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Agenda item III/le/vi

SNAM PROGETTI UREA STRIPPING PROCESS[1]

by

U. Zardi

Snam Progetti SpA
Milan Italy

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U. Zardi
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I. Process Description

Short description of the Snam Progetti urea process using the stripping technique. The process achieves almost total conversion of carbamate in urea in one isobaric system: reactor-stripper-carbamate condenser.

II. Plant performance

Plant performances data are given on steam and electric power balance, product quality, and operability. The power balance has been optimized. All the heat used for decomposing the carbamate contained in the reactor effluent is recovered at high temperature and directly used in the subsequent urea concentration steps.

The high purity of the product, which shows low iron content, low turbidity and color, is a good indication of no corrosion problems in the plant, and that a minimum quantity of impurity such as lubricating oil is introduced into the process streams.

This result is obtained with: (a) low operating temperature and pressure in the reactor: (b) use of ammonia as stripping agent in the stripper where ammonia acts as

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corrosion inhibitor; (c) elimination of corrosion critical items such as carbamate pumps and high ΔP expansion valves.

Short description of the synthesis loop control system is given. An easy control of the synthesis loop gives very steady conditions and good plant operability.

III. Large Snam Progetti stripping urea plants

The Snam Progetti process enables the construction of single line plants up to 2000 MT/D using only one train of operating machinery.

Snam Progetti has been the first in using a centrifugal machine for CO_2 compression up to the synthesis pressure. This type of machine is ideal for high capacities.

A centrifugal CO_2 compressor assures high time efficiency, which is essential in large plants. It also reduces investment and operating costs.

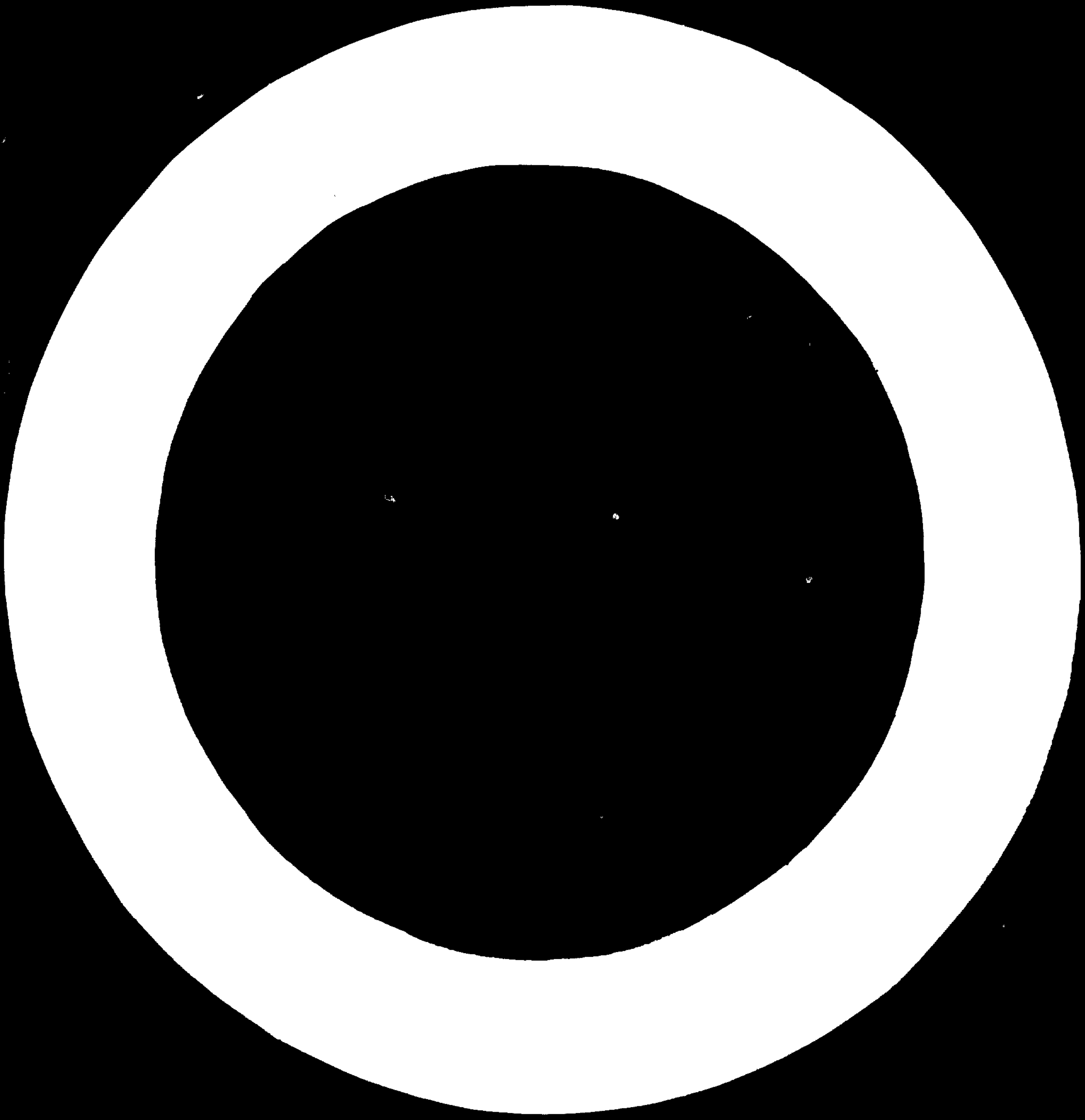
In the Snam Progetti plants the carbamate solution is recycled by an ejector, while for this service reciprocating pumps are used in conventional plants.

The capacity of reciprocating pumps is limited by hard technological problems still unsolved; consequently, several pumps operating in parallel must be used in large plants with high investment and operating costs.

In large Snam Progetti plants the main synthesis loop equipment can also be on a single line. They can all be located at ground level with the use of an ejector for carbamate recycle. This arrangement is very important for large plants.

