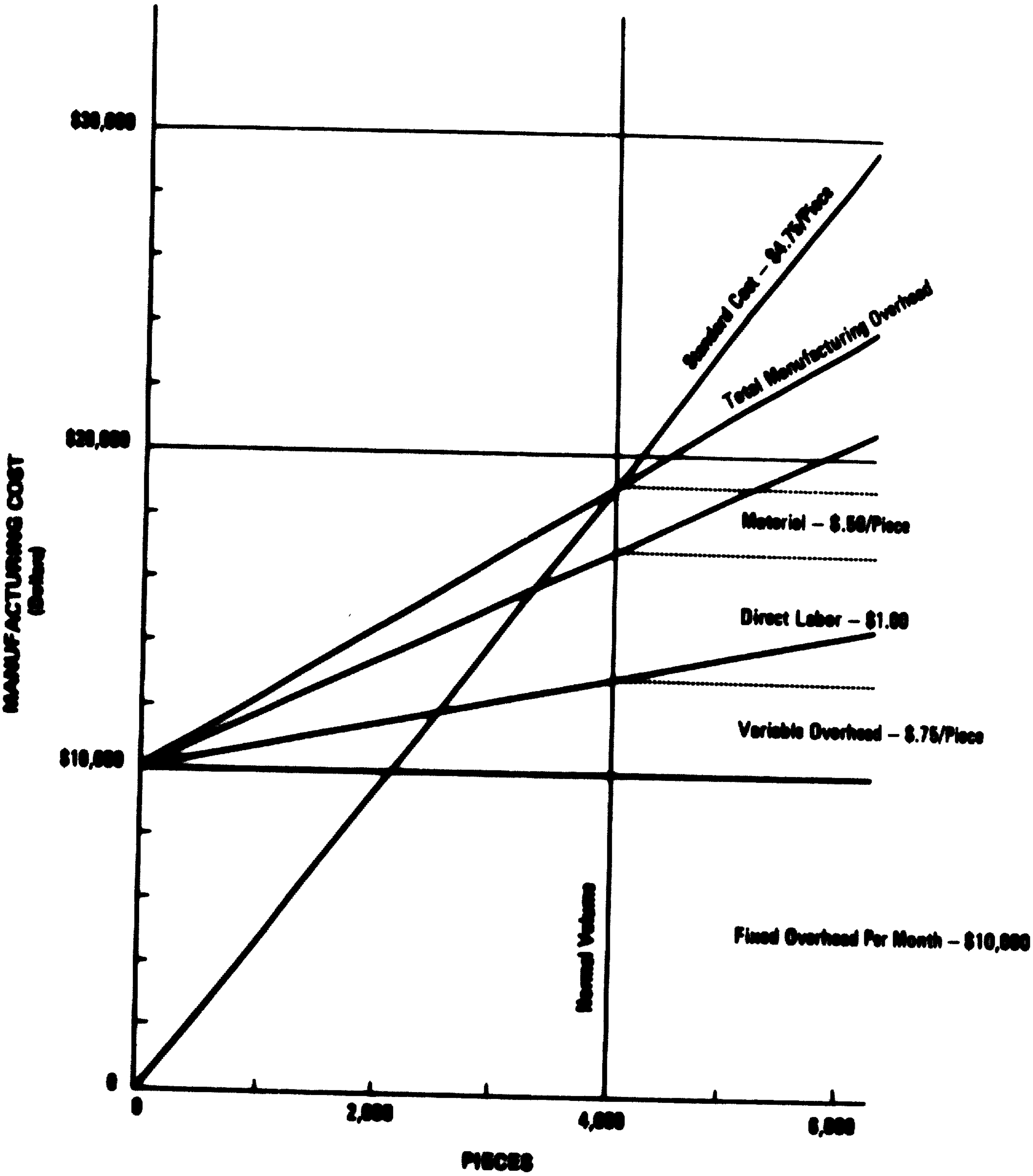


MANUFACTURING COST VERSUS PRODUCTION VOLUME

METHOD A – Investment $100,000

Figure 3.

