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SINTERING PRACTICE ON LARGE SCALE: CONTINUOUS STRAND PLANTS

by

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SUMMARY

Due to larger integrated iron and steel installations and the positive influence of sinter on blast furnace operation, high capacity sinter plants are desirable. Continuous sinter machines of strand type are preferable. To meet the requirements of increased production, the size of sinter machine has been enlarged progressively up to over 300 sq.m. from 75 sq.m. which was standard size hitherto. Sinter machines have helped to reduce investment costs. Ancilliary equipment such as mixing units, sinter coolers, etc. have been designed to suit the higher capacities. Automation of large plants helps to avoid errors and maintain constant quality of production with cheaper operating costs. Sintering tests are very important and should form the first step in planning new plants. Sizing and stabilising of the finished sinter as well as continuous quality control are essential to satisfactory sintering to achieve economic blast furnace operation.

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INTRODUCTION

It is now more or less generally recognized that under normal conditions integrated steel plants of large capacities both in respect to investment and operation costs are more economical. The increased number of blast furnace installations with hearth diameters of 9 - 10 meters is one indication. Not long ago such sizes would have been considered to be unrealizable. Fig. 1 shows how the costs (1) per ton of ingot steel are decreased with increasing capacity of the plant. In many countries now engaged in building up their heavy industry, for example India, integrated steel plants of capacities of 1 mil. ton per year and more have been or are being installed.

Small iron or steel plants, however, have their own case. Other factors such as national economy, welfare considerations, transport conditions, raw material conditions may justify the installation of a plant of comparatively smaller capacity. Again quoting the example of India, installation of many 100,000 tons per annum pig iron plants and 30,000 tons per annum special steel plants spread over the continent is being considered and planned.

1. <u>Development in Sinter Output and Influence of Sinter on Blast Furnace Operation</u>

The concentration of very large capacities at one place has resulted in increased sizes of plants for ore preparation and handling. Sinter plants have been especially affected by this development, more because the percentage of sinter in the blast furnace burden has been on the increase (table 1) (2) during the past few years and today in many plants 100 % sinter burden is used.

Sintering was initially adopted to agglomerate, for charging into the blast furnace materials such as flue dust, mill scale, etc., forming a recirculating load in an iron and steel plant. Small amounts of fine ores were also utilized.

(1) M.N. Dastur, R.D. Lalkaka, <u>Layout of Large Integrated Steelworks</u>, preprints Symposium on Iron and Steel Making, Jamshedpur 4th-8th Feb. 1963, 3/7. Costs were estimated under Indian conditions and include freight and custom duty as well as costs for ore and limestone mines and the township.

(2) Statistisches Bundesamt. Außenstelle Düsseldorf. <u>Eisen- und Stahlstatistik</u>, Statistische Vierteljahreshefte.

With the greater demand for iron ores due to the rise in pig iron production (2) (Fig. 2) the amounts of fines contained in the ores supplied to the steel plants have increased. At the same time, more attention is being paid to physical burdening necessitating crushing and sizing of lump ores at the works which gives rise to additional amounts of fines. Again it is very often necessary to beneficiate the ores where the concentrates are obtained as fines. These factors and the positive influence of sinter on the blast furnace operation have contributed to the enormous rise in the world sinter production as shown in Fig. 2.

Numerous examples are already known of the positive influence of sinter on blast furnace operation. Use of sinter contributes to increasing output and decreasing coke consumption. Results (3) obtained in some of the blast furnaces are reproduced in Fig. 3.

The use of sinter in the blast furnace can be made more effective by charging sized sinter. Fig. 4 illustrates the results (4) obtained in an Australian blast furnace. The sized sinter was produced there by stabilizing. By the use of screened sinter of narrow size range similar good results have been obtained in the blast furnaces at Appleby-Frodingham. (5)

It could be inferred generally from the above example that sinter plants are a comparatively cheaper means for increasing pig iron production considering that the investment costs (6) for a blast furnace plant amount to about DM 200,-- per year ton pig iron capacity as compared to only DM 40, -- per year ton pig iron for sinter plants. This is especially applicable to plants using at present no or very little sinter.

(2) Statistisches Bundesamt. Außenstelle Düsseldorf. Eisen- und Stahlstatistik, Statistische Vierteljahreshefte.

(3) H. Wendeborn The Importance of the Sintering process in the Production of Pig Iron, reprint from Metallgesellschaft Review of the activities, No. 1 1959

(4) K.J. Figgis, F.E. Charke, Blast Furnace Practice in Australia, Blast Furnace and Steel Plant, 1180, December 1962.

(5) N.D. Macdonald, The Effect of Screened Sinter on Furnace Productivity, Journal of the Iron and Steel Institute, preprint (C) 1961

(6) Friedrick Lüth, Planung und Bau von Hüttenwerken, zweite neu bearbeitete Auflage, Springer-Verlag, Berlin/Göttingen/Heidelberg (1958)

2. Size of Sinter Machine

Sintering is carried out on a grate which can be stationary in the form of a pan or of the continuous strand type according to the Dwight-Lloyd system (Fig. 5). In recent years continuous strand type sinter plants have been generally recognized as more suitable for larger capacities say for example from 300 tons per day upwards. Only continuous type sinter machines have been able to successfully meet the challenge of the demand for high capacity.

For fulfilling the requirement of large capacities due to the factors described above, big sinter machines were developed and put into operation. Whereas until 1945 sinter machine having an effective sinter or suction area of 75 m2 was considered to be a normal standard size, a sinter machine with a suction area of 300 sq.m. is now available. Fig. 6 illustrates the development in the size of sinter machines. The largest sinter machine (7) in the world, already in operation since 1960, has a suction area of about 225 m2. As shown in Fig. 6, for constructing bigger sinter machines the width of the pallet was increased over many years step by step from 1 m to 4 m.

With the design of large sinter machines many technical details were improved. To quote a few examples, the drive of the machine was simplified (Fig. 7), the pallet seal between the moving pallets and stationary wind boxes (Fig. 8) was made more effective and a pivoted discharge end was designed to automatically take up the expansion in the chain of pallets due to heat (Fig. 9) etc..

Fig. 10 shows how, besides the improvement in engineering, the design of larger sinter machines has helped to reduce the relative investment costs. The curve in this figure makes easier the decision whether the required output of sinter should be met by the installation of a single or a number of sinter machines. In this respect the following factors have to be taken into consideration:

1. Investment costs
2. Stages of construction of the works
3. Flexibility in the product
4. Existing facilities
5. Space available

(7) Jones and Laughlin start sintering machine at Aliquippa. Blast Furnace and Steel Plant, 259-266, March 1961

3. Ancilliary Equipment

To cope with the high material throughput required by high sinter outputs, ancilliary equipment to the sinter machine had to be redesigned. For example on a sinter machine with a suction area of 2[illegible]5 m^2 as already in operation in USA, 7000-8000 tons sinter per day can be produced depending on the physical and chemical characteristics of the ores to be sintered. Such an amount of production requires intensive mixing, wetting and rerolling of about 1[illegible] tons of raw materials per minute. The mixing units such as drums, discs etc. have been designed to meet such large capacities (Fig. 11, Fig. 12).

Plant trials (8) in various works showed that by charging self fluxing sinter into the blast furnace, additional advantages in its operation can be achieved. In such cases the burden consists often of 100% sinter. This development has transferred the responsibility of correct blending of various materials for the burden to the sinter plant, which necessitates accurate discharge of various materials from the raw material bins or at least correct proportion of flux to the ore to keep the basic acid ratio constant and within the required limits. This requirement is met by the installation of constant weight feeders (Fig. 13) under the bins.

In order to reduce operating costs and to simplify handling the sinter is conveyed by belts to the blast furnace bins or in modern works even to the top of the blast furnaces. To achieve this cooling (9) of sinter had to be developed and is now considered necessary to the modern sinter plants. Cooling of sinter on coolers is affected by drawing or forcing air through a bed of sinter. To meet the various local conditions regarding layout of the plant three different designs of cooler have been developed. These are:

Straight cooler (Fig. 14)
Circular cooler (Fig. 15)
Cellular cooler (Fig. 16)

All the three types are built as suction or forced draught coolers. In one special case a stationary cooler (10) was built on the principle of the cellular cooler. On the cooler the sinter is cooled to such an extent that it can be conveyed on normal belt conveyors.

