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International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

THE INTERNATIONAL
SUPERPHOSPHATE MANUFACTURERS' ASSOCIATION

AGRICULTURAL COMMITTEE
AVENUE FRANKLIN D. ROOSEVELT
PARIS (8E)
TEL. BALZAC 57-25

CENTRAL OFFICE
44 RUSSELL SQUARE.
LONDON W.C.1
TEL MUSEUM 8927

TO ALL MEMBERS:

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GRANULATION OF FERTILISERS IN A CONICAL DRUM.

by NILS LAGERHOLM, CIVILINGENJOR,

of AB Forenade Superfosfatfabriker, Sweden.

During the last few years much work has been done by the Reymersholms Gamla Industri AB, Sweden, x) on the problems of agglomerating pyrites cinders by pellet or ball sintering. This work comprised two separate process stages, namely

1) Ball formation from the pyrites cinders and

2) subsequent sintering of the balls thus obtained.

The experiments were performed at Hälsingborg, Sweden, and eventually a pilot plant was developed in which spherical sintered pellets with a diameter of roughly 20 mm were produced. The work on this pilot plant was successful and resulted in the construction of a full scale plant at Oskarshamn which is now producing 100 tons of sinter per day. At this plant the pellets are formed by first grinding the cinders together with a small amount of coke in a specially constructed mill, where the amount of water required is simultaneously added, and then rolling the material in a conical drum. The pellets thus formed have acquired sufficient strength for them to be introduced into an oil-fired shaft furnace where sintering takes place.

The highly satisfactory results obtained with the conical drum gave rise to the thought that its agglomerating or granulating properties might equally profitably be applied to fertilisers. Therefore a series of experiments were carried out using a conical drum for granulation of superphosphate and fertiliser mixtures containing superphosphate.

The experiments have not hitherto been completed but it is the object of this paper to describe the results obtained up till now.

The conical drum, design and working principle.

The design of the pilot plant drum is seen in fig. 1. The drum's largest diameter is 2 m and it has a top angle of 50°. It is supported on a rack which within limits can be tilted as desired by means of a screw. The drum is rotated by means of a motor via a worm

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x) A company allied to the AB Förenade Superfosfatfabriker.

gear at the small end of the drum. Furthermore, it is equipped with a rotating scraper of angle iron in the form of a conical cage which, however, is merely indicated in fig. 1 (item 13). The angle of inclination of the drum axis with the ground plane is about 10 - 15°. Round the circumference of the large end of the drum is an overflow rim for the granules produced.

A drum of this type not only forms the granules by rolling and kneading the material but also separates the granules from other material not sufficiently agglomerated. The principle of this separation is mainly as follows. When the drum rotates the material is lifted along the wall of the drum and at a certain point falls more or less vertically downwards. Owing to the incination of the drum axis the material is transported inwards during this phase. When the material has fallen to the lower part of the drum it proceeds to roll outwards towards the opening owing to the inclination of the conical wall in this part of the drum. After this the first phase is repeated and so on.

During the first phase a smaller particle is lifted higher than a larger one and is thus moved farther into the drum and in the second phase it rolls less far out of the drum than a larger particle. The result of this action is that when material is fed into the drum a stream of granules flows over the rim, whilst the finer particles are retained farther inside the drum until they have been sufficiently agglomerated. This separating principle is illustrated in fig. 2 where two particles of different size originally lying side by side are separated from each other. The track of the larger particle is represented by the dotted line.

The drum was equipped with one belt conveyor for feeding the powdered fertiliser and one for removing the granules. The latter was placed under the overflow. Thus the vertical planes through the conveyors were at right angles with each other and the plane through the feeding conveyor coincided with the one through the axis of the drum. The powder was fed to the feeding conveyor via a desintegrator by which lumps were removed. At the same time the flow of material from the desintegrator was controlled by a shutter. The material leaving the drum was collected in a wheelbarrow which was weighed and emptied from time to time, the load on the drum thus being determined, water, when necessary, was supplied by means of a pressure nozzle placed inside the drum.

Above all two types of fertilisers were studied, ordinary 20% superphosphate and a PK-mixture containing 14% P_2O_5 and 14% K_2O. The potassium of this mixture was added as chloride. Besides these experiments a few were carried out with NPK 7-7-14 made from superphosphate, ammonium sulphate and potassium sulphate.

Granulation of superphosphate.

Quite early in the investigations it was established that a bed of freshly granulated material was necessary for a satisfactory performance of the granulator. Unless such a bed is made up before granulation proper begins, the material simply glides up and down along the wall of the drum without any effective rolling motion being brought about in the mass. The building up of such a bed of granules generally demands the addition of a certain amount of water but after this the feed can begin and granulation can be carried out without further addition of water unless the superphosphate is too old and matured.

The influence of the following factors on the granulating capacity of the drum were investigated:

1) The age and free acid content of the superphosphate.

2) The inclination of the drum.

3) The position of the feed in the drum.

4) The revolving speed of the drum.

1. The age and free acid content of the superphosphate.

As previously mentioned, it was possible to granulate superphosphate without addition of water, unless the superphosphate was too old (6 - 7 hours). This was thought to be due to the decreasing content of free acid in fresh superphosphate. For the study of the rate of this decrease two curves were determined showing the free acid content as a function of time, one referring to superphosphate made from 60% Khouribga and 40% Louis Gentil and the other to superphosphate made from 1/3 Khouribga, 1/3 Louis Gentil and 1/3 Pebble. These curves are shown in fig. 3. The age of the superphosphate is counted from the time when it leaves the den. The curves show that the free acid content decreases very rapidly and that the rock phosphate containing Pebble gives a superphosphate with a higher free acid content at such times as are of interest. A trial was therefore made with superphosphate produced from the latter rock phosphate mixture (containing Pebble) and which was about 20 min. old at the beginning of the trial. The result of this trial was that the capacity was about 5 tons/hr. at the start but during the trial it decreased so that after 50 min. it amounted to 1,3 ton/hr. These facts are illustrated graphically in fig. 4. Another trial was therefore performed in roughly the same way but after 50 min. fresh superphosphate was fed into the drum which resulted in a sharp rise in capacity (fig. 5).