IV. Conclusion

To summarize, the main features of the Snam Progetti process, that represents a new technique to manufacture urea, are (a) saving in utilities, (b) very high excess of ammonia in the critical steps of the process to eliminate corrosion (c) minimum maintenance, easy operability and high on-stream efficency (d) economic construction of large plants particularly in world areas where maintenance of sophisticated machinery would be a problem.



I. BRIEF PROCESS DESCRIPTION

The process has been already described in the technical press; therefore, only a short general description of it will now be given. Detailed information will be supplied on the performances obtained in the plants already on-stream.

(Fig. 1)

Urea is produced by the chemical reaction of liquid ammonia and gaseous carbon dioxide at about 150 kg/cm^2 and 185°C in the reactor (1). The liquid ammonia from the battery limits enters the holding tank (2) and then part is conveyed into the urea reactor using pump (3), and part is vaporized in (4) to be used in the high pressure stripper (5).

Carbon dioxide is compressed in (6) up to the reaction pressure, and most of it is fed directly to the reactor, while a small quantity bypasses the reactor to be prereacted before being sent to it. This is because the heat of formation of carbamate from the entire carbon dioxide make-up stream is in excess of that required to sustain the overall reaction.

The reaction products leaving the reactor pass to the stripping unit which operates almost at the same pressure. The urea-carbamate mixture is heated with steam in the stripper (5) and carbamate decomposed by the stripping action of part of the fresh-feed ammonia. The bulk of the carbon dioxide content of the solution is so removed.

The low residual carbon dioxide and the residual content of ammonia in the stream (7) from the stripper are flashed and distilled in a downstream section where they are recovered and recycled.

The bulk of ammonia is sent to a recovery column and recycled as anhydrous NH_3 to the holding tank (stream 8); the small amount of CO_2 is recycled as ammonium carbonate solution to the carbamate condenser (stream 9).

The overhead vapors leaving the stripper mixed with by-passed CO_2, enter directly the high pressure carbamate condenser (10) in which the ammonia and carbon dioxide are recovered as liquid carbamate solution and recycled to the reactor.

The carbamate is recycled with an ejector (11) in which the motive fluid is the compressed liquid ammonia fed to the reactor.

The ammonia pressure drop through the ejector supplies the necessary driving force.

II. PLANTS PERFORMANCES

The process has been employed so far in six industrial plants ranging in capacity from 70 to 900 MT/D.

Four are actually on-stream, the largest of which has a capacity of 750 MT/D.

All plants are total recycle and on one stream-line.

Hereinafter will be described the most important results obtained in such industrial units.

II.1. Steam and electric power consumptions

The process has been studied to minimize production costs. The power balance has been optimized: all the heat used for decomposing the carbamate contained in the reactor effluent is recovered at high temperature and directly used in the subsequent urea concentration steps. Figure 2 shows the steam distribution in a plant for production of urea via concentration.

40 kg/cm^2 steam is available at battery limits and is used for driving the CO_2 centrifugal compressor turbine.

Turbine extraction steam at 25 kg/cm^2 is used for process in the stripper and in the last stage of the HP decomposer.

The 5 kg/cm^2 steam produced in the plant is used for urea concentration and vacuum ejectors. The 3,5 kg/cm^2 steam, which is also produced in the plant, is used for driving the reactor feed ammonia pump and for steam tracing.

In this case, the overall power balance will be as follows:

Steam from B.L.	1100 kg/MT urea
Electric power	15 kWh/MT urea

The power required is particularly low for the following reasons:

1. Low pressure of the synthesis loop: 150 kg/cm^2 against 200-250 of the traditional processes.
2. Recycle carbamate is available practically at the reactor pressure, and is recycled by an ejector.
   The ammonia pressure drop through the ejector supplies the necessary driving force. A very small amount of power is needed to obtain this result.
3. High yields are obtained in the reactor, due to the minimum amount of water introduced with carbamate.

II.2. Product quality

It is interesting to make an examination of the urea product characteristics obtained in the plants using the Snam Progetti process, in order to underline important plant performances. Those characteristics, normally not commercially labelled, are the ones we will comment. Products listed on Table I were obtained without activated carbon filtration.

- Iron content is always extremely low: this is a sure indication of no corrosion problem in the plant
- Low values of color, turbidity and ashes show that the quantity of impurities, introduced into the process streams, such as lubricating oil, process water, etc. is negligible.

This is the result of:

(a) Low operating temperature and pressure in the synthesis reactor (185°C and 150 kg/cm^2 against 195-220°C and 200-250 kg/cm^2 in the traditional processes)

(b) Use of ammonia as stripping agent in the stripper, where the high ammonia excess acts as corrosion inhibitor

(c) Elimination of corrosion critical items, such as carbamate pumps and high ΔP expansion valves handling urea solution with high carbamate content.

The low residual CO_2 content in the urea solution downstream the stripper is recycled to the synthesis section as carbonate solution at low temperature, with no corrosion problem.

II.3. Operability

A description is now given of the synthesis loop control system and of the actions to be taken for the control of the plant operations. (Fig. 3)

As already known, the synthesis loop reactor-stripper-carbamate condenser is practically isobaric.

In this system it is essential to control the carbamate circulation to the reactor.

A small difference in pressure between the reactor and the other equipment of the loop (stripper and carbamate condenser) is therefore controlled by valve "A".

The level control on the top channel of the carbamate condenser operates the reactor outlet valve according to the quantity of carbamate to be recycled.

The operating pressure of the synthesis loop is controlled by the inerts vented from the carbamate condenser.

Such an easy control gives very steady conditions of operability in the whole synthesis loop which is a basic condition for the overall operability of the plant. The operator will take care only of the pressure in the system (inerts vented from the condenser valve "B"), and the temperature of the reactor (by-pass of CO_2).

The reactor operates under steady conditions with a mole ratio of 3.5 ÷ 4. A CO_2 conversion per pass of 60 ÷ 65% is obtained. The plant can be started up in a very short time, 4-5 hours to obtain the finished product.