(8) J.S. McMahan, Experience with self fluxing sinter at the Steel Co. of Canada, Ltd. Blast Furnace and Steel Plant, 373-375, 497-49[illegible] (195[illegible])

(9) G.Brandes and E. Wendeborn, Sinter Cooling - an important part of the modern sinter plant, Reprint Stahl und Eisen, 693-69[illegible] (1957)

(10) New Sinter Cooler in Operation, Blast Furnace and Steel Plant, 1[illegible], (January 1961)

With the increasing quantity of sinter in the burden more attention has to be paid to the quality of sinter produced. Reducibility, size and physical strength are the main factors for determining generally the sinter quality. Unfortunately, until now, no standards for sinter quality are existing. In most plants quality is judged by physical strength only, for which again the methods and evaluation of tests vary from place to place. Continuous sampling equipment for testing sinter in large plants has been already designed and should be included in such plants. In connexion with the quality of sinter, sizing and stabilizing is of particular importance. By proper crushing and stabilizing, sinter of good strength and in narrow size range is produced. Stabilizing is based on the principle that the breakage of sinter pieces is reduced considerably with progressive stressing and one method consists of rumbling cooled sinter in a drum followed by screening.

The desire for a clean plant and clean working areas has led to the introduction of electro-filters as dedusting units in the sinter plants. This has been especiall the case for plants built in the vicinity of inhabited areas. Elektrofilters have been installed in recent years for dedusting both the waste gases as well as the dust laden air at transfer points and at other sources of dust in the plant (room dedusting). By introduction of such filters (Fig. 17) sinter plants have been freed of the red brown discharge.

It is, however, pointed out that if a dust discharge of about 0.5 g/m^3 can be permitted in the area around the plant, cyclones (Fig. 18) may be used for the waste gas dedusting. For the room dedusting, however, electrofilters are to be preferred because the dust load for the room dedusting amounts to about 20 g/m^3 compared to 2-4 g/m^3 in the waste gases.

4. <u>Operational Control of the Plant</u>

For the operational control of the plant, it is necessary that as many variables as possible are continuously measured in order to take necessary corrective steps without delay if values deviate from normal. Wherever necessary these variables should be recorded to allow later checks.

Whereas smaller plants say up to a capacity of about 1500 tons sinter per day can be operated manually, the development of larger plants made it necessary to somewhat refine the interlocking system and introduce automation of the plant control.

Electrical interlocks in such plants prevent material jams in case of a failure of any unit in the material transport system. Electrical interlocking avoids this by automatically stopping all units preceeding the one which has failed.

Automation in big sinter plants not only helps in saving labour, which is an important factor for countries where labour is costly but also is a means for achieving constant product quality. Automation should eliminate errors and where necessary make corrections automatically as quickly as possible.

For automatic plant (11) control in modern installations the various operations involved are grouped into independent operating cycles. Each cycle is controlled by the variable which is the deciding and most important in the circuit. The automatic operation of these cycles is described as under:

(a) The discharge end section of the sintering machine is equipped with a device which indicates the completion of the sintering process and which regulates, if necessary, the speed of the sintering machine so that it suits the required sintering time. The supply of raw materials and removal of finished sinter is adjusted to suit the speed of the sinter machine.

(b) Continuous check is kept on the amount of material contained in the hearth layer surge bin above the sinter machine and, if necessary, the control device switches in the screens and belt conveyors for the hearth layer supply.

(c) Without disturbing the previously fixed gas/air proportion, the supply to the burners of ignition hood is so regulated that a constant temperature is maintained in the hood.

All the measuring and control instruments as well as switches of the plant are incorporated in a control panel (Fig. 19) installed at a centrally located point at the plant.

5. <u>Planning a New Plant</u>

It is outside the scope of this paper to deal with this matter to full justification. Only the few most important points which are to be considered for planning a new plant will be discussed.

(11) Matthias Nievelstein, Die Regelung von Bandsinteranlagen mit Teleperm-Reglern, Siemens-Zeitschrift, 373-377, May 1961

It has already been indicated above, that the sinter output of an ore depends on its physical and chemical characteristics. Unfortunately these characteristics cannot be evaluated theoretically for determining the sintering (12) properties of the ore. These can be studied only by tests with actual samples. The first step for planning a new sinter plant, after investigating the requirements on the quantity of sinter for the required pig iron production, is therefore the conducting of sinter tests with representative samples of the raw materials. Suppliers of sinter plants generally possess such facilities for carrying out sinter tests and they have the experience of evaluating the results for laying out the plant. Sinter tests prior to the designing of the plant are to be recommended even if the plant is based on varying ore supply. In such case a certain basic mix should be taken as the basis which would be probably used in the sinter plant during at least the initial periods after start up. From the test work, such data as is most essential for designing, is evaluated, such as the specific output which can be achieved with the mix, the mixing methods, the return fines load to be recirculated, the coke consumption, the optimum bed height of the mix and the application of special sintering process such as mixed firing, stabilizing etc. From the test results the sizes of the individual machines of the plant are determined and a layout is worked out to suit the space available.

Fig. 20 shows a perspective view of the layout of a sinter plant with a daily capacity of 2500 tons sinter. This plant is complete with ore crushing, screening and ore mixing beds. The ores supplied to the plant are crushed below 50 mm in two stages and in the final screening the fine ores below 10 mm are screened out and conveyed to the raw material storage bins via the mixing beds. The ore fraction 10 mm to 50 mm is charged directly into the blast furnace. Mixing beds are provided for achieving uniformity in the chemical analysis of the ores. Self fluxing sinter is produced in the plant. The sinter machine has a suction area of 100 m^2 and is equipped with a mixed firing hood. The sinter is screened hot and the hot return fines are conveyed by a pan conveyor to the raw material storage bins to be returned to the process. The sinter cooler is circular in type having a cooling area of 134 m^2 and works on the principle of forced draught. The sinter is screened before it leaves the plant. For dedusting the waste gases and for room dedusting electro-filters are planned.

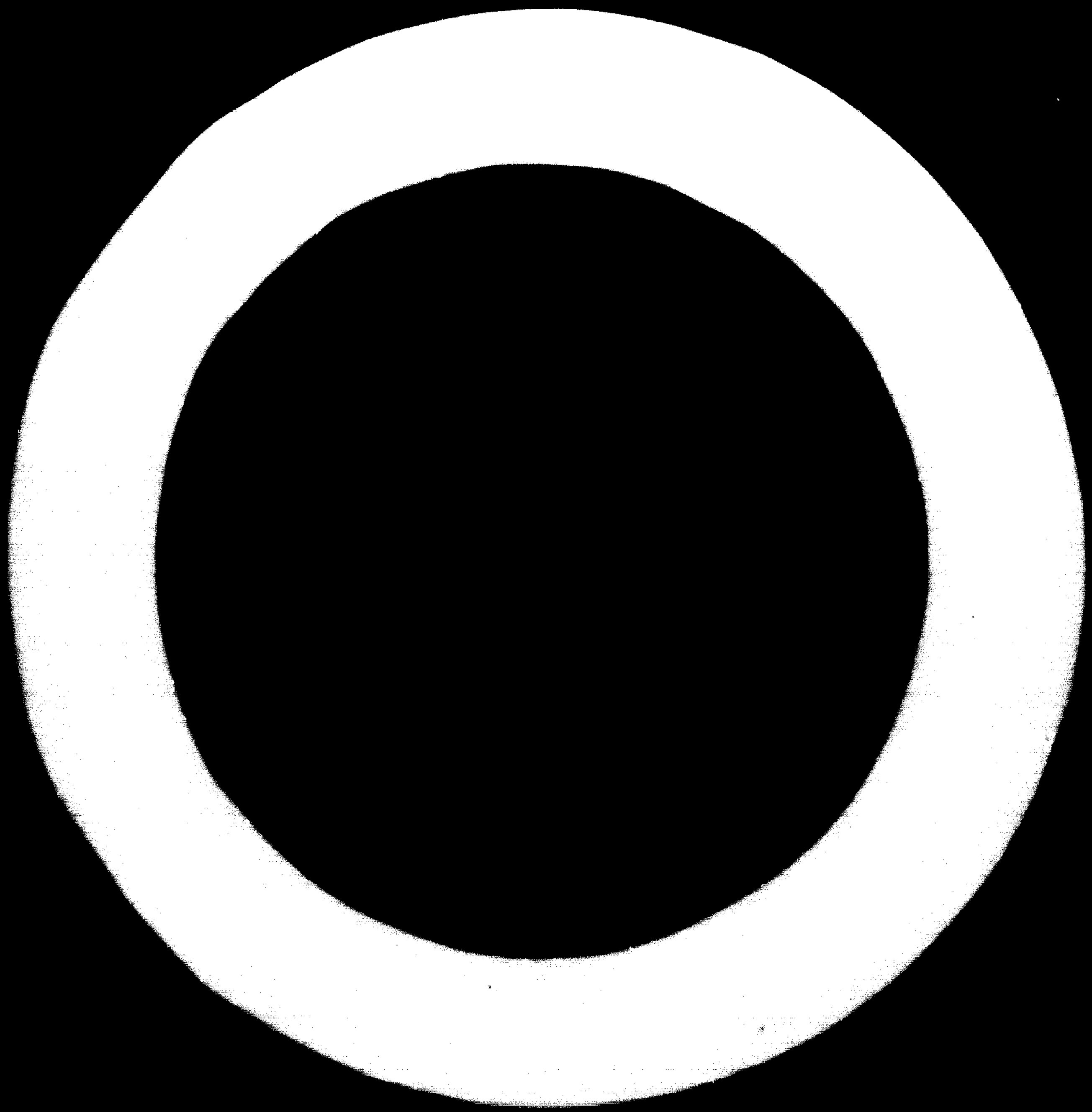
(12) H. Wendeborn, Sintering as a physical process, Symposium on sinter, special report No. 53 of The Iron and Steel Institute, London, 1-2, March 1955

