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Revamping of an AN/CAN prilling plant to produce a granular product of high quality

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- AZOMUES SA fait fonctionner à Tirgu Mures, Roumanie depuis 1972, entre autres, une unité Stamicarbon de nitrate d'ammonium prillé (AN) 33.5% / ammonitrate (CAN) 27% avec une capacité de production de 1 400 t/j AN et de 1 600 t/j CAN. La tour de prilling, le bâtiment et tout l'équipement sont en bon état.

- Orphanco est, depuis le début 1999 impliqué comme Consultant Technologie du nouveau propriétaire, un groupe privé d'entrepreneurs turcs.

- En 1998, l'unité d'Azomures a été privatisée et la décision du Bureau du nouveau propriétaire en 1999 a été d'améliorer la qualité du AN/CAN prillé et de le remplacer par un produit granulé qui aurait de meilleures chances de vente sur le marché international et obtiendrait de meilleurs prix grâce à des propriétés de manutention-stockage améliorées de granules par rapport aux prills et des possibilités de mélange des granules de AN/CAN avec d'autres engrais NP ou NPK.

- Différentes sociétés d'engineering ont été contactées et différentes études ont été réalisées concernant deux projets alternatifs :

  1- Une nouvelle unité de granulation basée sur une technologie éprouvée (Petrium UHD, granulation en lit fluide H-A, tambour granulateur Kaltenbach FB, ou tambour grossissant Grande Paroisse – Spherodizer)

  2- Une unité de grossissement utilisant comme semences des prills de bonne qualité représentant environ 50% de la production réalisée dans les tours de prilling existantes. Les granulés sont produits dans des granulateurs spéciaux à tambour de grossissement en pulvérisant la bouillie mélangée avec un ballast.

- La qualité du produit fini obtenu par les 2 solutions devrait être équivalente, capable de concurrencer le meilleur produit sur le marché et de satisfaire aux exigences les plus sévères en matière de propriété de stockage, de manutention, de stabilité thermique et de sécurité.

- La forme du contrat était dans les deux cas EPC clés en main
  - Projet avec une somme forfaitaire pour l'engineering de détail roumain
  - La construction et la majeure partie des équipements devant être fabriqués en Roumanie.

- La décision finale a été en faveur de l'unité de grossissement car le coût d'investissement devait être de 50% du coût d'investissement pour une unité indépendante de granulation.

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1. INTRODUCTION

- AZOMUES SA operates in Tirgu Mures, Romania since 1972 among others one Stamicarbon design, prilled ammonium nitrate (AN) 33.5% / calcium ammonium nitrate (CAN) 27% plant with a design capacity of 1400 MTD AN and a design capacity of 1600 MTD CAN**.** Prilling tower, building and all equipment are in good condition.
- **ORPHANCO** is, since the beginning of 1999, involved as technology consultant of the new owner, a private group of Turkish entrepreneurs.

- In 1998 the Azomures plant has been privatised and board decision of the new owner in 1999 was to improve the quality of the produced AN/CAN prills and to replace the prilled product with a granular product, which has better sales chances in the international markets and could obtain higher sales price, due to the improved handling-storage properties of granules against prills and the ability to blend AN/CAN granules with other granular NP, or NPK fertilizers.
- Various engineering companies have been contacted and studies have been performed concerning two alternative concepts:
  1. A new granulation unit based on proven designs (UHDE pug mill, H-A Fluid Bed Granulation, Kaltenbach FB Drum Granulator, or Grande-Paroisse Fattening Drum – Spherodizer)
  2. A fattening unit using as seeds good quality prills, representing about 50% of the output, produced in the existing prilling towers. Granules are produced in special fattening drum granulators by spraying melt mixed with filler on them

- The quality of the final product from both alternatives should be equivalent, able to compete with the best product in the market and to fulfil the most stringent requirements concerning storage - handing properties and thermal stability and safety.

- The contract form for both cases was for a EPC turnkey-lump sum project with Romanian detail engineering – erection and most of equipment to be manufactured in Romania

- The final decision was in favour of the Fattening unit, as the investment cost was about 50% of the investment cost for an independent Granulation Unit.

2. EXISTING PRILLING PLANT DESCRIPTION

In Fig. 1 the existing layout of the AN/CAN production facilities is shown. There are two twin prilling towers(PT) with 16.5m ID and 36m free falling height(FFH). The total air flow to each of the induced draft PT is 500000 Nm3/h and the design ambient air temperature 30^0 C. 95% AN solution is concentrated at 99.7% in vertical evaporators heated by 16 bar steam. A final concentration of 99.8% is obtained in hot air swept concentrators. Filler and ammonia for pH control is added in the homogenizers, from where the spinning buckets are fer by gravity.
The plant capacity is 1400 MTD AN 33.5%, or 1600 MTD CAN 27% when both PTs are in operation. With only one PT in operation the plant capacity is 1000MTD AN and 1200 MTD CAN. Main additive and filler is dolomite, delivered to the plant in powder form and transported to the PT top pneumatically.
The PFD of the prilling unit, designed by Stamicarbon is shown in Fig.2
It has to be noted that about 800 MTD of the ammonium nitrate solution is coming as by-product from the N-H Odda process Nitrophosphate NPK plant and the rest is product of

direct neutralization of nitric acid and ammonia. 82% AN solution from the Nitrophosphate plant together with synthetic produced AN is preconcentrated at 95% and then pumped to the top of the twin PTs where it is first concentrated up to 99.7% in twin ascending flow evaporators and then to a 99.8% final concentration in a hot air swept horizontal final concentrator. Dolomite as filler is dosed and mixed together with AN melt in the agitated Homogenizer, where ammonia for pH control is added too. Prilling is effected by a Stamicarbon type spinning bucket.
The prills are leaving the bottom of the PTs at 110^0 C and are conveyed to the Prilling Conditioning Building (PCB) section, shown schematically in Fig. 3. This is a large concrete building housing also therein the AN solution neutralization and pre-evaporation. A side view and some sectional views, as well as some top views of the PCB are shown in Figs. 4a to 4d
It should be noted the rather complex arrangement to handle the prills and to dedust the air (prescreen – screen, large cyclone batteries, a powerful blower, etc)

3. IMPROVEMENT OF THE PRILL QUALITY

As it is mentioned above, most of the AN solution is supplied from the Nitrophosphate NPK plant and contain some silica, P2O5 salts and higher than usual calcium nitrate. These impurities certainly affect adversely the quality of the produced prills and cause an excessive erosion to the Stamicarbon design spinning buckets, limiting the life of the original 4 mm thick wall bucket to about 5000 h. The original spare bucket with precision perforation holes being very expensive, it has been replaced by a thin wall self made bucket, which certainly has not helped to improve the prill quality. Produced prills contained excessive amount of fines, shells and clusters. The result was a relatively low prill quality and 15% fines separated by screening and re-melted, increasing the production cost.

This quality of prills was not suitable for the requested high final product quality and following actions have been undertaken to improve the prill quality:

- Several additives have been considered to improve the quality (strength, thermal stability, narrow prill size spread)
- New adapted to the severe melt composition prilling device have been investigated

Finally the addition of aluminium sulphate (AS) and calcium or ammonium sulphate and the proper pH control was found to be the most suitable to give a high strength, to reduce fines and shells and to get an average prill size $D_{50\%}$ of 2.2 to 2.3 mm.

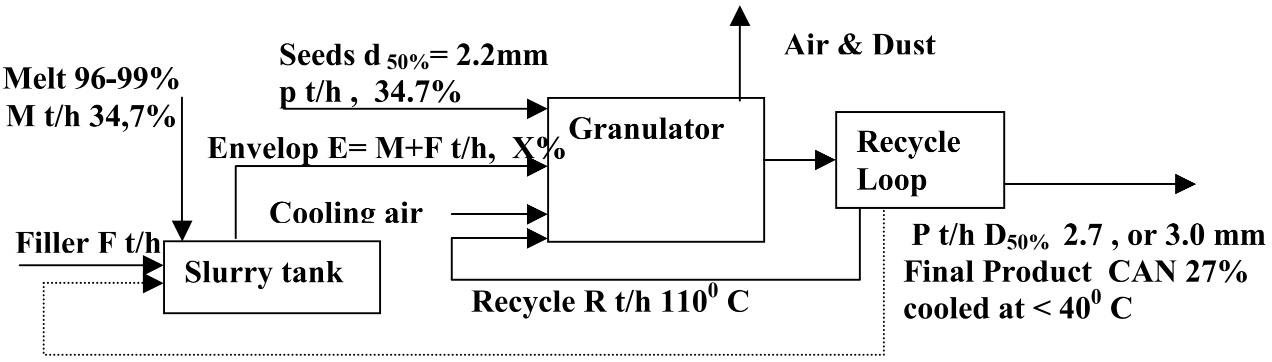
As for the prilling device the investigation resulted in the selection of an Ukranian design prilling device, called vibration granulator and is shown in Fig. 5. The device is vibrating vertically and spinning at 200 to 250 RPM. This device is in operation in many East European AN and urea plants and gives a calibrated, strong, round prilled product, which for the specific Azomures PT is expected to give a product with $D_{50\%}$ at about 2.3 to 2.4 mm and 90% of prills to be between 2-4 mm.

The prilling device will be in operation by the middle of July

4. FATTENING UNIT VERSUS PURE GRANULATION CONCEPTS

The difference between **fattening once through, multifattening, and pure granulation** is briefly explained by the show below block diagram showing the basic arrangement of a fattening – granulation plant

For an average prill size of about **$d_{50\%}$= 2.2 to 2.4 mm** and for a final product average size **$D_{50\%}$ 2.7 to 3.1mm** mass ratio in the final product between prill and sprayed melt envelop is also close to 1.



If we ignore that the density of the final product is slightly higher than that of the seed prills the Fattening mass rate $\mathbf{m_r}$ is :

$$\mathbf{m_r = P/p = D^3_{50\%} / d^3_{50\%}} \qquad \textbf{(1)}$$

The mass ratio is 1.95 for $D_{50\%}$ 2.75 mm, or 2.5 for $D_{50\%}$ 3.0 mm

The material balance of AN dictates that

$$\mathbf{E} \text{x } \mathbf{X + p}\text{x } \mathbf{0.347 = P}\text{x } \mathbf{0.27}, \text{ where } \mathbf{E = P - p} \qquad \textbf{(2)}$$

For $D_{50\%}$ = 2.75 mm it gives the grade of the Envelope slurry X = 18% , that means a very concentrated in filler slurry. For $D_{50\%}$ = 3.0 mm, X=22%, that means less filler.