All the equipment of the synthesis loop starts working simultaneously, and it is not necessary to store start-up carbamate solution.

III. LARGE SNAM PROGETTI STRIPPING UREA PLANTS

The possibilities offered by the Snam Progetti process in plants of great capacity in a single stream-line are now examined.

In large plants, investment and operating savings are not very significant if equipment only is on one stream-line and machinery on several units in parallel.

The Snam Progetti process enables the construction of single line plants up to 1500 ÷ 2000 MT/D by using one train only of operating machinery.

In high capacity conventional plants, very large reciprocating CO_2 compressors are normally used.

In this type of plants, carbamate is recycled by reciprocating pumps. The capacity of these pumps is limited by hard technological problems still unsolved.

Well-known are the inconveniences occurred around the world in the stainless steel valve bodies and stuffing boxes of reciprocating carbamate pumps, which cracked after a short period of operation. In fact, it is very difficult to obtain alloy steel forged pieces of large size without internal defects, as are required in carbamate service.

Another limit is given by the plunger diameter and by the RPM, due to the severe operating conditions of the packing seals.

A conventional 900 MT/D plant requires at least 3 pumps: 2 operating in parallel and one spare.

In the large plants using the Snam Progetti process, the reactor low operating pressure favours the use of a centrifugal CO_2 compressor, which is ideal for high capacities.

Snam Progetti has been the first in using this type of machine for CO_2 compression up to the synthesis pressure.

A centrifugal CO_2 compressor assures high time efficiency, essential in large plants. It also reduces investment and operating costs.

Figure 4 shows a centrifugal compresser for a 900 MT/D unit.

Figure 5 shows a reciprocating compresser for a 750 MT/D unit.

In the Snam Progetti plants the carbamate solution is recycled by an ejector. Figure 6 shows the ejector used in a 900 MT/D plant.

The low residual CO_2 content downstream the synthesis loop is recycled at low temperature as a lean solution by a small reciprocating pump, with no maintenance problems (12 m^3/h capacity for a 900 MT/D plant). In large Snam Progetti plants the main synthesis loop equipment can also be on a single line.

Table II shows the sizes of ~~main~~ equipment for a 900 MT/D Snam Progetti plant.

Being ~~the~~ stripper a falling film exchanger, in large size units it is important to study the liquid distribution in the top channel. This problem has been carefully studied by Snam Progetti.

Figure 7 shows a full size scale test distributor for a 1500 MT/D plant, which was used for designing this important part of the equipment. Figure 8 shows a stripper, ready in a workshop, for a 900 MT/D plant. Figure 9 shows an overall view of the 900 MT/D Manfredonia plant (Italy).

In the first Snam Progetti plants, when the technique of carbamate recycle via ejector was not yet developed, the carbamate condensers were placed at reactor top level, while reactor and stripper were located at ground level.

In the most recent units, all the synthesis loop equipment is at ground level. This arrangement is very important for large plants, being very expensive to install heavy equipment at high levels.

IV. CONCLUSION

To summarize the content of this paper, for what concerns the Snam Progetti process features, we wish to point out that the saving on utilities is only one factor.

It may be more or less interesting, according to the various local conditions.

The main point is that Snam Progetti's new technique represents really an easier way to manufacture urea.

The very high excess of ammonia, in the critical steps of the process, has completely eliminated corrosion.

The system has also minimized maintenance and operating problems and gives a very easy operability and high on-stream efficiency.

The Snam Progetti process makes really economic the construction of large plants, particularly in world areas where the maintenance of sophisticated machinery could be a problem.

PRODUCT QUALITY FROM SNAM PROGETTI UREA PLANTS

PRODUCT ANALYSIS	PLANT LOCATION			
	GELA (ITALY)	TERNI (ITALY)	PUERTOLLANO (SPAIN)	MINATITLAN (MEXICO)
Nitrogen % wt	46.5	46.43	46.45	46.4
Biuret % wt	0.3	0.8	0.4	0.9
Moisture % wt	0.25	0.3	0.3	0.25
Iron p.p.m.	<0.5	<0.5	< 0.5	< 0.5
Color (A.P.H.A)	4	6	4	7
Turbidity (Hazen in H_2O)	3	.	5	5
Ash p.p.m.	4	3	5	5

TABLE 2

900 MT/D PLANT

MAIN EQUIPMENT DIMENSIONS

ITEM	TOTAL LENGTH	DIAMETER	WEIGHT
REACTOR	-	-	100 MT
STRIPPER	14 m	1.2 m	63 MT
1. ST. CARBAMATE CONDENSER	15 m	1.1 m	50 MT
2. ND. CARBAMATE CONDENSER	18 m	0.9 m	40 MT

