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PROJECT AND RESULTS FOR 500 MTPD UREA PLANT REVAMP

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SUMMARY

This paper gives a description of a revamp project carried out in the Urea plant of FESA-FERTILIZANTES ESPANOLES, S.A. at Palos de la Frontera - Huelva - which included:

a) Increased capacity of 750 MTDP

b) Reduced energy consumption, mainly to reduce steam consumption to about 54%

c) Improved product quality

This paper presents the key points for the project development in:

. Project feasability

. Decision for revamp

. Basic and detail engineering

. Planning and development of erection works

. Pipe tie-ins

. DCS installation and operation

. Commissioning of the revamped plant

. Report of results for 1989 and 1990

REASONS FOR THE REVAMPING AND FEASIBILITY

Our urea plant is located in Palos de la Frontera - Huelva. Constructed during 1973/74 and started in 1975.

It was designed by Toyo Engineering Corporation (TEC), incorporating "The Total Recycle C Improved Process", with a capacity of 500 MTPD.

In 1980, with the addition of a CO_2 reciprocating compressor and of another reboiler for the high pressure descomposer, we reached a production of 600 MTPD under steady conditions.

However, it was clear that steam consumption and ever increasing production costs had led to the situation where this plant was becoming obsolete and losing competitive edge in the market.

For this reason, in 1985, before the restructuring of the fertilizer sector in Spain, diverse studies were made about the possibility of carrying out a revamping of this plant which would place it in a competitive position in the European scene of the manufacture of urea. These studies were:

. The initial study for revamping of the Urea Plant.
Carried out by "Tecnicas Reunidas, S.A." (TR) and TEC in March 85.

. Test run in August 1985 in the presence of technicians from TEC to check the viability of the revamping

. Revision of the preliminary study by TEC and TR.

These investigations, together with a visit made to the revamped plant from the process "Total Recycle C Improved" to the new ACES of the KOREAN FERTILIZER COMPANY (KFC) in ULSAN (Korea), confirmed the technical feasibility of carrying out a revamping of the urea plant to a much more attractive unit in terms of energy consumption and production.

DECISION FOR THE REVAMPING

With this background, the general view of the urea market in Spain, and the manufacturing role of the National Plan of Reconversion of Fertilizers, it was decided, after carrying out the necessary economic studies which showed sufficient profitability, to undertake a revamping of this urea plant with the following objectives:

. Increase the production of the plant to 750 MT/D
. Reduce the steam consumption from 1,29 MT of steam/MT of urea to at least 0,7 MT/MT
. Improve the quality of the urea product

These were the parameters which the revamped urea plant had to achieve:

Performance Figures

Production Capacity	
Urea Product	750 metric tons per day
Product Quality	
Nitrogen content	46,4% by wt. min.
Moisture content	0,3% by wt. max.
Biuret content	1,0% by wt. max.
Size 1-2,38 mm.	95 by wt. min.
Consumption of Raw Materials and Utilities	
	Per metric ton of Product Urea
Liquid Ammonia (100% NH_3 basis)	0,58 metric tons max.
Steam at 38 Kg/cm^{2}G and 330°C (except for space heating service)	0,64 metric tons max.
Steam at 38 Kg/cm^{2}G and 330°C (except for space heating service)	0,64 metric tons max.
Electric Power (Excluding for lighting, instrument, ventilation, air conditioning service, cooling water facility and CO_2 compression system)	45 kwh max

The "Kickoff meeting for the Urea Plant revamping in Huelva (SPAIN)" took place with the presence of TR, TEC and FESA on April 2-4.

BASIC AND DETAILED ENGINEERING

The basic engineering for the revamping was given to TEC, licensee in the operation process, and who had developed the process ACES for the urea synthesis. This process with the incorporation, among other concepts, of a high pressure stripper, gives the above figures.

The contract for the supply of the basic engineering was signed on 12th April 1986.

The information which TEC delivered in the Basic Design Packages (BDP) was supplied on the following dates:

. 1st BDP	delivery date	May 17th 1986
. 2nd BDP	delivery date	Jun 20th 1986
. 3rd BDP	delivery date	July 20th 1986

The checking by TEC of the vendors drawings of the critical equipment was also included in the score of work for TEC:

. Reactor	U-DC-1001
. Scrubber	U-DA-1002
. Stripper	U-DA-1001
. Carbamate condensers	U-EA-1001 N° 1 and 2

The detailed engineering, purchase negotiations, inspection and activation of supply, as well as the supervision of the construction and technical assistance for the starting up of the plant was contracted to "Tecnicas Reunidas, S.A." on the 25/4/86.

The revamping of some of the sections which were not included in the scope of work of TEC, above all the section of CO_2 compression, was also included in the supply of TR.

The period for detailed engineering and mechanical construction was fixed at 22 months, although the final connections and the starting up of the installations had to be carried out at a date which was compatible with the programme of fabrication of urea for the year 1988 (Figure 1). For this reason, the final works were carried out from the 17th of July to the 2nd of September 1988 and the start-up of the plant began on 24th of September, together with the final works for the revamping of the ammonia plant and its start-up, which was carried out parallel to that of the urea plant.

CHANGES CARRIED OUT

In Figure 2, a block diagram for urea plant shows the sections that remain intact, the new sections, and those that need changes.

The most significant changes in the urea plant that were introduced by this project were the following (Figure 3):

. CO2 compression section

The centrifugal booster compressor's prime mover was changed from steam turbine to electric motor, adding a speed increaser between them.

The condensate separators of the different stages of compression were checked and some of them were modified.

. The low pressure barrel of one of the reciprocating compressors was also modified.

. With the modification performed in this section, the capacity of compression was increased from 10400 Nm^3/h of CO_2 saturated at 40° C with a final discharge pressure of 260 kg/cm^2q to 13000 Nm^3/h with a final discharge pressure of 185 kg/cm^2q.

. One of the compressor's inter-cooler was replaced too.

. The oil separator in the CO_2 discharge line to the synthesis section was also changed.

. Synthesis section.