A modern plant recently started is shown in Fig. 21. This plant is designed for a sintering capacity of 8000-10,000 tons per day and is equipped with two sinter machines each having a suction area of 183 m^2. Cellular coolers are provided for cooling the sinter. The picture also shows the electro-filters for dedusting.

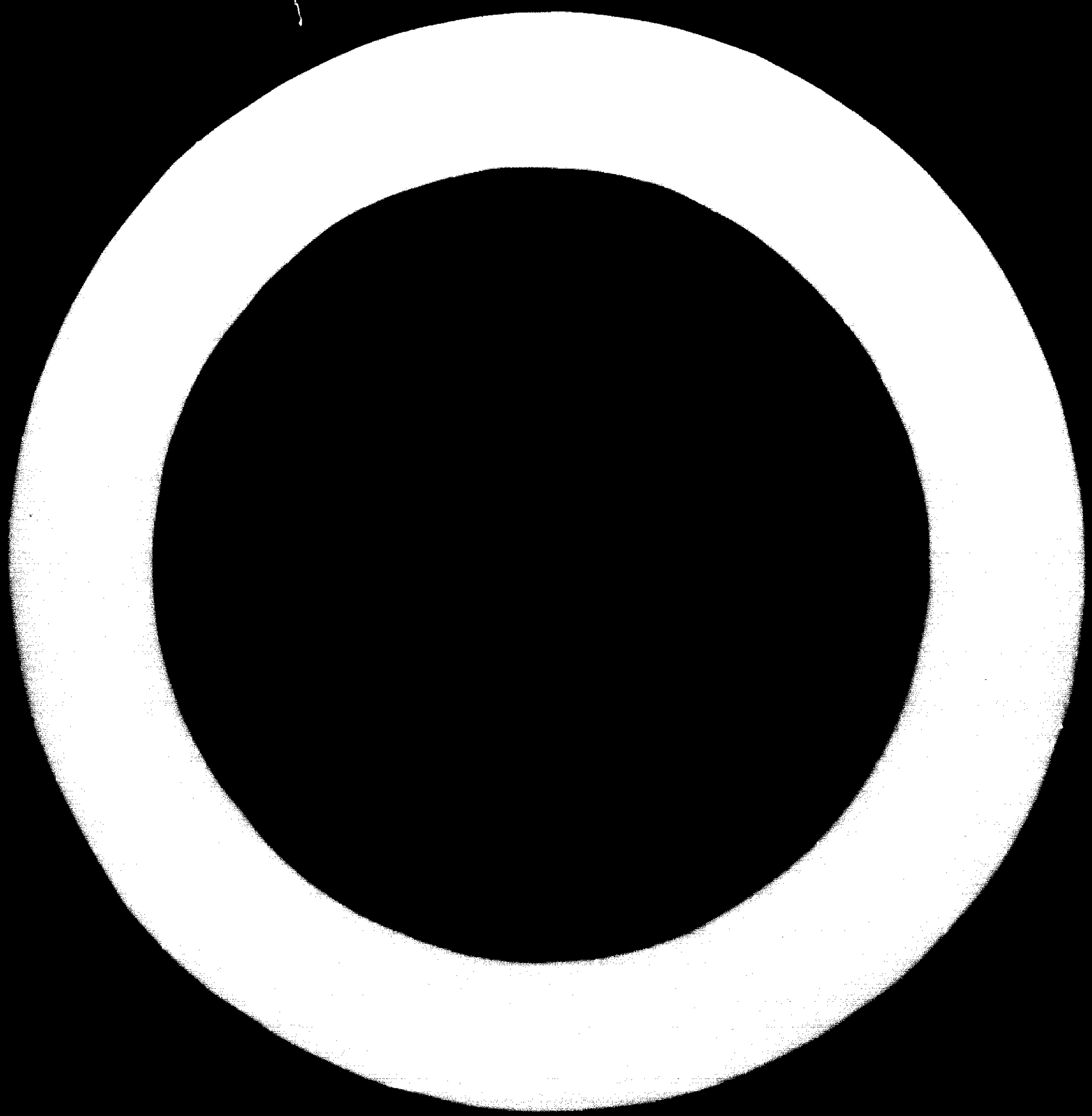
Fig. 22 shows a flow sheet for the stabilizing of the sinter. Properly crushed and cooled sinter, after hearth layer screening, is tumbled in a drum. After tumbling the product is re-screened at 6 mm and the fines returned to the sinter process.

Fig. 23 shows a flow sheet for sampling and testing the strength of the finished product. Samples at regular intervals are drawn at a transfer point in the finished product conveying circuit and carried either to the grinding or the strength testing circuit. For testing the strength a weighed sample is subjected to stressing for 5 minutes in a drum 1 m long, and 1 m in dia, revolving at a speed of 25 R.P.M. The amount of fines so produced during this rumbling, indicates the sinter strength.

In closing this paper the authors emphasize that sizing, stabilizing and close quality control as described above are now engaging the attention of many large plant operators as it is realized how very important these factors are to the economic operation of a blast furnace.



FIGURES



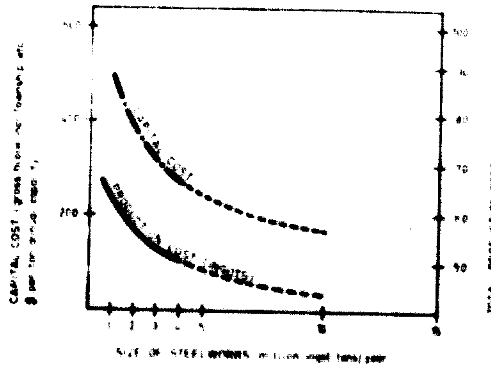


Fig. 1	RELATION OF PLANT SIZE TO CAPITAL AND PRODUCTION COSTS	H-1169

	1957	1958	1959	1960	1961
UdSSR	1,2	1,20	1,3	1,30	1,30
USA	0,56	0,67	0,71	0,95	0,95
GERMANY	0,64	0,74	0,76	0,78	0,82
ENGLAND	0,66	0,73	0,92	0,94	0,9
FRANCE	0,17	0,23	0,31	[illegible]	0,53
JAPAN	0,66	0,78	0,72	0,7	0,87

