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LARGE-CAPACITY PLANTS FOR THE PRODUCTION OF GRANULATED AMMONIUM NITRATE[1]

by

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CONTENT

INTRODUCTION

The Soviet Union is known to be a pioneer out of the most industrialized countries throughout the world in a large-scale ammonium nitrate production used by agriculture as a fertiliser.

The problem of development and rapid commercialization of modern plants based on progressive technology, has arisen due to an extensive program, scheduled in the USSR for the seventies, of nitrogen fertilizer production necessitating considerable expansion of existing and construction of new plants.

A process and new equipment designs for high quality granulated ammonium nitrate production in 1400 tons daily capacity plants have been developed in State Scientific Research and Design Institute of Nitrogen Industry within the last three years on the basis of the experience accumulated in relation to the designing, engineering and operation as well as on the basis of comprehensive analysis of physical-chemical regularities of the process and selection of the most optimum conditions of its implementation.

The aims and purposes put forward when designing and engineering this plant, in brief, boil down to the following:

1. Firstly, providing the possibility to cut down capital investments and operation costs compared to the best analogous projects submitted carlier as well as the possibility of the project realization within the shortest period of time.

2. Solution of this complicated problem was considered to be inseparable from the task of providing conditions for turning out cheap, high quality product, which propertywise is not inferior to the best Soviet and foreign specimens.

3. It was also equally important, when designing and engineering a large plant, to solve the problem of boosting labor productivity of the personnel operating this plant.

4. We felt obligatory to carry out designing and engineering with due consideration to the best known achievements of Soviet and foreign experience.

5. Lastly, we set up a task to eliminate from granulated ammonium nitrate technology all the drawbacks and defects built up during past decades; since these being earlier tolerable in relatively small units, can not be tolerated in the case of operation of large plants.

Among these are:

a) Air and water pollution with harmful industrial effluents.

b) processing of various industrial wastes from adjacent units into ammonium nitrate.

c) Property instability of initial raw materials.

d) Widely established practice of duplicating equipment as stand-by.

The basic and the most rational ways and means for achieving the aims and goals mentioned above are as follows:

1. Limitation in the selection of initial raw materials, orientation on normal operating conditions of the plant as well as continuous supply of ammonia and nitric acid with pre-set parameters.

2. All-round simplification of the process line and apparatuses aimed at minimizing a number of technological operations and communications from the beginning to the very end of production cycle.

3. Equipment scaling-up.

4. Intensification.

5. Search for technical decisions preventing from water and air pollution with harmful industrial effluents.

6. Rational equipment layout in the buildings.

7. Automation of control and regulation of the basic processes in the plant.

BRIEF CHARACTERISTICS OF BASIC TECHNICAL DECISIONS ADOPTED IN THE COURSE OF DESIGNING PROCESS EQUIPMENT OF A LARGE PLANT.

Single capacity of a large plant

put forward in the project is to be 1400 tons per 24 hours in round figures (or to be more exact-1363 tons per 24 hours) or 450 thousand tons a year with the operation period equal to 330 days.

Table I

Capacity per stream (in tons per 24 hours) at existing plants in the USSR, and as offerred by foreign companies.

1. Plants operating in the USSR (typical project in 1964)	425 -570
Foreign companies	
2. Kaltenbac France	600
3. Kaltenbac, Plant in Pulavi (Poland)	1200
4. C.J.B. Ltd., England	500
5. Foster Wheeler (USA)	676
6. Chemico (USA)	1800
7. C&I Girdler (USA)	1500
8. Continental Engineering (Holland)	1060
9. ICI (England)	1050

As seen from the above data the accepted capacity of a large plant is in compliance with modern technological level.

2. Process flowsheet

Neutralization process is carried out at atmospheric pressure (1,05 atm.abs.) through the interaction of preheated 50-60% nitric acid (up to 80°C) and gaseous ammonia (up to 120°C). 95%-96% solution of NH_4NO_3 obtained is evaporated in a film massexchange evaporator. The melt with 99,8-99,9% concentration is then filtered and goes to prilling in a granulation tower, where it is converted into a granulated product through air cooling. The latter is then additionally cooled down to 40-45°C in the fluidized bed apparatus occupying the whole cross section of the tower bottom, and conveyed to bagging section. In order to improve the finished product quality, it is treated with a special composition (disperser) prior to packing in polyethylene bags.

Exhaust air, leaving the tower and the evaporator is purified from ammonium nitrate particles before discharging into atmosphere. Control and regulation of the basic process parameters are automated.

3. Specific features of the process line and the quipment concerned

All the main assemblies of the process system have been revised in order to obtain maximum simplification and optimization, Designing of new non-typical equipment was aimed at developing highly productive process line containing minimum number of monotypic apparatuses and units.

Basic features of the process and equipment developed for a large plant are as follows:

3.1 Only 100% gaseous ammonia and nitric acid with the concetration not below 58% are accepted as initial components for ammonium nitrate process.

Due to stringent limitations in the choice of initial raw materials elimination of a number of process asseblies and units was made possible. Refusal to use dolomite and phosphate additives,since they failed to improve ammonium nitrate quality, has resulted in a further simplification of the process line and the quipment concerned.