TABLE II

UREA SYNTHESIS LOOP

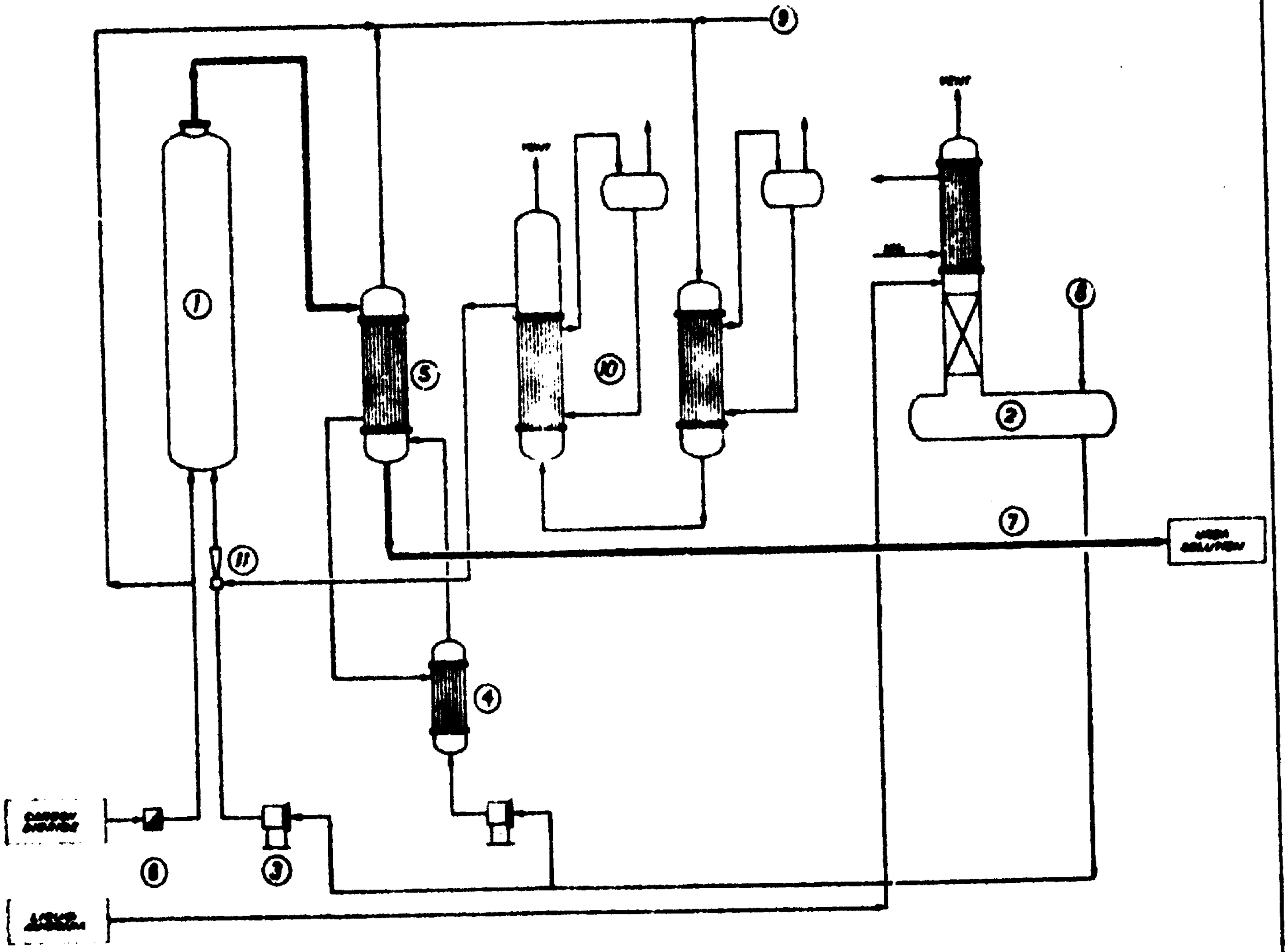


FIGURE 1