Table 1	SINTER USED PER TON OF PIG IRON	H-1175

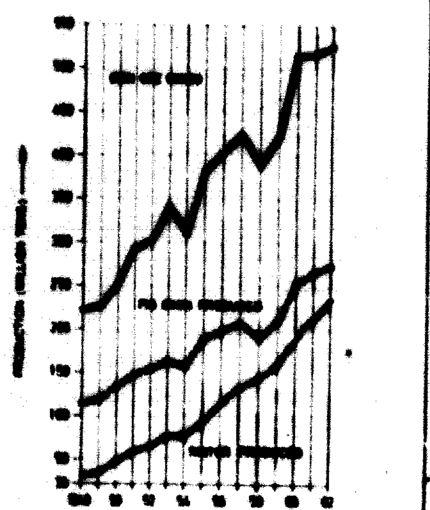


Fig. 2

WORLD TONNAGES OF IRON ORE MINED AND OF PIG IRON AND SINTER PRODUCED IN 1948 - 1962

H-1170

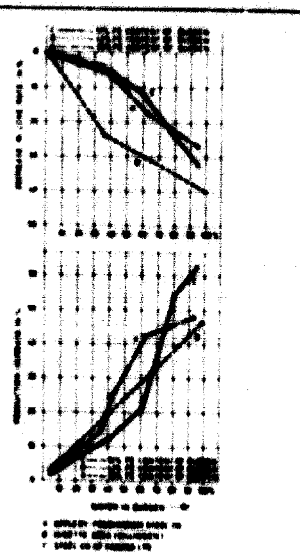
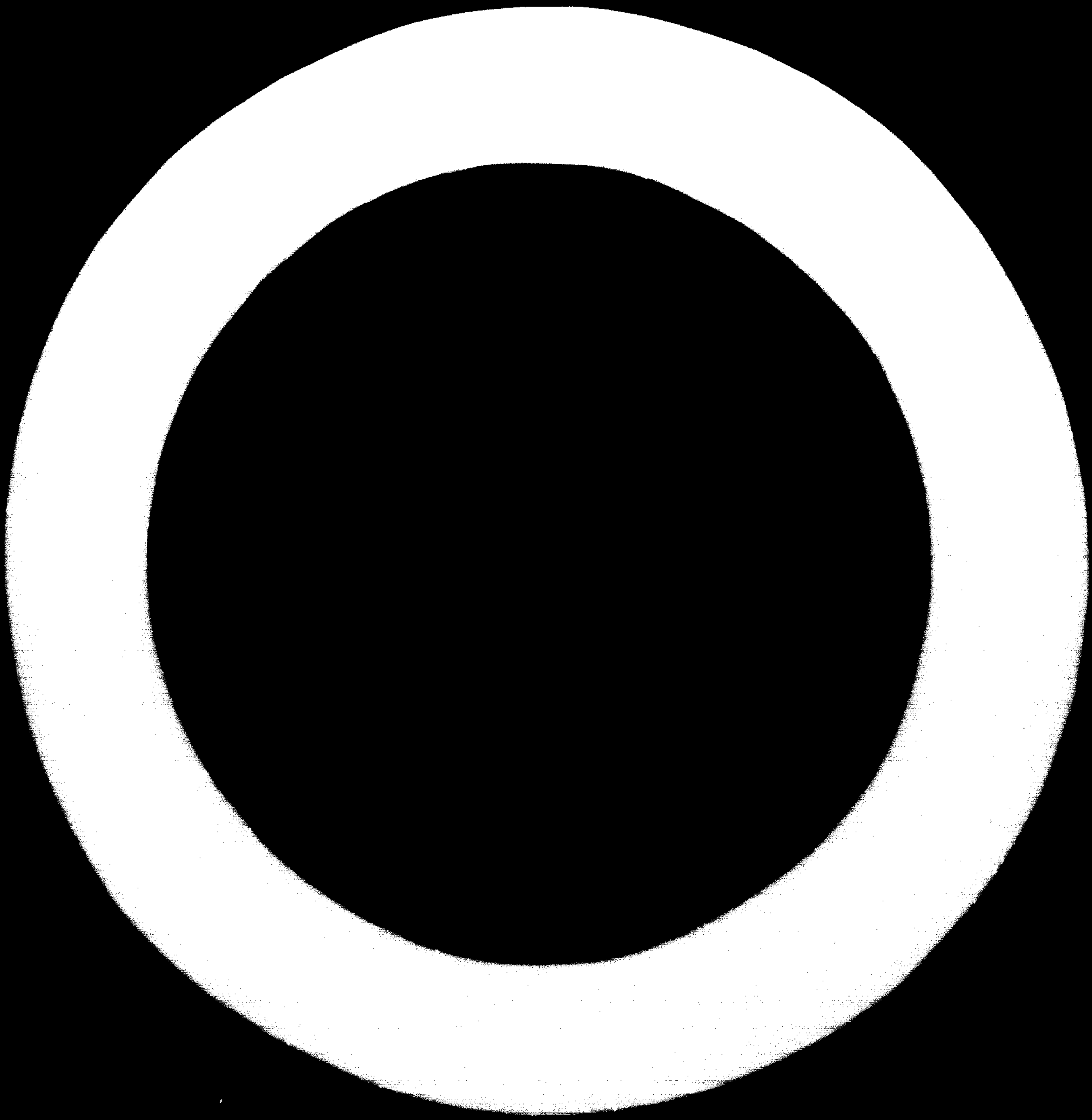