It should be noted that all the proposals of foreign companies for the supply of granulated ammonium nitrate plants contemplate only liquid ammonia and nitric acid with the concentration ranging from 54% to 65% as initial raw materials (with the exception of C.J.B.Ltd. using 49% nitric acid).

3.2 Neutralization process proceeds at atmospheric pressure with nitric acid and ammonia being preheated.

A neutralizer with a small reaction volume and intensive natural circulation has been specially designed in order to carry out this process. Juice steam formed in the course of nitric acid neutralization with ammonia is purified at the top of neutralizers from ammonia particles and ammonia nitrate solution droplets. The juice steam is purified down to complete absence of ammonia and ammonium nitrate residual content equal to 50mg/kg

Final evaporation of 95% - 96% ammonium nitrate solution formed in the course the neutralization process, was made possible using only one massexchange evaporator.

3.3 An original design of an evaporator has been developed making it possible to obtain deep solution evaporation to highly concetrated melt with residual humidity equal to 0.1-0.2%

3.4 Granulation section has been designed in a different way, the difference being that all the air fed into the tower, passes through the fluidized bed of cooled down granules placed in the whole tower bottom area. This method makes it possible to achieve uniform air distribution along the tower cross section as well as to reduce cooling degree of granules in flight; for example, instead of 70-80°C in modern towers, the temperature at the end

of flight amounts to 125-130°C.
Their further cooling and recrystallization (i.e. removal of considerable amount of heat approximately 45%) is transferred to a fluidized bed.

With the fluidized bed screen placed under the whole cross section of the tower, air linear velocity in the tower will be equal to the preset velocity of air coming through the screen holes. Linear velocity of the latter depends upon desirable average granule size and granulometric composition of the product. In order to cool down fluidized bed granules with the preset diameter averaging 1.9 mm, this velocity should amount to 1.8 m/sec thus exceeding air velocity in the towers with 16 m. diameter, installed at existing plants, by the factor of 4.3.

Due to more than fourfold increase of linear air velocity in the tower, spraying density has been raised approximately to the same value resulting in a corresponding decrease of the tower cross section as compared with the existing towers.

In order to obtain uniform density when spraying the tower with the melt droplets, stationary, sprinkler-like granulators have been adopted. New, original apparatus design has been developed for cooling and recrystallization of fluidized bed granules permitting to make the most efficient use of specific features of this process.

Intensification of the granulated product manufacturing process makes it possible to cut down expenditures for the construction of the bulkiest and most expensive buildings.

3.5 For the very first time in the Soviet and world-wide practice a technological line for the manufacture of granulated ammonium nitrate has been developed including purification (in a specially designed apparatus) of the air discharged from the granulation tower and massexchange evaporator.

The new system makes it possible to produce granulated ammonium nitrate without air and water pollution as well as to get rid of cooling water consumption.

Therefore, when engineering large plants, expenditures for the construction and operation of water recycle cooling towers and services pipelines, providing water supply for the whole plant as well as for the units for ion exchange purification of juice steam condensate, are no longer necessary.

3.6 The plant is equipped with a specially designed highly efficient machinery making it possible to minimize the number of machines and apparatuses in a plant and to simplify the process line.

The plant comprises the following basic units.

Table 2

Neutralizer	2
Evaporator (Area-700m^2)	1
Granulation tower (12 meters diameter) with a built - in double stage cooler in a fluidised bed	1
Washing scrubber	1
Air fans with the capacity of 30,200 and 500 thousand cubic meters for each item	1

Auxiliary heat exchangers (acid, ammonia and air heaters) for each item 1

Centrifugal pumps-2 for each item unit, second one being standby

Collectors and other auxiliary equipment usually 1 for each item

Total number of process apparatuses, machines and lifting devices amount to 58, including 14-lifting devices, 7 pumps and 18 extremely small apparatuses with the total weight of 2,2 tons (granulators, preneutralizers, hydraulic locks, baths and other equipment).

Stainless steel consumption for the plant amounts to 171 tons (including 161 tons for 6 large units) and 47 tons for valves fittings and piping. Total stainless steel consumption for the plant including exhaust air pipe (29 tons), amounts to 218 tons.

Stainless steel heat exchanger surface (acid heater and evaporator) equals 825 m^2, weight - 43.43 tons.

The number of machines in continuous work is 3 (2 fans and 1 pump). It should be noted that the proposals submitted recently by a number of well known companies (Kaltenbac, C&L Girdler, Chemico and other) do not specify standby basic machinery for large process lines.

<u>4. Equipment layout</u>

Special attention was drawn to the equipment layout in the buildings. Its distinguishing characteristics lie in positioning basic equipment in the shape of a vertical cascade: 2 neutralizers on top and an evaporator (standing almost on the same level), followed by a granulation tower with the fluidized bed apparatus below, terminating in finished product conveyors. Fans and air heaters are located outside.