Cost Chart, Method A

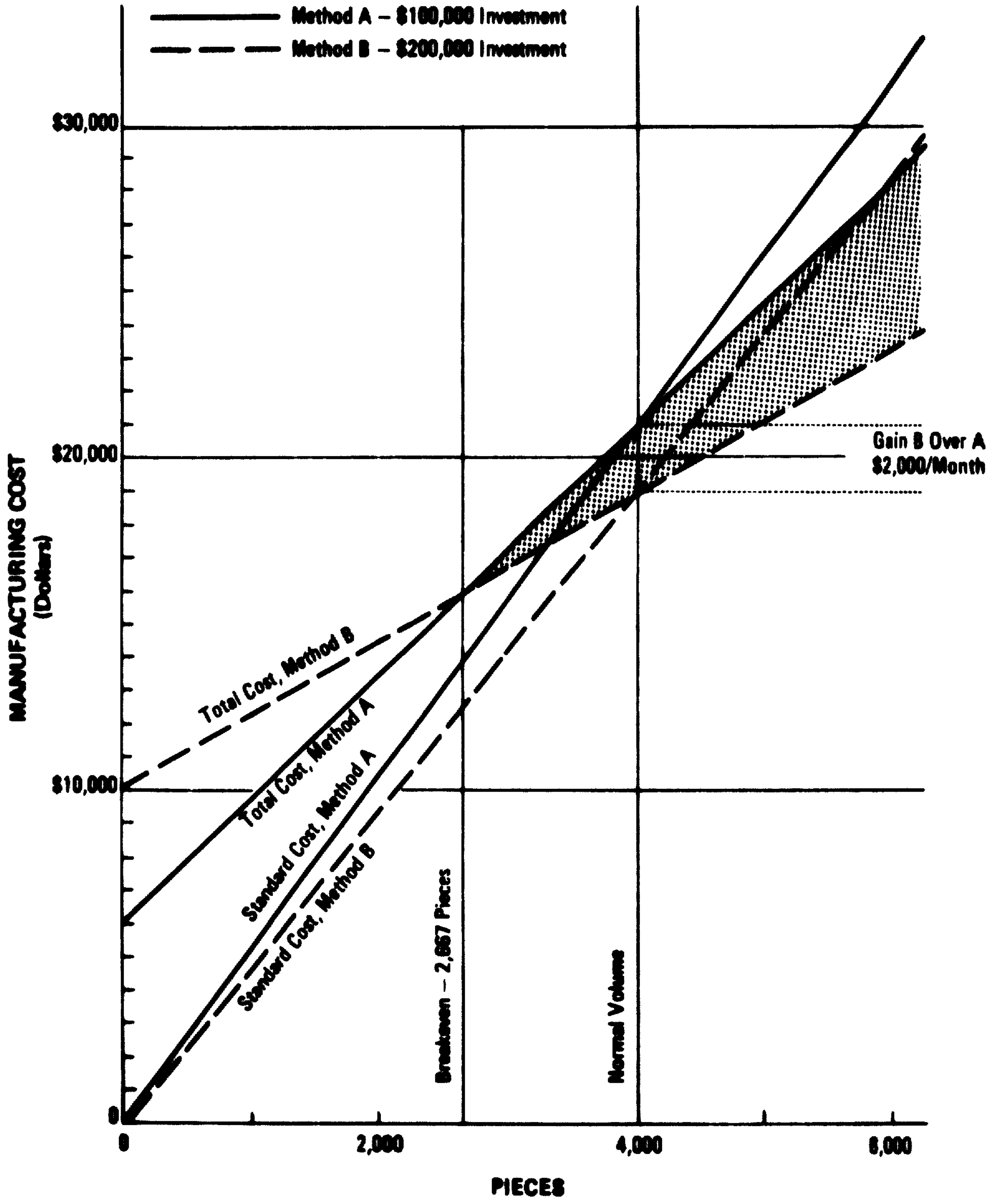


MANUFACTURING COST VERSUS PRODUCTION VOLUME

METHOD B – Investment $200,000

Figure 4.

Cost Chart, Method B



COST COMPARISON BETWEEN METHOD A AND METHOD B

Figure 5.

Cost Comparison Between Two Methods

Figure 6.

Visual Inspection at End of Valve Line

Figure 7.

Centerlink with Two Ball Stud Assemblies

Figure 8.