Fig. 3

INFLUENCE OF INCREASING SINTER IN BURDEN ON PIG IRON PRODUCTION AND COKE RATE IN % FOR THREE DIFFERENT BLAST FURNACES

H-1171



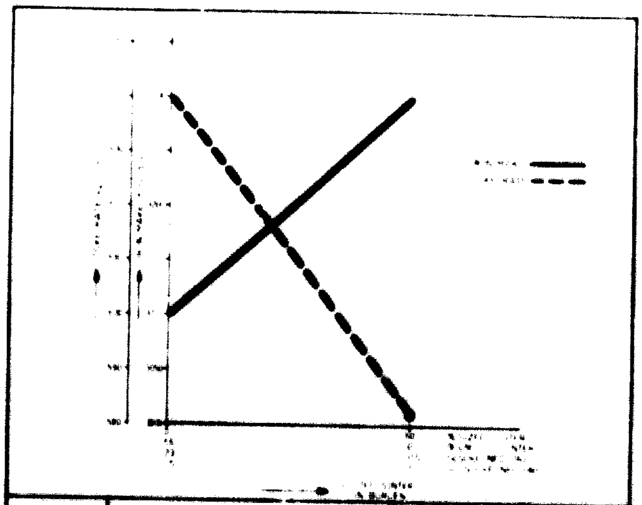


Fig. 4	INFLUENCE OF SIZED SINTER ON BLAST FURNACE PERFORMANCHE	H-1172

Figure 5

Continuous strand sinter machine

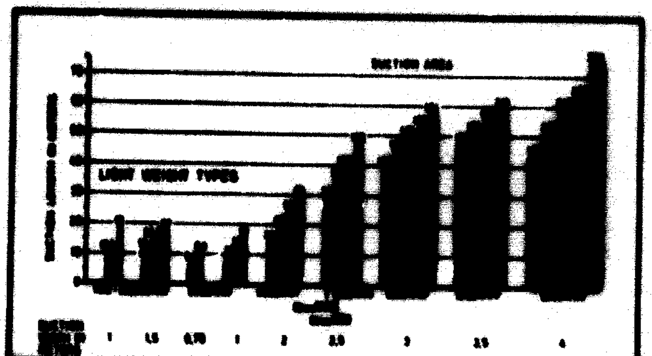


Fig. 6	DEVELOPEMENT IN THE SIZE OF SINTER MACHINES	H-1174

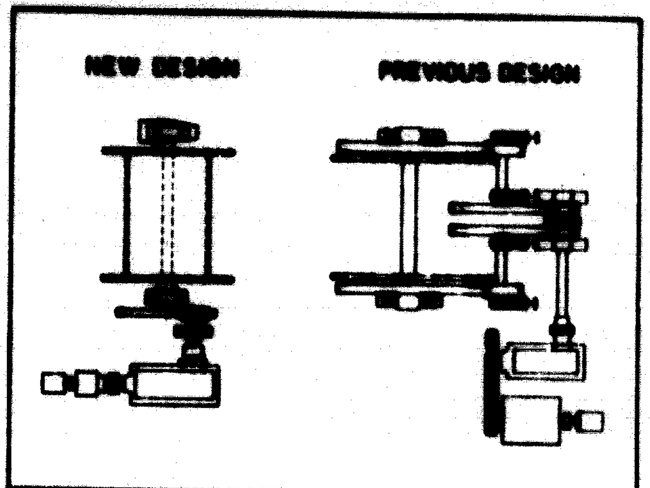
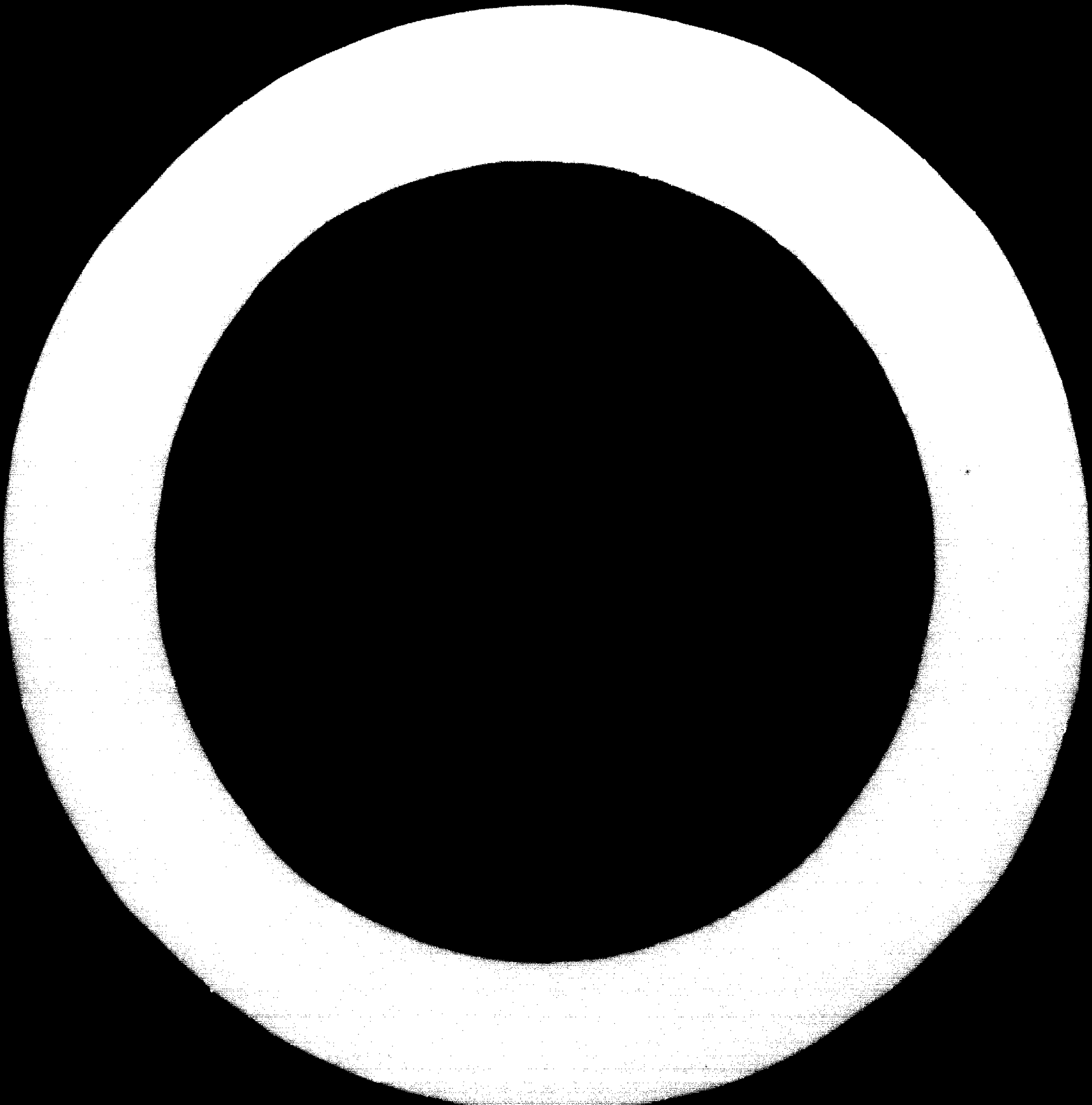
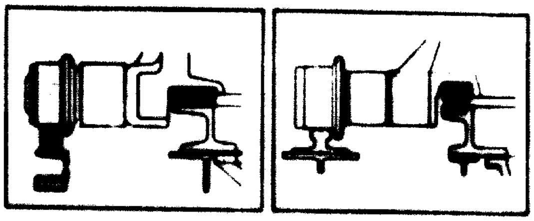


