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07403

Distr.
LIMITED

ID/WG.247/5
28 March 1977

ENGLISH

United Nations Industrial Development Organization

Joint UNEP/UNIDO Seminar on the Implication of Technology Choice in the African Sugar Industry

Nairobi, Kenya, 18 - 22 April 1977

AUSTRALIAN CANE-GROWING AND SUGAR MILLING - SOME IMPLICATIONS OF THE TECHNOLOGY EMPLOYED 1/

by

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id.77-1642

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INTRODUCTION

In recent years there have been a number of changes in the relative importance of some sugar producing countries. A number of industries have experienced declining production, while others, especially Brazil and Thailand, have expanded production rapidly. These changes reflect to some extent the relative success with which technologies in these countries have adapted to changes in the economic and social conditions prevailing in their domestic economies.

The Australian sugar industry has adapted relatively successfully to changes in its operating environment. Major technical changes have been made. This paper examines the broad implications of some of these major changes. The Australian industry is now based on independently operated family canefarms. The change from a plantation basis of production has a number of important ramifications, these are outlined in this paper. In order to meet the combined effects of declining real prices of sugar, increasing wage levels, and increasing scarcity of seasonal labour it has been necessary to expand the scale of industry operations and to rely on mechanization. The implications of this change are also examined.

Finally the paper surveys in greater detail the implications of some of the specific aspects of technology used in Australia. Problems related to the introduction of cane burning and to the mechanical harvesting of cane are discussed.

I THE CANEFARMING BASIS OF PRODUCTION

The initial technical development of sugar production in Australia was influenced by techniques used in the West Indies. Production was in small mills with cane supplied mainly from factory owned plantations. The conversion to canefarming as a basis of cane supply was a deliberate policy to foster settlement in areas which were undeveloped and where other cropping opportunities were limited. The establishment of an independent canefarmer basis of production required specific measures of encouragement. The measures adopted included

- protection of the domestic market
- domestic sugar price determination on the basis of farm cost of production.
- establishment of research and extension services

and

- legislation to protect the interests of canefarmers and to provide for the necessary integration of the agricultural process and the industrial process of sugar milling.

Settlement was also encouraged by the establishment of government owned sugar mills. These mills were later converted to grower co-operatives. The farms first established were small, usually with between 4 and 8 hectares under cane. Labour intensive methods of field cultivation and harvesting were used.

The decision to encourage canefarming has had the desired impact on regional development. Most ofthe settlement of north eastern coastal Australia is the result of canefarming and sugar manufacturing activities. This area is now one of the most decentralized areas of the continent. It is interesting to note that the development of towns providing servies to the sugar industry has been most successful where more than one sugar mill has been established in an area. Those isolated canegrowing areas where the establishment of only one mill has occurred have not pro-

vided a sufficient basis for the establishment of a town of more than a few hundred persons. The experience has been that, for the development of regional industry based on the requirement of sugar producers, a canegrowing area of at least 20,000 to 30,000 hectares is required.

Canefarming has advantages in providing settlement and promoting equality in the distribution of land. As an alternative to factory owned estates however, this method of production may suffer major drawbacks. Firstly, it is potentially a higher cost operation if land utilization or yields of cane are lower than those achieved under estate conditions. Secondly it may be difficult to achieve the degree of integration between canefarming and sugar manufacture which is required if a low-cost structure is to be maintained. Because of the limitations to storage and to the long distance transport of cane, factory viability and performance may be impaired if independent farms do not provide a consistent supply of millable quality cane. The factory also effects the profitability of farming as its operation may determine the price paid for cane, the method of harvesting cane and the length of the milling season.

Under Australian conditions it has been possible to maintain cane farm yields by providing for the licencing of canegrowing land and by establishing production incentives. There are also well developed district extension services to provide assistance to farmers. Canegrowing has been maintained as a profitable agricultural persuit by controls over marketing and by limiting the entry of persons to the industry. Comparisons between the yields on the few estates now operated* and canefarmer yields would indicate that canefarmer yields are now equivalent to those achieved under

*Estate production now constitutes less than 5% of Australian cane production.

large scale estate conditions.

Solution of the second problem of providing integration in an industry based on farms requires a high degree of control to be exercised over the activities of farmers. This control may be vested in the factory. It is the Australian experience however, that the controls required to provide a consistent supply of high quality cane to mills are best exercised by an independent authority on which the views of canefarmers and mill owners are represented. It is believed that the principles used in providing this control are essential for the successful establishment of canefarming. The principles are also important in determining the technology of production.