The energy balance in the granulator, in order to ensure good granulation conditions requires the ratio of total liquid to solid input to be about 1. That means E =R+p, or:

$$\mathbf{R = P\text{-}2p = p\,[m_r - 2]} \qquad \textbf{(3)}$$

For seeds $d_{50\%}$ =2.2 mm and $D_{50\%}$ = 2.75 mm the mass ratio m_r according to relation (1) above is about 1.0. and consequently recycle R is almost zero. This is the case of an **Once through Fattening** , as there is no need to recycle product to keep the required solid to liquid mass balance. This is a low investment cost but inflexible granulation concept. An other disadvantage is the high amount of filler in the envelop slurry, as we have seen before, which means high erosion in the slurry pumps, spray nozzles and more filler dust in the gas outlet the granulator.
For seeds $d_{50\%}$ =2.2 mm and $D_{50\%}$ = 3.0 mm the mass ratio m_r according to relation (1) above is 2.5 and R = 0.5p, E= 1.5p or R=0.2P. That means about 60% of the weight of the final product is supplied by the envelop, only 40% by the seeds and 20% of the final product must be recycled in the case of AN 33.5% production. Consequently in this case a certain portion of the amount of seeds must be supplied either :

a) by properly crushed and recycled oversize,
b) by recycled product,

c) by recycled granulometric fraction of the final product, which fits to the size of the prilled seeds.

It is obvious that the last solution is the best, but requires two screens in series.
In any case for 1400 MTD AN 33.5% the granulator output must be designed for about 570 MTD seeds 34.7% and 830 MTD Envelop (melt plus the required filler), plus 300 MTD Recycle. This is the so called **Multifattening** concept. This concept has a higher investment and operating cost, as granulator, cooling air, duct work, elevator, screens, recycle crusher have a bigger size. The flexibility of the unit increase, as well as the strength of the final product as the sprayed envelop is more dense. In case of zero seed – prills we have a **Pure Granulation** requiring more bigger equipment, that means higher investment and operating cost and eventually not a nice round aspect of the final product.

5. FATTENING PROCESS DESCRIPTION

In Fig.6 the revamped prilling section is shown. The PT #I will produce in both concepts the about 700 MTD prills needed as seeds for the fattening. In the final melt concentration will be dosed the additives only required to give to the seeds: high crushing strength and thermal stability. The grade of the seeds will be about an AN 34% to 34.2% for both final products AN 33.5% and CAN 27%. In other words the filler (dolomite) will be added only to the slurry tank feeding the granulator.

In Fig.7 and 8 the proposed fattening concept of Kaltenbach-Thuering and respectively of Grande Paroisse are shown schematically. Both are typical drum granulation processes. In both processes seeds and eventually recycled crushed oversize entering the granulator at about 100 to 110^{0}C. AN slurry of about 97.5 to 99.5% mixed with filler and blowdown 35 to 40% AN solution from the scrubber is sprayed into the granulator. The crystallisation heat is removed by slightly preheated air, blown into the granulator, which is used also for drying. The granules are coming out at a temperature of 110 to 115^0 C, are elevated pass on sieves to separate the on grade fraction between 2 and 4 mm from the oversize and fines. Fines are remelted and oversize after size reduction in special crusher are, according to the requirements, either recycled back to the granulator, or remelted too. For the on grade product is also foreseen to be partly recycled in case the granulation at granulator outlet is too good. The final product is cooled in a fluidized bed cooler (FBC) to a temperature below 40 ^{0}C and a final moisture of about 0.3%. In order to avoid water pick up the cooling air is dehumidified in an ammonia chiller and then, as AN/CAN are relatively hygroscopic granulas are treated, for improved anticacking properties in a coating drum, before sent to the storage, or to the bagging unit.

Dust loaded air can be separated from the coarser fine particles in cyclons before to be sent to the wet scrubber, or to be sent directly there to be cleaned to values around 30 mg/m3 of dust. To catch the small amount of ammonia released in the slurry tank by the unavoidable reaction of AN with the dolomite filler, the recirculating AN solution is acidulated by the addition of nitric acid. As the scrubbed hot air is relativery dry, large amount of water is evaporated in the scrubber. Make up water is added and blow down from the system in order to keep solution concentration below 40% is sent to the slurry tank. In order to reduce the water vapour plume at the outlet of the scrubber, air from the FBC, containing 50 to 70 mg/m3 of dust is mixed with scrubber outlet before sent to the stack.
Additives such as aluminium sulphate, with another sulphate salt such as ammonium, or iron, or calcium, or aluminium oxide with sulphuric acid, to increase the strength and to improve the thermal stability of the seeds and of the sprayed envelop are added.

6. WHY FATTENING IN AZOMURES?

The differences and the particularities of both concepts will be explained in the next chapter. Here below are given first the main differences between fattening and pure granulation of AN/CAN as experienced in this specific case. It is obvious that all these differences, advantages/disadvantages can not be generalised and certainly only partly applicable, or valid in other cases.

The advantages of the fattening concept for this specific case as developed by Kaltenbach-Thuering and by Grande Paroisse, compared to the pure granulation processes are the following:

- As for a final granular product of $D_{50\%}$ around 3.0mm, about half of the melt is needed, the size of equipment in the granulation loop is much smaller than that needed in the granulation concept, resulting in the reduction of the operating and the investment cost
- As the seeds in the fattening process are mainly round prills and only a small fraction of recycled product, the aspect of the final product and its free flowing characteristics are superior
- A further important investment cost reduction results from the fact that the plant can be housed in the existing PCB. That means:
  a) civil work cost is reduced,
  b) main equipment, like fluid bed cooler (FBC) and its air conditioning unit, its blowers, coating drum, elevator, etc can be reused without to be relocated,
  c) electrical equipment MCC, cables, transformers, lighting etc. will be reused,
  d) existing control room will be reused,
  e) the completion time will be substantially reduced.

The main disadvantage of the fattening process in this specific case are:

a) the dust emission from the prilling tower
b) the necessity to stop AN/CAN production for at minimum 6 to 8 weeks to make the tie-ins and to re-condition certain equipment which will be reused to the operating conditions (FBC perforated plates, conveyor belt, duct work, etc.)
c) due to the peculiar characteristics of the by-product from the Nitrophosphate plant AN melt used in this case, there is need for rigorous control of the quality of the prills, but it has been calculated that the operating cost of the Fattening plant will be less than that of the pure Granulation plant.

As to the emission following can be said: compared to the actual prilling operation there will be certainly a dust reduction, as only one prilling tower will operate. Further more it is claimed that the vibrating granulator (VG) is producing less aerosols and AN dust. Although it is very difficult to measure dust content emissions from non scrubbed prilling towers and to differentiate 50 mg/m3 from 75, or 100 mg/m3 dust content. In any case the vendor of the VG is guaranteeing a dust emission value of 50 mg/Nm3.

As to the problem of a rather prolonged shut down of the actual prill production, this can be alleviated by a very detailed and rigorous planning in order to maximize preparatory work when the plant is in operation (see Time Schedule in Fig. 9). Furthermore in this specific case there is a mothballed AN prilling plant, which eventually will be made ready to be put back in operation if required.

In the Fig. 10a and Fig. 10b two side views of the Kaltenbach preliminary concept arrangement are shown. and in Fig. 10c a top view showing the level +5.5m on which the granulator is installed. In this preliminary concept the coating drum is removed to the floor +11.0m and an extension of the building by a steel structure and a light roof to house the new screen is foreseen. The final design it is expected to be more rational, the modifications on the existing equipment reduced to a minimum, and the additions to the existing building eliminated.

Similar arrangement is conceived by GP, with their bigger granulator installed also in the +5.5m floor.
In both preliminary concepts the existing equipment on level +11.0 and +16.5 shown in Fig 4c and 4d will be eventually removed: cyclone battery (not needed) screens (to be replaced by new more efficient screens), dedusting cyclones (not needed)

7. COMPARISON OF BOTH FATTENING PROCESSES.

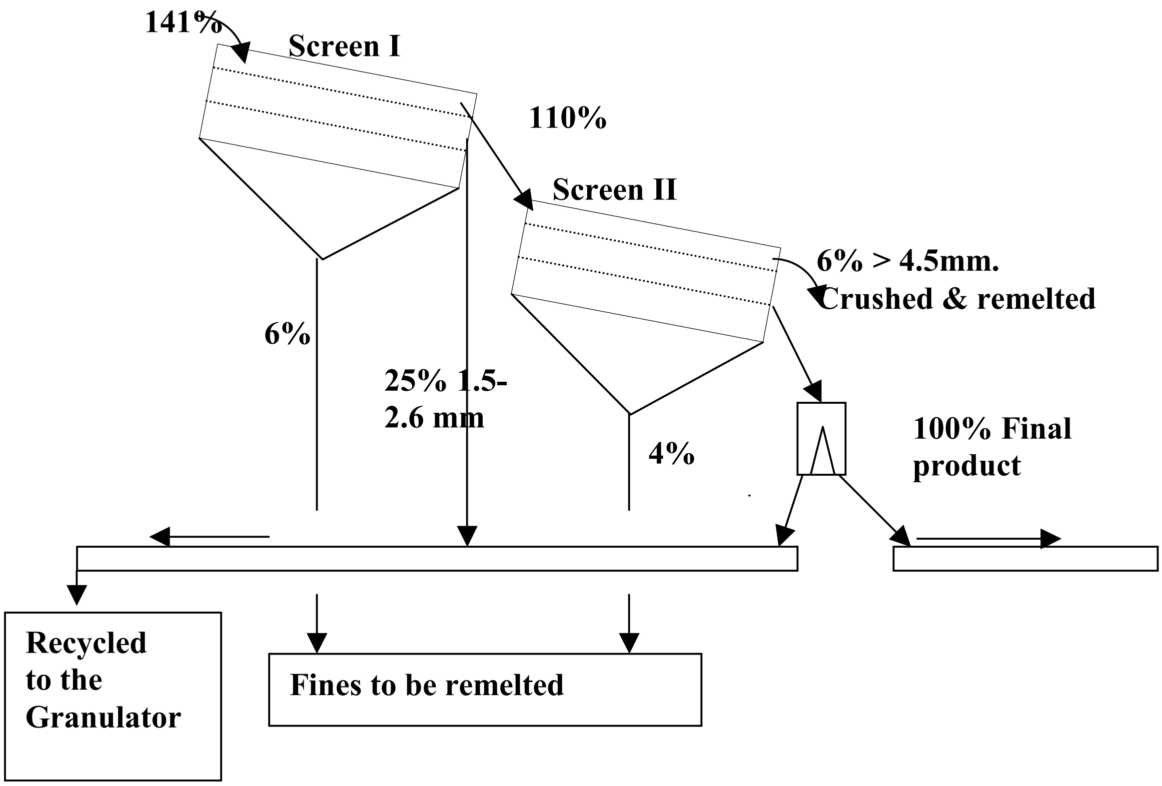
The major difference between the two concepts are the following:

1. **the Granulator design**:

In the case of Grand Paroisse (GP) the Fattening Drum (FD) is a type spherodiser drum with lifters, where the prepared slurry is sprayed are two sprayers at the inlet of the granulator and cooling –drying air is entering with. The size of the FD is relatively big, as it is at the same time fattening drum and dryer.
The Kaltenbach (KT) Drum Granulator is fitted with an internal fluidized bed, lifters and two longitudinal removable axially manifolds spraying the slurry on the falling curtains of granules. The size of the granulator, due to the internal fluid bed is smaller in diameter and in length. Material of construction here again SS 304L.