FIGURE 7	DRIVE OF SINTER MACHINES	H 1181





WIND BOX SEAL
NEW AND OLD DESIGN

FIG.8

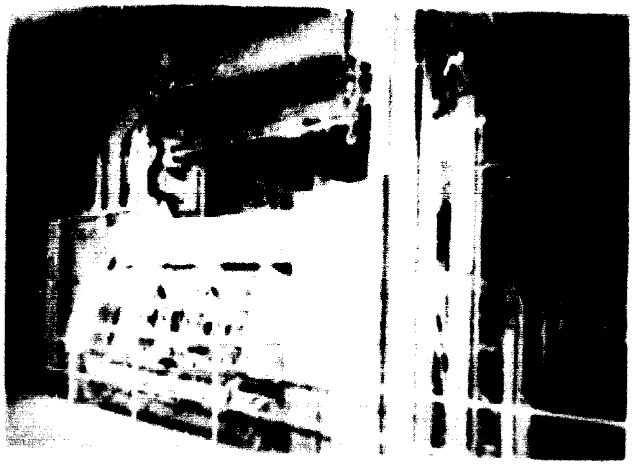


__Figure 9__

Pivoted discharge end of sinter machine

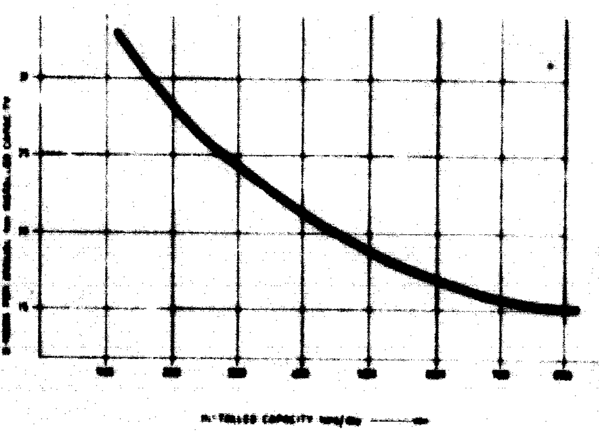


Fig.10 CAPITAL COST IN RELATION to INSTALLED CAPACITY OF A SINTER PLANT H-1178

1) INVESTMENT COSTS

2) STAGES OF CONSTRUCTION OF THE WORKS

3) FLEXIBILITY IN PRODUCT

4) EXISTING FACILITIES

5) SPACE AVAILABLE

Cont'd

FACTORS FOR DECIDING THE NUMBER OF SINTER MACHINES

H-1173

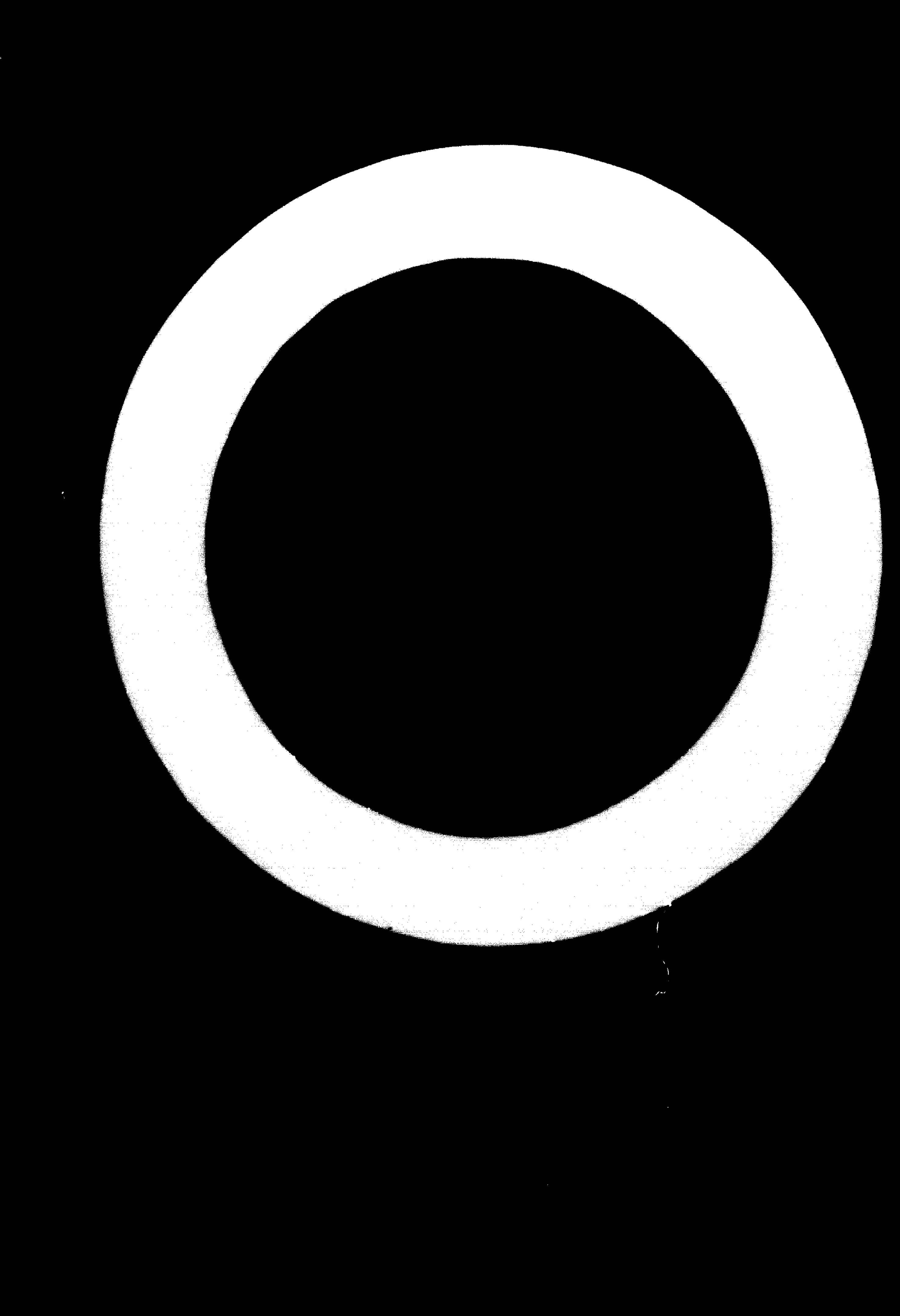


Figure 11
Mixing drum capacity 650 tons/hr mix

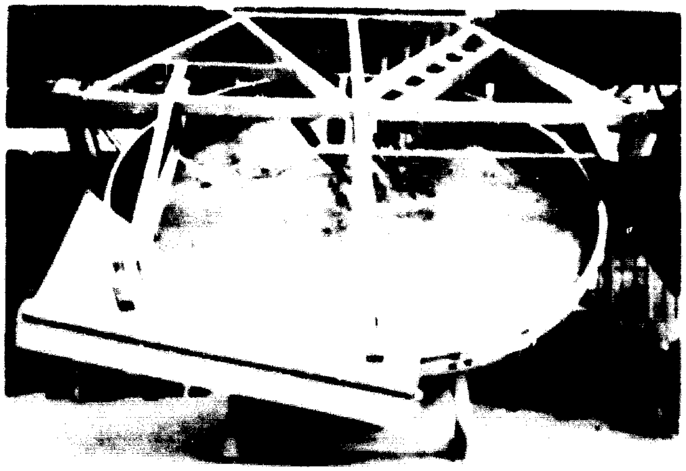


Figure 12
Disc for a capacity of 200 tons per hour

Figure 13
Constant weight feeder

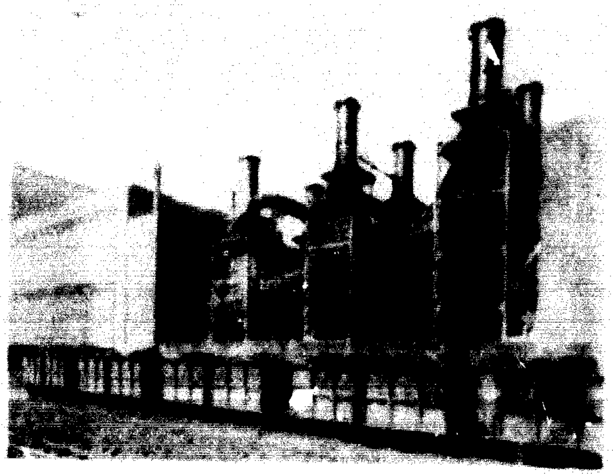
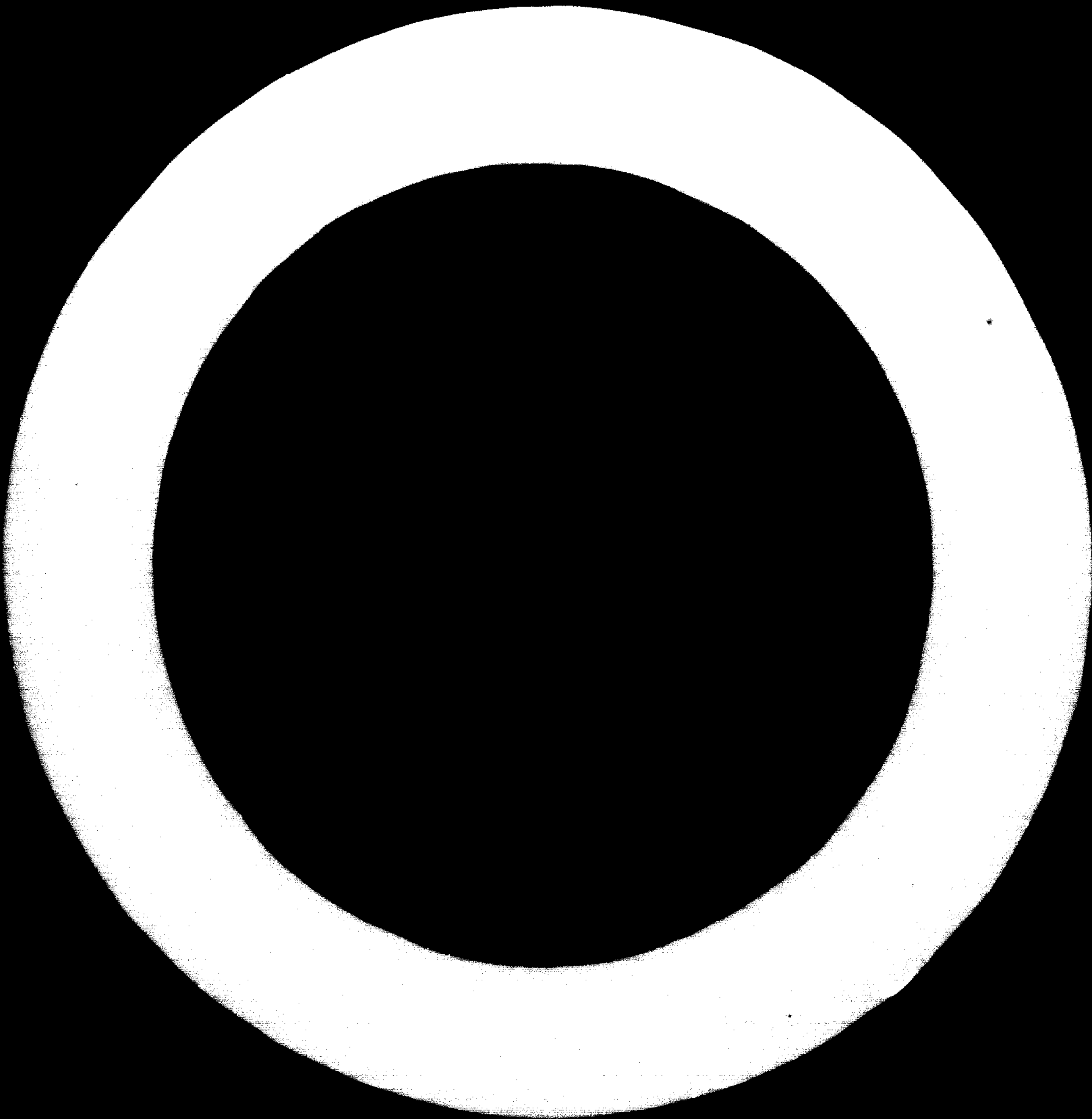


