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INVESTMENT IN MACHINE TOOL MANUFACTURING FACILITIES SOURCES OF FINANCE AND CREDIT ARRANGEMENTS 1/

by

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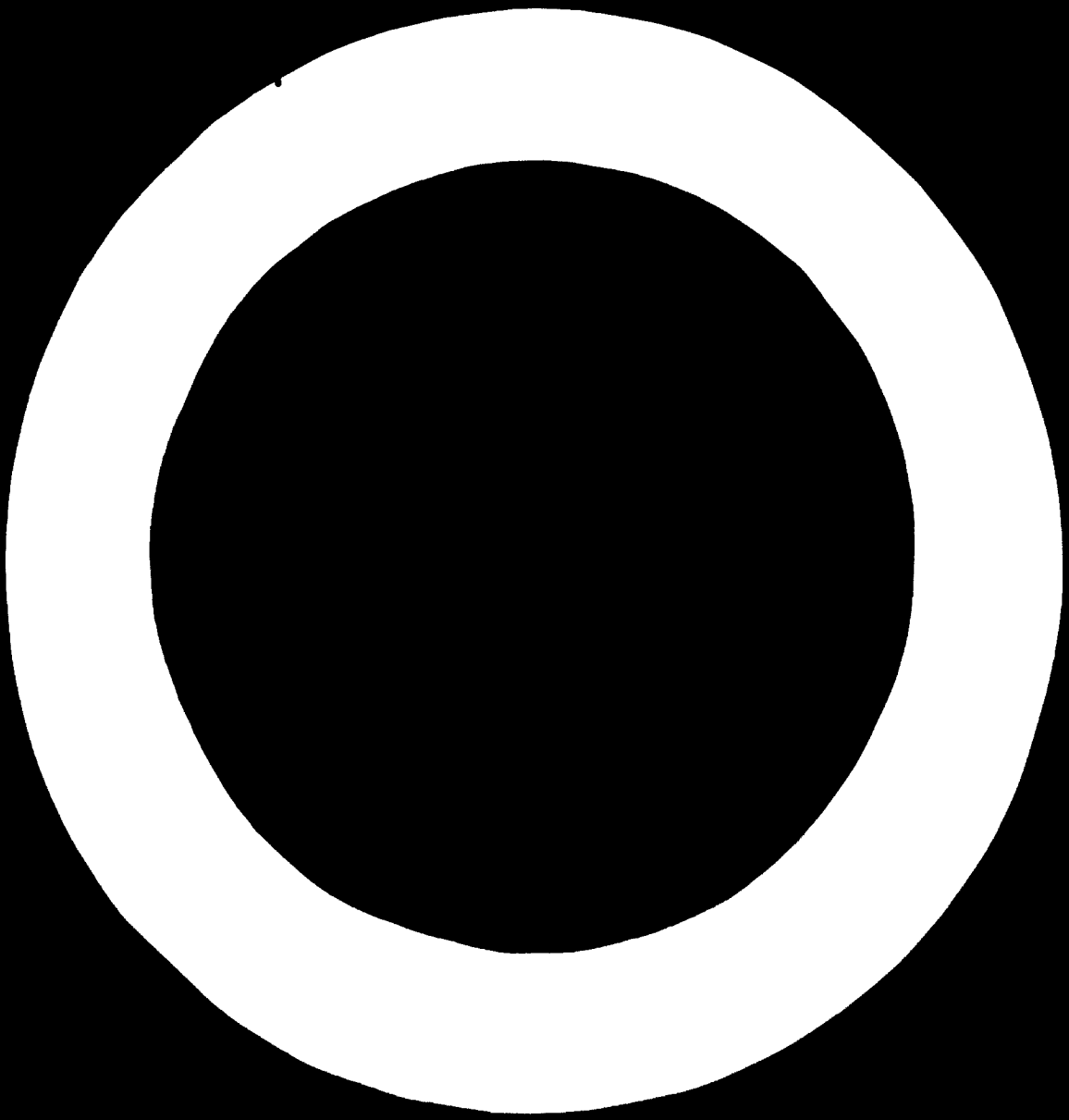

This paper shows the size of machine tool companies in certain countries and the required investment to achieve suitable levels of output.