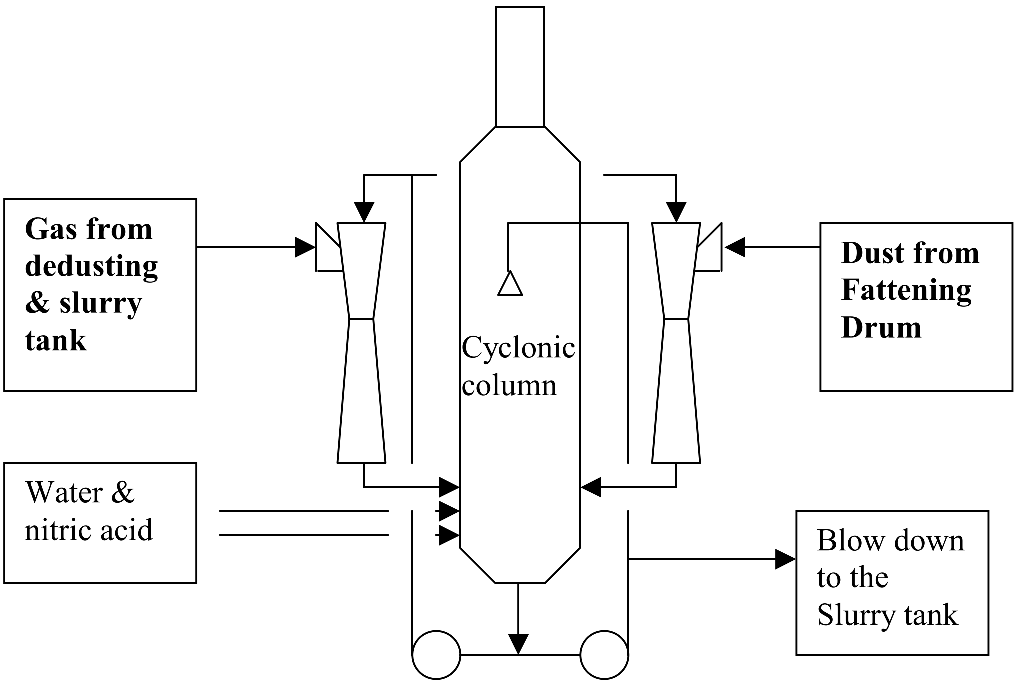
2. **The treatment of dust**
GP prefer to have the granulator exhaust air passing through cyclones before being sent to the scrubber. This, especially in the case of CAN they claim will reduce the content of entrained filler into the scrubber, resulting in less blow down to the slurry tank. This could reduce the required final concentration to the slurry tank to about 97% and to steam savings for concentration to 99%. Because there are installed final concentrators and the installation of a new battery of cyclones could require the extension of the building, there will not be cyclones foreseen.

3. **Screening**
GP is proposing two double deck gyratory type screen, installed in series as shown below. By this arrangement a fraction suitable as seeds is recycled to the granulator, securing by this an output from the granulator with only few % of oversize and fines, i.e. a more and of uniform aspect final product.
The investment cost of this arrangement is certainly more expensive, than the one, or two double deck screens in parallel.



4. **Scrubbing System**

GP is proposing an AZF design Scrubbing system consisting from two separated venturies combined to one cyclonic column



This GP proprietary scrubber system can be replaced by another one offered by well known vendors, giving the same performance guarantees. KT is offering their proprietary scrubbing system shown in Fig. 7

8. CONCLUSION

When this paper has been drafted (June 15), the situation with this project was the following:

1. A letter of intend has been signed with the General Contractor

2. The Basic engineering package from the two Process Licensors has been discussed and agreed

3. The Process guarantees for capacity, product quality, specific consumption have been agreed with both process Licensors and with the General Contractor (identical process guarantees on capacity and product quality)

4. Both Licensors have references of AN/CAN Granulation-Fattening plants in operation, but KTs references are limited to plants with small capacity (up to 650 MTD

5. One Licensor (Grande Paroisse) announced on June 11 2000 their wish not to participate to this project
6. The plant lay out of the Fattening unit to be housed in the existing Prill Conditioning Building, the equipment to be reused, the equipment to be removed and the new equipment needed, as well the particular civil engineering and erection problems related to this have been discussed in detail between all parties involved and an optimised final lay out will be worked out,

7. The local Detail Engineering, and Construction Subcontractors has been selected and the project management scheme has been agreed.

8. The main vendor list for equipment to be imported has been discussed and in principle agreed.

9. The draft Contract for the Turn key Lump sum project has been discussed

10. The review of the statical stability of the building structure of the existing Building to house the Fattening unit to make it conform to the new building regulations applicable today in Romania has been and the new imposed loads has been started