Figure 14
Straight cooler



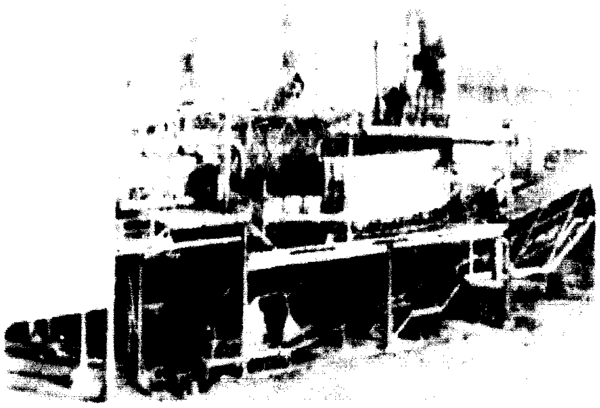


Figure 15
Circular cooler

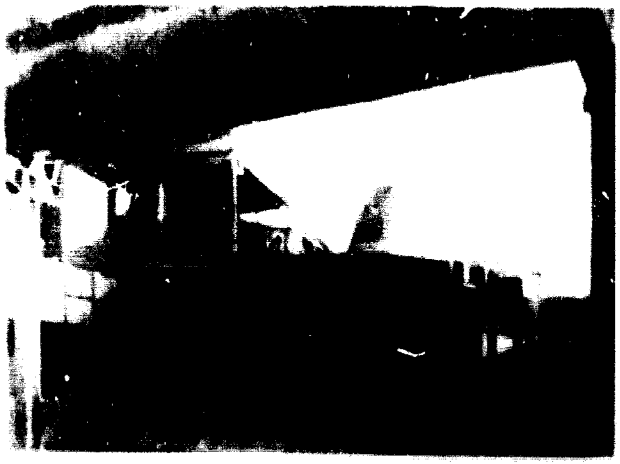


Figure 16
Cellular cooler

Figure 17 (a)
Sinter plant with electro filter

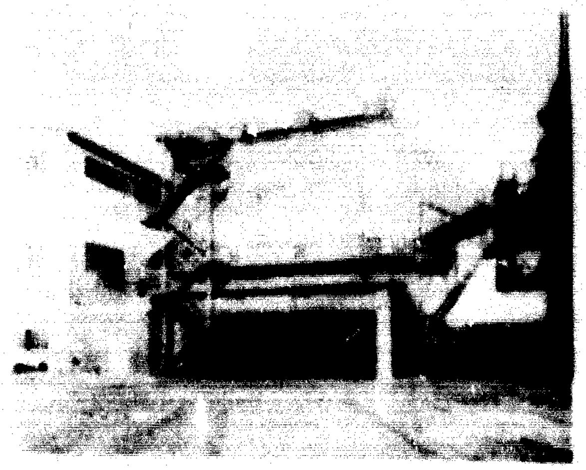


Figure 17 (b)
Electro filter for waste gas dedusting

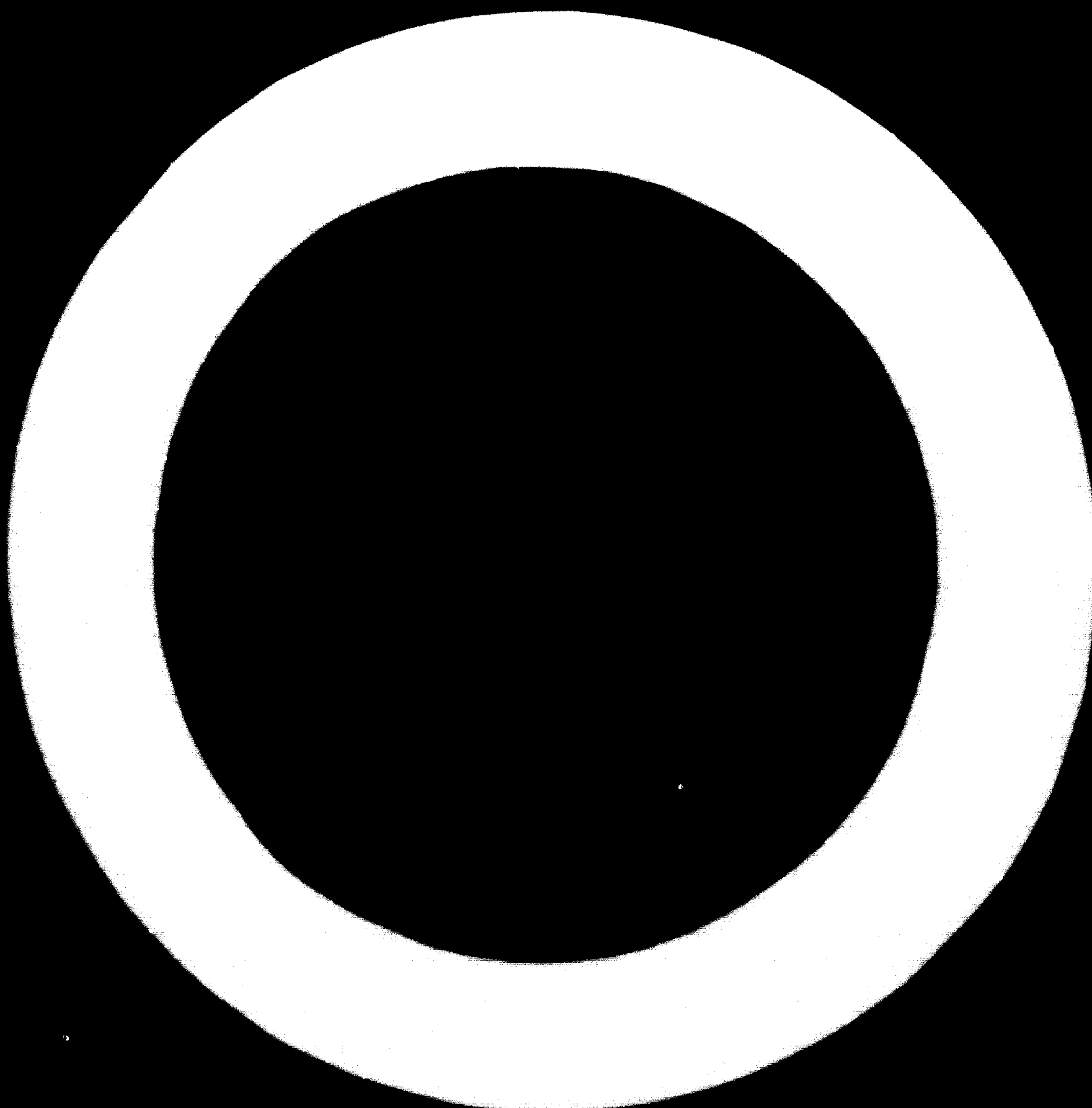


Figure 18
Cyclones for waste gas dedusting

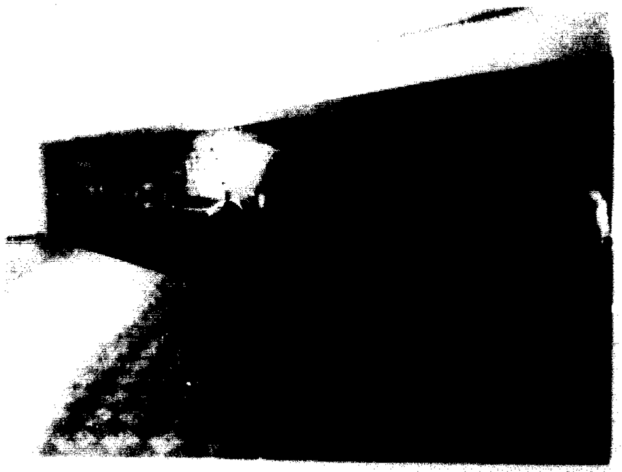