Control over canefarming and the implications of the controls as they exist in Australia are considered here under the sub-headings

- Methods to ensure a regular cane supply
- Methods to determine the price of cane
- Methods to ensure the suitability of the cane supply for milling.

Methods to Ensure the Cane Supply

Depending on the method of sugar manufacture used, normally between 40% and 60% of factory operating costs (excluding the cost of cane purchases) are attributable to overhead expenses. These costs can be minimized by ensuring that there is a consistent seasonal and daily supply of cane. This consistency is provided in Queensland, where most Australian sugar is produced, by providing for penalties on farmers who fail to fill delivery quotas or who fail to grow cane on their licenced area. These penalties include the reduction of the farm quota or reduction of the licenced cane area on the farm. By exercising institutional control over both the area of

land used to grow cane and the farm production quota it is possible to influence the intensity of cane cultivation. Factors including the yield of cane, length of ratooning practiced and crop rotation are influenced in this way. The Queensland experience would indicate that it is desirable to control also

- the entry of absentee land owners.
- the sub-division of farms to ensure that they remain of sufficient size to maintain a family.
- the land used for canegrowing and the use of designated canegrowing land for other purposes.

and
- the sale of cane to mills by other than licenced canegrowers.

Methods to Determine the Price of Cane

A major influence on the technology of cane production and milling is the price of cane. The determination of cane price for farmers cannot normally be left to market forces because of the monopoly power of mills. The equipment which is economic to use in mills will be determined by the relative price of cane compared to the value of sugar produced. The level of sugar recovery, which is determined mainly by the capital intensity of milling, will be highest where the cost of cane relative to the price of sugar is highest.

There are a wide variety of methods used throughout the world to determine the price of cane, the simplest method being to pay a fixed proportion of the sugar manufactured or a fixed price per tonne to growers with all growers receiving the same price. The system used to pay for cane in Queensland provides that the long term average price of cane is sufficient to cover cane production costs (defined to include an imputed wage for the farmer) and is sufficient to provide the same percentage return on farm assets as are earned on mill assets. Farm

assets include land used for canegrowing. This method of establishing average price does have the drawback that it is necessary to periodically conduct sample surveys to establish production costs of the industry but it has the advantage of equitably distributing sugar proceeds. The basis of payment ensures that the benefits of technical progress or of higher sugar prices are shared.

A supplementary and equally important aspect of price is that payment to individual growers is made on the sugar content, assessed by simple methods, of the grower's delivery. The cane payment scale provides an incentive to the grower to improve the sugar content of his delivery. The scale also incorporates an incentive for the mill to increase the level of sugar recovery from the cane. These incentives explain why the cane : sugar ratio for the whole of Australia is normally between 7.5 : 1 and 7 : 1. The emphasis given to the sugar content influences

- varieties used - upright canes, less prone to lodge are preferred
- fertilizer applications - nitrogen applications are limited to about 160 kg./hectare
- pre crushing cane preparation - fine preparation is a standard milling practice.
- the length of the crushing season - this is normally about 23 weeks.

By providing a basis for cane payment which provides an incentive on recovery of sugar from cane, losses of sugar in molasses, bagasse and mud are minimized by Australian factories. Sugar losses for the above reasons seldom exceed 7% of the sugar delivered in the cane.

Methods to Ensure the Suitability of the Cane Supply for milling.

The use of canefarming also necessitates control of other quality aspects of the cane supply. Restrictions are

placed on Queensland growers which limit

- the selection of cane variety.
- the minimum sugar content of cane sold for milling.
- the extraneous matter content of deliveries.

and . the staleness of the cane supplied.

These controls are important to ensure profitable milling operations.

In summary then the Australian experience is that canefarming can provide a satisfactory alternative to plantation cane production. It does provide benefits in promoting regional development. Provided that a satisfactory degree of independent control can be exercised over canefarmers the problems of integrating farming and sugar milling can be overcome.

II INCREASING OPERATING SCALE AND MECHANIZATION

Most sugar industries, both those catering for domestic requirements and those with export markets, have experienced a long term decline in the price of sugar relative to domestic costs. These pressures have been experienced by the Australian industry and have been met by increasing the scale of operations and by decreasing the labour used per unit of output. The increase in the size of the domestic market in Australia has been limited to a rate of growth of about 2 percent annually. Due to the slow domestic growth it has been necessary to increasingly rely on export marketing of production. Some small increases in scale have also been achieved by reducing the number of mills and growers in the industry, but this alternative defeats the settlement benefits provided by sugar production.