11. The Licensor selection has been made by the middle of June.

12. The lump sum contract will be presumably signed by the beginning of July.

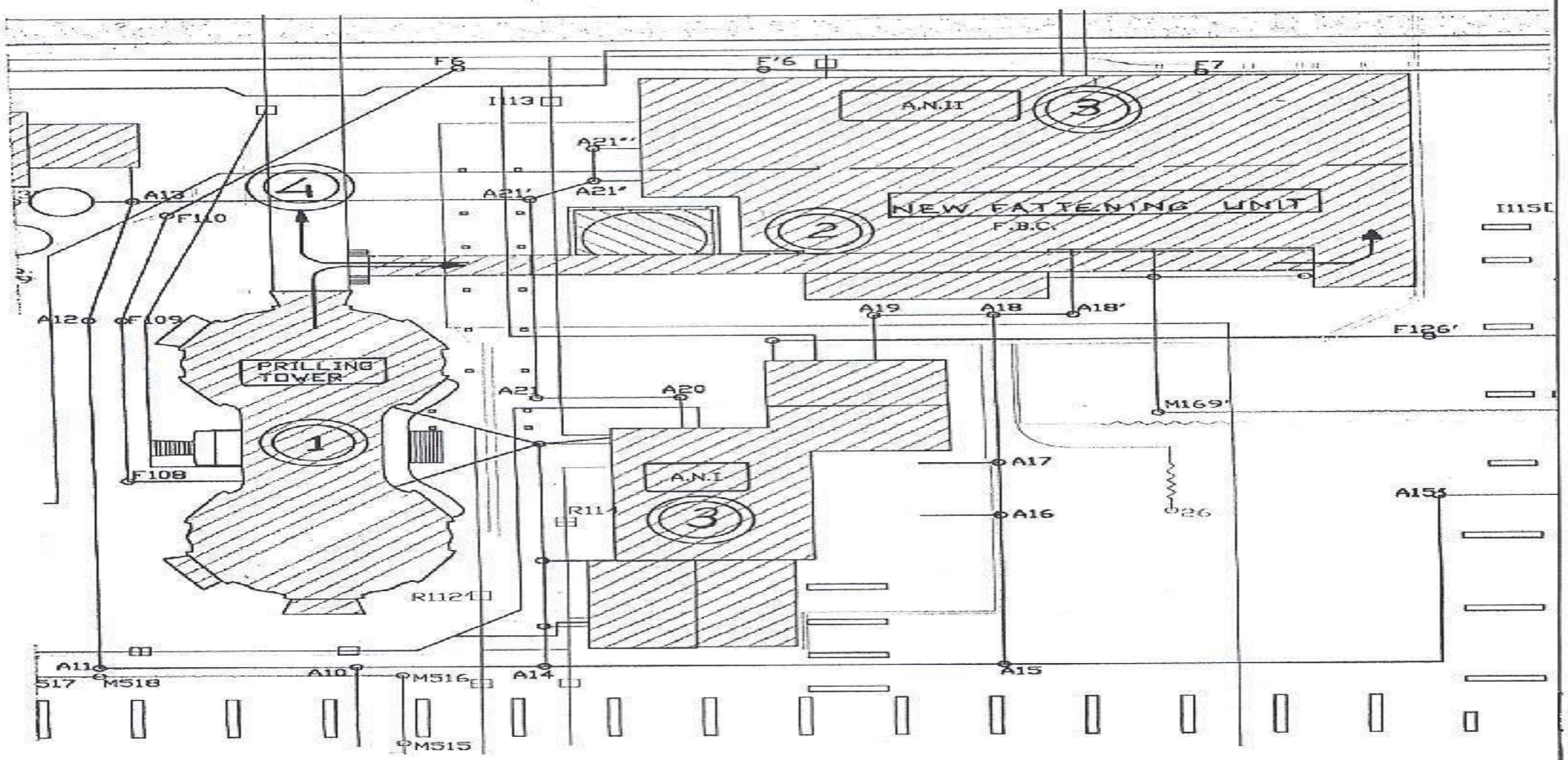


Fig.1 Azomures AN/CAN Prilling plant No II,I

1. Twin Prilling Towers, 2. Existing Prill conditioning building

3. AN solution preparation , 4. Prilled AN/CAN to storage

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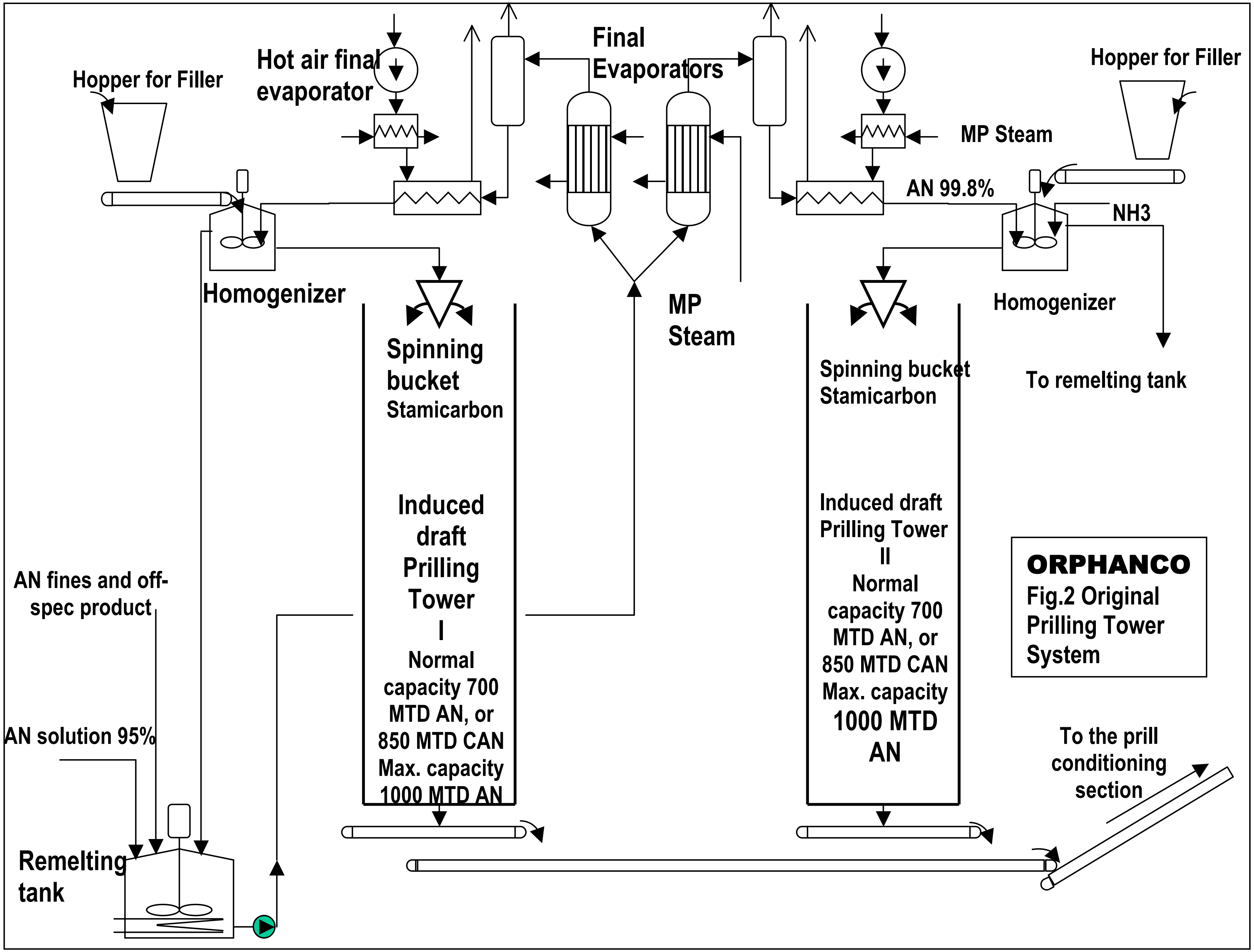

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Fig.2 Original Prilling Tower System

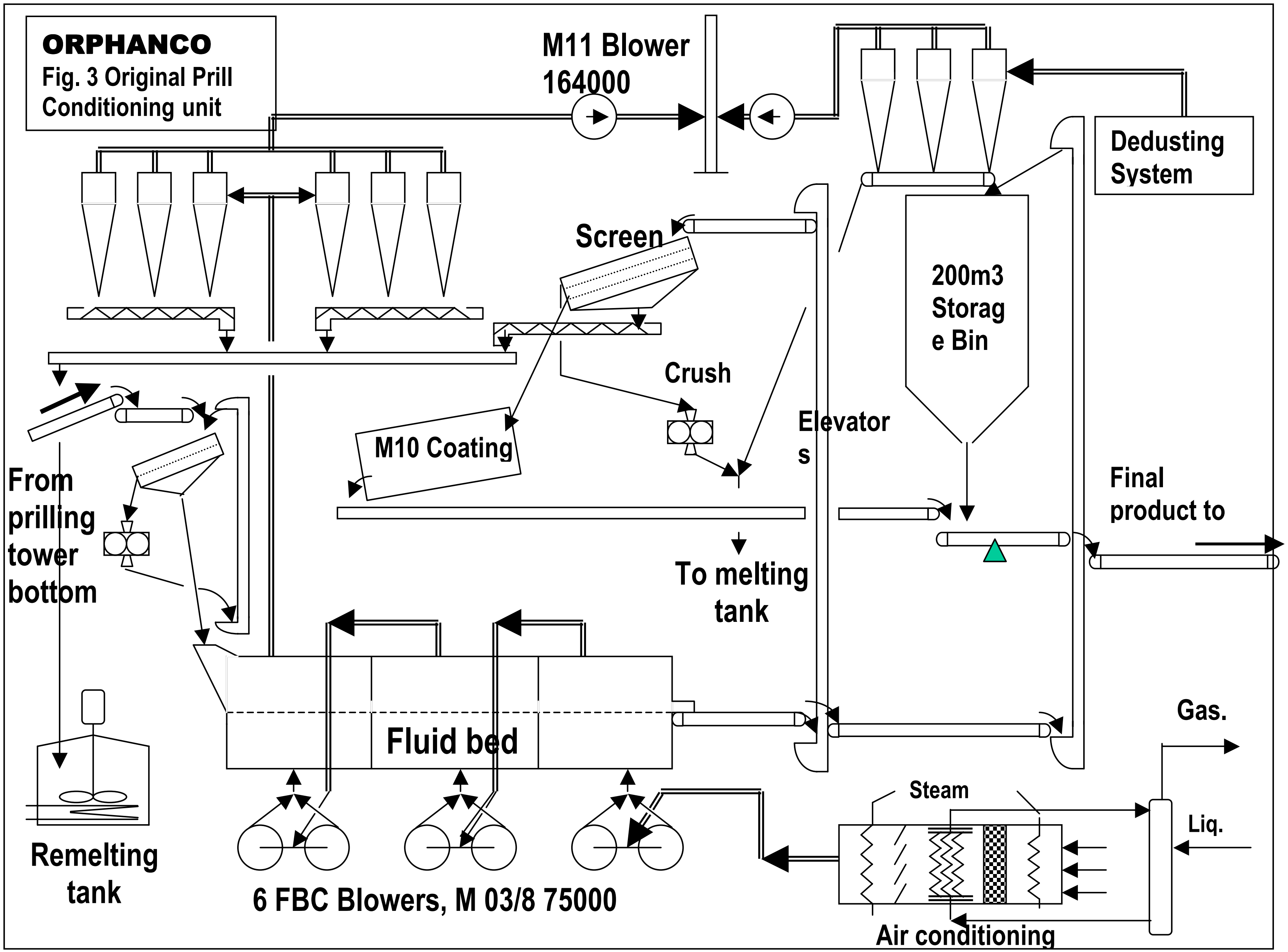
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Fig. 3 Original Prill Conditioning unit
M11 Blower 164000
Dedusting System
Screen
200m3 Storag e Bin
Crush
M10 Coating
Elevator s
From prilling tower bottom
To melting tank
Final product to
Fluid bed
Gas.
Steam
Liq.
Remelting tank
6 FBC Blowers, M 03/8 75000
Air conditioning