This was the most strongly affected by the revamping. The old reactor was substituted by the new ACES system, which works at a lower pressure, incorporating a high pressure of composition and heat recovery equipments. This new synthesis section the diagram of which is shown in Figure 4, is essentially composed of:

- Reactor
- Stripper
- Two carbamate condensers
- Scrubber

The CO_2 is introduced at the bottom of the stripper and with the addition of heat, decomposes part of the carbamate of the solution coming from the reactor. The gases from the stripper's head, are sent to the two carbamate condensers.

The recycle solution is sent to the carbamate condensers, the stream which goes to one of them, previously washes the outgoing gases from the reactor.

The streams of the recycle solution and the outlet gases from the stripper are joined in the carbamate condensers, which once condensed in this equipment, go to the synthesis reactor where they join the feeding ammonia stream.

The synthesis reaction takes place in the reactor and the liquid part, which flows to the CO_2 stripper, is separated from the unreacted gases which go to the scrubber.

Part of these gases are condensed in the scrubber and the rest are sent to the absorption section.

The outlet liquid stream from the reactor goes to the stripper where it undergoes a first descomposition and afterwards flows to the descomposition section.

All the high pressure equipments and others auxiliairies are located in a support structure of considerable height (70 meters) and it has a foundation of 13,6 m x 13,6 m. with pillate in a rectangle of 9 x 6 m.

This structure is placed next to the old reactor and the decomposition and absorption sections. This layout, away from the existing urea plant, allowed sufficient space for the erection works without interfering in the normal process of manufacture.

. Concentration section

A new vacuum concentrator was installed with its auxiliary equipment

. Heater

. Vacuum generating ejector

. Surface condenser

. Urea solution pumps

The diagram of these sections is shown in Figure 5.

. Prilling section

The prilling tower remained with the same height and the cooling air induced in it was increased with the installation of two new fans.

Acoustic granulators were installed instead of the gravity showers for the formation of the prills.

The air to the atmosphere scrubbing system was notably improved, adding a mesh ring-bed before the induced air fans.

. Other sections

Keeping in the modified plant the same volume of ammonia in the recovery system purge, as it has before the revamping, in spite of the introduction of a greater inert gas volume, together with the existing, a new recovery absorber was added.

The capacity of the urea solution tanks were increased as the original ones were insufficient to satisfy the new demand.

In the high pressure pump section, which feeds the recycle solution and ammonia to the reactor, the recycling solutions pumps were modified and their motors were changed, using those of the ammonia pumps. The ammonia pump motors were changed 380 V instead of 6300 V. In order to regulate the quantity of ammonia sent to the reactor, a speed variator was installed in one of the high pressure ammonia pump.

PLANNING AND DEVELOPMENT OF ERECTION WORKS

The project for the revamping of the urea plant started with an initial programme of 22 months, from the signing of the detailed engineering contract to the mechanical completion with the special consideration that the final connections between the old plant and th enew equipment should be carried out in a period in which it was possible to meet the commitments of the urea market demand. On these bases, the development of the execution of the plan showed the following dates of executions:

May 1987	The civil work for the structure of the ACES system began: (Elev. 24 m).
September 1987	The erection the metallic structure for the ACES system began: (from Elev. 24).
January 1988	The installation of the equipment and pipes began.
Jan. 1988 - June 1988	The installation of the equipments, piping, electricity and instrumentation were carried out.
June 1988 - 15 July 1988	While we were waiting the general shut down to make the connections, in the meantime, we carried on the final works and hydraulic tests.

For marketing reasons, the shut-down of the urea plant and the corresponding shut-down of the ammonia plant were made at the same time. This gave extra time for the final works of revamping of the urea plant which could have been carried out in a period of 20 or 30 days.

Nevertheless, as we did these works, parallel to the final connection works for the revamping of the ammonia plant, 42 days were given for the final works of both. In September 1988, the final arrangements for the start-up of the urea plant were concluded while the ammonia plant was being started.

On September the 24th, we began the start-up of the urea plant.

PIPE TIE-INS

As a curiosity about 260 weldings were done joining the existing lines to new ones, the greater part of them were done in the final period of the plant shut-down. The steam tracing is not included in this figure.

DCS INSTALLATION AND OPERATION

Besides the installing of a new synthesis system for the manufacture of urea, the ACES system and the other complementary process systems which were modified, another important innovation was done in the overall revamping of the urea plant. It was the transformation of the traditional pneumatic control system for an electronic distributed control system (DCS).

The new signal transmitters are electronic. However, the existing pneumatics in the instruments that remained in operation have been maintained. The control valves are also still pneumatically activated. For this reason, we had to install I/P converters to connect these elements to the new D.C.S. For the interlocking system and the emergency shut-down, the electric system which originally existed in the plant has been kept.

The control room, where the pneumatic control panel was located, was dismantled.

The panel operator passed to the control room of the ammonia plant, where two operating stations were placed for process control of the fabrication. This control room is located at a short distance from the urea plant ; the old control room was placed practically in the centre of gravity of the urea plant.

All this change meant an additional effort in the starting up from the point of view of control as the operators had not any experience in this type of operative system. Besides we had to assimilate the peculiarities which the gravity flow of the urea and carbamate solutions present in the new synthesis system.

Also the change in the location of the control room, at a longer distance now from the urea plant, added a slight difficulty for the human team who operated the urea plant.

The operation of this system to control the manufacturing process has proved to be sufficient and certainly more precise than the original.

PREPARATION AND START-UP OF THE REVAMPED PLANT

During the first days of September 1988, we began the pre-commissioning of the plant with our attention on the ACES system, especially to the level transmitters of the synthesis reactor and the CO_2 stripper. The internals of these equipments were also carefully inspected.

Using water instead of urea solution, we tested the gravity flow of the ACES system. All foremen and panel operators were trained in this operation.

On September the 24th, we began the commissioning of the plant. Once the initial problems of the start-up were overcome, the plant reached steady operating conditions early in November, together with the ammonia plant, where we performed another revamp. During that period, there was a power failure that forced both plants to shut-down.