The decision to export, combined with the requirement to handle bulk sugar, and the need to secure consistent prices under long term arrangements does limit the technological choice available to the industry. In particular the quality, and consistency of quality, of sugar produced influence the techniques of milling and to some extent techniques of field production and harvesting are effected.

The expansion of the scale of production has been achieved without increasing the amount of labour employed. In fact, the introduction of mechanization in harvesting has reduced seasonal labour requirements of the industry. The mechanization developed has enabled output per person engaged in sugar production* to increase from about 15 tonnes of sugar in 1930 to the present production of about 150 tonnes of sugar per man.

* including farmers, harvesting and transport operators and mill employees.

The process of mechanization has enabled the wage rate for workers and the returns to farmers to increase at approximately the same rate as living standards have improved in the rest of the community. In this way parity has been maintained between the sugar industry and other industrial sectors of the economy.

Changes in social conditions led to the contraction of the supply of seasonally available labour. Mechanized harvesting has overcome this problem and has led to the stabilization of the population of the sugar districts throughout the year. The introduction of mechanization has contributed to the decline of the permanent population of some of the smaller townships in sugar districts. The larger centres have been advantaged and have developed small engineering, manufacturing and repair industries to cater for machine operation. Some of these firms now supply other local industries and export markets.

Large scale milling is essentially a self-contained process without the linkages which canegrowing provides for local industrial development. The canegrowing communities have benefited however from the labour training functions which the mill provides. Many of the skilled men in small businesses in canegrowing districts served their mechanics, boiler makers, fitters or carpenters apprenticeships with the local sugar mill.

The basic lesson learned during the process of field mechanization has been that it is virtually impossible to introduce some cane impliments from overseas sugar industries. With the exception of land preparation equipment all implements used in Australia cane production have been developed to meet local conditions. A number of machines have been imported from overseas but these have usually required substantial modification or have been unsuitable for use.

This has also been the experience with most harvesting equipment imported. The need to develop equipment suitable for local conditions has played a large part in supporting local engineering firms. Most of the equipment development has been by canefarmers working either in their farm workshop or in association with a local engineering firm.

It is important to note that the introduction of mechanization has been a process of gradual evolution where mechanization of one part of the production process has either required or facilitated mechanization of another aspect. The process has been relatively slow, with machinery changing as conditions have changed. For example the evolution of the currently used trash cane planters, which enable 3 men to treat setts, plant and fertilize up to 10 hectares a day, has taken a period of 25 years. Initially planters, which provide the basic design of the present machine, required a larger labour force and had a planting capacity of less than one-third of the latest machine.

The rate of growth of the size of machines has recently been faster than increases in farm size. This change has been largely met by increasing the amount of contracting with machinery that is undertaken either by canefarmers or by other local residents. While machinery sharing and co-operative ownership of the larger scale machinery is practiced to a limited extent, the use of contracting is a more popular means of utilizing machinery where purchase of the machine by an individual farmer is not justified. Contract cane planting, fertilizing and harvesting is now common in most districts. The system works well and reduces potential disputes between joint owners of machines as to their operating rights.

While mechanisation has provided economic benefits in the high cost labour environment, the introduction of mechanisation in some districts has reduced the amount of

land available for canegrowing. A number of farms on steep slopes and on stony ground have been retired from production since mechanized techniques have replaced manual methods. In some areas the economic viability of the mill has been placed in jeopardy for this reason. The requirement for long rows of cane and for wide, safe headlands has also dictated the need for higher capital investment in earth-moving and drainage on many cane farms.

Finally in considering the impact of field mechanization it would be difficult to argue that mechanized techniques per se have resulted in higher yields of cane or increased sugar output. There have been some minor benefits by providing more timely cultivation, however if a large well organized labour force is available many operations using machinery could be performed with equal proficiency by labour intensive methods. The techniques used in Australia have been developed mainly to enable an increase in the scale of operation without an increase in the labour force.

III SOME SPECIFIC ASPECTS OF THE TECHNOLOGY EMPLOYED

Pre-Harvest Burning of Cane

This practice is probably the simplest of any technical change that can be adopted in a sugar industry. The practice substantially increases output of cane cutters and of harvesting machines but it has a number of ramifications which were not appreciated when burning became a standard practice in the Australian industry.