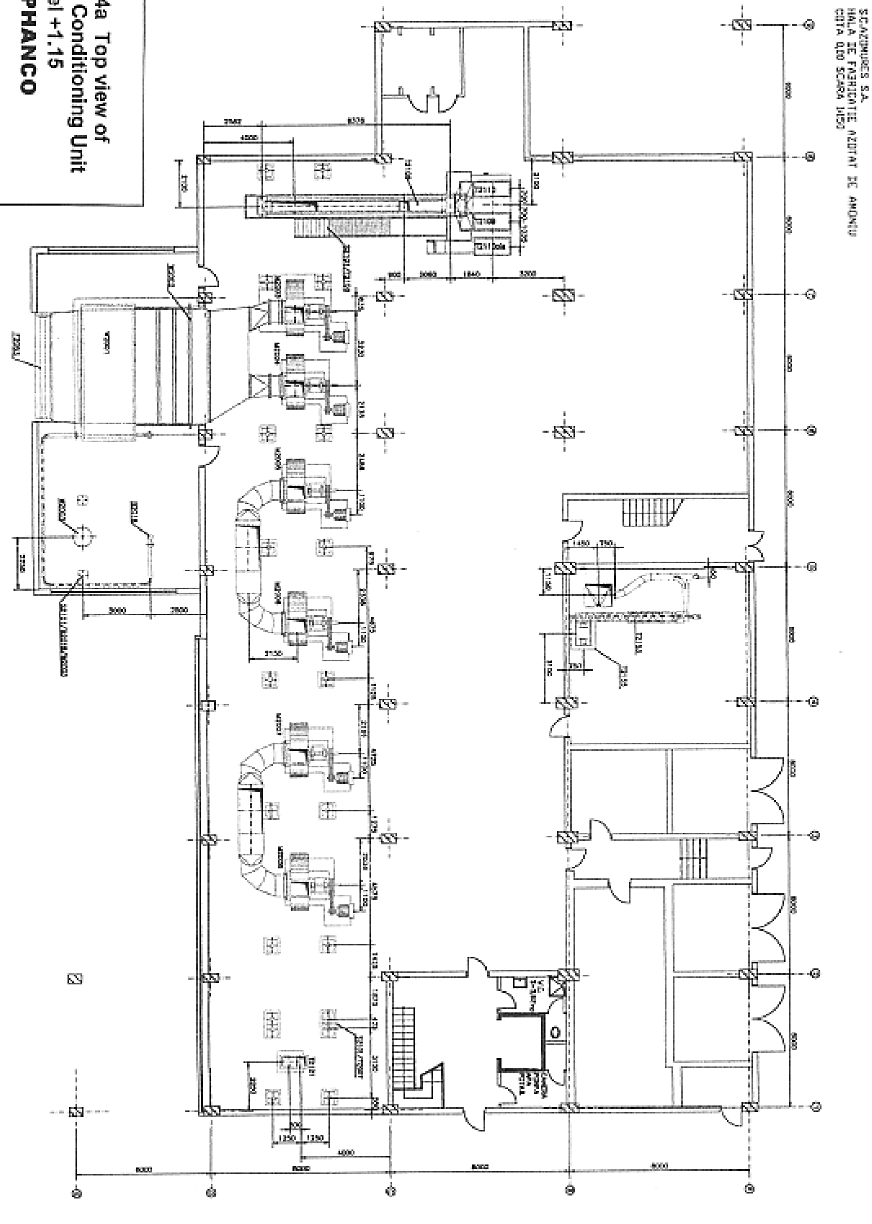


Fig.4a Top view of Prill Conditioning Unit Level +1.15
ORPHANCO

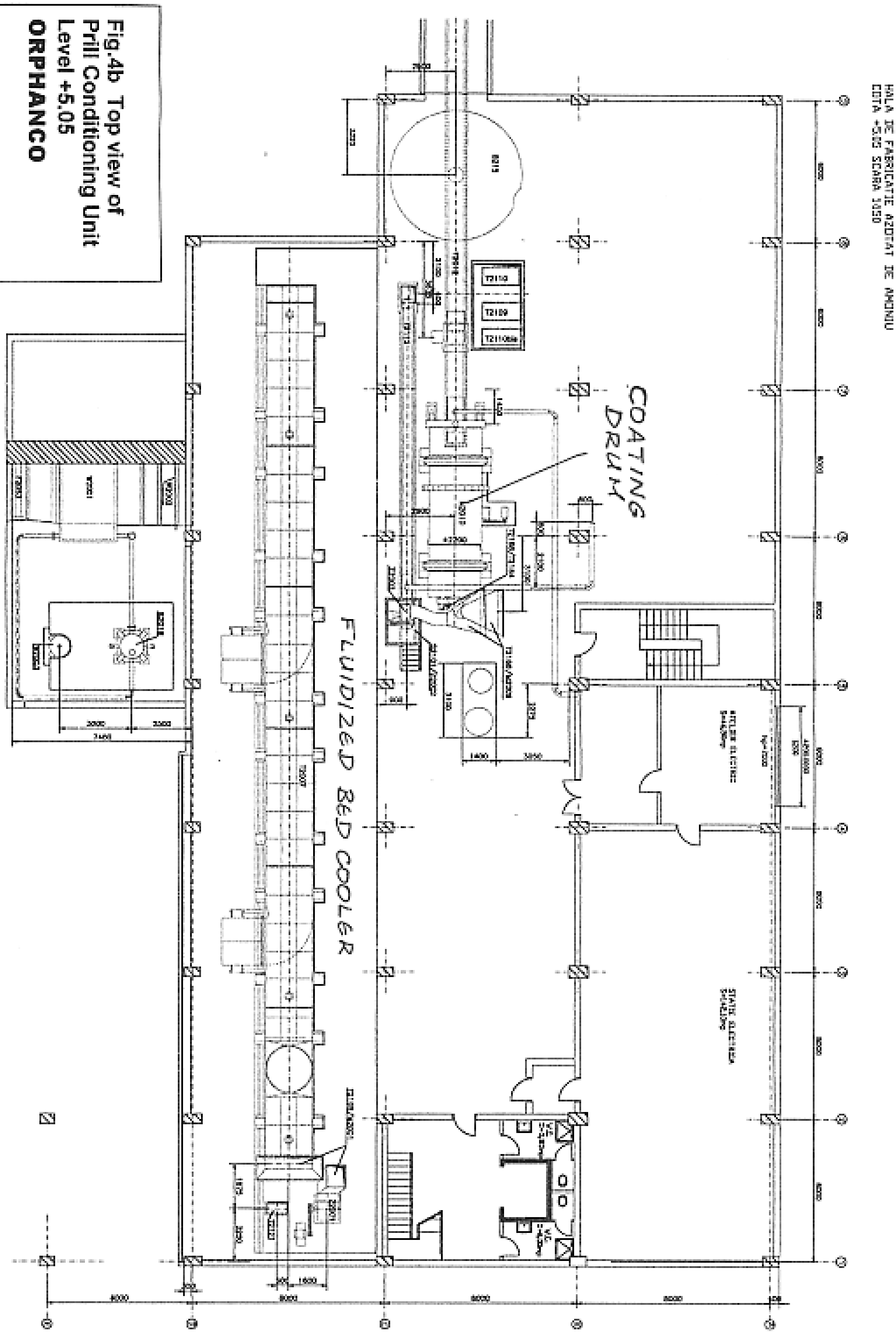


Fig.4b Top view of Prill Conditioning Unit Level +5.05
ORPHANCO

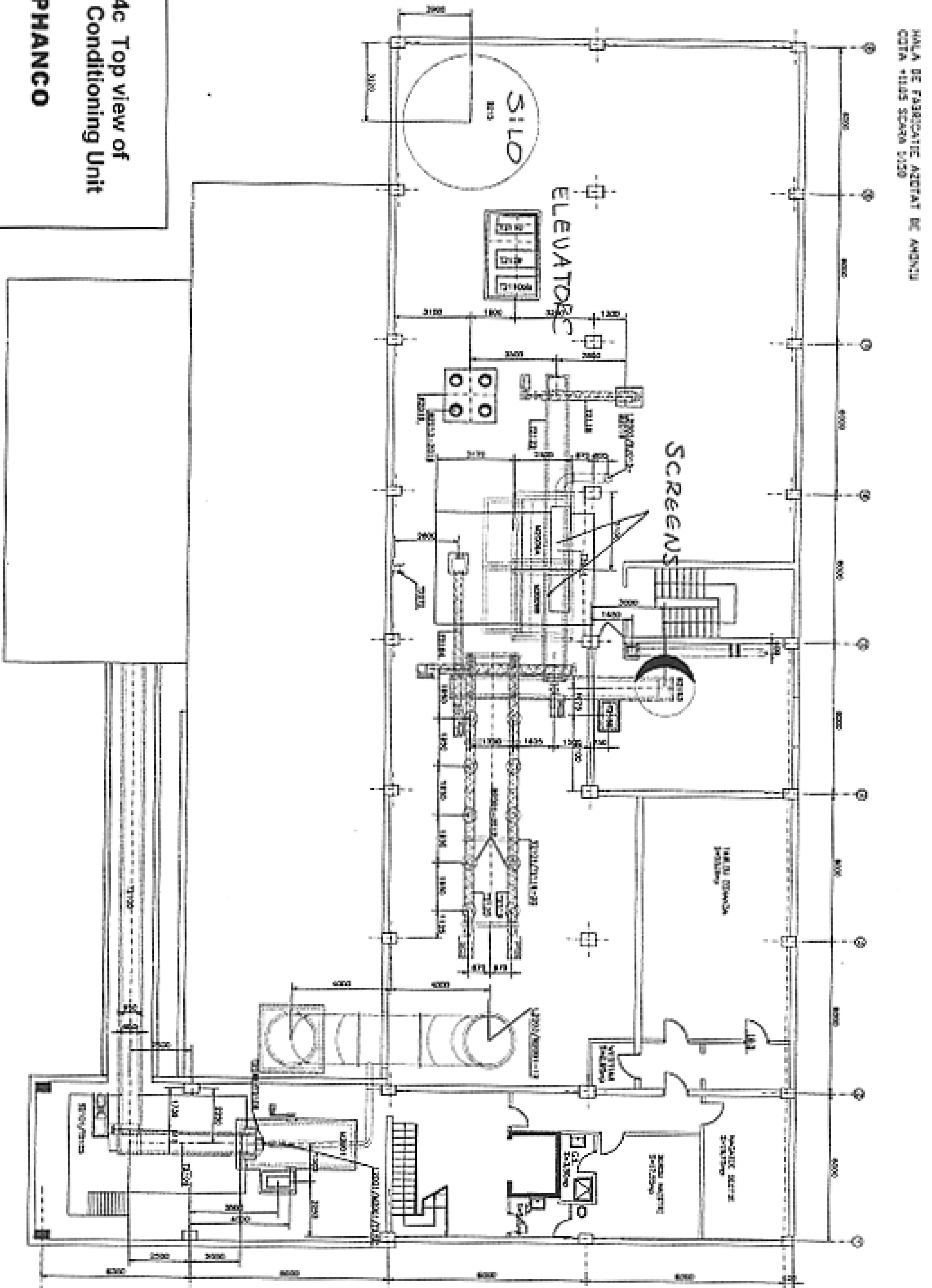


Fig.4c Top view of Prill Conditioning Unit