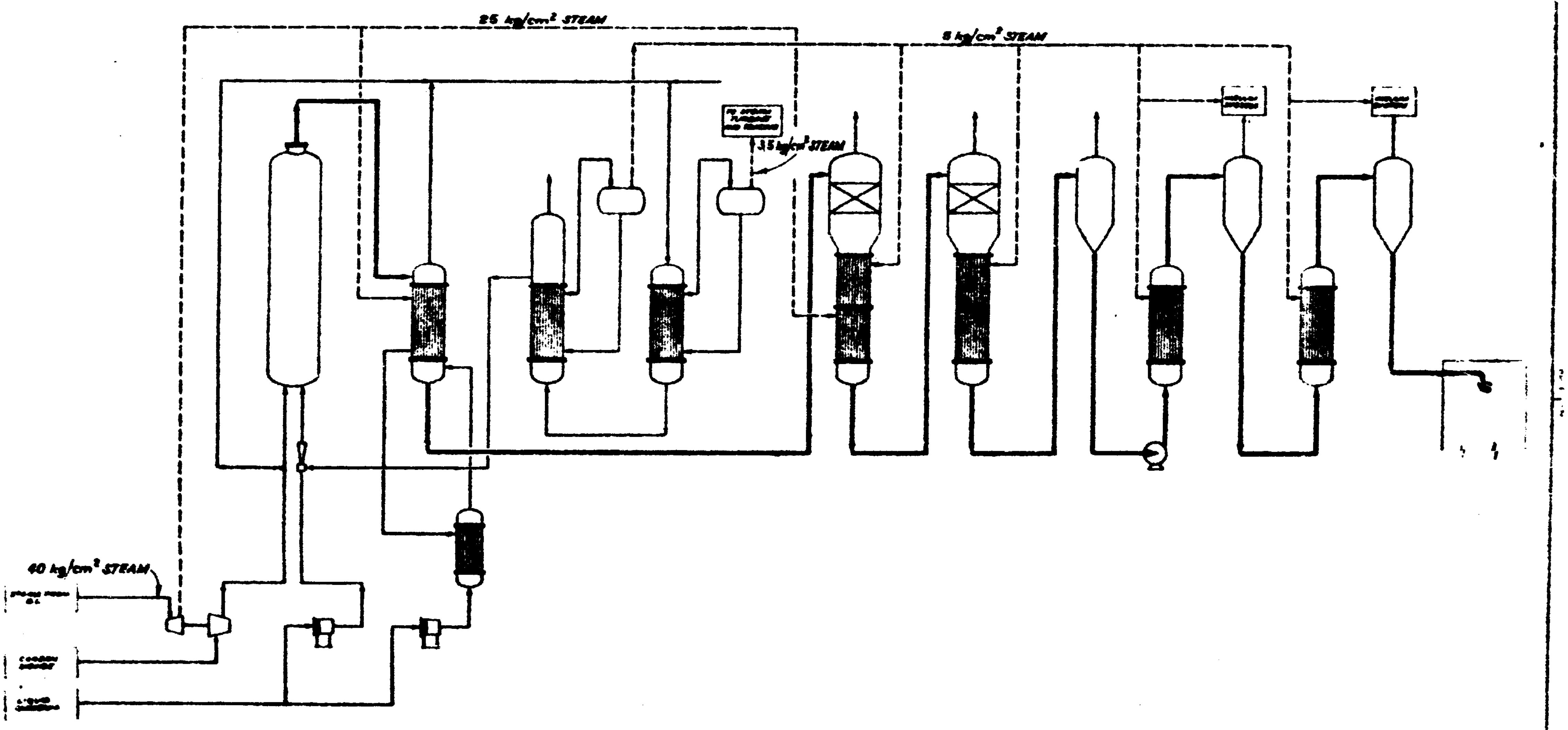


FIGURE 2

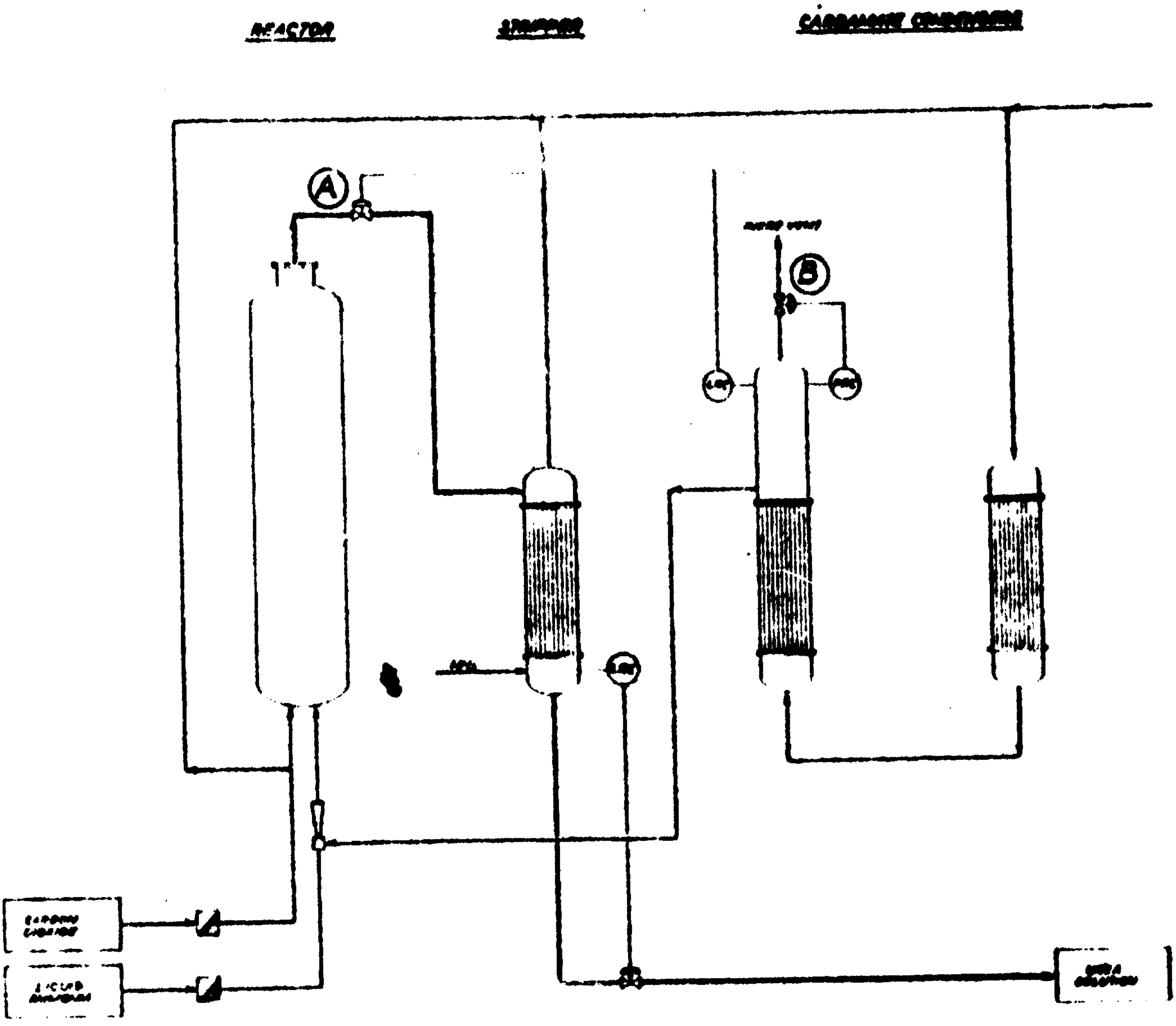


FIGURE 3