During the months of November and December and with the plant running quie steadily, small mismatches were solved and the operation of the plant was made more and more reliable and safe. Although on some occasions, the synthesis section has had to be drained. Only one carbamate condenser was opened until the end of May 1990 to change the gasket of one channel. It was not necessary to open the CO_2 stripper for cleaning, which was one of the problems that we were concerned about.

The urea plant, once revamped, did not have a general shut-down until the month of June 1990.

THE COST OF THE PROJECT

Trying to keep the cost to a minimum, we took advantage of the existing equipments and pipes, that's why some of them were used in different places, as we already mentioned with the motors for the high pressure recycle solution pumps. For the same reason, the reboiler of the high pressure decomposer with minor modifications, is used as an evaporator in the concentration section.

The total cost of the project reached 1093 m.Pts between 1986 to 1989 during which the payments of the investment have been made.

	Approx. cost m. Pts	% of the total investment
. Pressure vessels and high pressure heat exchangers (reactor, stripper, carbamate condensers, scrubber and oil filter)	345	31,4
. Structure of ACES system	62	5,7
. Mechanical assembly	100	9,2
. Prilling tower (granulators, packing and fans)	36	3,3
. Electricity and instrumentation (including erection)	70	6,4
. Engineering and supervision of construction	166	15,2

SUMMARY OF THE RESULTS

The following results show the differences between the real operation of the plant before and after the revamping:

BEFORE REVAMPING

PERIOD	PRODUCTION (TM)	STEAM (MT/MT)	SPECIFIC CONSUMPTIONS AMMONIA (MT/MT)	ELECTRICITY (KWH/MT)	C.W. (M3/MT)
Jan.- June 88	94.326	1,249	0,605	117	88
		AFTER REVAMPING			
Oct. - Dec. 88	49.306	0.854	0.593	146	80
Jan.- Dec. 89	230.935	0.759	0.592	141	78
Jan.- April 90	86.123	0.699	0.590	133	68

Electric consumption include power for CO_2 compressors and plant lighting.

As mentioned before, during November 1988, the plant reached steady operating conditions and was running for 679 hours, but had to shut down due to a failure in ammonia plant. In December, the plant was in operation for 28 days, and it took 3 days to repair the leakage in a carbamate condenser.

The following figures give an idea of the operation of the plant in 1989:

Working hours of the plant	7.720
Shut-down hours due to external causes	636 (26.5 days)
Shut-down hours due to internal causes	404 (16.8 days)
No. of shut-downs draining liquids from the plant	4
. For outside reasons	2
. Due to the urea plant	2
Maximum daily production	762 MT.

Regarding the quality of urea, it has satisfactorily reached the values demanded. The principal difference with the product before the revamping is that we have obtained a more uniform distribution of size and a greater hardness of grain.

CONCLUSIONS

The target of improving the quality of the urea product with respect to the size distribution and in hardness, has been satisfactorily reached.

The normal capacity of the plant was reached.

Under continuous and steady operating conditions, we obtained a reduction in the steam specific consumption which reached 0,7 MT/MT.

The data of the specific consumption mentioned in the above paragraph include shut-downs and start-up. To be able to compare these values with those of the design, which were drived from the guarantee tests with the plant operating steadily, the negative influence of the start-ups and shut-downs of the plant must be considered.

From the operating point of view, the urea plant has gained a lot in stability. The medium and low pressure, decomposition and absorption sections, have reduced their charges.

The electronic distributed control has shown itself to be completely operative and more precise than traditional pneumatic control.

The prilling tower which needed frequent shut-downs (4 hours every 15 days) to clean the accumulation of dust in the communication become more stable and would not need programmed shut-downs.

This article is intended to give a general view of the development of the project for the revamping of the urea plant in Palos de la Frontera (Huelva) and the results obtained during its first and a half years in operation.