ORPHANCO

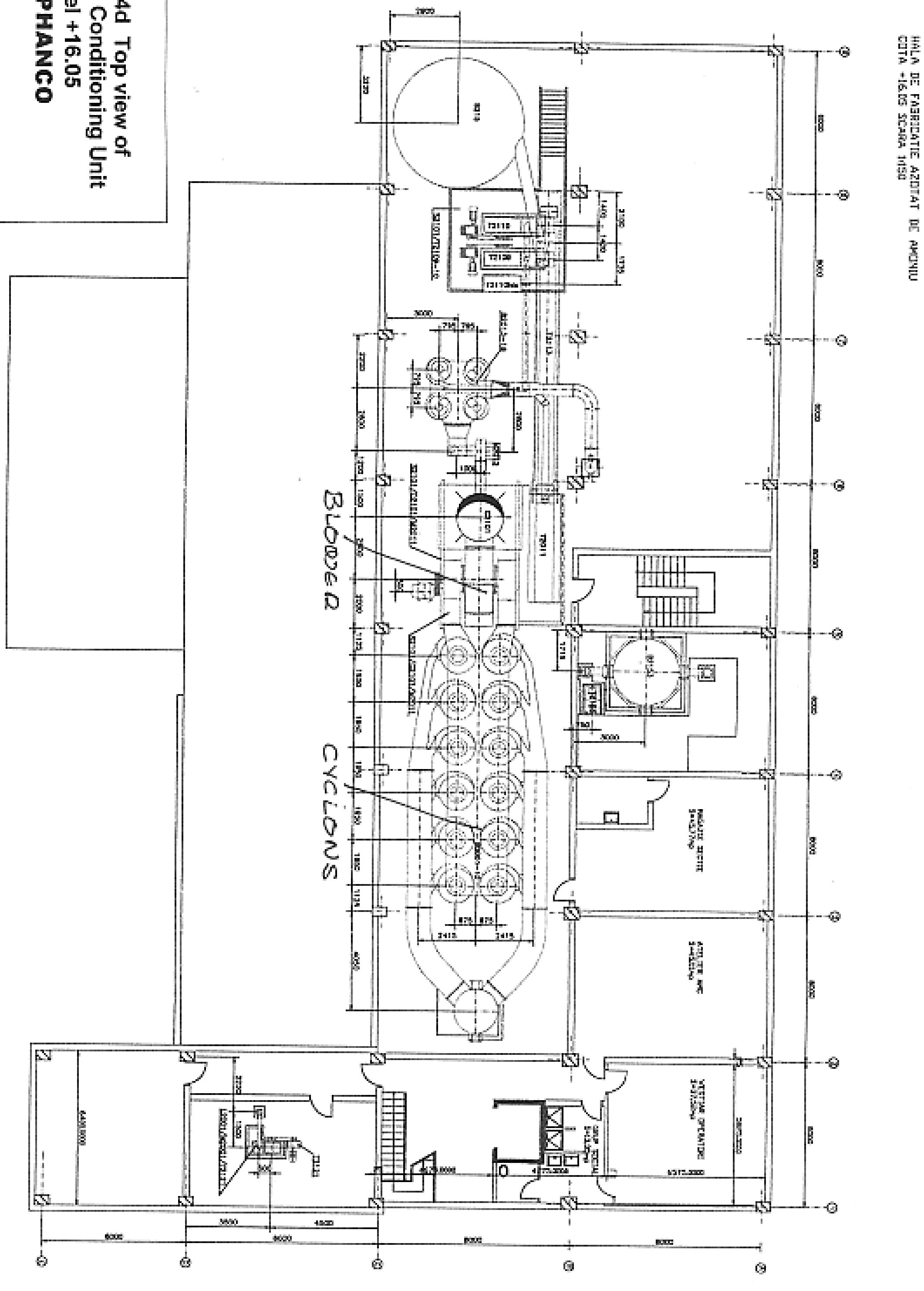
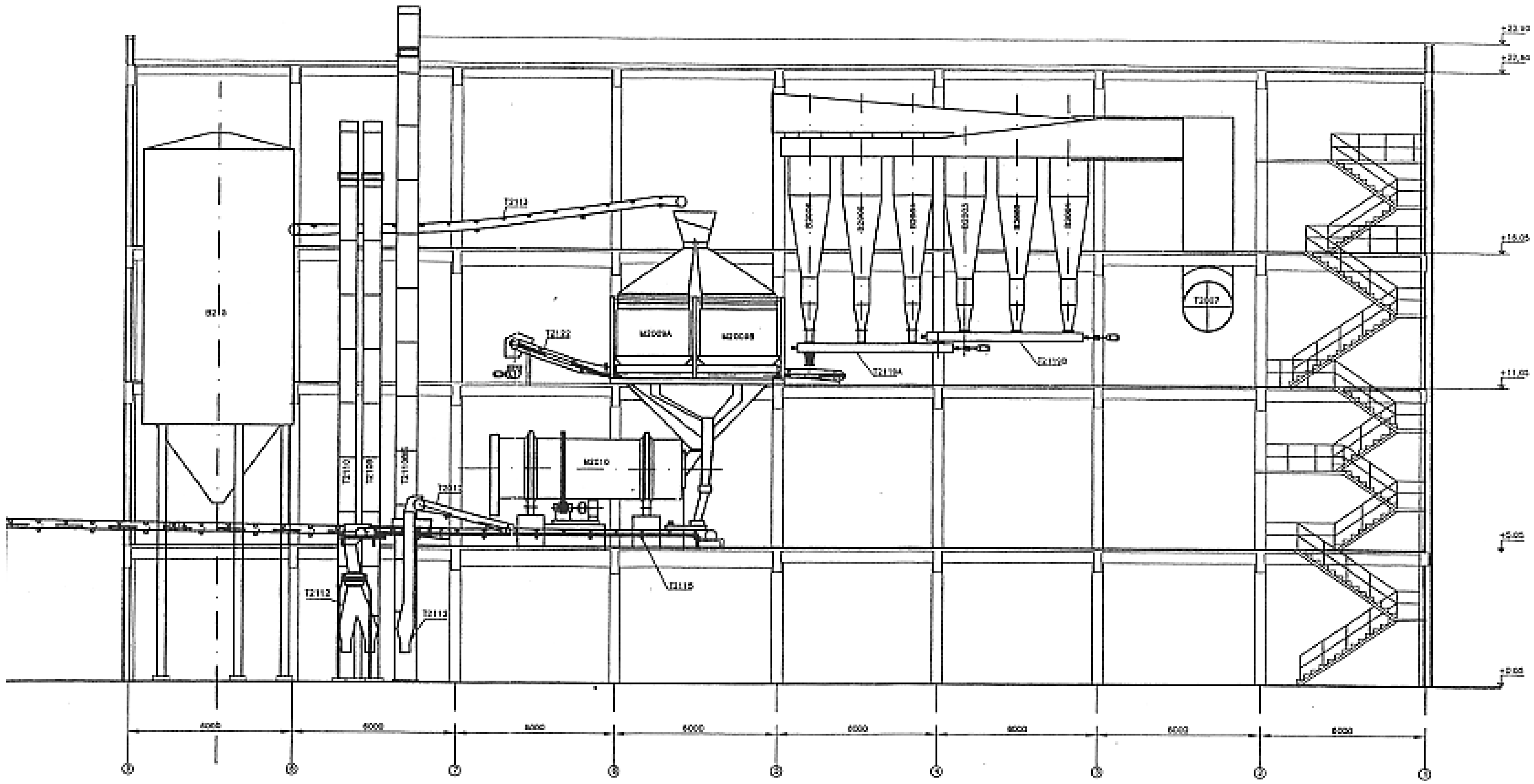


Fig.4d Top view of Prill Conditioning Unit Level +16.05 ORPHANCO

Fig.4e Side view of
Prill Conditioning Unit
Level +11.05
ORPHANCO



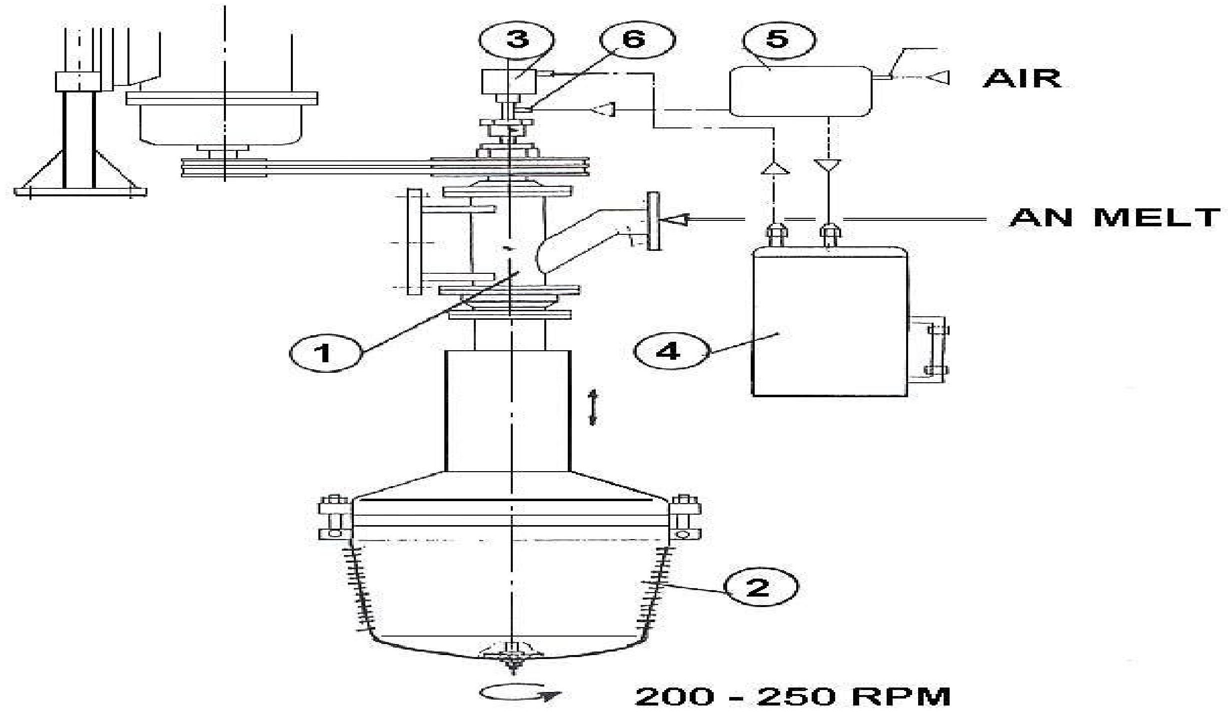
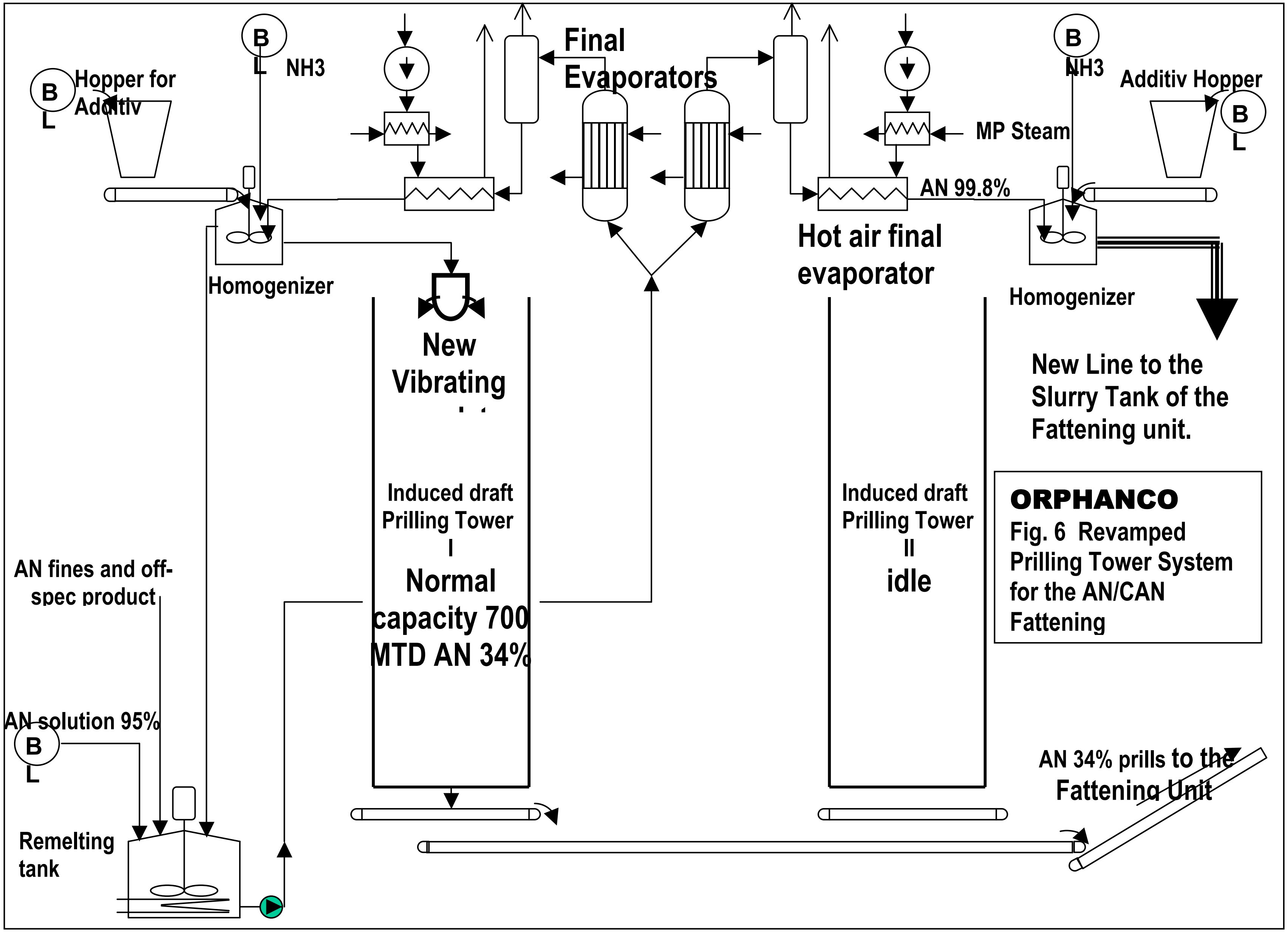