Some indications are given concerning the many different sources of finance.

Financial requirements

The machine tool industry is not a capital intensive industry such as steel making and the oil or chemical industries but requires much heavier buildings and more expensive plant than many consumer goods industries.

An analysis of capital equipment used by machine tool companies shows on average that the investment per employee varies between £2,000 and £[illegible],000. A new plant will require a figure near the top end of the scale if all the plant installed is new.

The working capital will account for some £4,000 to £8,000 per employee, or 50% to 75% of the annual sales value, mostly consisting of materials in the raw and semi-finished condition apart from the usual financial requirements for debtors and creditors.

In an industrialised country the annual output should be at least £20,000 per employee. It must be noted that in some developing countries the output per employee is only £3,000 in the machine tool industry, but in these cases the investment is usually very much lower, due to use of old buildings and inferior plant.

The following figures give mean floor areas in square metres per £1,000 of sales in the U.K.; the corresponding figures for U.S.A. are also given to show how much difference there is even between one industrialised country and another. The floor utilisation from one plant to another can differ from the mean by a factor of 2 or more.

Mean floor area requirements - m^2 per £1,000

	U.K.	U.S.A.
Productive Areas:		
Machining	.24	.13
Assembly & Test	.15	.10
Stores	.18	.12
Offices:		
Admin	.06	.04
Technical & D.O.	.03	.04
Totals	0.64	0.43

The factory is to be furnished with machine tools, to a value of 40 % to 60 % of annual turnover. In the United States of America, machine tool plants have an average 0.64 machine tools per employee. In the U.K. there are about 0.35 to 0.40 machine tools per employee in this industry.

Altogether, an efficient industry running at full capacity should turn over its capital employed 1½ times a year. However, it is quite common for capital to be turned over only once a year - though this normally renders the profit return inadequate. It must be repeated that the very general guidelines and ratios in this Section would apply to a developed industrialised organisation in Western Europe and the performance of inexperienced staff and work force would be considerably lower.

Size of Company

Historically the machine tool industry is a small business industry. This is illustrated in Table 1 which shows the size distribution of machine tool establishments in the U.S.A. and in the United Kingdom in 1963.

TABLE 1

DISTRIBUTION BY SIZE OF ESTABLISHMENT

a) U.S.A. - U.K., 1963

Average Number Employed by Establishment.	% of Establishments	
	U.S.A.	U.K.
1 - 49	80	50
50 - 99	8	16
100 - 499	8	27
500 - 999	2	5
1000 - & over	2	2
	100	100

b) U.K., to 1968

Average Number Employed by Establishment.	% of Employment	
	1963	1968
1 - 24	4	9
25 - 99	10	11
100 - 499	42	39
500 - 999	24	22
1000 - & over	20	20
	100	100

Sources: U.S. Census of Production 1963
U.K. Censuses of Production 1963
Board of Trade Journal - April 1970 (based on incomplete returns)

For the purpose of these statistics, establishments are defined as premises under the same ownership or arrangement at a particular address. In the U.S.A., and in the U.K., establishments with less than 500 employees accounted for roughly half the total

national output of machine tools.

The overall picture is therefore one of a very diffuse industry, with very many more small firms than large, making an enormous variety of different products. There has been a spate of mergers, acquisitions, and co-operation agreements of recent years, which has created some few giants and reduced the number of independent companies. These changes were not initially followed by physical rationalisation of manufacturing facilities, at least not to a significant extent; so that the size distribution of establishments remained relatively unchanged.

The largest machine tool corporations have emerged in the U.S.A., followed by Japan and the U.K., in that order. The largest group in the U.S.A. could have a machine tool capacity of £300 million; in the U.K., of £100m; and in Western Germany of only £70m.

Even amongst the larger groups, there is often a high degree of product specialisation. Small companies - and certainly the successful ones - tend to specialise on only one class of product. For example, out of 429 West German machine tool establishments listed in the Fachgemeinschaft Werkzeugmaschinen Catalogue:-

47% specialised on one class of product;
28% made only two classes;
17% made three or four classes; and
8% made five or more.

The recent trend has been not only for increasing mergers, but also towards greater specialisation and product rationalisation amongst the larger companies.