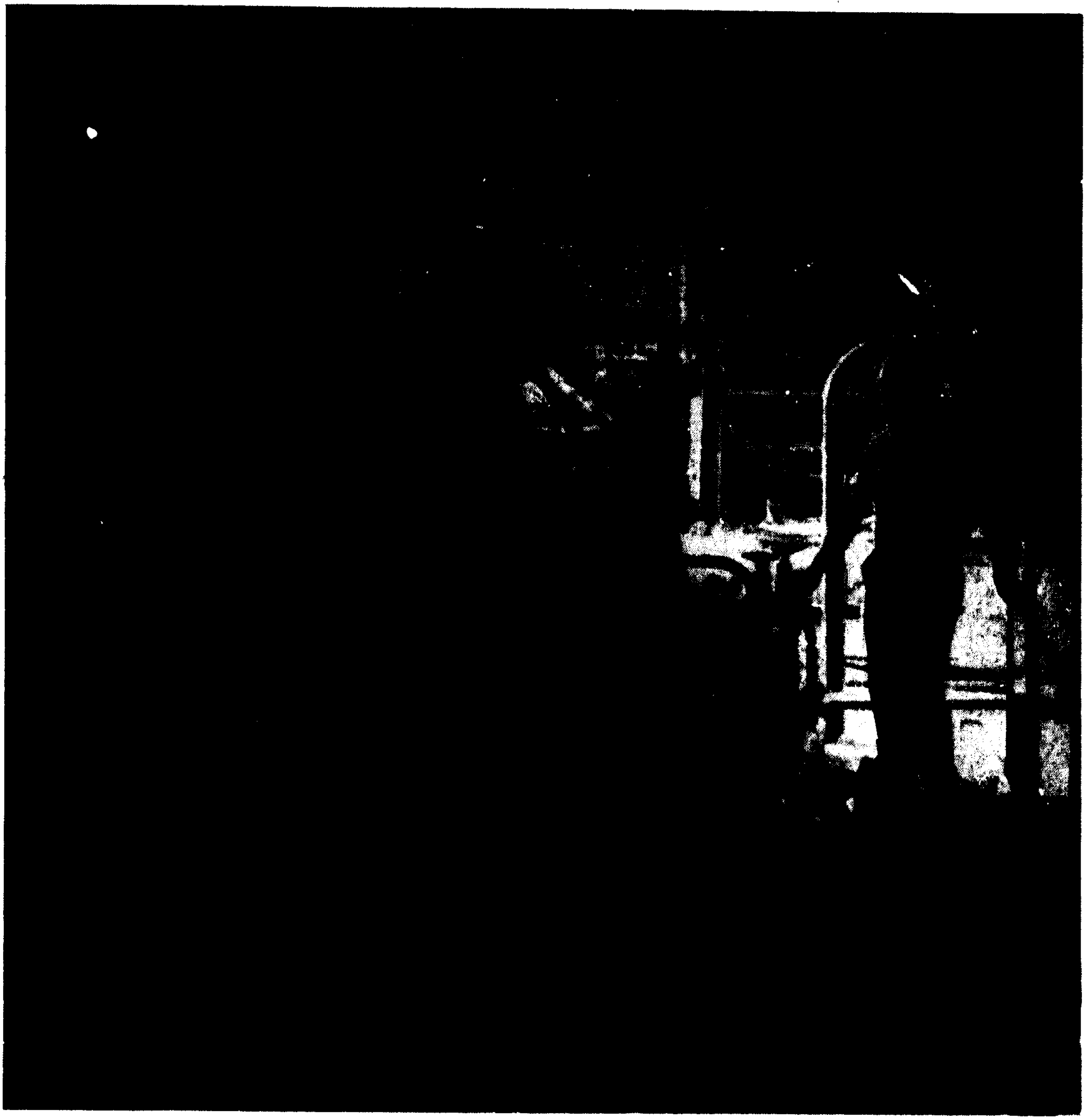


Figure 4

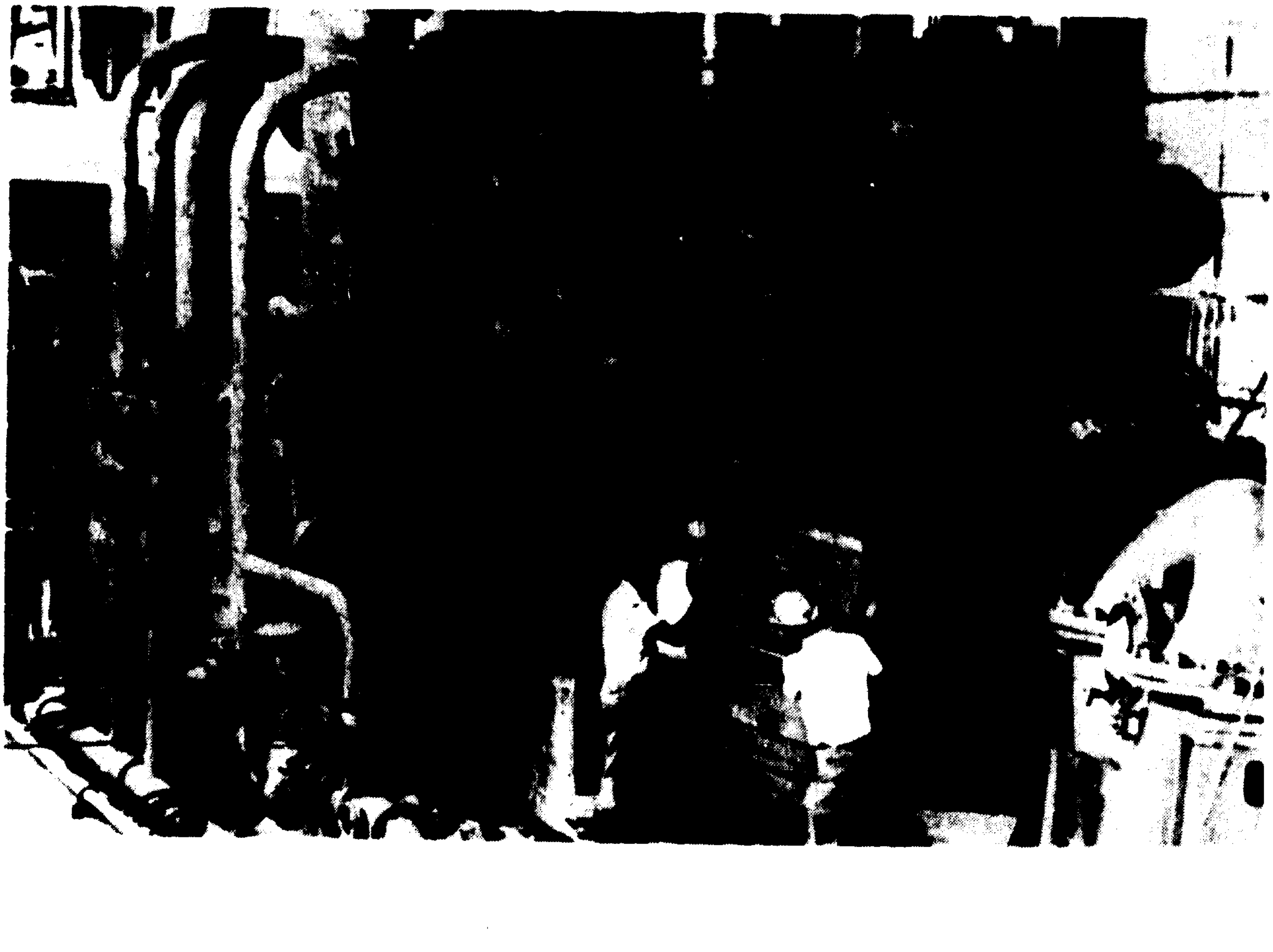


Figure 5

Figure 6