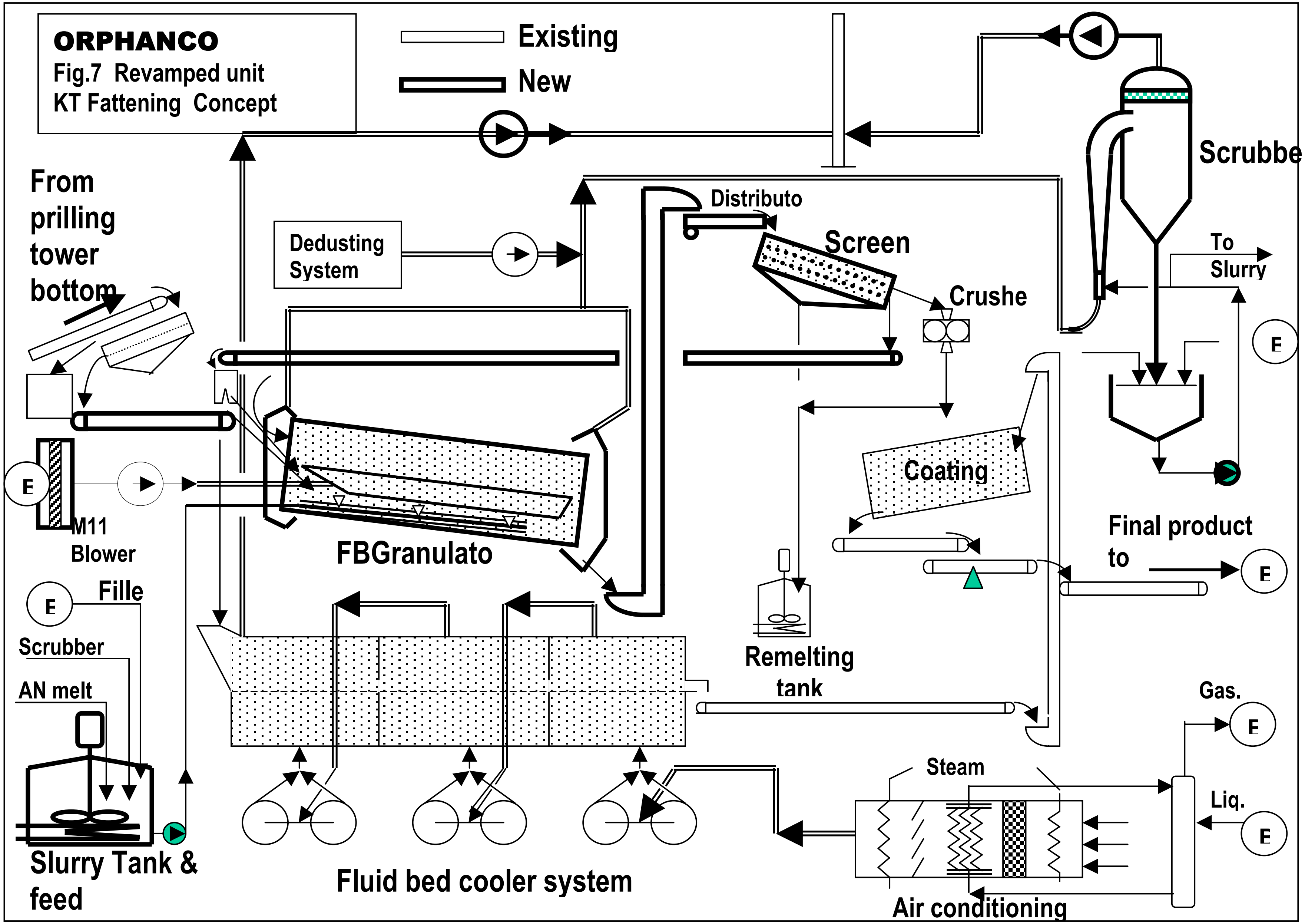
Fig. 5 Scheme of Vibrating Granulator

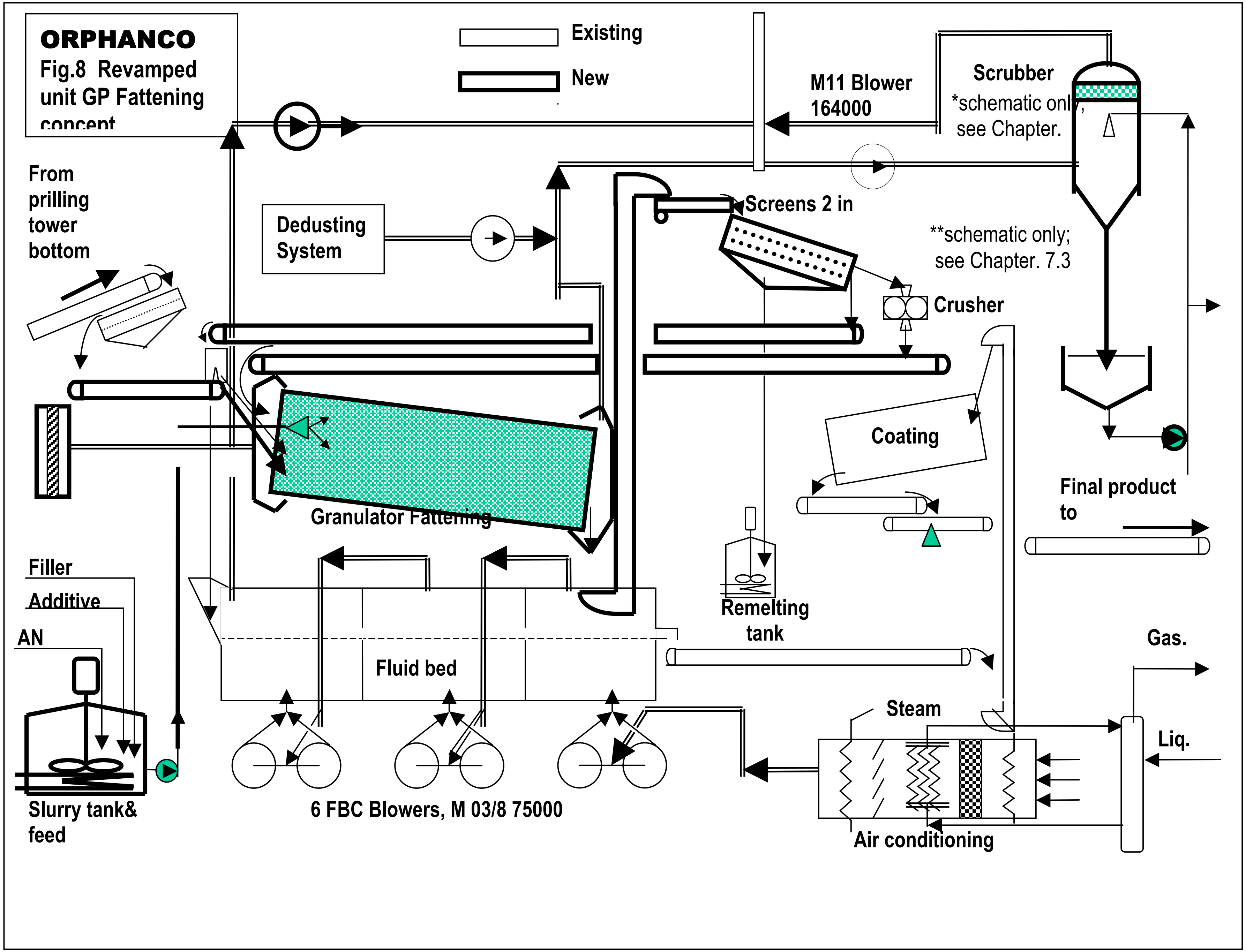
1 melt inlet body
2 perforated basket
3 vibrator
4 oil-aerosol generator
5 control panel for vibrator
6 impulse line for melt level measurement