In Japan this trend has been fostered within and between large machine tool companies by specific legislation. It recognises the rising cost of development and it is designed

to secure the economies of scale in this and in other respects.

Development Costs.

In the early days of the industry, the development of a new machine tool depended on the inspiration of an individual designer or engineer. He would recognise or be presented with the need for a particular machining operation, and he would build a machine in his workshop to meet the need. These machines were sturdy and wholly unsophisticated, but adequate for the purpose. They were not particularly efficient to build or to operate, but easy to use and to maintain.

Whilst such an approach might still be suitable for a primitive and strongly protected market, it is far removed from the needs of the modern industrialised society. The cost of developing a new model to the point at which it can be successfully introduced to the market includes that of the initial design and development; but also the cost of patterns, special jigs and tools, and of the complex production planning and control procedures associated with manufacturing a machine as part of a production programme.

The character of the design and development effort depends to a large extent on the type of machine tool to be developed. In the case of simple models which are to be sold in significant numbers, concentration is on making the machine perform reliably to specification, but above all it must be engineered so that it can be produced relatively cheaply. At the other end of the scale, more sophisticated machine tools are designed for more taxing tasks - with regard to quality, to quantity production, or to complex automatic control; the design effort goes to achieve these aspects, and cost is relatively less important.

As in other spheres, the technology of making machine tools is advancing rapidly. In order to be competitive in industrialised

markets, it is necessary to be at the head of this advance, or at least not far behind. The cost of making technical advances is great, and there is a heavy penalty for failure.

In the early days of the industry, there were many small or moderate sized machine tool companies, each of whom made a wide range of products. They served a limited group of local customers and they met requirements by developing almost any kind of machine that was needed. In recent years the situation has changed completely, and development is carried on successfully, either by small and highly specialised companies, or by the large corporations.

In all cases the cost of development should rightly include also the cost of introducing the new model into production, and of introducing it to the market. It is commonly expected that the first production batch of the new model will be made at a loss, because of initial mistakes which have to be ironed out and particularly because the work force throughout the factory has to "learn" how the machine is made. Equally, the selling costs of the new model are very much greater than those for a machine which is already well known.

The cost of development up to the stage of producing the prototype for a machine tool will vary very widely, depending entirely on individual circumstances. However, a cost of £250,000 up to and including the manufacture of the prototype would be an entirely normal figure. The cost of getting the machine tool into production could be as much again. Marketing costs will then come on top of that.

The cost of the initial development has effectively to be recovered over the life of the product. It used to be possible to sell a design of machine tool unchanged over a great number of years; but with the faster rate of development, a new design today is expected to have an average life of only seven years.

A recent study showed that the initial development costs could account for as little as 5%, or as much as 30% of the total production cost of a machine tool. The higher percentage applies to a model which has a sale of only ten units per year, whilst the lower percentage relates to a model with a sale of 500-1,000 units per year.

In practice, many companies operate with a research and development budget which is met out of general overheads, so that specific development costs are not directly attributed to the designs to which they relate. However, the growing cost of development has been recognised more and more in recent years, and this has led to many licensing agreements, co-operation agreements, and it has been given as a major reason for acquisitions and mergers. The ability to spread development costs over a greater number of unit sales clearly offers a significant scope for economy of scale.

Batch Size

The ability to manufacture in large batches introduces economies because of lower setting-up costs, lower costs of administration, and because of the ability to use more specialised and more efficient production methods.

It would be highly inefficient to manufacture machine tools one at a time, and this is only done in very rare cases where a highly specialised machine is required for a specific purpose. Some companies manufacture machine tools on a production line, like motor cars, but there are not many of these. In the majority of cases machine tools are made in batches. It is quite usual for the smaller components to be made in large numbers at a time, the larger and more expensive components only a few at a time, and complete assembly in even smaller numbers - often only against

specific customer orders. This is particularly the case where machine tools are designed on the "modular" principle, that is to say, a wide range of machines can be assembled to meet individual customer requirements, using a limited set of standard components.