The plant is designed as one granulation tower capped by a superstructure for the operation staff. This layout makes it possible to eliminate practically all the pumps from the process line. In 1971 we have developed another version of the flowsheet and equipment layout for the pumping of a highly concentrated melt to a separate granulation tower by means of a special pump.

5. Finished product quality

The finished product will consit by 96% (by weight) of 1-3 mm spheroidal granules with the average diameter amounting to 1.9 mm. Fractional screening of this product is not required and this stage is eliminated from the production process. Nitrogen content in the product dry matter is 34,8%, humidity - 0.1.-0.2% (by Fischer); reaction is neutral,weakly alkaline (not more than 0.05% when calculated into NH_3) or weakly acid (not more than 0.02% when calculated into HNO_3); the product is 100% loose, the granules retaining their shape after half year storage in welded polyethylene bags.

Table 3 below indicates that qualitywise the product manufactured in a large plant will not be inferior to the specification for ammonium nitrate made by foreign companies.

	Measure unit	Large capacity plant USSR	Kaltenbac France	CJB England	Foster Wheeler USA	Chemico USA	C&I Girdler USA Belgium	C&I Girdler USA	ICI England
Nitrogen content	%	34.8	34.8	34.8	34.0	33.8	33.5	34.0	34.5
Humidity,% (by Fischer)	%	not more than 0.2	-	-	-	-	-	-	-
Granule size	mm	1-3 Average size 1.9	1-3	1-3	1-3	0.84--4.0	1-3.5	Data is not available	1.2-3.0

Consumption figures

Process losses of raw materials and power consumption are minimized in a large plant. Table given below shows comparative figures relating to the consumption of raw materials and power consumption per ton of finished product calculated as 100% ammonium nitrate (35%N) under normal operation. Comparison is drawn between the characteristics of the Soviet process systems and the systems developed by the foreign companies.

Table 4

	Unit measure	Large plant in the USSR	Operating plants in the USSR	Proposals by the foreign companies							
				Kaltenbac France	CJB England	Foster Wheeler USA	Chemico USA	C&I Girdler USA Belgium	C&I Girdler USA	Continental Engineering Hoàland	ICI England
Gaseous ammonia	kg	213	215–218	–	–	–	–	–	–	–	–
Liquid ammonia	–"–	–	–	218	214	218	218	222	215,6	217	220
Weak nitric acid in (calculated as 100%)	–"–	794	800–808	802	794	808	800	820	794,5	800	812
Electric power	KWh	26,2	10–24	15	14,7	19,6	15,1	1.74	9,8	18	15
Steam	kg	180	300–800	160	150	93	250	516	402	150	500
Water	m^3	0,5	29	13,5	24,2	2,6	data not available	0,5	data not available	23	data not available
concentration of nitric acid used	% by weight	58–60	45–55	55–56	49	65	58	56	57	55	57

7.Operation of the plants.

Simplicity of the process line, powerful, highly efficient equipment, and therefore, small number of the apparatuses and machines in the plant as well as complex automation and rational equipment layout makes it possible to limit operating personnel (only 35-40 people). Under normal operating conditions the plant is attended by 3 people per shift: operator at control pannel and 2 operator - inspectors.

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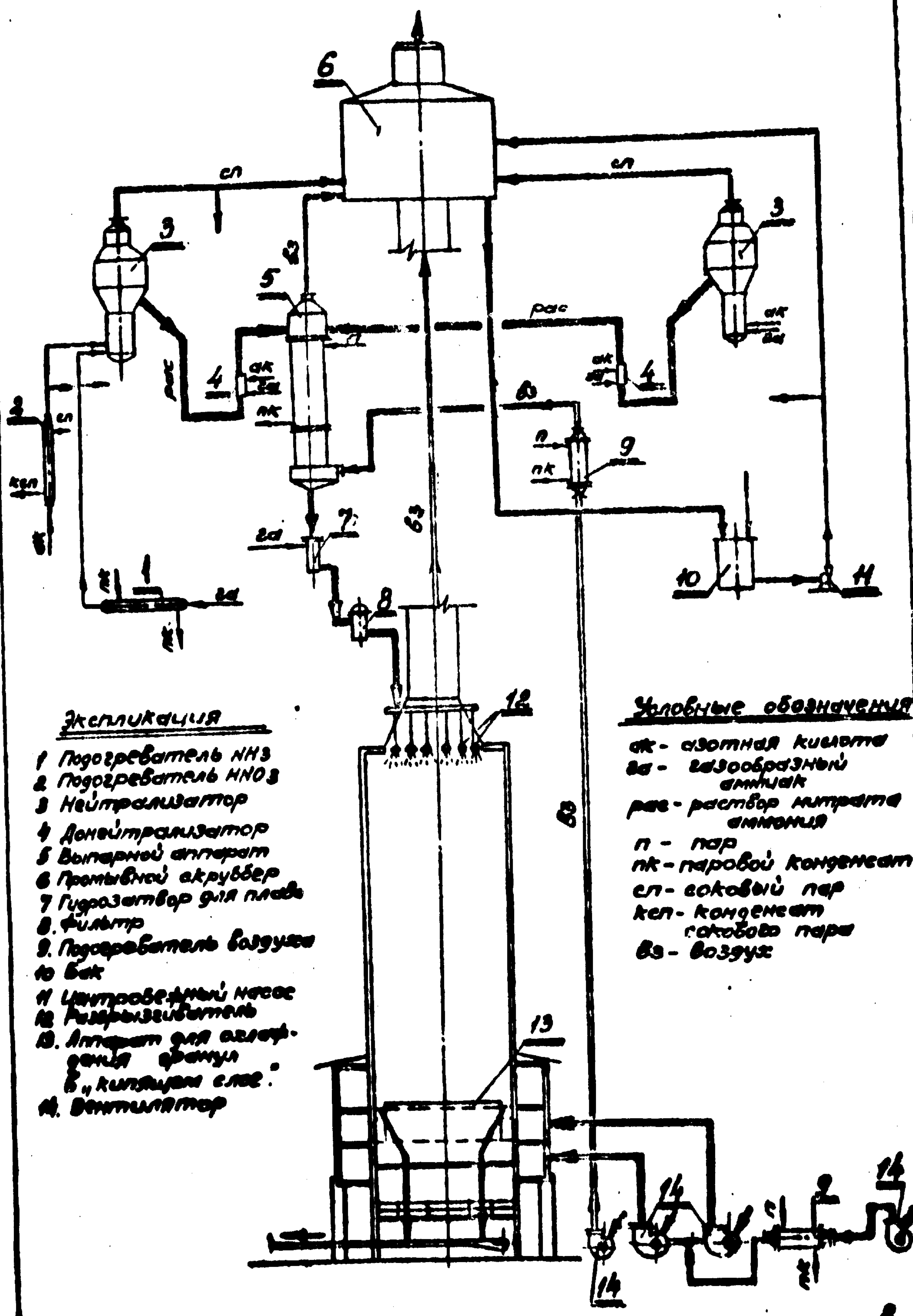
Принципиальная схема производства нитрата аммония в агрегате АС-67