ORHANCO



ORPHANCO
Fig. 6 Revamped Prilling Tower System for the AN/CAN Fattening


ORPHANCO
Fig.7 Revamped unit
KT Fattening Concept
Existing
New
Scrubbe
To
Slurry
From
prilling
tower
bottom
Dedusting
System
Distributo
Screen
Crushe
M11
Blower
FBGranulato
Coating
Final product
to
Fille
Scrubber
AN melt
Remelting
tank
Gas.
Steam
Liq.
Slurry Tank &
feed
Fluid bed cooler system
Air conditioning
E


ORPHANCO
Fig.8 Revamped unit GP Fattening concept
Existing
New
M11 Blower
164000
Scrubber
*schematic only, see Chapter.
From prilling tower bottom
Dedusting System
Screens 2 in
**schematic only; see Chapter. 7.3
Crusher
Coating
Final product to
Granulator Fattening
Filler
Additive
AN
Remelting tank
Fluid bed
Gas.
Liq.
Steam
Slurry tank& feed
6 FBC Blowers, M 03/8 75000
Air conditioning

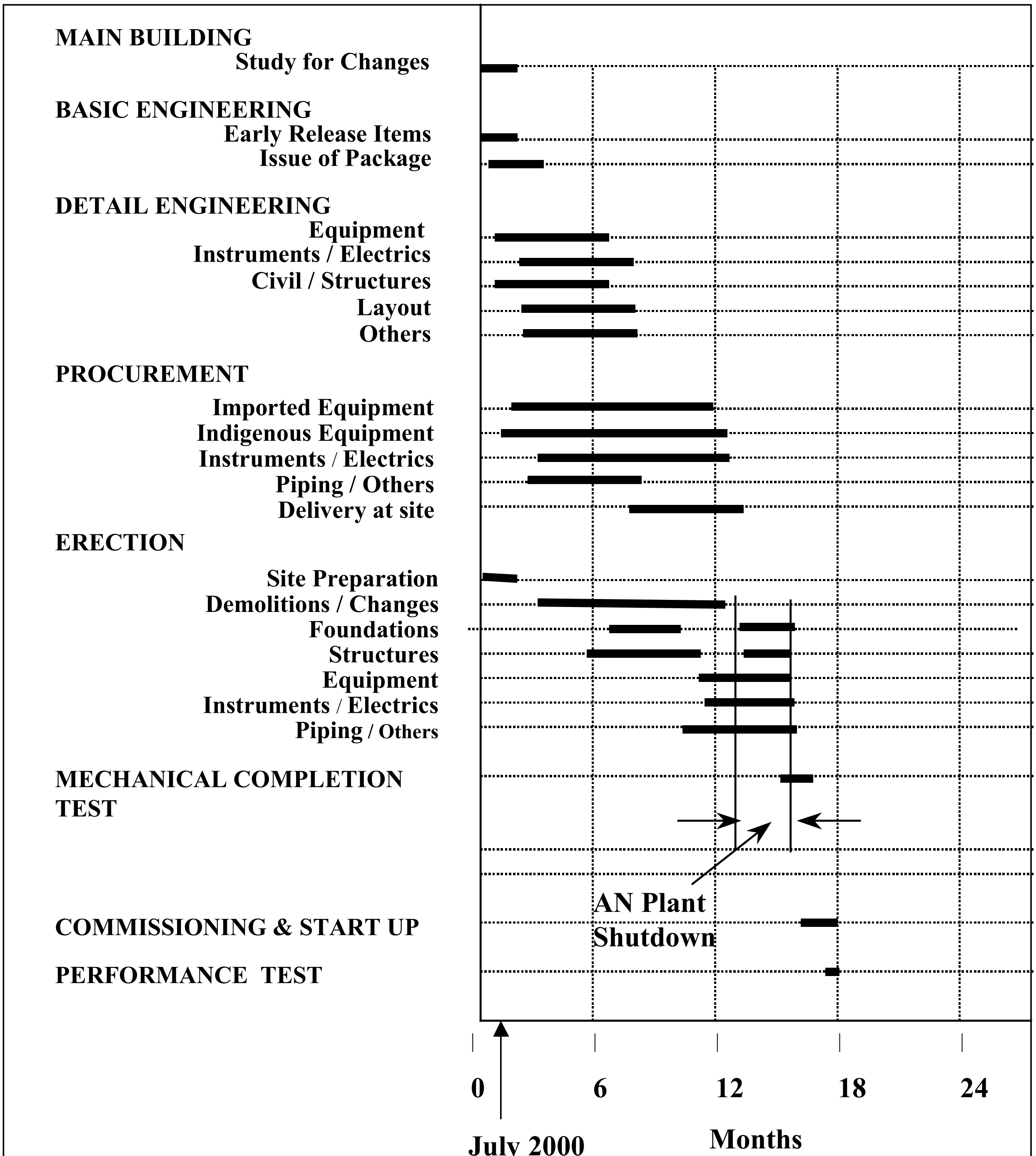


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Fig. 9 FATTENING PROJECT SCHEDULE

Fig. 10 a Side view of new Fattening AN/CAN unit - KT concept

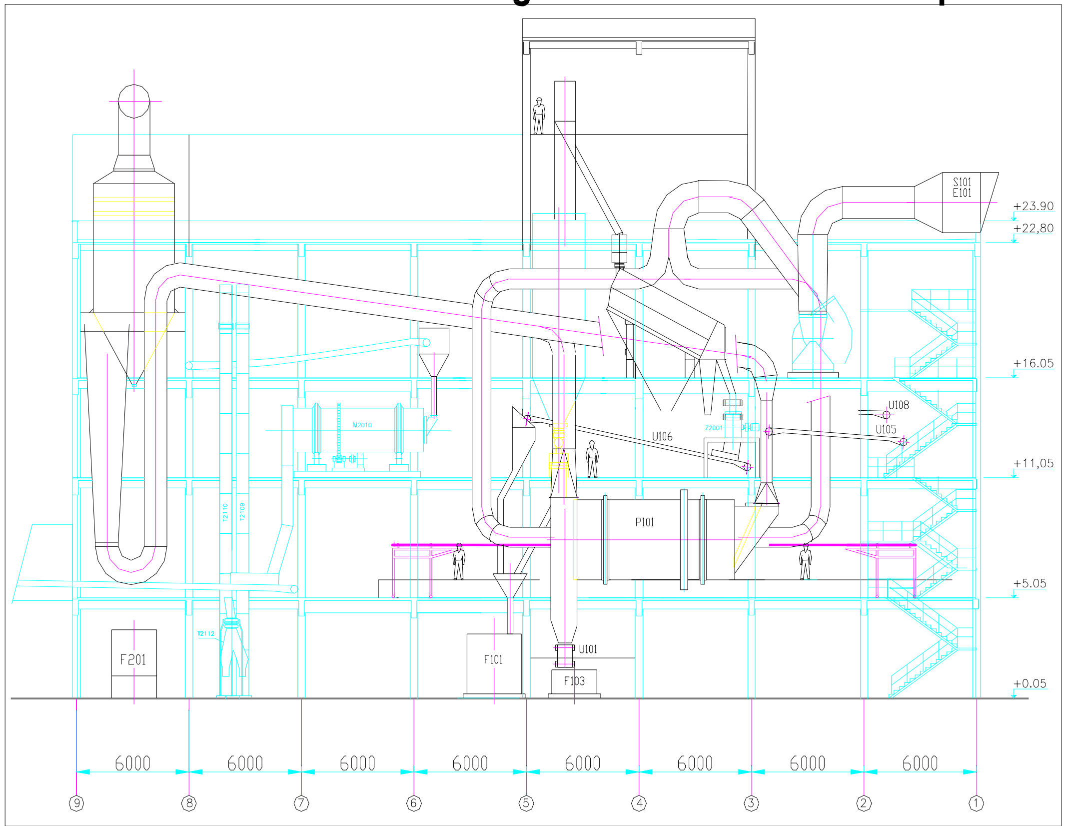

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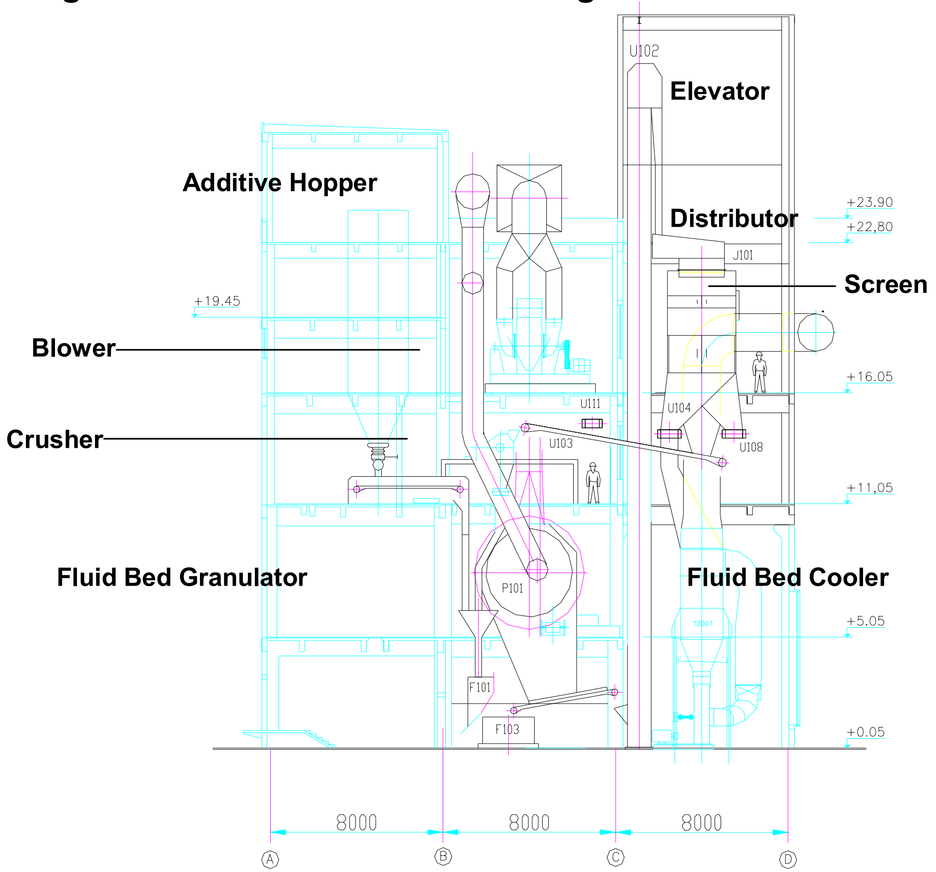
Fig10b. Sectional View of Fattening AN/CAN unit – KT concept



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