The larger batches of machining mean that there is less set-up time, but also that more efficient machining processes can be employed. This is illustrated in Table 2 which shows the index of turning cost for a specific component when made in different batch sizes, on different types of machine tools. The cost of machining the component in batches of five on a centre lathe is taken as 100. A multi-tool automatic lathe, which would be much too expensive for such a small batch size, becomes economic if a greater number is machined at one time, and when the batch reaches 120, the cost per unit is only 25.

TABLE 2

INDEX OF TURNING COST

Number of Units in Batch:	5	15	30	60	120
Type of Machine Tool Used:					
Centre lathe	100				
Capstan lathe		80			
N.C. lathe	65	40	35		
Multi-tool Automatic			45	30	25

On machining as well as on assembly - and possibly more on the latter - there is an economy associated with the learning curve. The greater the number of components which are machined and/or assembled by the same man in immediate succession, the more quickly and accurately is the work likely to be performed. One estimate of this effect is given in Table 3. It assumes that components are machined in three-monthly, and assembled in

monthly batches. It is clear that there is a diminishing return as the batch size increases. Going from one to two units a month gives a 20% improvement, but a further 20% improvement is only reached with about 15 units a month.

TABLE 3

INDEX OF MANUFACTURING COST

Monthly production	1	2	5	10	25	50
Cost index (machining and assembly only).	100	80	72	66	62	60

Experience in a process industry shows that there is a significant jump in the learning curve with transition from batch production - however large the batch - to an exclusive single product specialisation. Whilst the improvement from 50% to 95% specialisation is negligible, removing the last 5% and going to 100% specialisation makes a significant difference. The same may well be the case in machine tool production, and many companies try to organise manufacture so that men can specialise completely on one operation, sub assembly or assembly.

There is finally an economy in organising production for large batches in that the cost of providing drawings, tooling, and raw materials is much the same for one unit as for many.

Raw Material Costs and Cost Summary

There are economies of scale in quantity production, partly because it pays to look for cheaper materials, partly because buying power can be exerted and better prices obtained.

When manufacturing one model of a machine tool in large numbers, it pays to 'value engineer' it for cheaper production costs but particularly also for cheaper materials. In this way substitute processes and materials can often be found - sometimes by buying components from specialist manufacturers in preference to making them in-plant.

Purchasing in larger numbers also enables the buyer to get better terms. The best advantage can be obtained from buying identical components, but in general, a large company has some buying advantages over a small one; and if properly organised the divisions of a large diversified corporation can usually derive some buying advantage.

Table 4 shows an estimate of the improvement in material costs related to unit sales per year. This is particularly important as raw materials are the largest single cost item in machine tool manufacture, frequently in the region of 35–40% of final selling price.

TABLE 4

INDEX OF MATERIAL COSTS

Unit Sales Per Year:	5	10	20	50	100	200	400
Bought out materials and components - cost index.	100	98	96	94	93	93	92

It is now possible to summarise the factors discussed in this and the two preceding sections. This summary is shown in Table 5 which, together with the other numerical information in these sections, is taken from a recent study by C. F. Pratten ("Economies of Scale in Manufacturing Industry").

TABLE 5

ANNUAL UNIT SALES AND UNIT MANUFACTURING COSTS

Annual unit sales	10	50	100	500
Initial dev't cost (£000)	100	150	167	300
Initial " " per unit (£)	1490	300	240	60
Manufacturing costs (£)	2150	1950	1820	1500
Manufacturing cost per unit (£)	3640	2250	2060	1560

Notes: (1) The initial development cost per unit sold assumes a 7 year life for the model.

(2) Production costs include direct labour and materials only.

The costs presented in Table 5 are not those which would be shown in a normal costing system, but they relate to the factors which are relevant when discussing economies of scale. In particular, they demonstrate the importance of spreading initial development costs over a sufficient number of units sold.

Economy of Scale and Industry Trends

The economies of scale which have been described in the preceding sections are recognised by the industry, and we have mentioned that mergers, take-overs, and co-operation agreements have become commonplace in recent years. It is now relevant to question how far the effect of size is reflected in the efficiency of the industry.

It must first be said that the efficiency of an industry, or of a company within the industry, is not easy to define. It is even more difficult to get information about an industry which will allow meaningful comparisons to be made. For the purpose of this paper, comparisons are made of output per employee. This is a ratio which is regarded as relevant to the machine tool industry which is only moderately capital intensive.