Ball Stud Assembly

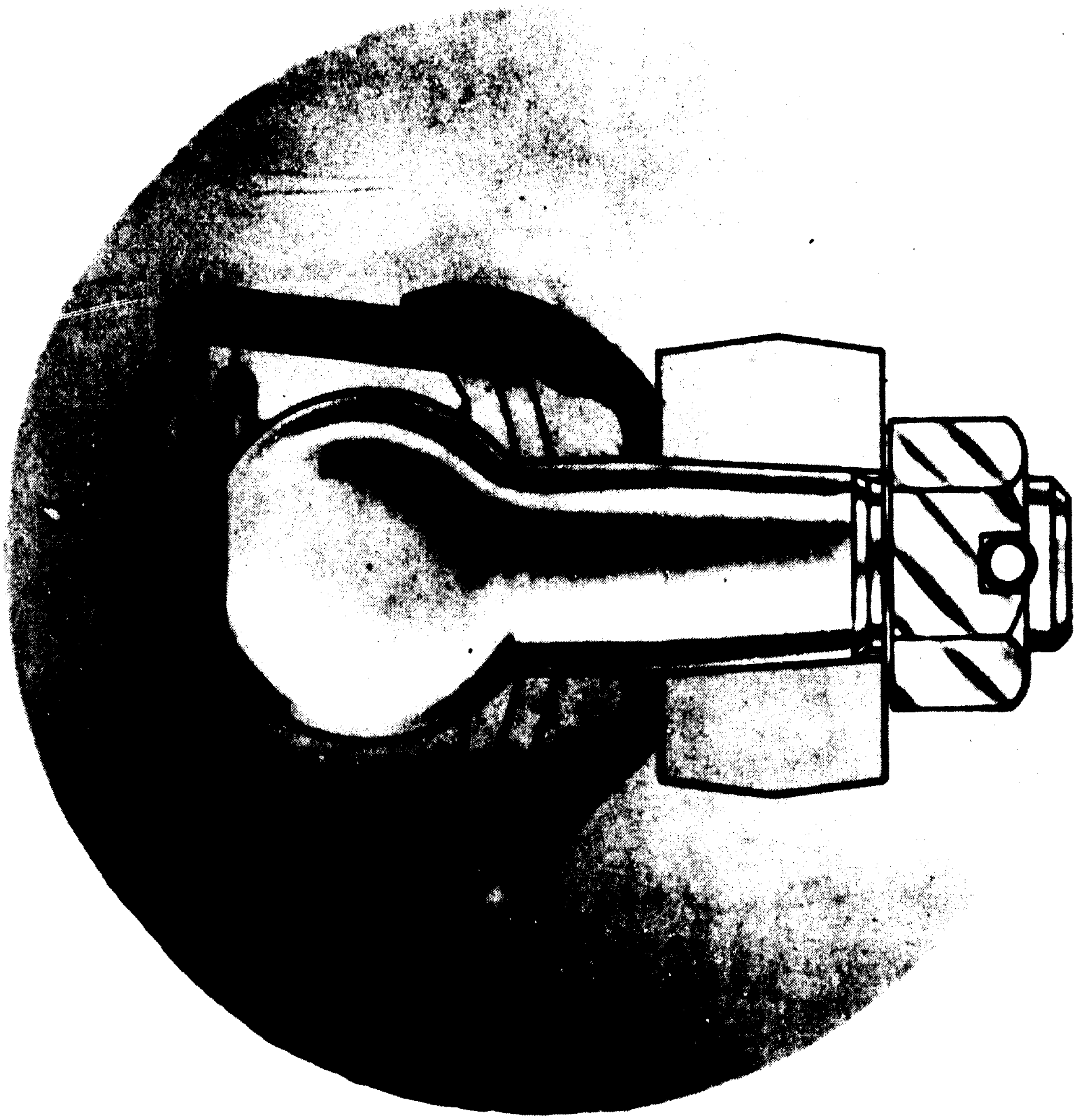


Figure 9.

Hollow Ball Stud

Figure 10.