In order to avoid the undesirable effect of this ageing of the superphosphate a trial was made in which fresh superphosphate was supplies to the desintegrator in small quantities during the whole trial. In this way the age of the feed was kept between 10 and 20 minutes which resulted in a very constant capacity of about 3,9 ton/hr being obtained (Fig.6).

All these trials, represented by figs 4, 5, 6, were made with superphosphate made from the Pebble containing rock phosphate mixture mentioned previously. Another trial was made with superphosphate made from 60% Khouribga and 40% Louis Gentil. This mixture gives, as has been stated, a superphosphate with a lower free acid content and it was therefore to be expected that the granulating capacity of the drum would be lower with this material. This was also the case, the capacity being only 1,25 tons/hr. Part of this trial is illustrated in fig. 7.

By capacity is meant the ability of the drum to plasticize and agglomerate the powdered feed into granules and afterwards separate these granules from unagglomerated material. The size of the granules should be about 3 mm. This definition of capacity is of course rather vague but has proved useful in comparing the trials. During operation, the load on the drum must within quite narrow limits equal the capacity of the drum. Thus, it is just as harmful if the feed is too small as if it is too large. If this is the case the granules grow too large and wet owing to excessive kneading, but on the other hand if the feed exceeds the capacity the granules become smaller and finally unagglomerated material is forced out of the drum.

The trials recorded in this section show that the age of the superphosphate has a very important influence upon its tendency to agglomerate. This is probably partly due to the diminishing content of free acid, which constitutes part of the liquid phase present, but may also be explained by the transformation of mono-calciumphosphate into the crystalline state. This, however, has no been investigated. The granules on leaving the drum are slightly moist and fairly soft but after an hour or two they have attained completely satisfactory strength and hardness, which increases still more during the next twelve hours. Therefore, from this point of view, drying might be avoided.

2) The inclination of the drum.

The effect of this factor was investigated before the influence of the age of the feed was properly appreciated. The material was two or three hours old and the capacity of the drum therefore low. However, it was shown that for instance an increase of the inclination from 13°1 to 17°5 caused an increase of capacity from 0,5 tons/hr. to 0,9 tons/hr. This increase is to be expected as an increase of inclination also leads to an increase of the volum of the bed of rolling granules and thus also of the kneading effect. Another consequence of an increase of inclination is that the separating capacity is also improved. The inclination cannot, however, be increased indefinitely for beyond a certain limit the material ceases to roll freely throughout the whole length of the dr and the functioning of the drum is impaired.

3) The position of the feed in the drum.

The trials showed that the feed should be placed between 0,5 and 1 m from the overflow of the drum. If the distance is less tha 0,5 m the drum will not have time to separate the powder from the granules, and if it is larger than 1 m the powder will accumulate at the bottom of the drum and finally force the bed of granules out of the drum without agglomerating.

4) The revolving speed of the drum.

The speed of the drum was in one instance increased from 15 r.p.m. to 22 r.p.m. which caused an increase of capacity from 0,9 tons/hr. to 1,2 tons/hr. (two or three hours old superphosphate) Naturally the speed must not be increased beyond a limit where the centrifugal force begins to disturb the rolling motion.

Control of granule size.

During several of the trials with fresh superphosphate it was noticed that the granules had a tendency to increase excessively in size towards the end of the trial. Thus, in a few cases, the granules ended up as large as 6 - 8 mm. The problem how to master this difficulty was studied in several trials where two factors were varied, the inclination of the drum and the position of the feed. These trials showed that a smaller inclination produced smaller granules but that, of course, the capacity decreased.

If, however, the feed was moved farther into the drum the granules also decreased in size but no decrease in capacity was noticed. This is probably due to the formation of a larger number of granule nuclei.

In fig. 8 the result of a trial is illustrated where these observations were applied. The granules were about 4 mm large and the mean capacity was 2,7 tons/hr. Fig. 8 also shows the influence of the age of the feed.

Granulation of matured superphosphate.

A few trials were also made with more or less matured superphosphate (7 - 14 days old). As has been mentioned previously such material demands the addition of water and these trials showed that 3,5 - 4% water was necessary, giving a capacity of about 3,5 to