Table 6 shows a detailed analysis of enterprises in the U.K., according to size,. Comparisons have previously been made of the size distribution of establishments; the present comparison refers to enterprises, which are defined as one or more firms under common ownership or control.

TABLE 6

Distribution by Size of Enterprise, and Output per Employee.

U.K. 1963

Numbers employed by Enterprise.	Number of Enterprises 1963	Average Output per Employee (factor) 1963
25 - 49	27	.93
50 - 99	38	.95
100 - 199	39	.98
200 - 299	19	1.16
300 - 399	11	.93
400 - 499	13	.90
500 - 749	11	.91
750 - 999	8	.93
1000 - 1499	3	1.07
1500 - & over	9	1.06
	Average	1.00

Table 6 shows the output per employee for each size grouping in terms of a factor, the average for all enterprises being taken as unity. There are clearly great differences between groupings, and it is difficult to discern a consistent pattern. The information is presented in summary in Table 7.

TABLE 7

Size of Enterprises and Output per Employee			
U.K. 1963			
Numbers Employed by Enterprises	% of employment	% of output	Average Output Per Employee (factor)
25 - 199	15.1	14.5	.96
200 - 499	20.4	20.1	.99
500 - 1499	25.4	24.2	.95
1500 - & over	39.0	41.2	1.06
Source: Census of Production 1958 & 1963			

This table again shows inconsistencies in the middle range, but one might conclude a tendency for the smallest firms to produce below average, and the largest above average output per employee.

Reverting to the efficiency of different sizes of operation, similar studies of the United States machine tool industry, and of the West German machinery manufacturing industry as a whole, are consistent with that of the U.K. as regards a somewhat below average output per employee from the smallest establishments. It is not consistent in the case of the larger ones. Differences as between sizes of operation are completely swamped by other differences. For instance, the output per employee in the U.S.A. in 1963 was about three times as great as that in the U.K., or in Japan, at that time.

In the developing countries economies of scale will be much more pronounced in respect of certain cost aspects while in other aspects the effects will be of a much lower order. For instance special materials or manufactured components which have to be specifically imported will be much more expensive when only small quantities are required, whereas the labour cost is much less significant due to the low hourly rates. Initial development costs

may be particularly significant due to comparatively small annual sales, except where machines are manufactured under license, as will be the case in many developing countries, because a fixed fee per machine will apply in most instances.

Sources of Finance

There is an almost bewildering variety of finance that can be made available for the establishment of a new manufacturing company. Among the first questions to consider are whether the plant is being established by the Government of the Country in which it is to be located, or by private enterprise, and whether it is being established with co-operation from a machine tool company in one of the industrialised countries, or is a purely local enterprise seeking to design its own machines or perhaps require designs under a license, and/or know how contract.

If it is a Government project the International Bank for Reconstruction and Development can provide loans for periods of fifteen years, with interest normally at the rate of 7½%. Alternatively, in exceptional cases where very special terms would be justified, the International Development Authority may grant loans for fifteen years without any interest being payable, but requiring a service charge of 1¾%. In both the above cases, a Government guarantee is required and the minimum amount of loan is for US$2.0 million.

In the case of bilateral agreements between Governments, finance for the fixed assets required by the enterprise, is sometimes provided by the Government of the industrialised Country, supplying the technical know how and design information.

In the case of the private enterprise operation, loans may be obtained from the IFC which are granted over normal commercial periods on the usual arrangements for finance of this type, where interest is charged at 9 to 10%. In the case of comparatively

small projects, the World Bank loans money to banks in the local countries, who are then able to act as "retailers" for these small projects.

In the case of the private enterprise project in co-operation with a company in the industrialised countries a contract is frequently arranged for the company providing the technical information and know how, to take responsibility for the supply of all necessary plant fixtures and machinery, which is then financed by either the Government or by the private banks in the industrialised country. As the plant and machinery is an export from the country concerned, very favourable financial conditions can usually be negotiated with interest rates some times as low as 5% for a period of twenty years, although more recently interest rates have tended to be higher, and the duration restricted to ten years.