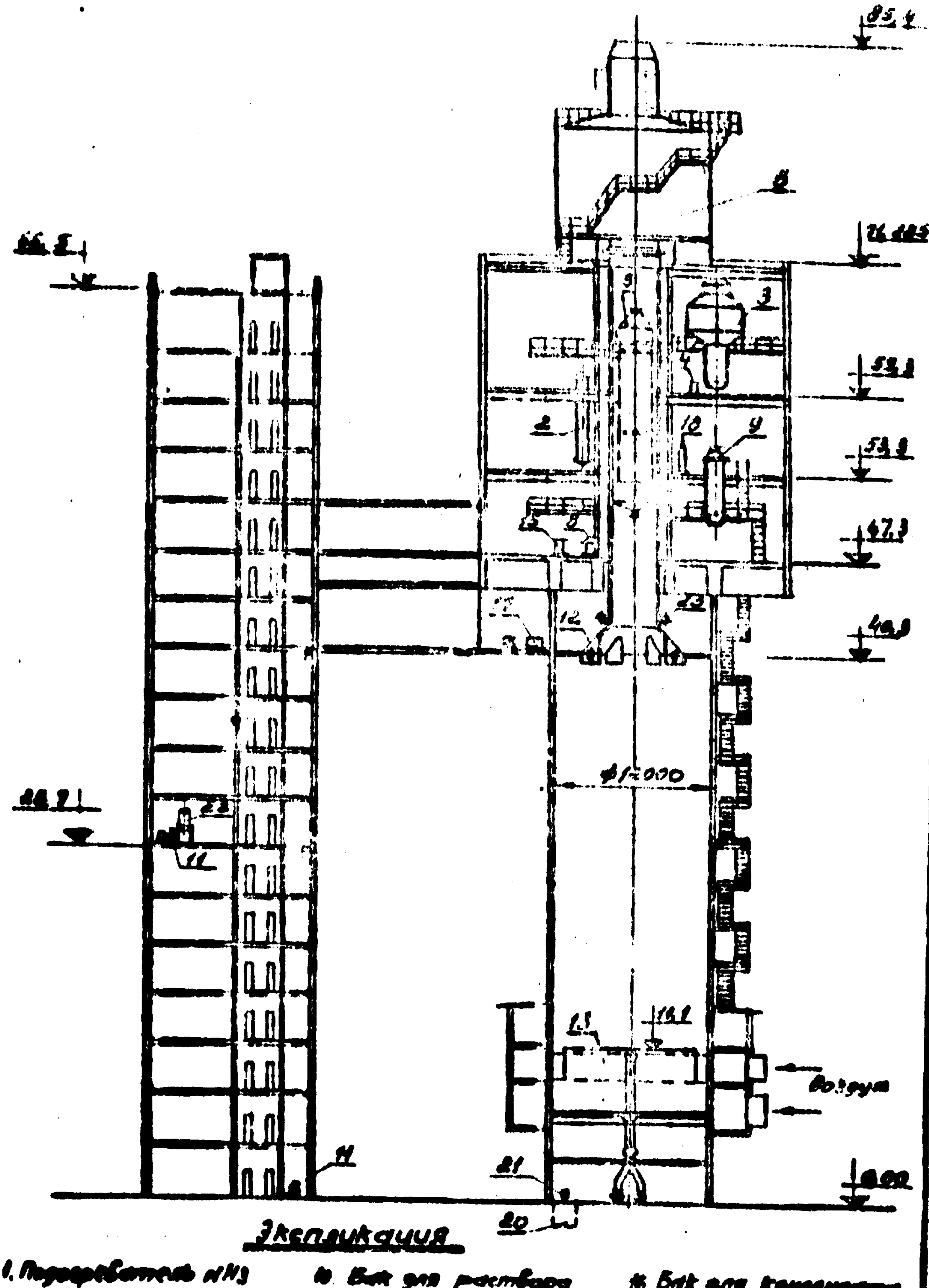
Экспликация

1 Подогреватель NH3
2 Подогреватель HNO3
3 Нейтрализатор
4 Донейтрализатор
5 Выпарной аппарат
6 Промывной скруббер
7 Гидрозатвор для плава
8. Фильтр
9. Подогреватель воздуха
10 Бак
11 Центробежный насос
12 Разбрызгиватель