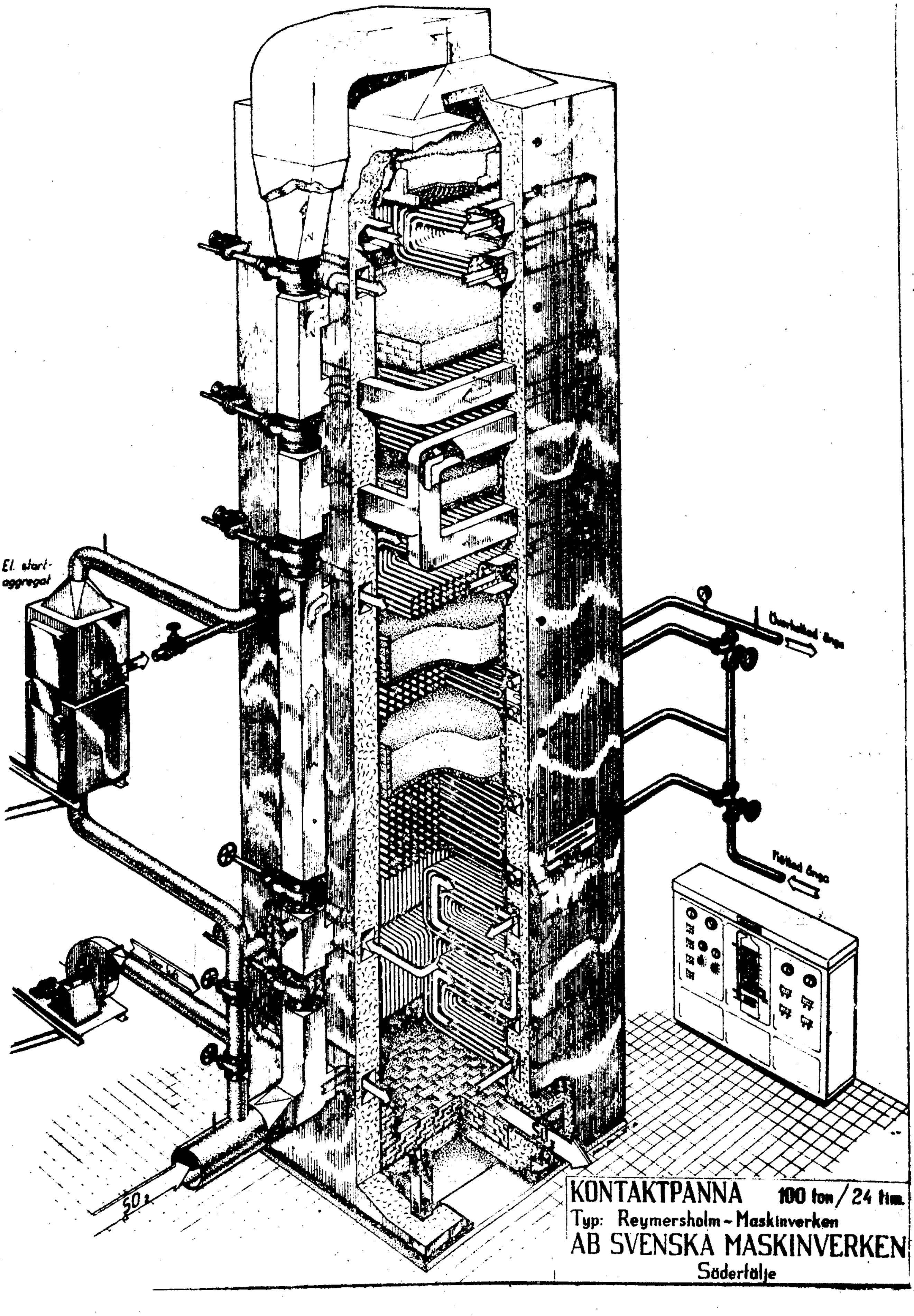
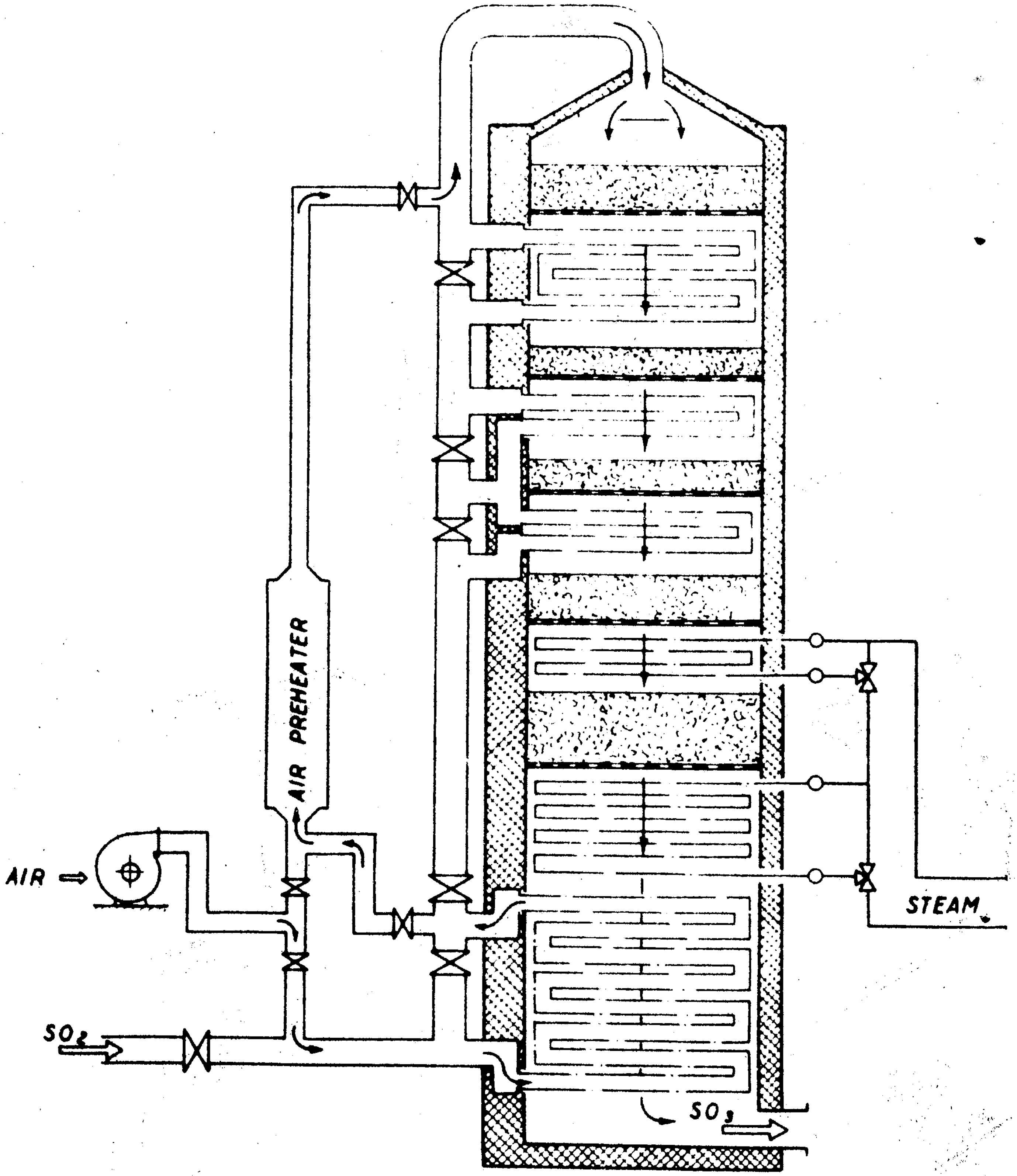