3/4" Coldheader for Hollow Head Ball Stud

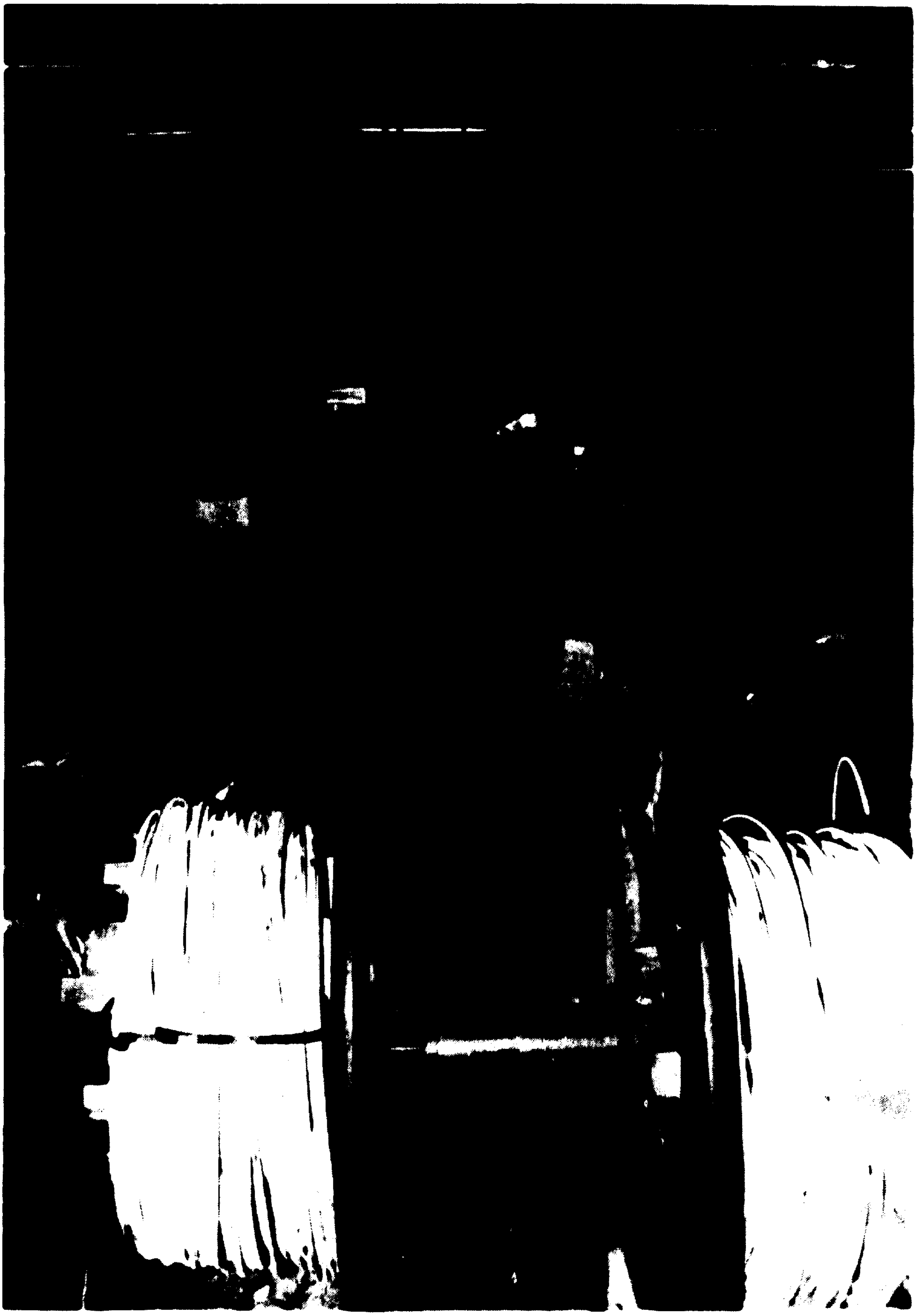


Figure 11.