13. Аппарат для охлаждения гранул в „кипящем слое"
14. Вентилятор

Условные обозначения

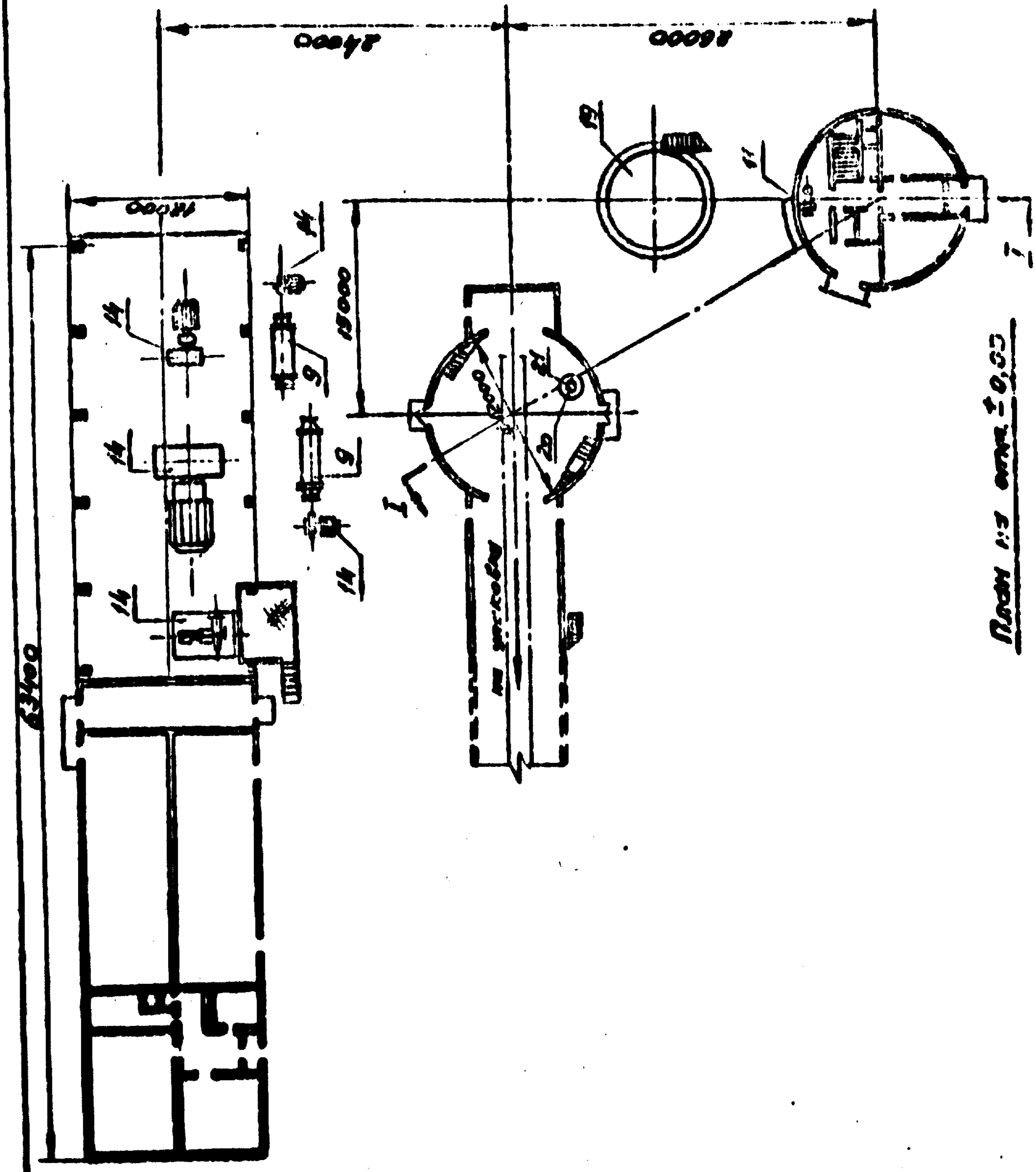
ак - азотная кислота
га - газообразный аммиак
рас - раствор нитрата аммония
п - пар
пк - паровой конденсат
сп - соковый пар
ксп - конденсат сокового пара
вз - воздух