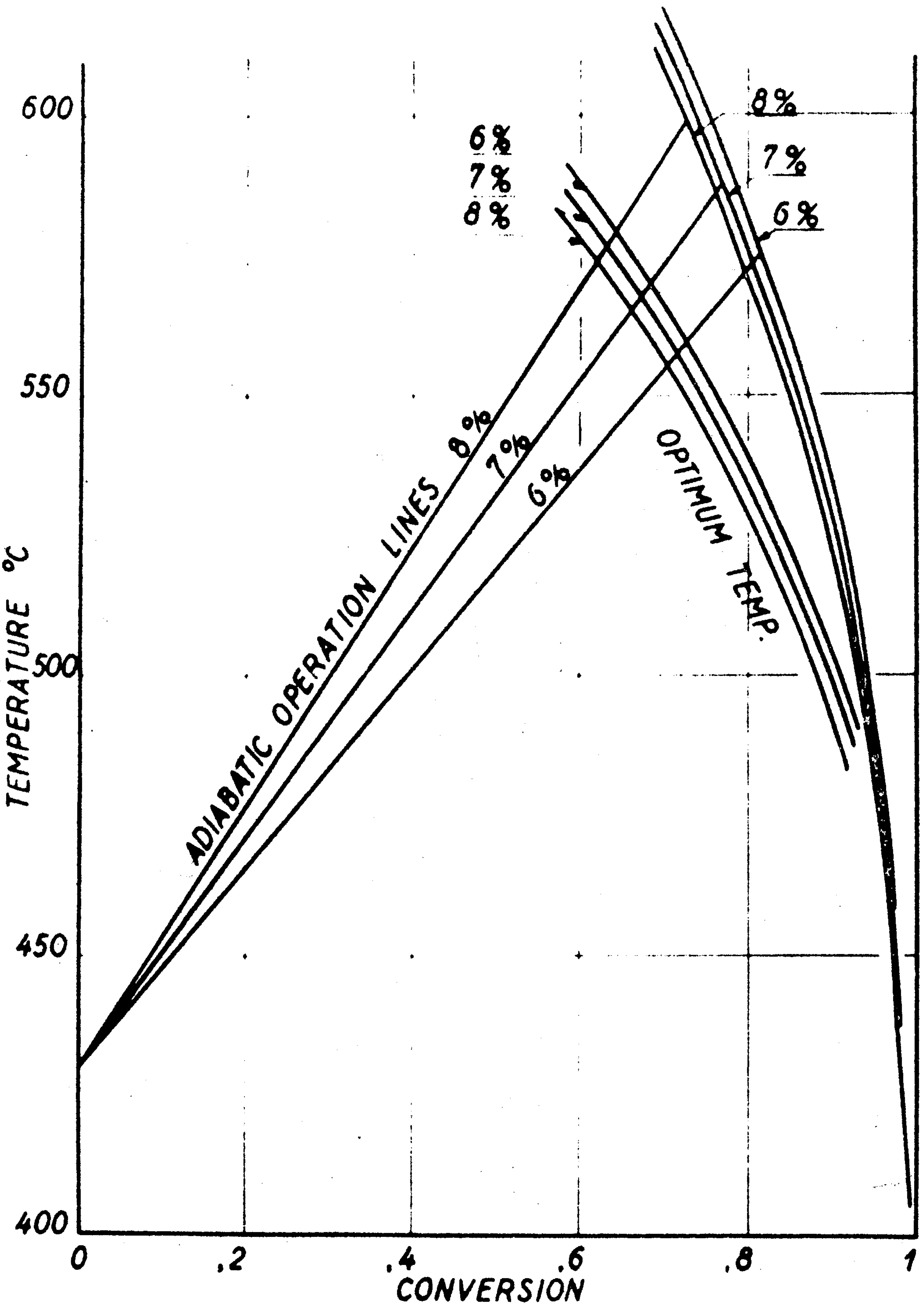