The practice of pre-harvest burning of cane was introduced into the industry to reduce the risk of the disease leptospirosis contracted by cutters from the rodent population in unburnt cane. The introduction of burning removed the disease risk and also increased cutter output by at least 50 percent. Working for 6 to 7 hours cutters can normally cut between 12 and 20 tonnes of burnt cane, depending of course on crop conditions. Burning also increases the cutting rate possible with machines, it improves the cleanliness of the cane supply, reduces the power requirement of the harvesting machine and reduces the risk of accident where ground-men are working in association with harvesting machinery. The practice also reduces the population of fungi that effect cane and may depress yields.

The major drawback to burning was found to be that the quality of cane was reduced, cane began to deteriorate from the time of burning and subsequent to harvesting the rate of deterioration was significantly higher than the loss of sugar which occurred when cane was cut green. To alleviate these losses it has been necessary to limit the time between burning and crushing, and penalties are imposed if cane is delivered more than two days after burning. The practice of burning increased the requirement for closer supervision of harvesting operations by mill staff.

A further problem has arisen since the introduction of large scale mechanical harvesting. These machines are unable to operate under wet conditions and where rain has followed burning substantial losses of cane have occurred. In the 1973 season for example over 200,000 tonnes of burnt cane was destroyed because it could not be harvested before deterioration rendered the cane unfit for milling. Attempts to overcome this problem have included the fitment of full or half tracks to harvesting machinery and the experimental operation of green cane harvesters. No satisfactory solution has yet been found although promising results have been obtained. The major problem is the need to increase the capital-cost of harvesting machinery which can only be justified in those circumstances where harvesting is normally performed under very wet conditions.

The experience of Australia would indicate that the practice of burning may be difficult to introduce in those circumstances where there are long delays between harvesting and milling of cane or where canefarmers' harvesting is not well organized. With present harvesting machinery operating under uncertain climatic conditions the practice may result in large losses of cane.

Aspects of Mechanical Harvesting of Cane

Australian designed cane harvesters have been developed to cut mechanically cultivated cane. A major emphasis of the design of these machines is to provide for the delivery of clean cane to the factory. No cane cleaning is practiced in the Australian industry subsequent to the harvesting operation. The requirement for clean deliveries has prohibited the use of bulldozer type cutters emplyed in other industries.

The process of development of caneharvesters suitable to Australian operating conditions was a long one. Various devices were used to increase the output of manual cutters

including topping machines and loading machines. Initially whole stick harvesters, both tractor mounted and independently powered models, were widely used to replace manual cutters. These machines cutting capacity was in the vicinity of 30-40 tonnes per hour but their range of operating conditions was limited to standing upright cane. Where cane was badly lodged their performance was poor. Whole stick harvesters do have a number of advantages. It is possible to use the same cane haulage gear as with manually harvested cane, and where grab loading is practiced, the dirt content of the cane supply is reduced below that encountered where front-end loaders are used to stock and load manually cut cane. Probably their greatest advantage is that they can operate separately to the cane transport system. The major drawback with the machines used in Australia was that cutting and loading were two separate processes, capital requirements were higher and the cane supply was doubled handled. Secondly, other than cutting the top from the cane, no additional cane cleaning mechanisms are incorporated in the design of these machines.

Chopped cane harvesting has become the almost universal practice in the Australian industry. While chopped cane harvesting does eliminate the need for loading machines it does increase the capital cost of cane transport equipment. The mesh containers used do however reduce the incidence of loss of cane in transport. Problems of loose chains and dropped loads are overcome and the width of the cane load is more easily controlled. Short, drought effected blocks of cane, can be harvested and transported where this method is practiced. The major reason for the adoption of chopped cane harvesting in the Australian industry has been the ability of these machines to perform under a wide range of cane conditions.

Both tractor mounted and independently driven machines

are now used within the Australian industry. Although the side mounted tractor drawn machines probably have greater stability on hillsides, the recent trend is towards the larger independently powered machines which give the ability to cut into a block of cane. The machines currently used have an output while operating of about 60 tonnes per hour in erect straight cane under dry field conditions. The output of the machines is particularly affected by ground conditions of operation, and by the transport system used. Although the throughput of 60 tonnes per hour is easily achieved by most of the machines currently marketed their daily capacity under most operating conditions is limited to between 300 and 400 tonnes.