FIG – 1

PROJECT SCHEDULE

FESA FERTILIZANTES ESPAÑOLES S.A. — HUELVA

UREA PLANT REVAMP — START: MARCH 1986

KEY

R REQUISITION — CONSTRUCTION

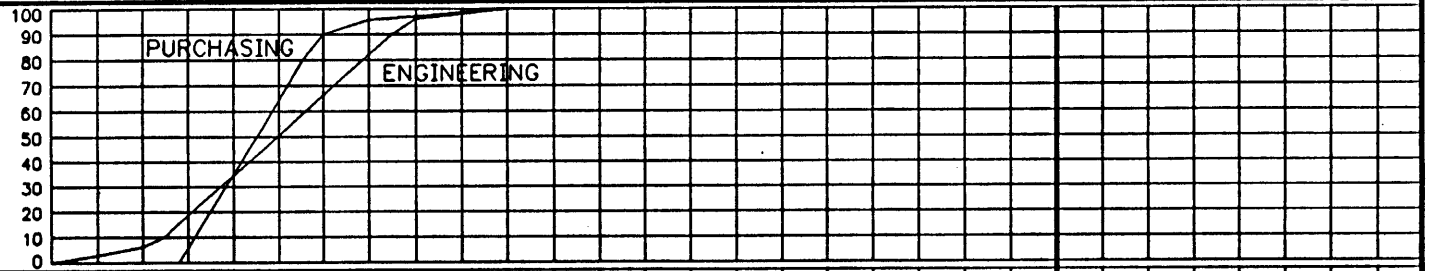
▲ PURCHASE ORDER

Ⓥ VENDOR'S DRAWINGS

••• DELIVERY AT THE PLANT SITE

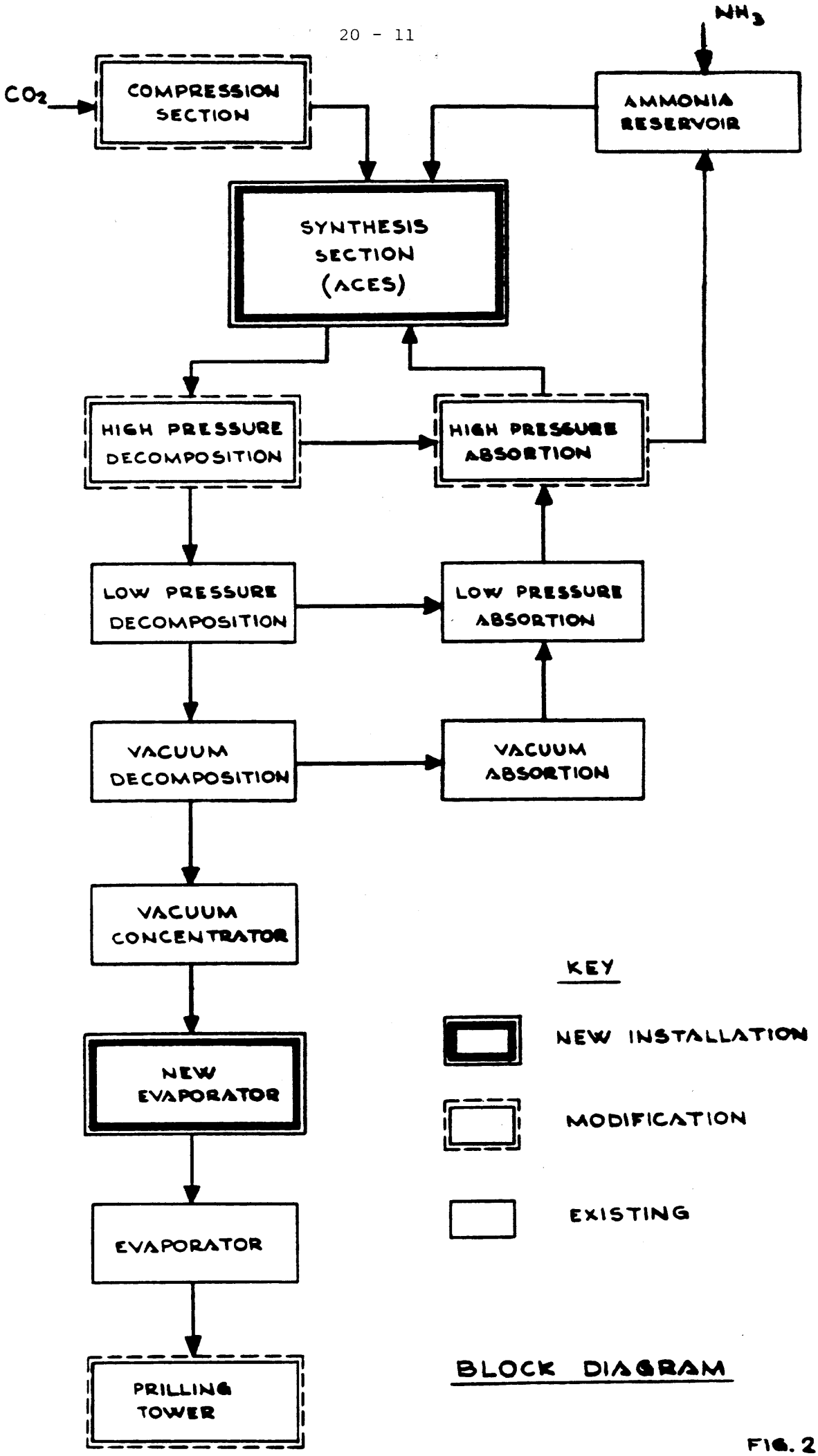
NOTES:

a) Initially the plant shut–down has been foreseed in the month n° 22. The final date will be scheduled in acordance whith the market expectations.



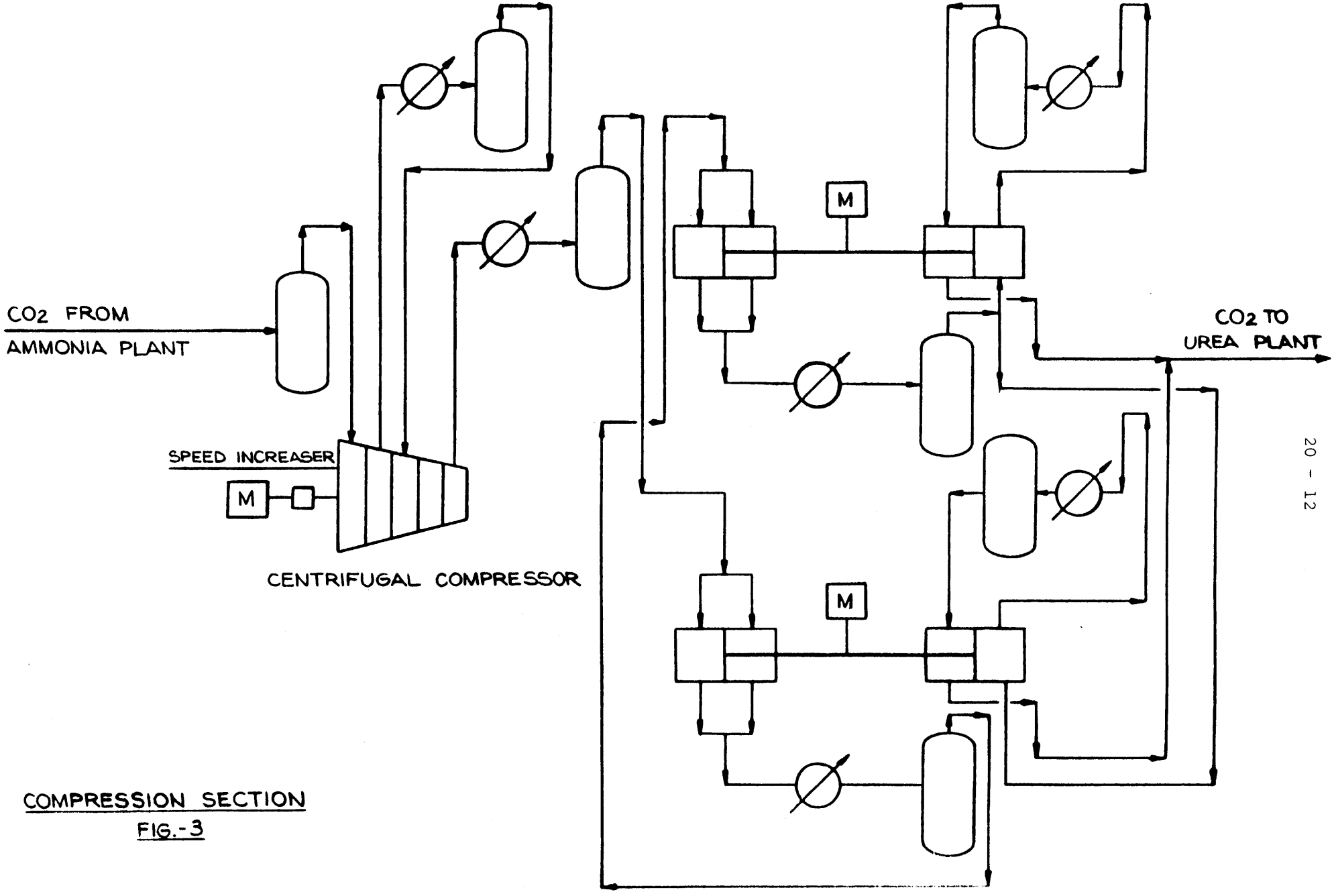
	ACTIVITY	MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
DESIGN & TECHNICAL OFFICE ENGINEERING	BASIC INFORMATION																															
	CRITICAL EQUIPIMENT INFORMATION																															
	PROCESS DIAGRAMS																															
	MECHANICAL ENGINEERING																															
	COMPRESSORS SURVEY																															
	PLOT PLANT																															
	PIPE DISTRIBUTION DRAWINGS																															
	PIPE ISOMETRICS																															
	ELECTRICAL DRAWINGS																															
	CIVIL DRAWINGS																															
	TOWER AND VESSEL'S DRAWINGS																															
PURCHASING, DELIVERY & ERECTION	STRIPPER				R	▲	Ⓥ												•••													
	REACTOR				R	▲	Ⓥ												•••													
	CARBAMATE CONDENSERS				R	▲				Ⓥ								•••														
	EJECTOR				R		▲			Ⓥ					•••																	
	VESSELS					R		R	▲	▲	Ⓥ				•••	•••																
	RECYCLE SOLUTION PUMP			R			▲		Ⓥ							•••																
	ANOTHER EQUIPMENTS			R		R	▲		▲		Ⓥ			•••	•••	•••																
	PIPE AND FITTINGS						R			▲		▲			•••	•••	•••															
	ELECTRICAL MATERIAL					R			▲			▲			•••	•••	•••															
	INSTRUMENTS					R		R	▲			▲				•••	•••															
	CIVIL WORK																															
	METALLIC STRUCTURE																															
	EQUIPMENT ASSEMBLY																															
	PIPE ERECTION																															
	ELECTRICAL WORK																															
	INSTRUMENTS ASSEMBLY																															
	INSULATION																															
	PAINT																															