El. start-
aggregat
SO_2
KONTAKTPANNA 100 ton / 24 tim.
Typ: Reymersholm - Maskinverken
AB SVENSKA MASKINVERKEN
Södertälje

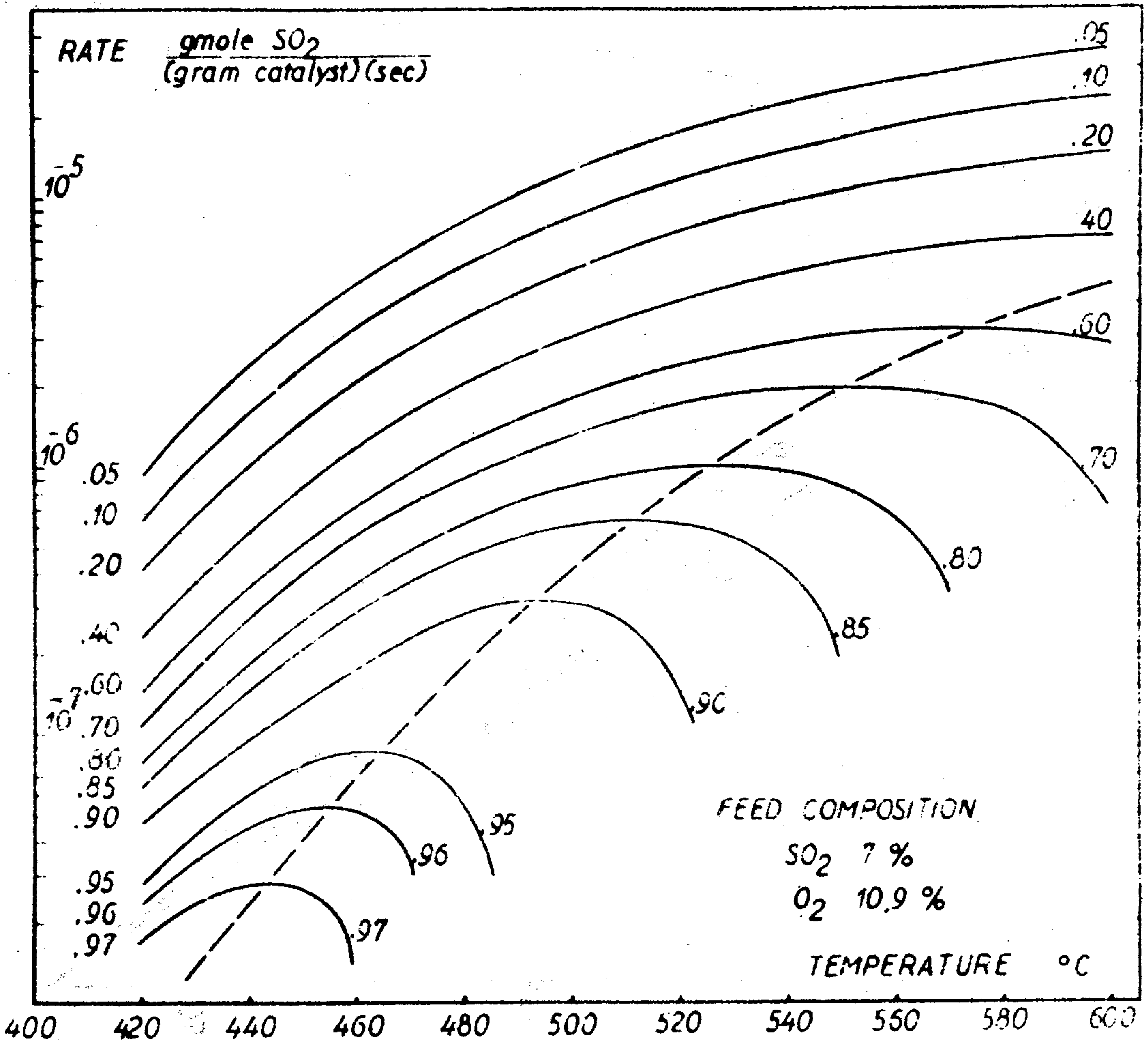
Fig. 7.



AIR PREHEATER
AIR
STEAM
SO_2
SO_3



TEMPERATURE-CONVERSION DIAGRAM



RATE gmole SO2 / (gram catalyst)(sec)
10^-5
10^-6
10^-7
.05
.10
.20
.40
.60
.70
.80
.85
.90
.95
.96
.97
FEED COMPOSITION
SO2 7 %
O2 10,9 %
TEMPERATURE °C
400
420
440
460
480
500
520
540
560
580
600

Under these circumstances it proved difficult to control the size of the granules. Besides this, there was difficulty with formation of large lumps and caking on the walls of the drum. The granules obtained were less strong and hard than those from previous trials, probably owing to their higher content of moisture. They would no doubt have to be dried in order to attain satisfactory strength.

Granulation of PK 14-14.

The trials with this material showed that the factors important in granulating superphosphate had the same effect in this case. PK 14-14, however, proved easier to plasticize and granulate than superphosphate and the capacity of the drum for this material was about 5 tons/hr. without addition of water when the superphosphate of the mixture was fresh. The granules produced became hard after a few hours as in the case of superphosphate. A caking test was made by first letting the new granules lie in a heap overnight and then bagging 20 bags of it which were afterwards piled on each other 10 bags high. After 2 months the bags were inspected and no sign of caking or crushing of granules could be detected.

Two or three trials were also made with PK containing somewhat matured superphosphate (9 days old). Unlike matured pure superphosphate it was possible to granulate this material without addition of water, the drum having a capacity of roughly 1 ton/hr. An addition of about 1% of water increased this capacity to 2,1 tons/hr.

Granulation of NPK 7-7-14.

The ingredients of this mixture - 37% superphosphate, 28% potassium sulphate and 35% ammonium sulphate - were mixed before being fed to the drum. Addition of 6 - 7% of water proved necessary and resulted in a capacity of about 2 tons/hr. The granules had to be dried in order to attain sufficient strength.

The trials with the conical drum, of which only a few have been cited above in order to avoid undue prolixity, have proved so promising that a larger drum with an opening diameter of 4 m. has been built. A number of trials have been made with this drum but have as yet not progressed far enough to be included in this paper.

Summary

Granulation experiments with a pilot plant conical drum are described. The materials granulated were mainly 20 % superphosphate and PK 14 - 14. The drum forms granules and separates them from unagglomerated material. Granulation was possible without any addition of water if the material was sufficiently fresh. In this case the capacity of the drum for superphosphate was about 3 tons/hr. and for PK about 5 tons/hr. The granules thus produced attain sufficient hardness and strength without drying. The influence of several factors upon the operation of the drum is described.