Thread Roller for Ball Studs

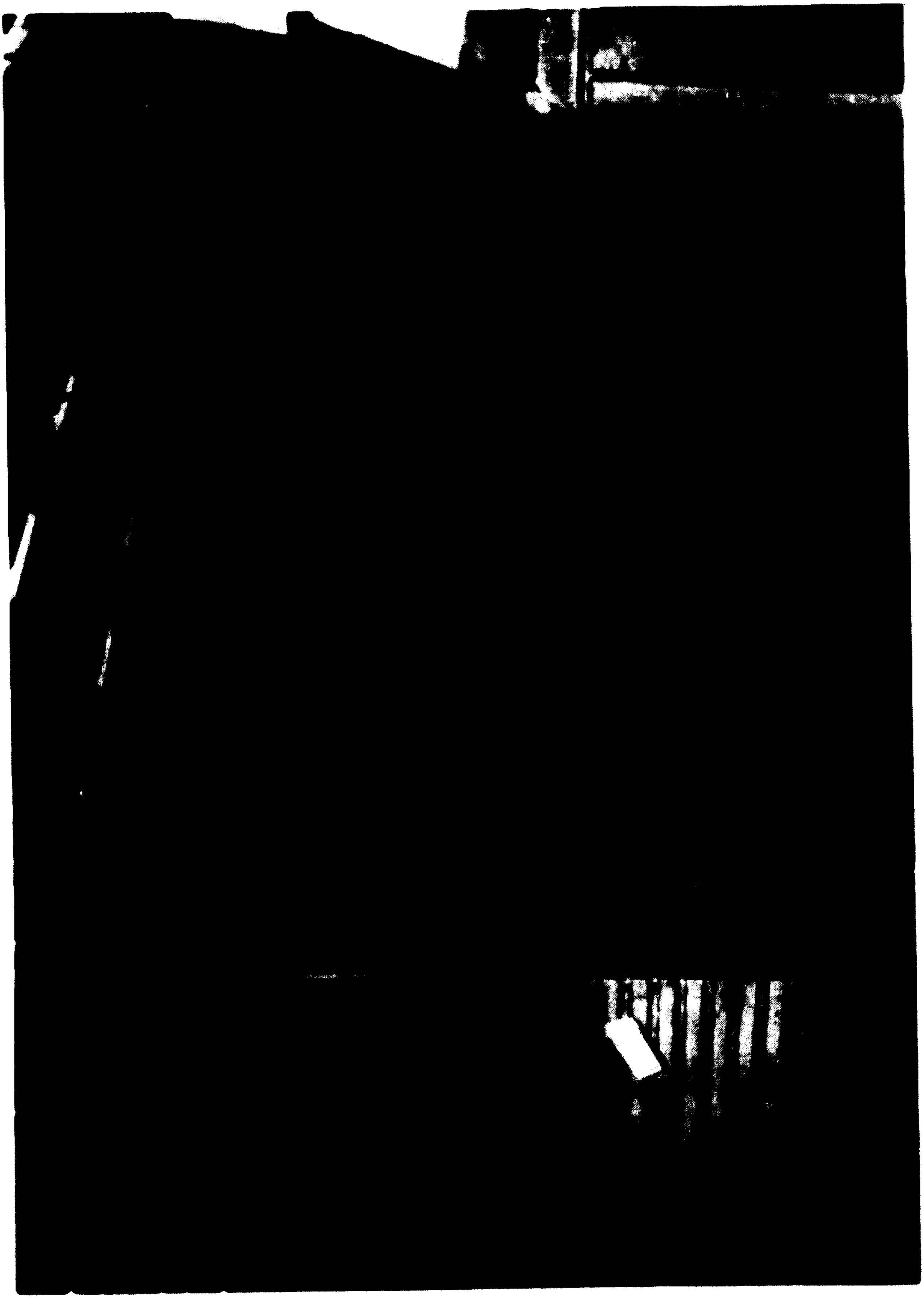


Figure 12.