This limitation is mainly due to the practical difficulty of maintaining a constant supply of receptacles for the delivery of chopped billets from the harvesting machine. Even under ideal transport conditions some 30% of harvesting time is lost waiting for the return of infield transport equipment. The loss of time increases as the distance of cane haulage increases. If cane haulage is more than two or three kilometers, transloading of cane from infield haulout equipment is normally necessary.

A wide range of bin sizes are currently in use in Australian mill areas, the smallest have a capacity of about 3.5 tonnes of chopped cane, the largest have a capacity of over 20 tonnes. The limit to bin size for in-field operations appears to be about 12 tonnes. Where larger equipment is used, specialized smaller tipping bins of about 4 tonnes capacity are used to cart cane from the harvester to the roadside where billets are tipped to the larger bins. This system can provide the benefit of using large scale road transport equipment while eliminating the damage to ratoons and to this equipment which occurs when it is operated in the canefield.

Mechanical reliability of harvesting machines has increased markedly in recent years, partly the result of better design and partly the result of the replacement of chain and other mechanical drives by hydraulic motors. Lost time under normal operating conditions due to mechanical failures is about 10% of total operating time. The machines currently marketed would appear to have a commercial operating throughput of about 160,000 to 200,000 tonnes of cane over their working life. Under normal Queensland conditions in a 25 week operating season 3 men working with a harvester and 2 haulout tractors can cut, load and cart (up to say 3 kilometers) about 25,000 tonnes of cane by working about 6 hours a day.

Currently most machines are operated under daylight conditions only, although some harvesting with field lighting is practiced. The experience of night harvesting has been that some difficulty is encountered in maintaining the cleanliness of the delivery and in turning machines. Although there is the problem of disturbance to others due to noise there would appear to be some cost advantages in the practice of three shift harvesting. The advantages to cane quality by further reducing the cut to crush time from the present norm of 12 to 14 hours may lead to further development of this practice in the future.(1)

A number of major problems have been encountered with the introduction of chopper cane harvesters. Firstly although experimental work is continuing, it would appear that possibly as much as 10% of cane is lost through using this method of harvesting.

The extent of losses of yield due to harvesting is determined by

- operating conditions
- the standard of machine maintenance
- and operator skill

Cane is being lost due to incorrect topping which is difficult to control in uneven crops of cane and through actual dropping of sticks or billets of cane from the feeding mechanisms on the harvester. These losses cane be partly overcome by using ground-men to work with machines topping some cane and returning the sticks of cane missed to the bin. It is more difficult to overcome the losses of cane and of cane juice which occurs in the machines. Regular sharpening of chopper blades will reduce the expression of juice which occurs when the cane is cut into billets and some reduction of losses of cane can be achieved by reducing the power to cane cleaning devices that tend to shatter some billets. This latter action will reduce the effectiveness of the machine in cleaning cane.

The major difficulty with the introduction of chopped cane harvesting has been those problems associated with the deterioration of cane. Increased deterioration occurring because of the increase in the number of points of possible entry for bacteria into the cane stalk. Deterioration results in the reduction of the recoverable sugar in the cane and causes difficulty in the boiling process of the factory. The quality of the sugar produced is also reduced where large quantities of deteriorated cane enter the factory process.

The deterioration rate of chopped cane is primarily determined by the prevailing weather conditions, hot humid conditions favouring faster cane deterioration.[2] Deterioration in chopped up cane can be reduced by increasing the length of the billet of cane cut. However, most effective use of transport equipment is made with shorter billet lengths as the bulk density of the load can be increased. To reduce the deterioration adjustment of machines to cut billets of from 350 mm to 400 mm in length has been necessary. Load weights have been reduced by these longer billets. In addition it has been necessary to reduce the stock of cane on which the factory operates. Stock piling the equivalent to more than one days supply has not been practiced in Australia due to sugar losses which occur even in wholestick cane, and due to increased capital and oper-

ating costs where the cane supply is double handled. The introduction of chopped cane supplies has necessitated further reductions in the normal factory operating stock. Close attention to the scheduling of cane transport is necessary particularly where, as is the case in some districts, haulage distances exceed 30 miles.