MECHANICAL COMPLETION

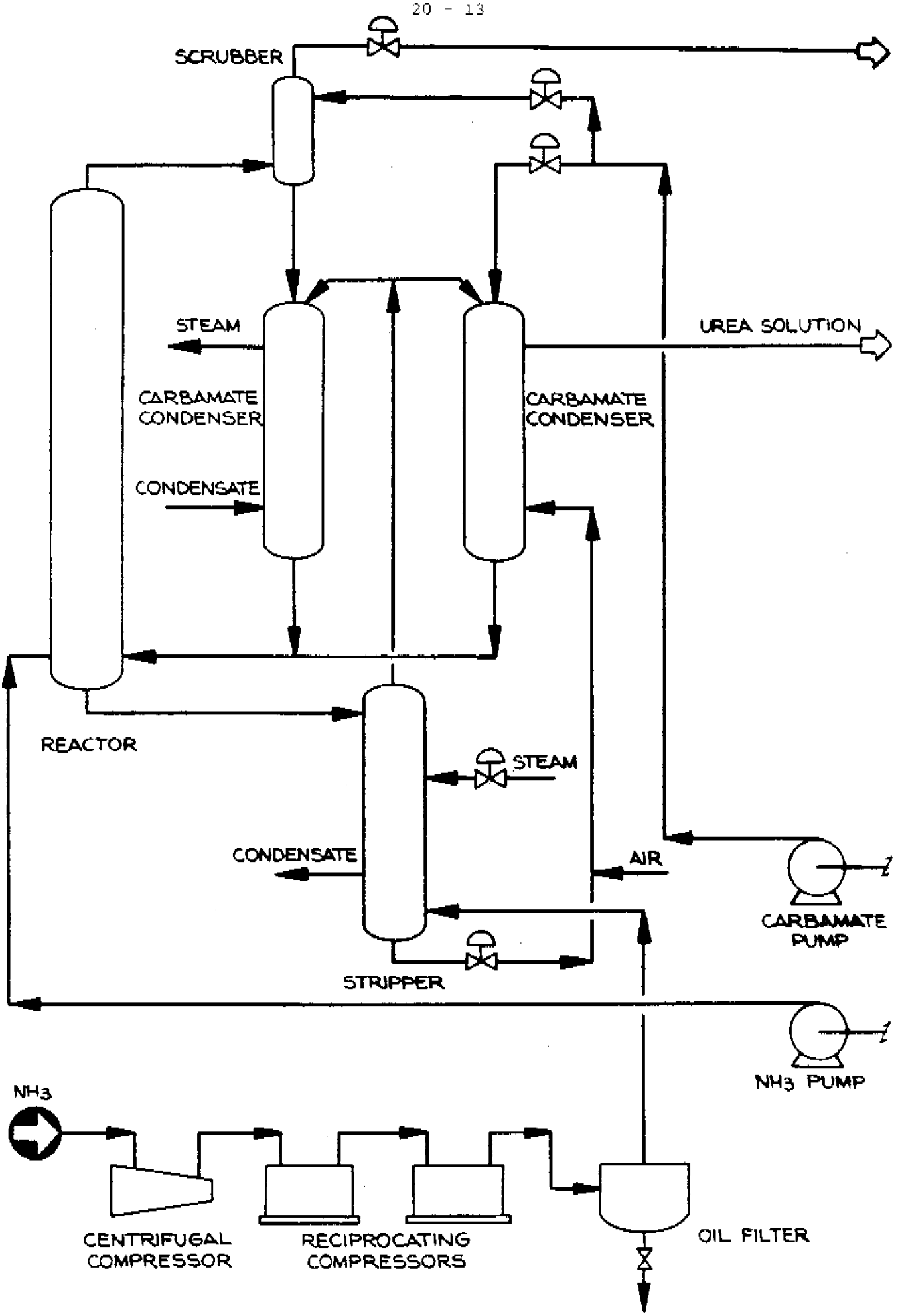


BLOCK DIAGRAM

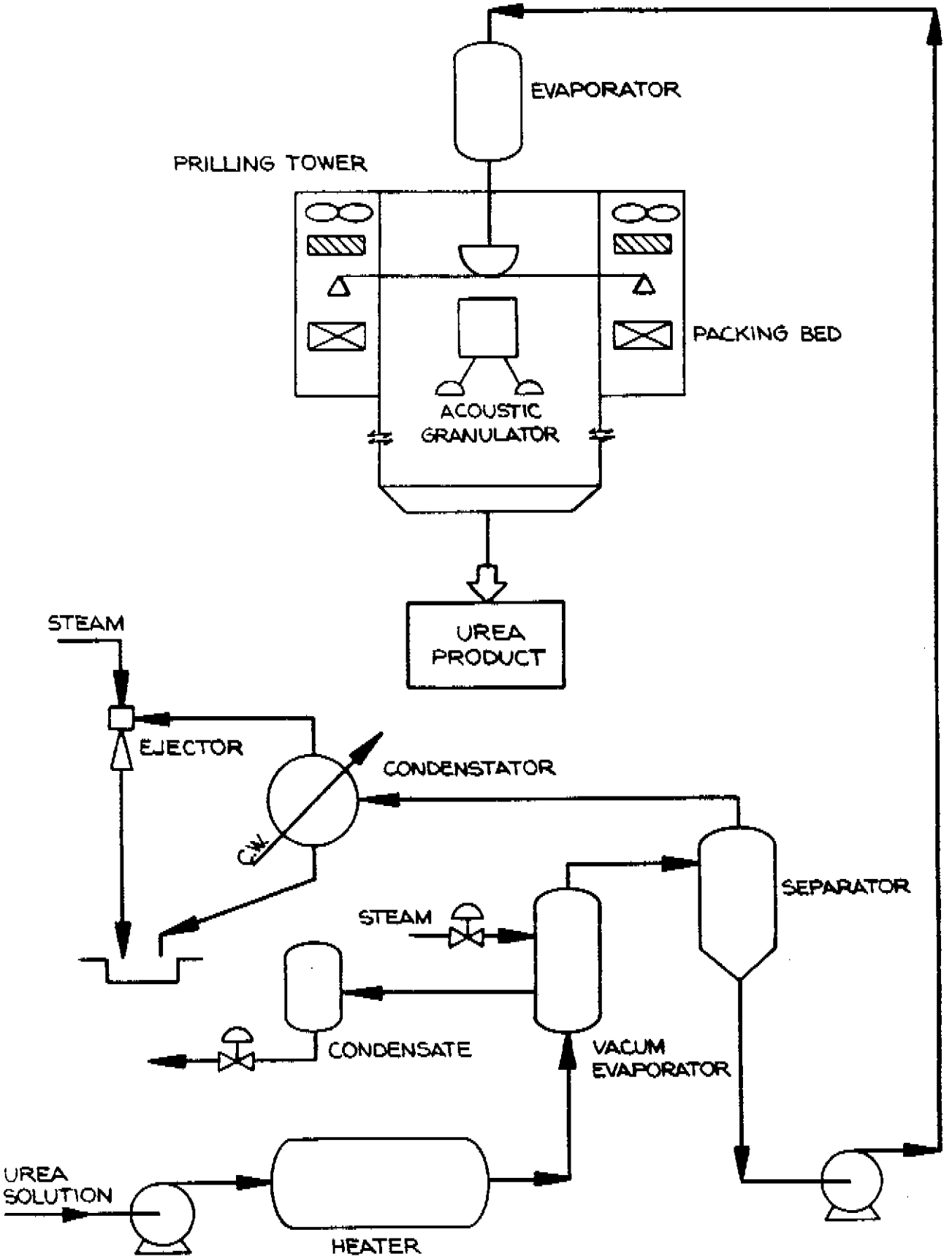
FIG. 2



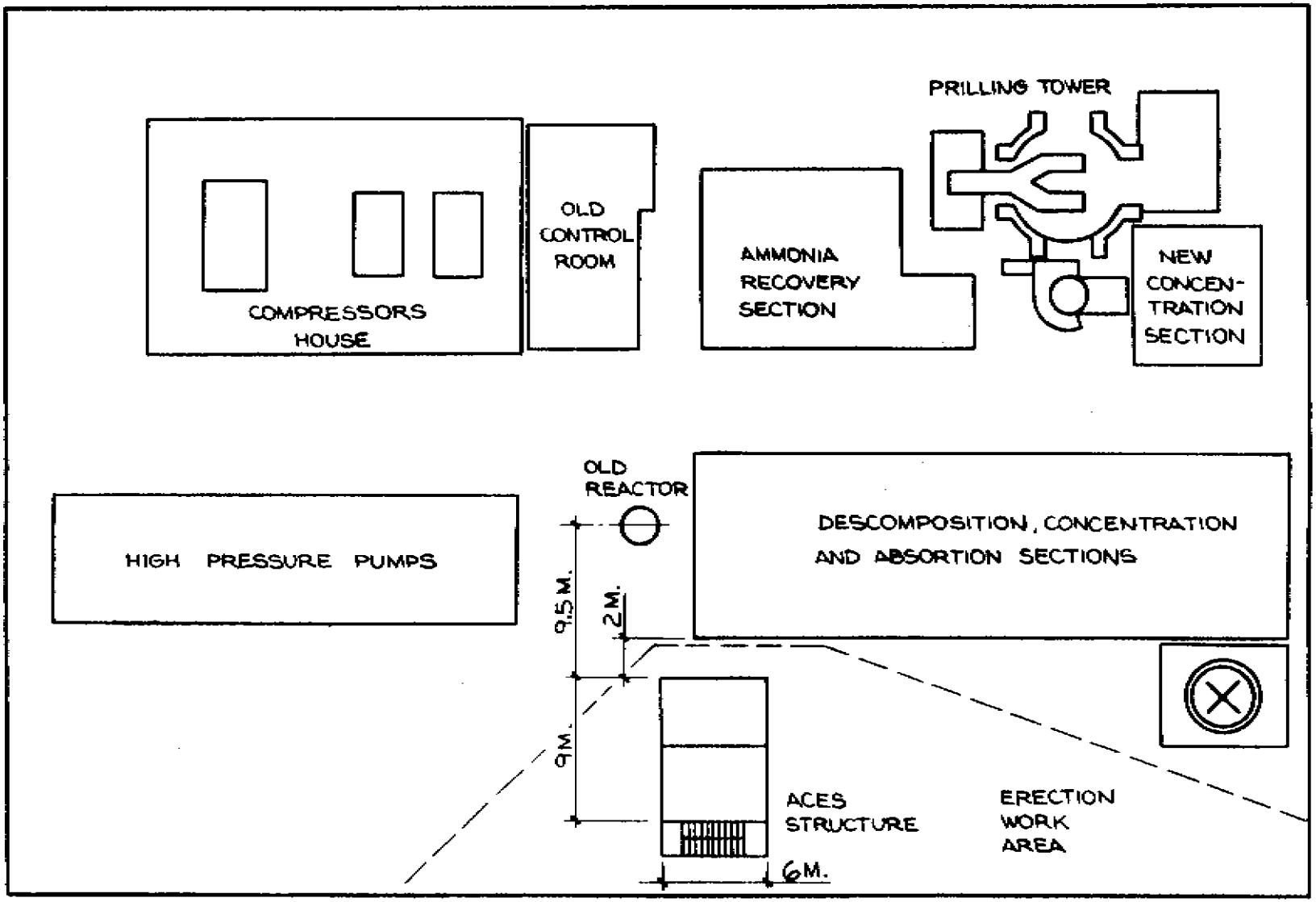
COMPRESSION SECTION