3" Upsetter for Centerlinks and Conveyor

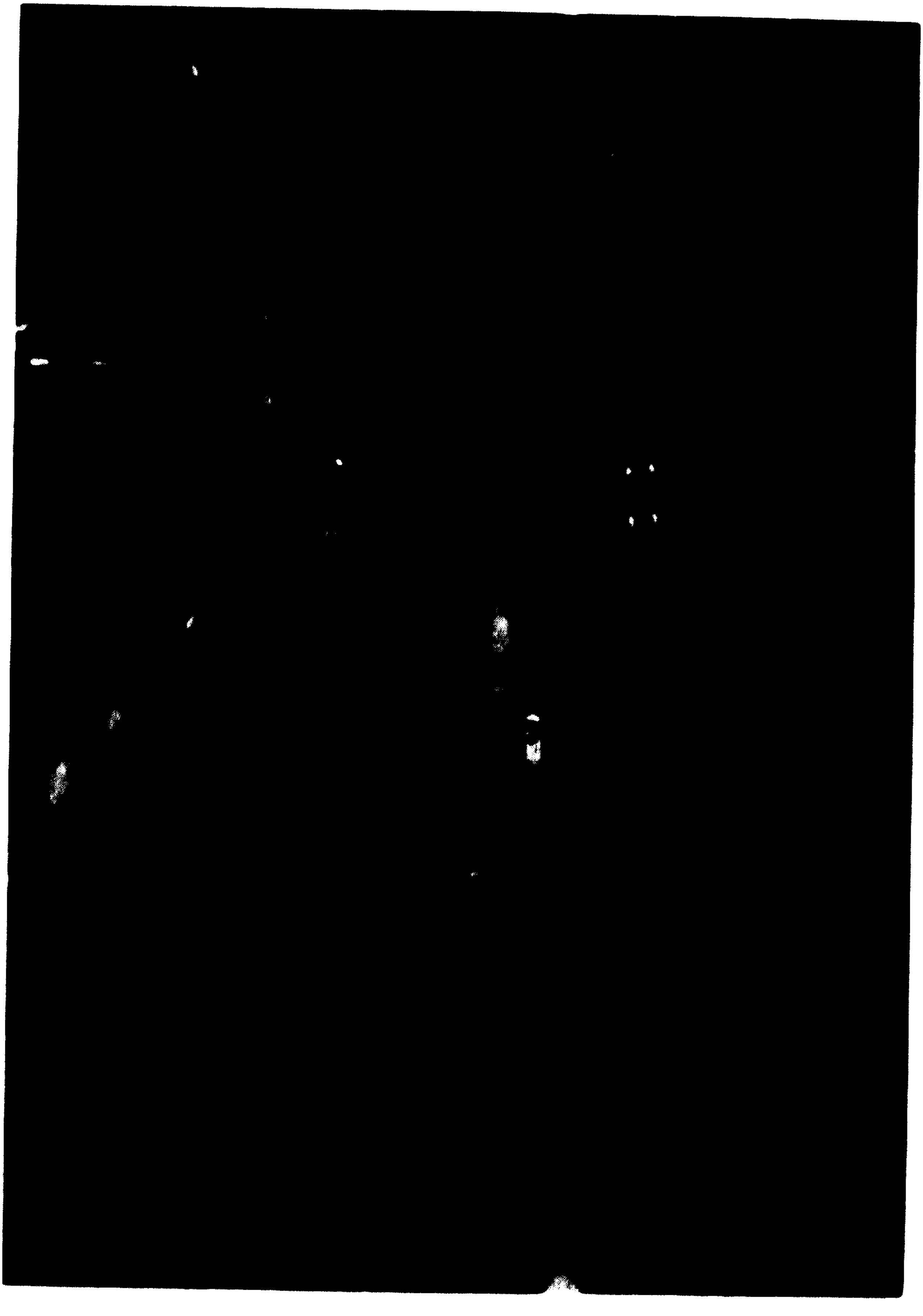


Figure 13.