Large scale mechanical harvesting has reduced production costs in the Australian environment where costs of manually cutting cane are in excess of £1.50 (STG) per tonne. The process of mechanical harvesting has also reduced the problem of the seasonality of the labour requirement of the industry. As has been shown the introduction of mechanical harvesting poses a number of problems which have not yet been satisfactorily resolved.

REFERENCES

(1) D.H. Foster, "Sugar Quality in Queensland" Proceedings of the Queensland Society of Sugar Technologists, 1976.

(2) K.A. Leverington, "Deterioration of Sugar Cane", Bureau of Sugar Experiment Stations Research Publication, 1970.

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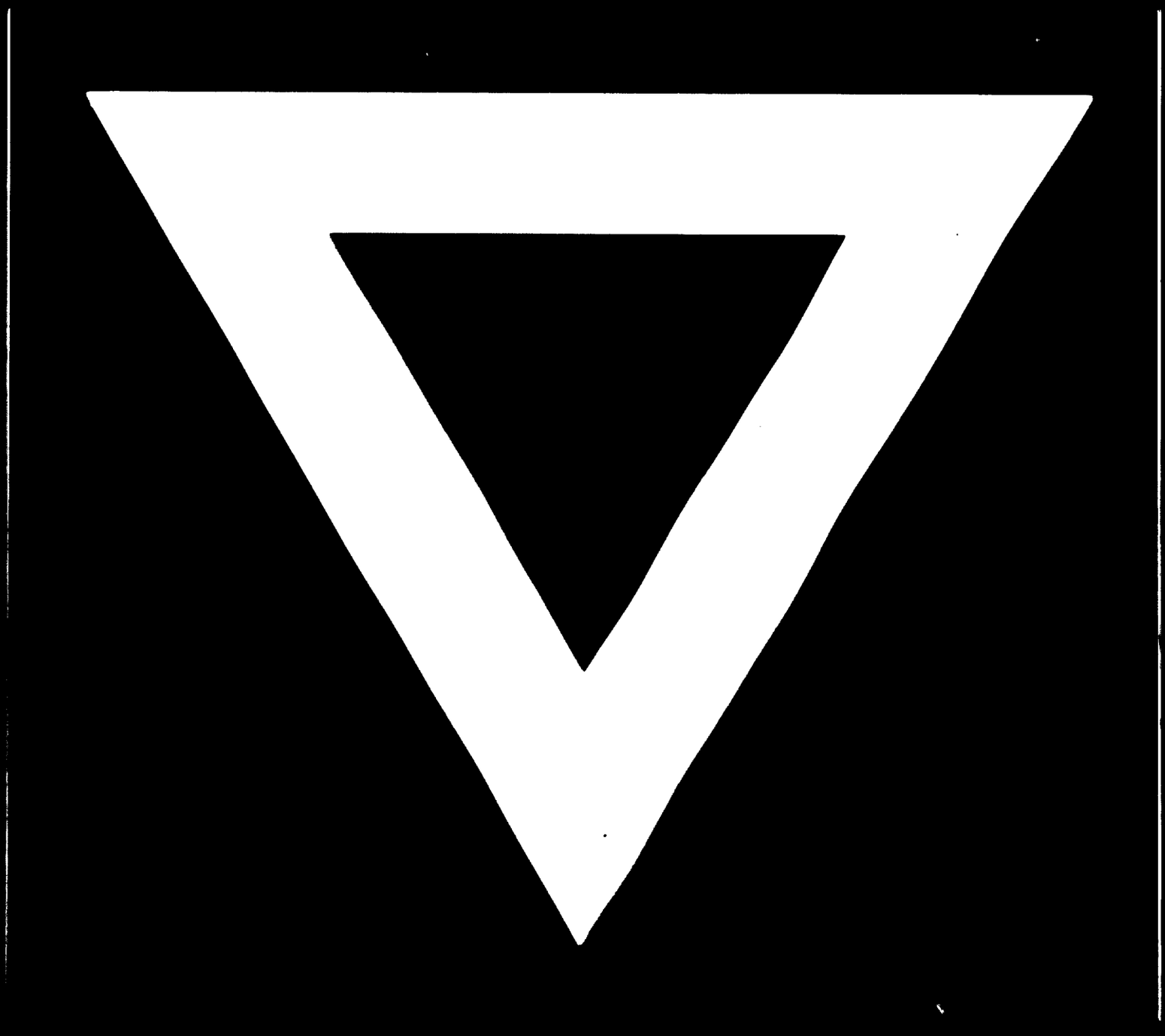

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