FIG.-3



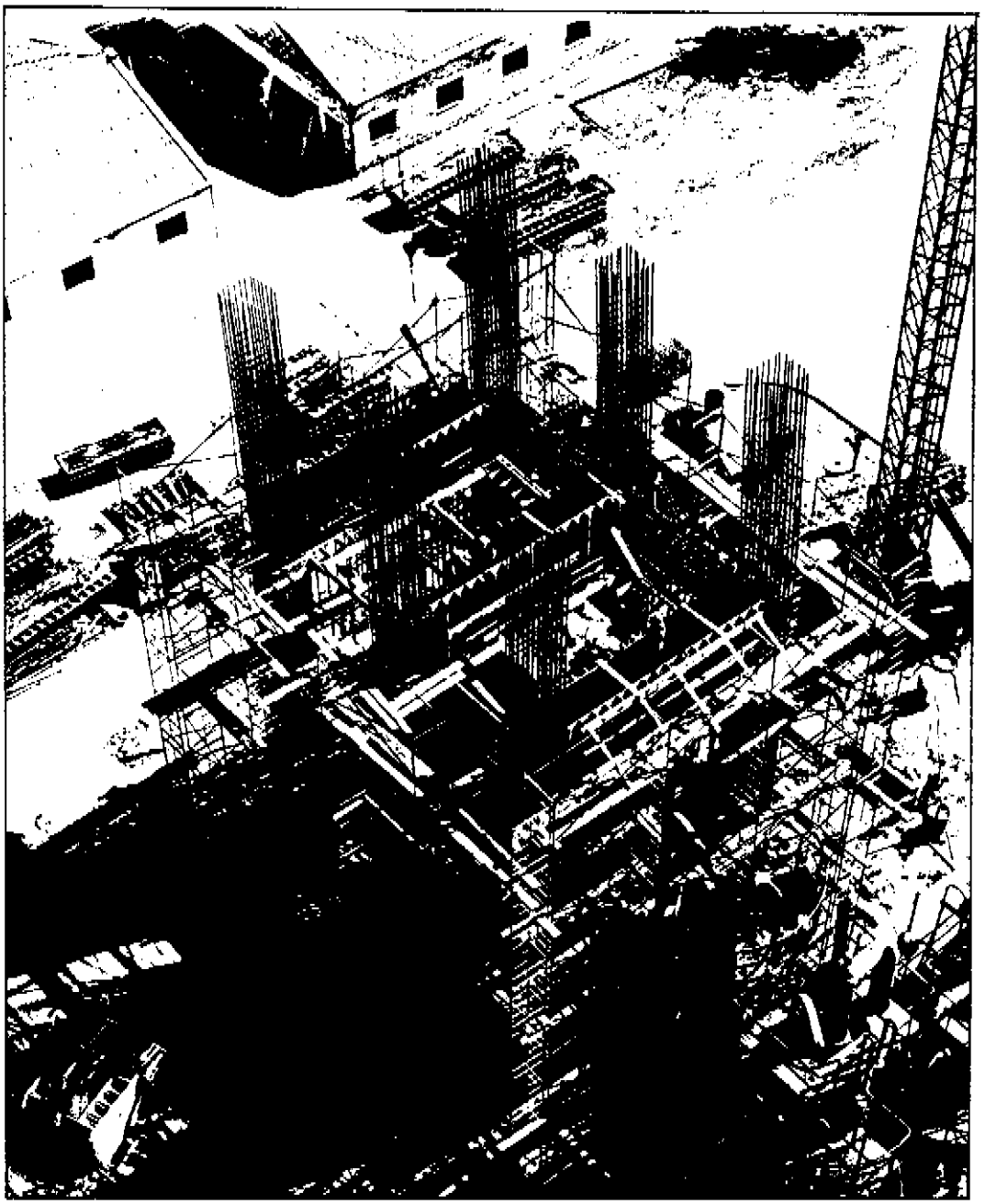
SKETCH FOR ACES AND FEED SYSTEMS FIG.-4



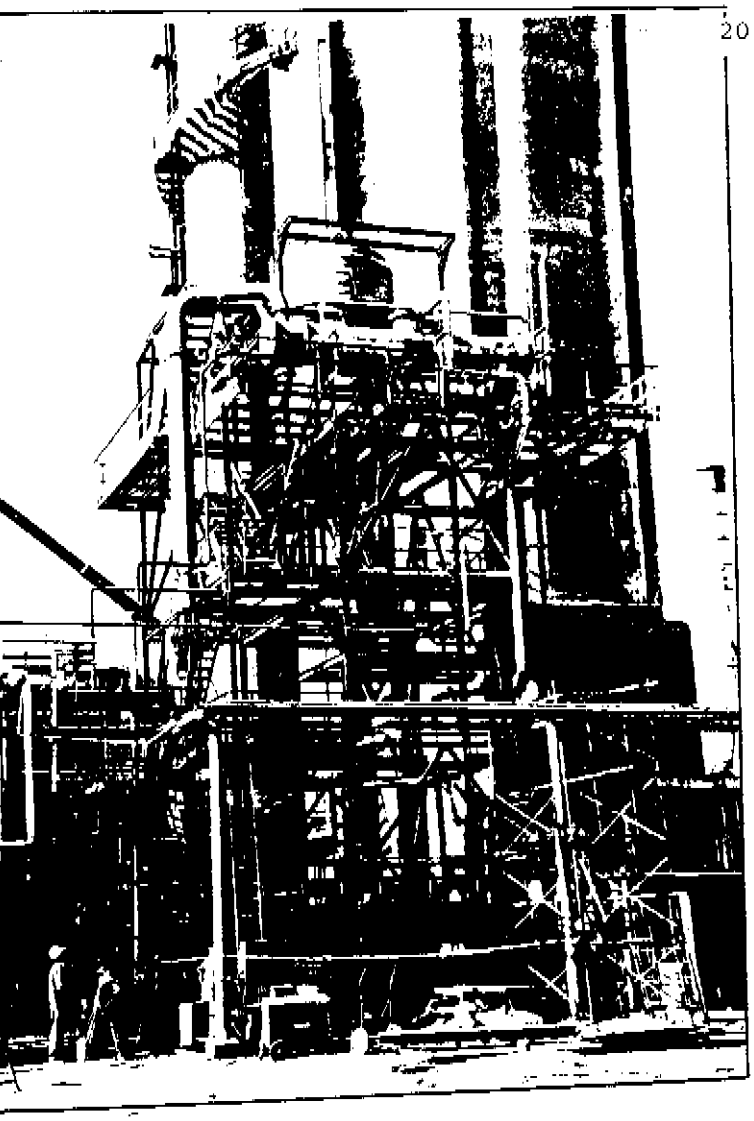
SKETCH FOR NEW
EVAPORATOR AND PRILLING FIG. - 5