Figure 19
Control panel

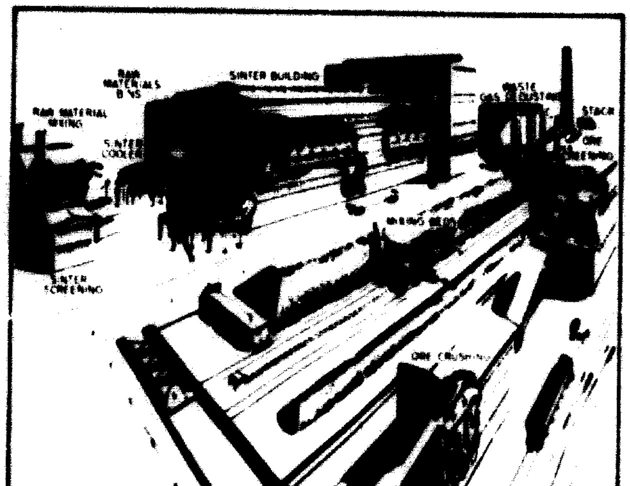


Fig 20	PERSPECTIVE VIEW OF A SINTER PLANT	H-1170

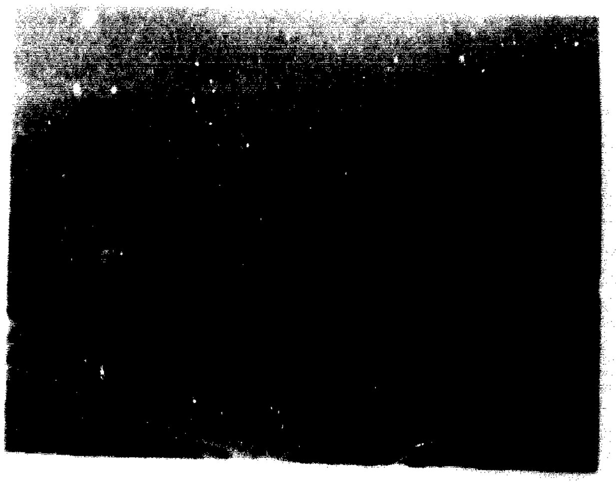
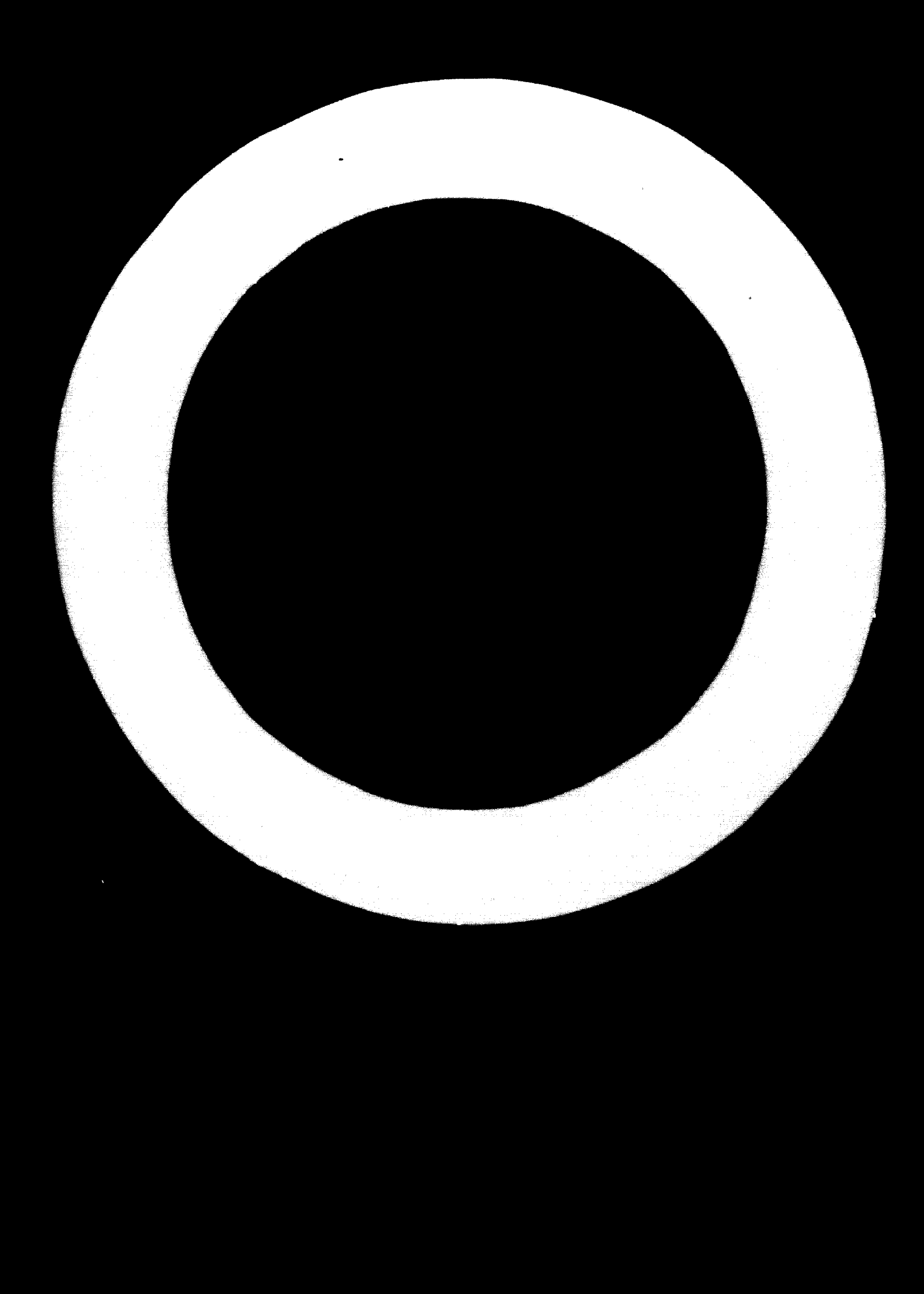


Figure 21
General view



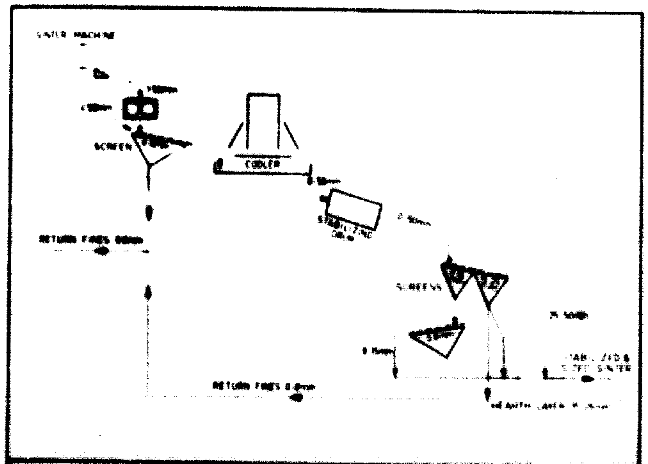


Fig. 22 FLOWSHEET FOR STABILIZING AND SIZING OF SINTER H-1179

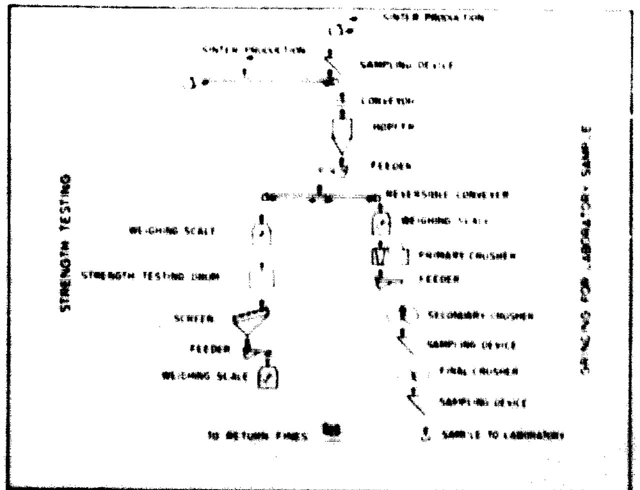


Fig. 23 FLOWSHEET SAMPLING AND STRENGTH TESTING FOR SINTER H-1180

10.7.74