6 Station Rotary Drill for Centerlink in High Volume Line

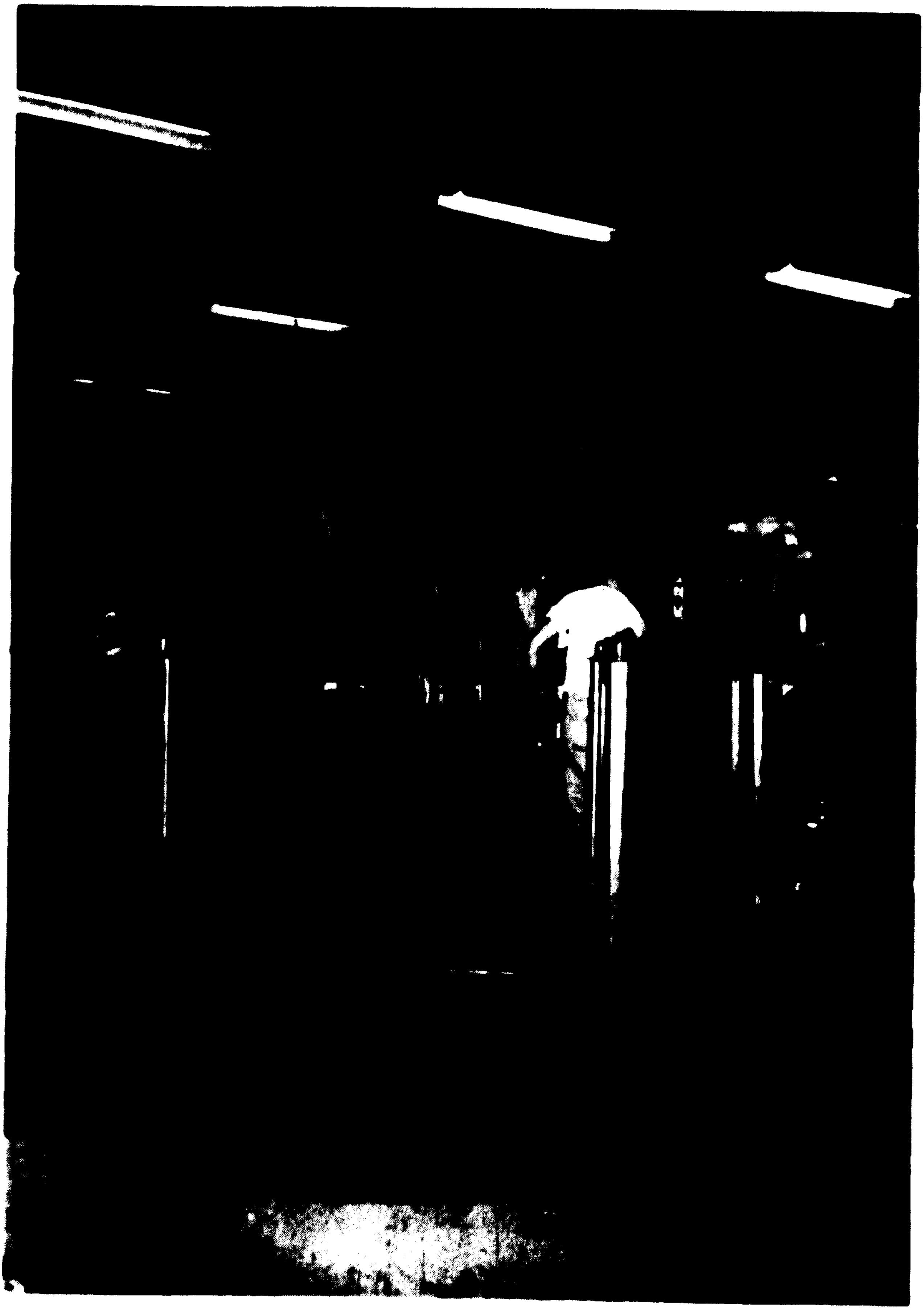
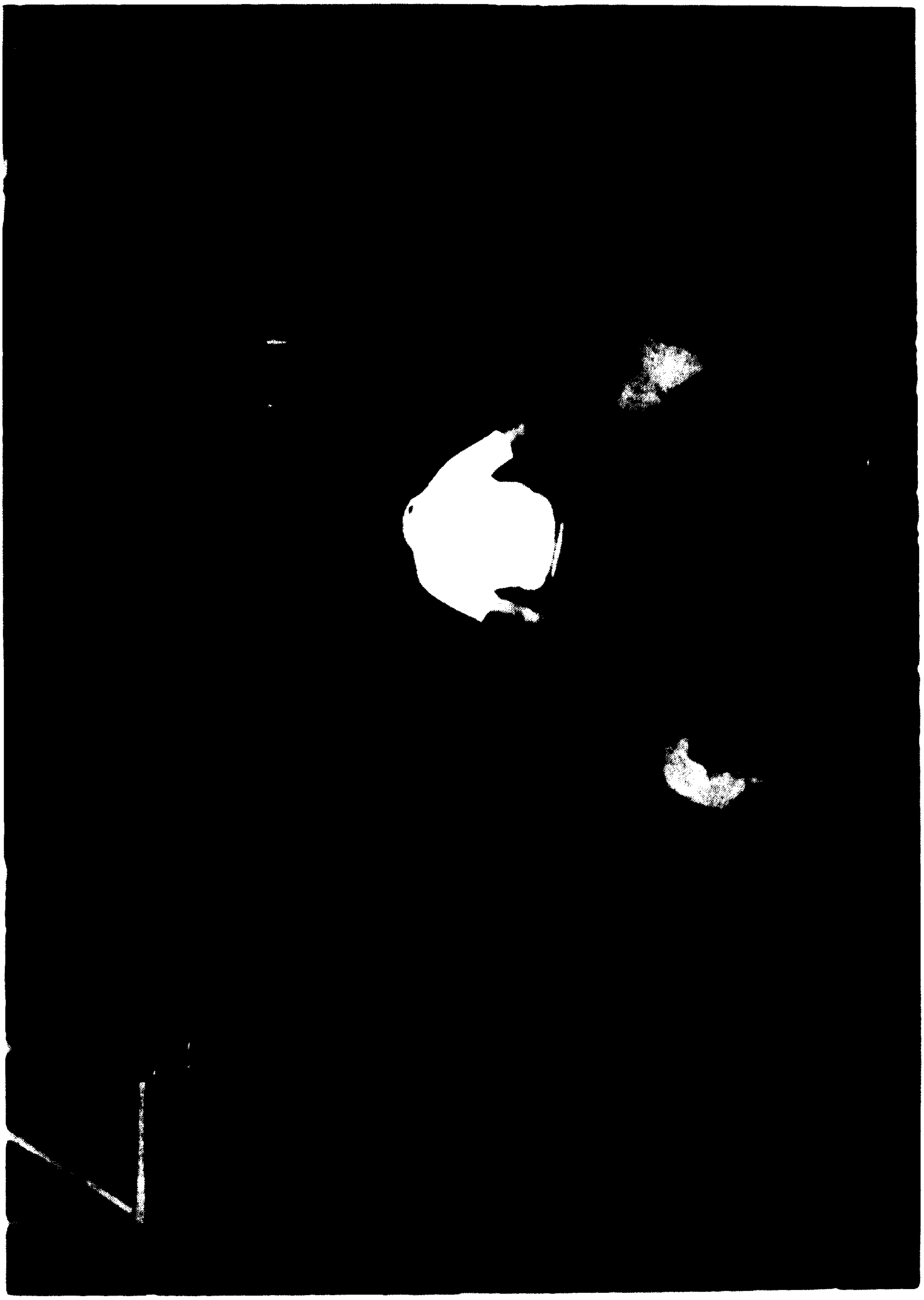