Fig. 1

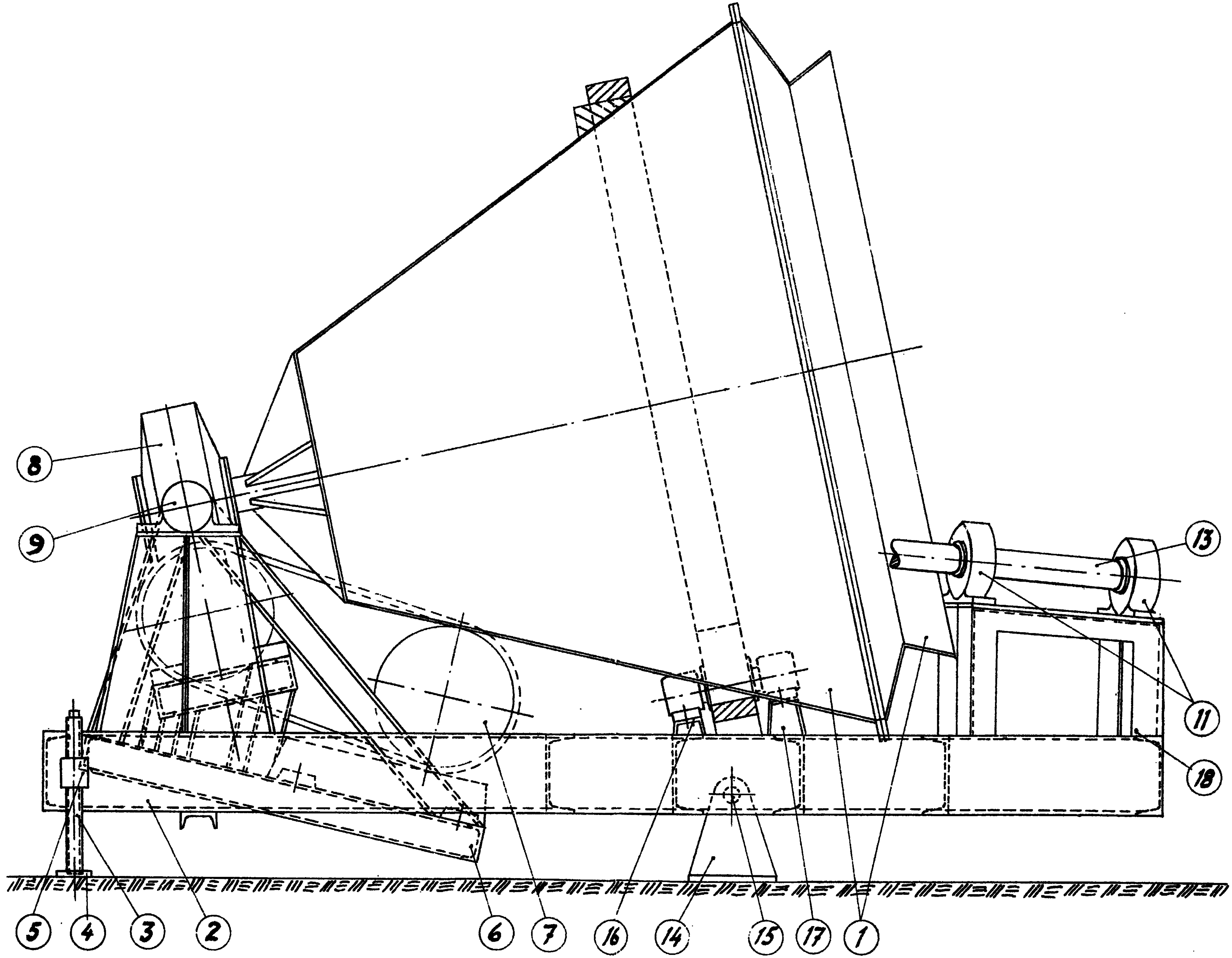