Разрез I - I



Экспликация

1. Подогреватель NH3
2. Подогреватель HNO3
3. Нейтрализатор
4. Донейтрализатор
5. Выпарной аппарат
6. Промывной скруббер
7. Гидрозатвор для плава
8. Фильтр
9. Подогреватель воздуха
10. Бак для раствора
11. Центробежный насос
12. Разбрызгиватель
13. Аппарат для охлаждения гранул в "кипящем слое"
14. Вентилятор
15. Ванна для промывки фильтров.
16. Бак для конденсата
17. Ванна для промывки грануляторов
18. Гидрозатвор
19. Хранилище раствора
20. Дренажный бак
21. Погружной насос
22. Пароувлажнитель 15
23. Коллектор плава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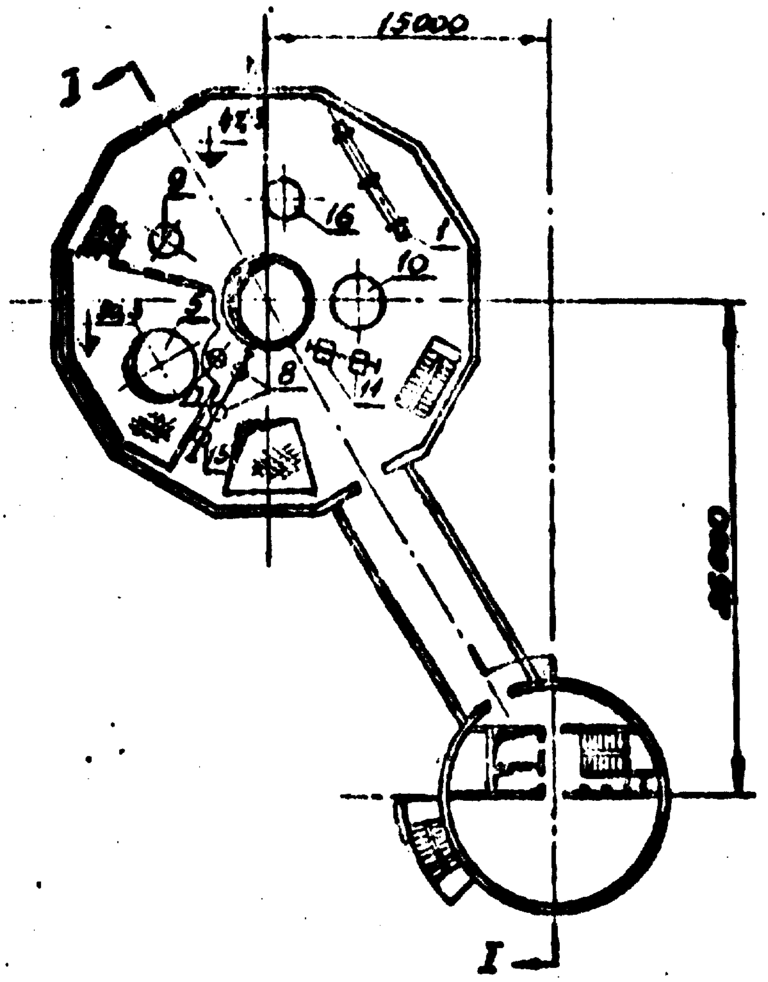

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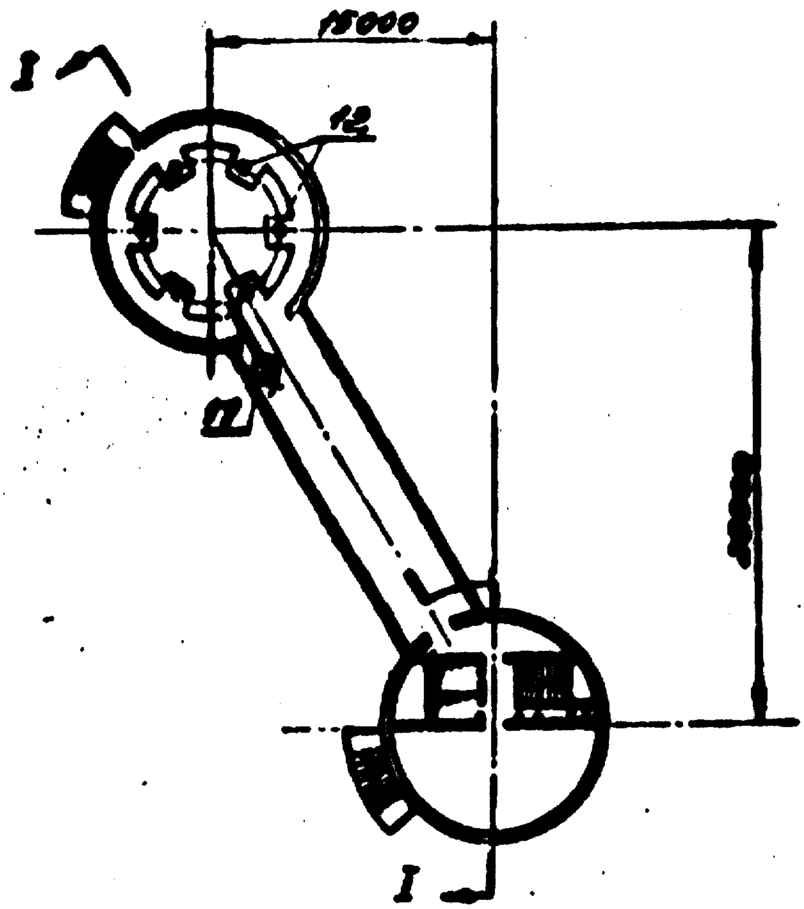