SIMPLIFIED PLONT PLAN FIG.- 6

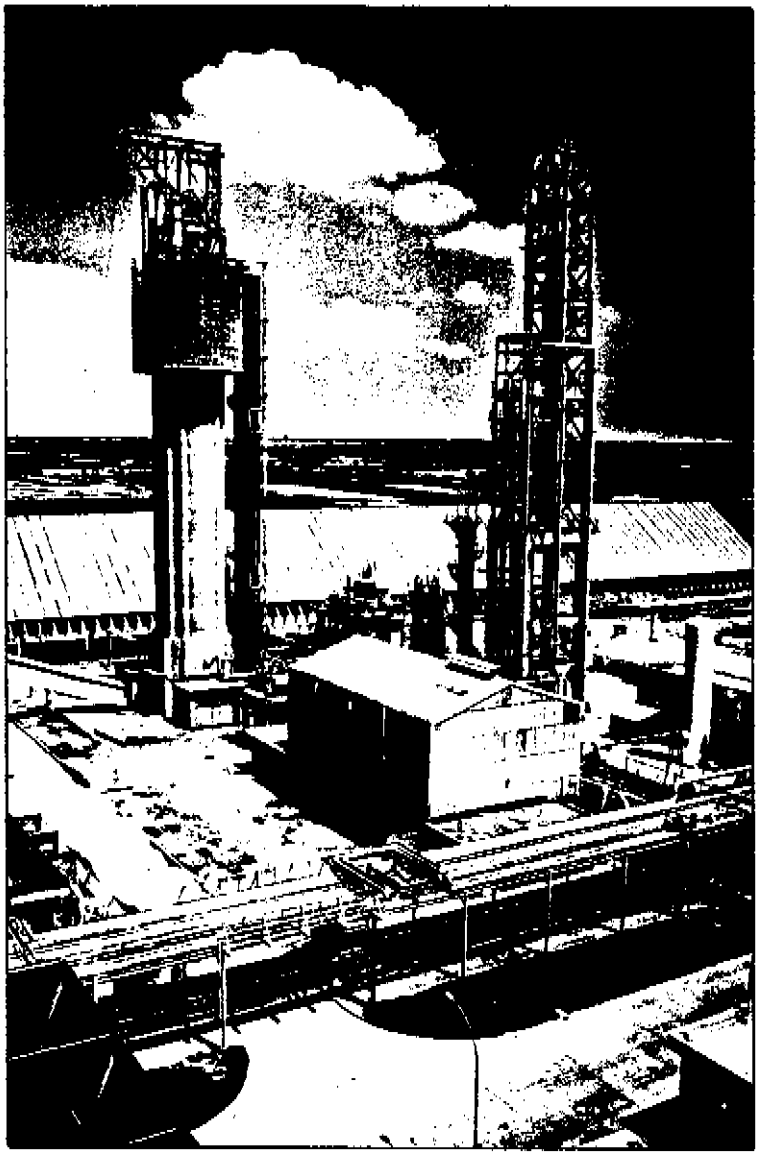


ACES STRUCTURE UNDER CONSTRUCTION



NEW CONCENTRATION SECTION

OVERVIEW OF ACES STRUCTURE AND REACTOR



OVERVIEW OF UREA PLANT