Figure 7

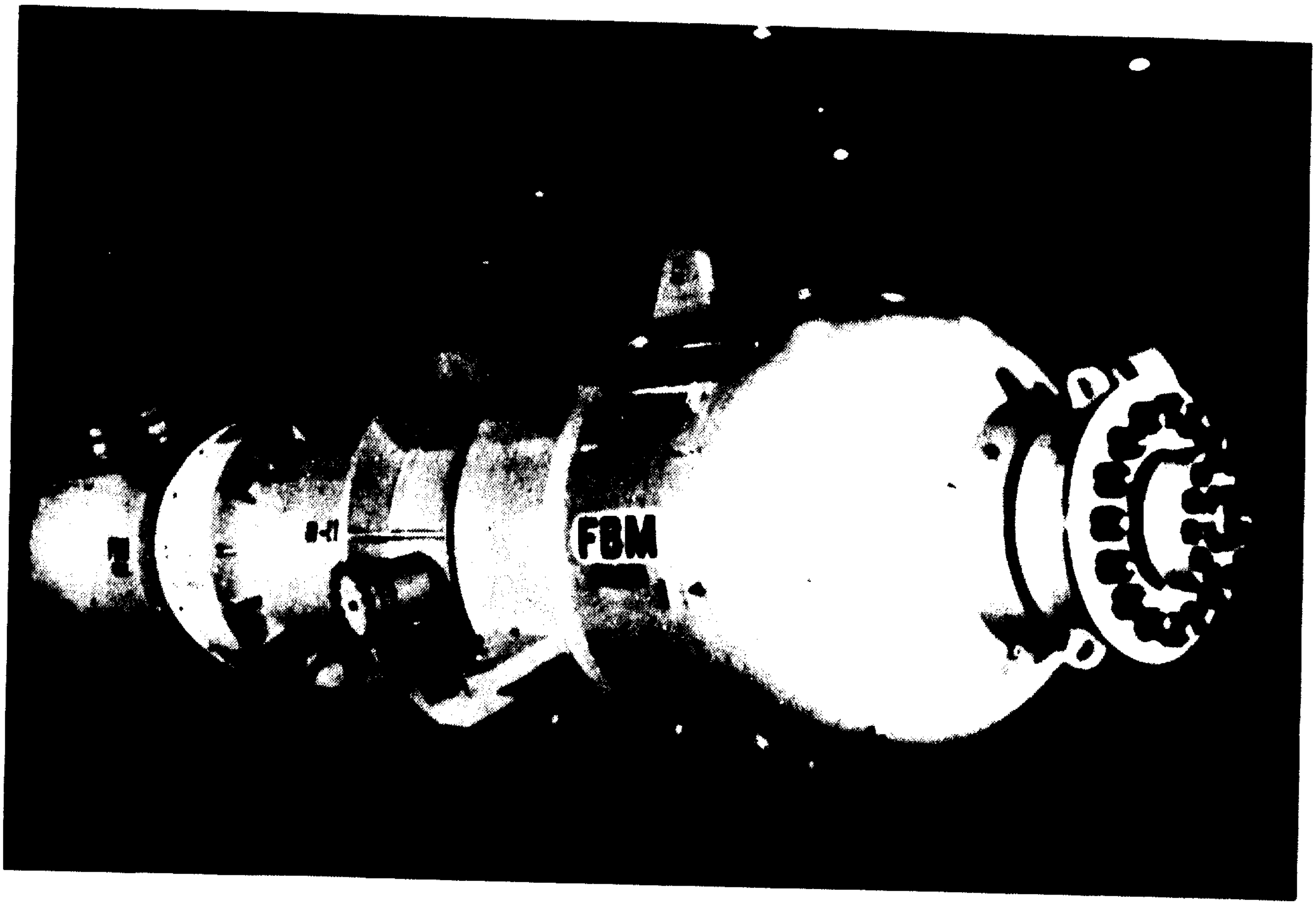


Figure 8

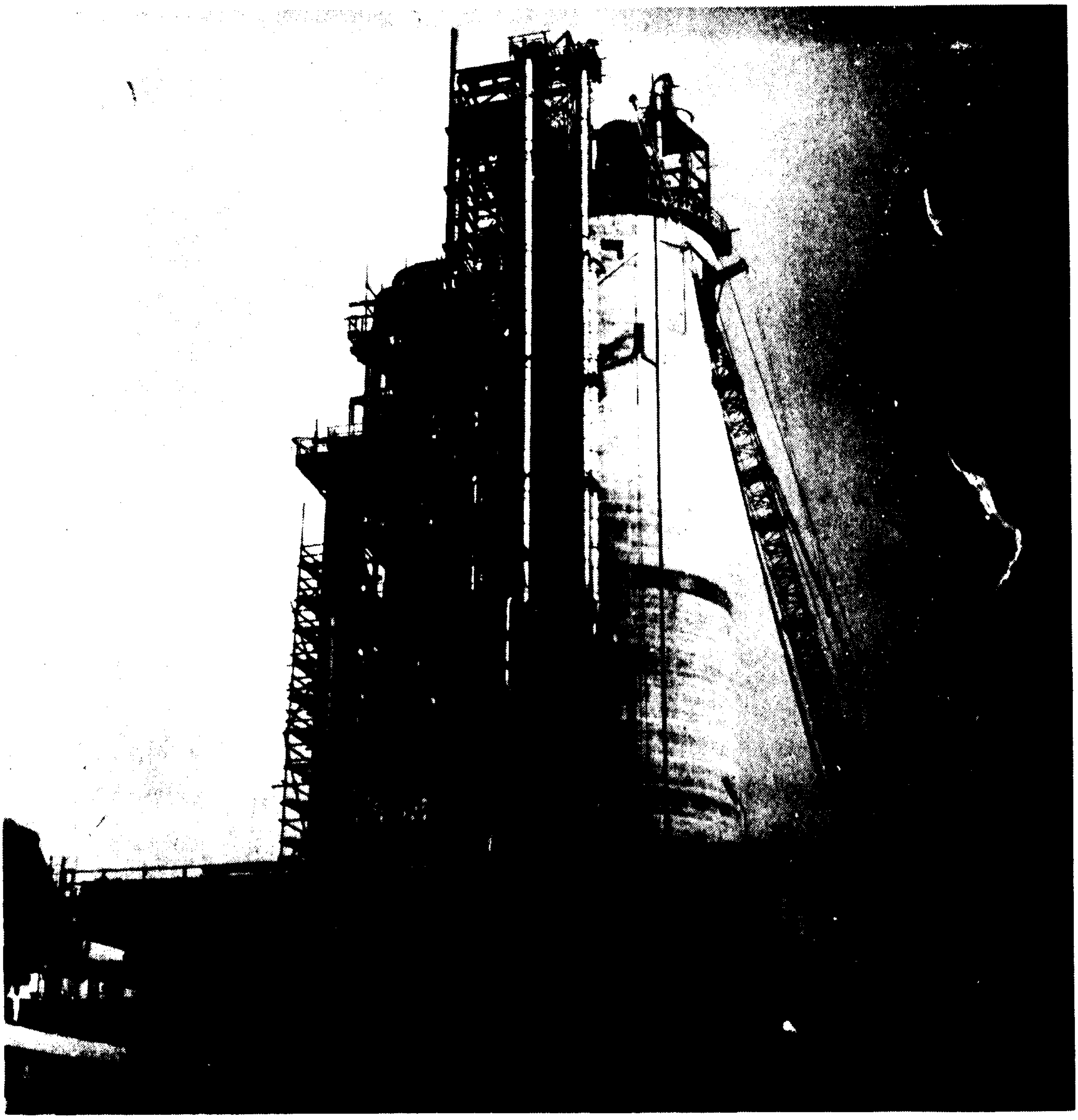