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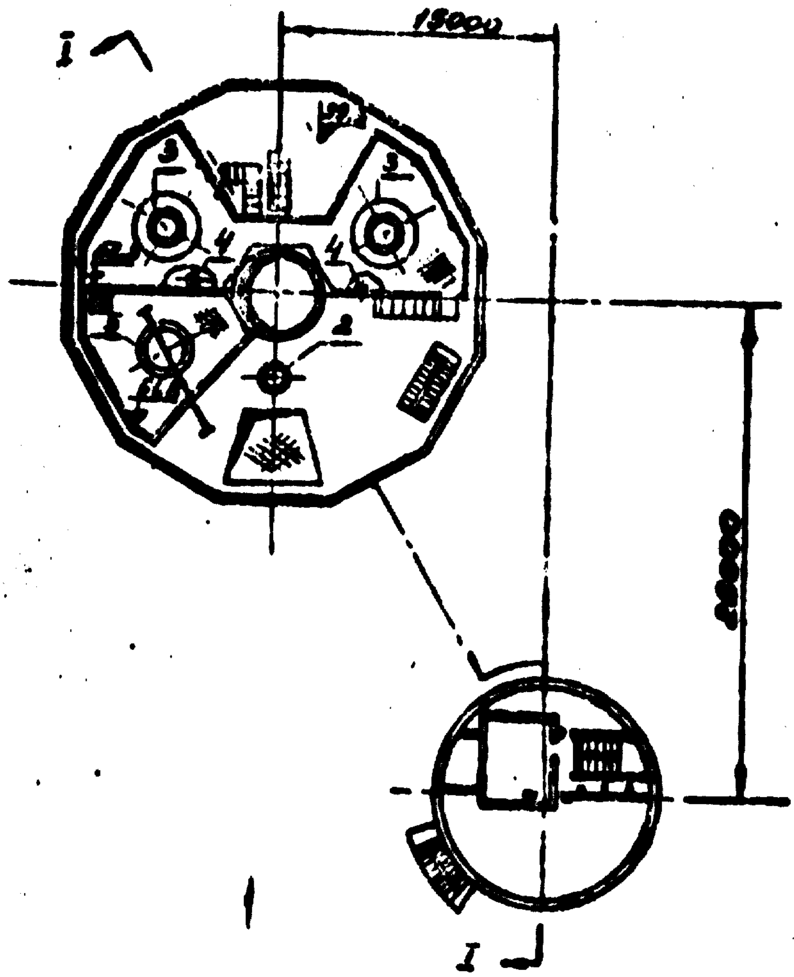

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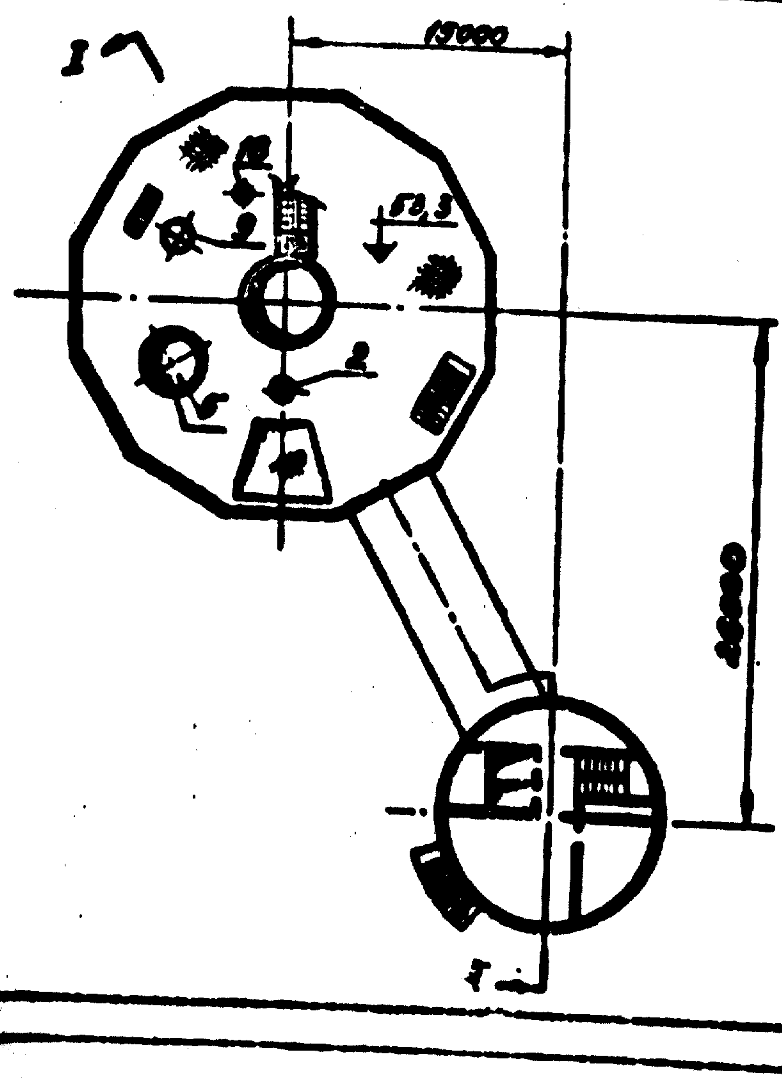