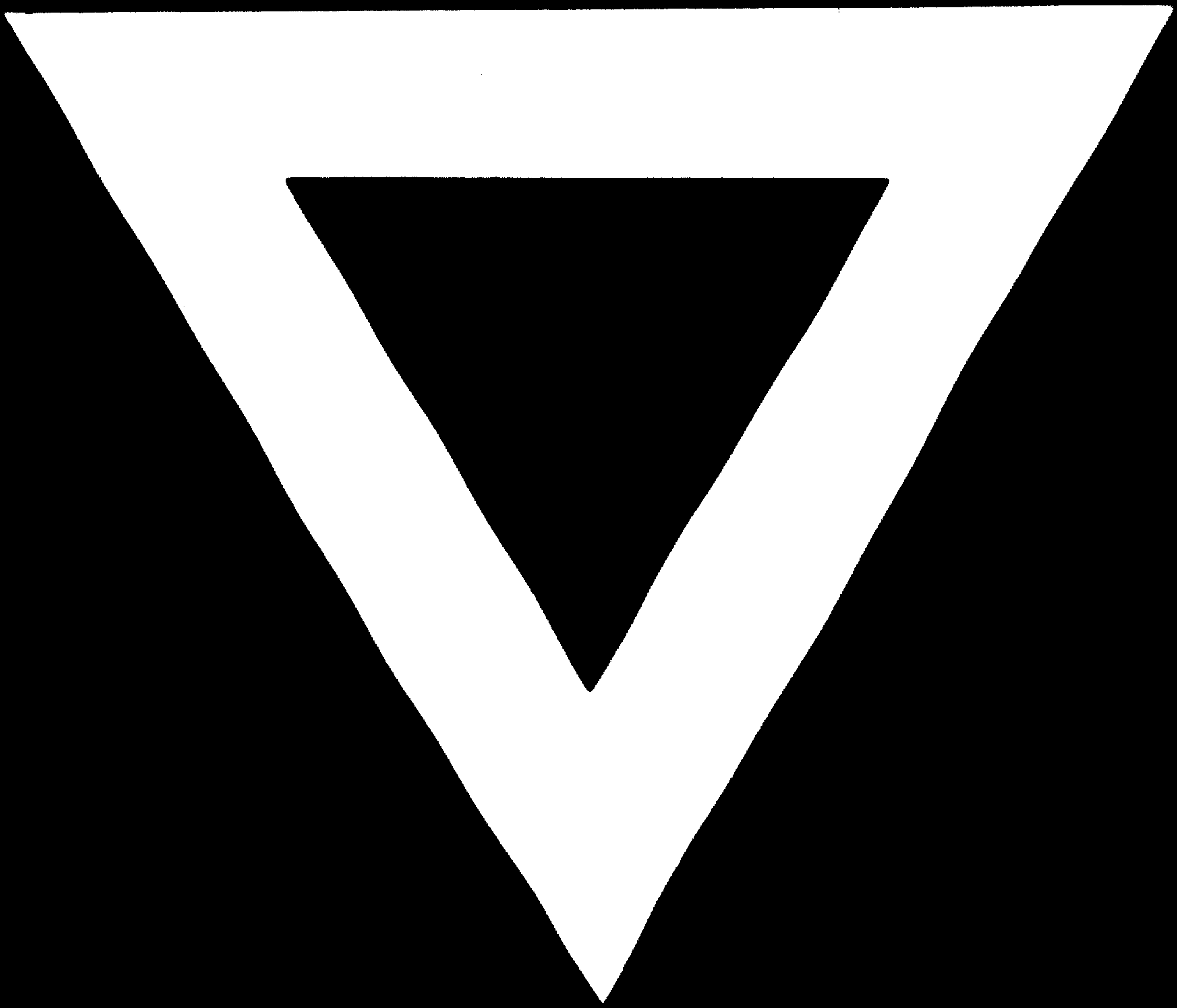


Figure 14.

One Set of Two 2-Spindle Drill Presses for Centerlink in Low Volume Line





74.10.14