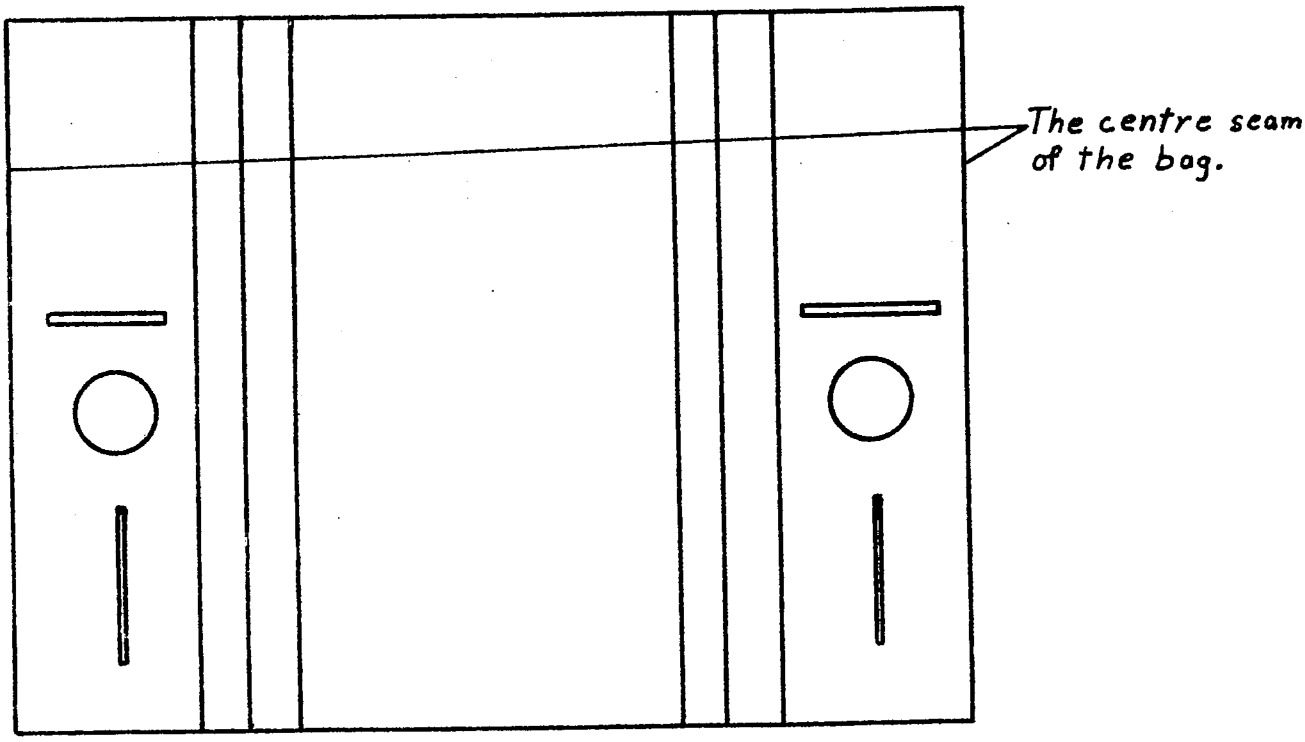
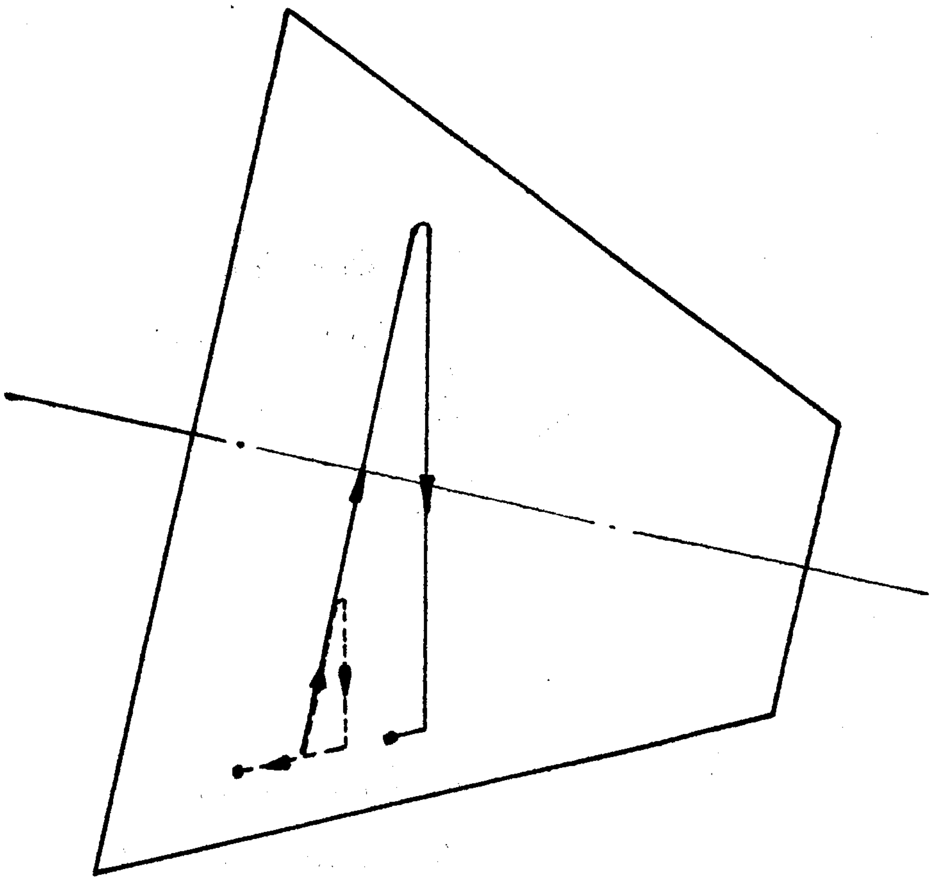