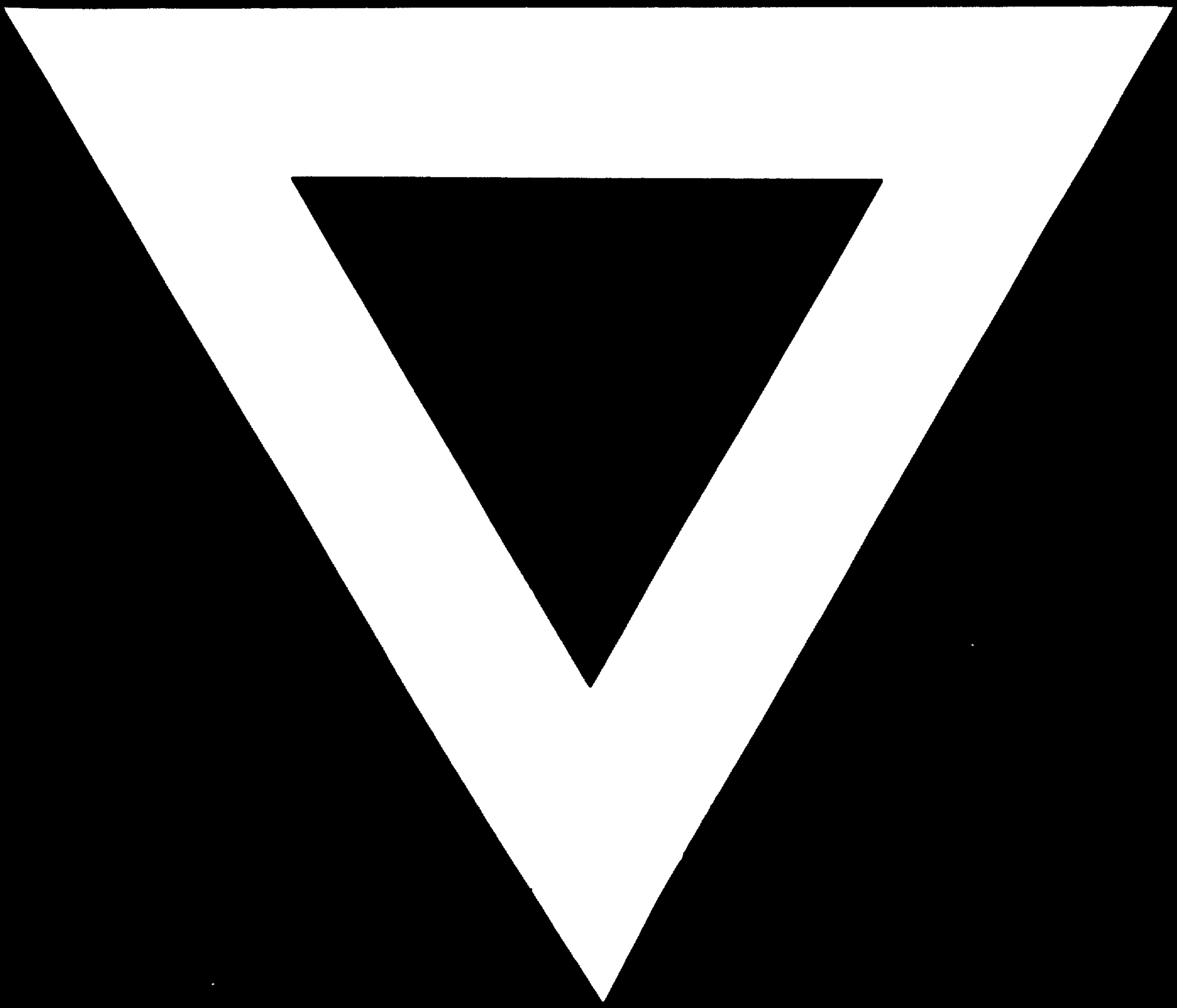


Figure 9



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