Financial negotiations

It should be emphasised that while the previous section gives some indications of possible sources of finance, the conditions are continuously changing, and expert advice should always be sought at the time it is desired to obtain finance for an important project. Appropriate advice may be obtainable from the banks in the countries concerned, through negotiations with the companies or the Government interested in the supply of the technology and machinery, or from the IRTD advisers.

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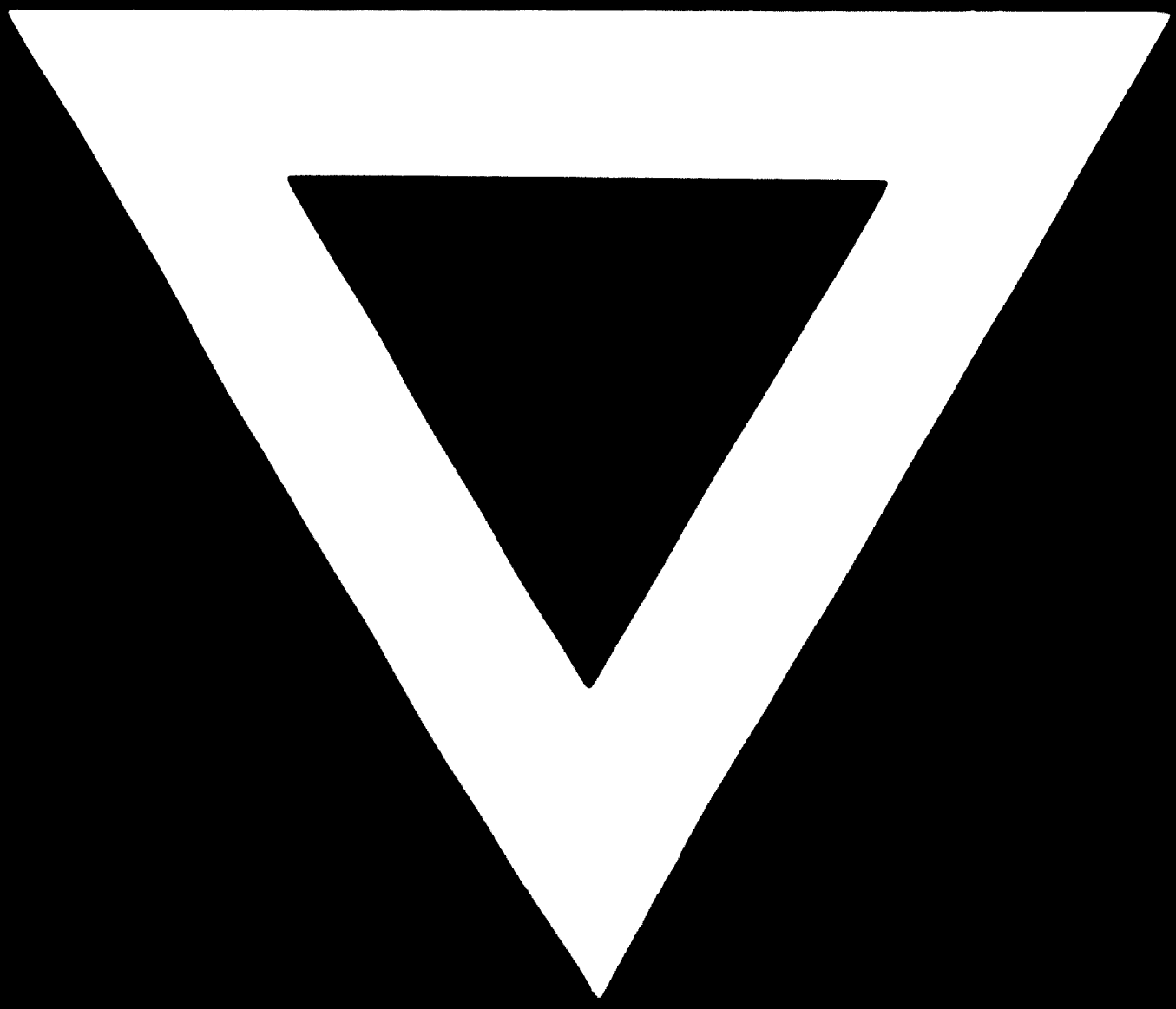

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