Schematic diagram of ammonium nitrate manufacture in AC-67 plant

Legend

1. NH_3 heater
2. HNO_3 heater
3. Neutralizer
4. Preneutralizer
5. Evaporator
6. Washing scrubber
7. Hydraulic lock for the melt
8. Filter
9. Air heater
10. Tank
11. Centrifugal pump
12. Spraying unit.
13. Fluidised bed granules cooler
14. Fan.

Abreviations

АК - nitric acid

ГА - gaseous ammonia

рас - ammonium nitrate solution

П - steam

ПК - steam condensate

СП - juice steam

КСП - juice steam condensate

ВЗ - air

Elevation

I-1

Legend

1. NH_3 heater
2. HNO_3 heater
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4. Preneutralizer
5. Evaporator
6. Washing scrubber
7. Hydraulic lock for the melt
8. Filter
9. Air heater
10. Tank for the solution
11. Centrifugal pump
12. Spraying unit
13. Fluidized bed granules cooler
14. Fan
15. Filter washing bath
16. Tank for condensate
17. Condensate washing bath
18. Hydraulic lock
19. Solutions storage
20. Drainage tank
21. Submerged pump
22. Steam humidifier
23. Steam collector

Plan at ± 0.00 level

Plan at 47.3 level

Plan at 59.3 level

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SUMMARY

LARGE-CAPACITY PLANTS FOR THE PRODUCTION OF GRANULATED AMMONIUM NITRATE 1/

by

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On the basis of a comprehensive analysis of the physico-chemical principles governing the process and the selection of the optimum conditions for carrying it out, a process has been developed and new equipment designed in the Soviet Union for the manufacture of granulated ammonium nitrate of high quality in plants of high production capacity (1,400 tonnes per day).

The process developed and the equipment used in these high-capacity plants differ from the methods currently used in the world for the industrial production of ammonium nitrate in a number of interesting ways:

1. The production process is carried out without contaminating the air or water with harmful substances.

2. Technological losses of raw materials and of the finished product are kept to a minimum.

3. The production process is carried out without using cooling water. There is thus no need for any expenditure on installing and operating cooling towers in the

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water circulation system or on installing engineering systems for supplying water to the production process.

4. The capacity of the process for producing the granulated product is increased, which means that the specific volume of the granulation tower can be considerably reduced, i.e., expenditure on the construction of the most bulky and expensive item can be reduced.

5. After ganulation the product is 96 per cent by weight granules of 1-3 mm diameter, the average diameter being 1.9 mm. There is no need for fractional screening of this product.

6. Packed in polythene bags, the granulated product does not deteriorate during long storage.

7. The plant is fitted with specially developed high-output reliable equipment, which in addition to simplifying the technological process considerably reduces capital investment and operating costs.

8. Automation of the main production operations and an appropriate layout of the equipment in the plant makes it possible to operate the plant with a small service staff.

The starting material for the process is 58 to 60 per cent nitric acid and gaseous ammonia.

Ammonium nitrate intended for use in agriculture as a nitrogenous fertilizer is produced with a dry-product nitrogen content of 34.8 per cent, while the moisture content in the final product is not more than 0.2 per cent.

The process of neutralizing the nitric acid with gaseous ammonia is carried out close to atmospheric pressure.

The aqueous nitrate solution obtained is concentrated in a film-type mass-exchange unit. The melt is then sent for prilling to a high-capacity granulation tower, where by air-cooling it is turned into the granulated product. This is further cooled to the required temperature in a fluidized-bed plant under the tower and sent for packing.

Before being released into the atmosphere, the hot dry air exhaust from the granulation tower and evaporator is purified to remove traces of ammonium nitrate dust.

Consumption of raw materials and power per tonne of finished product is as follows:

Gaseous ammonia (100 per cent) at a pressure of 3 atmospheres (absolute)	213 kg
58-60 per cent nitric acid (with respect to 100 per cent acid)	794 kg
Saturated steam at a pressure of 14 atmospheres (absolute)	100 kg
Electricity	20 Kwh

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