Fig. 1.

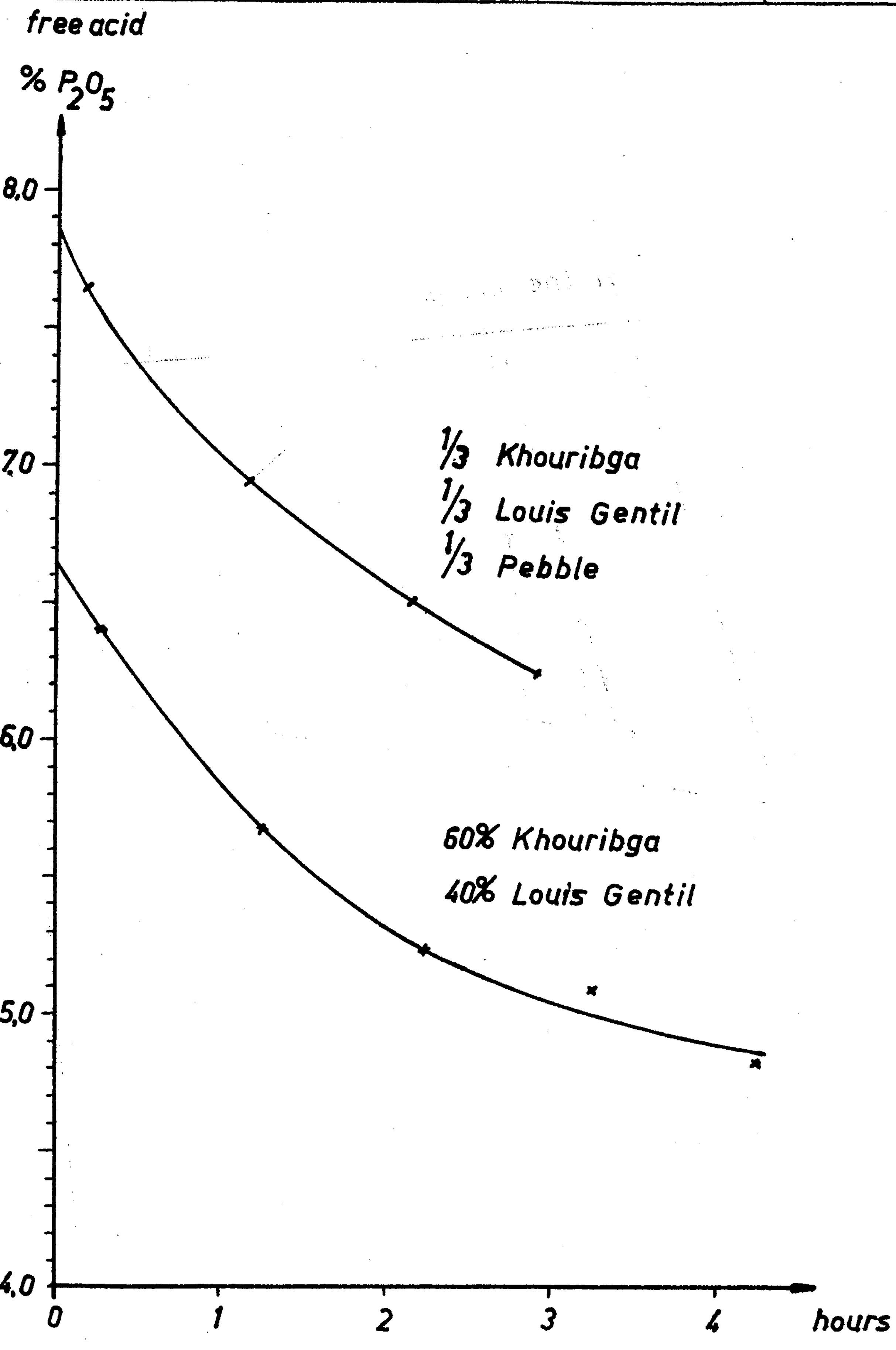


	The separating principle of the drum.	Fig. 2



Content of free acid as a function of time.

Fig. 3



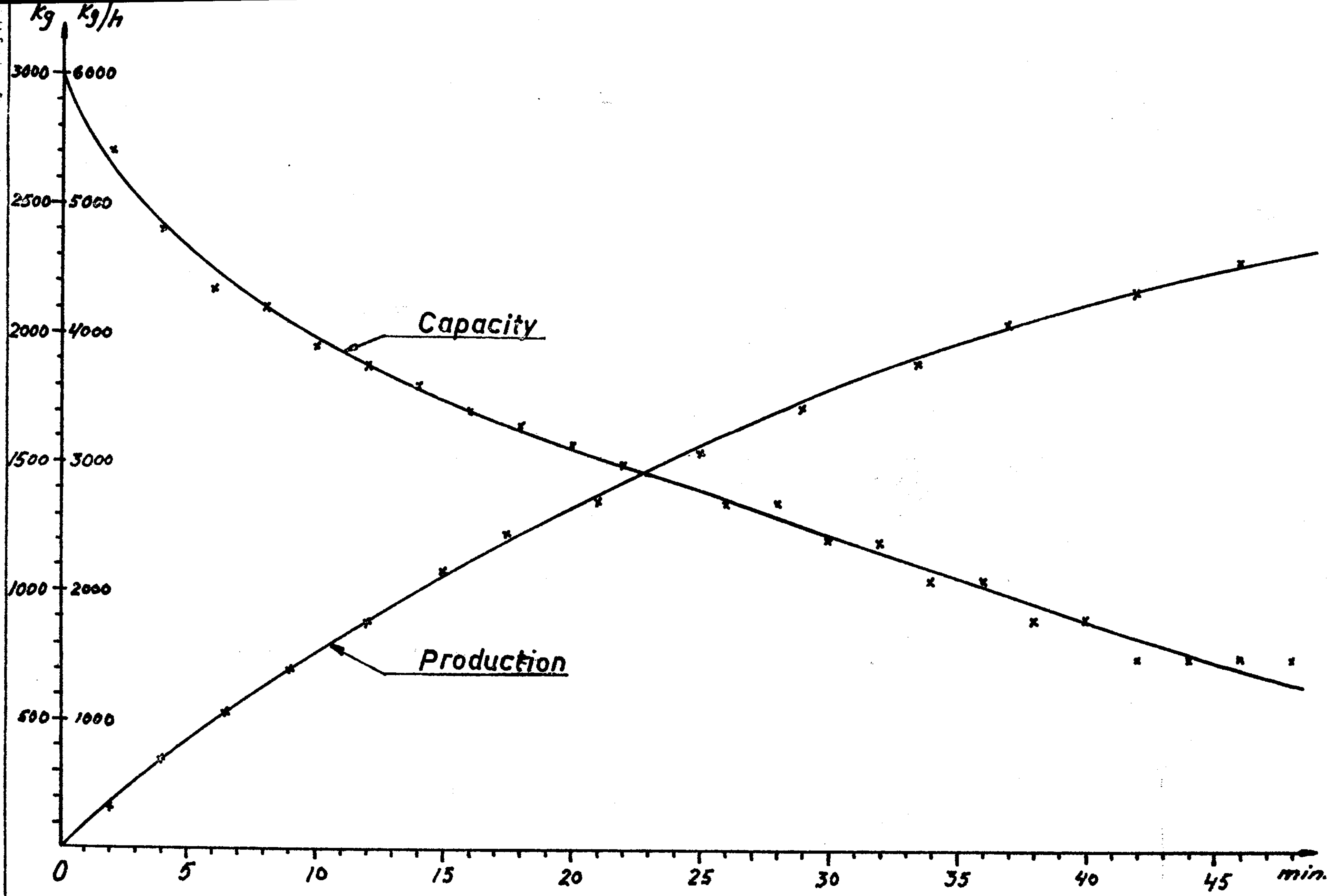

kg
kg/h
3000
6000
2500
5000
2000
4000
1500
3000
1000
2000
500
1000
Capacity
Production
0
5
10
15
20
25
30
35
40
45
min.

Fig. 4

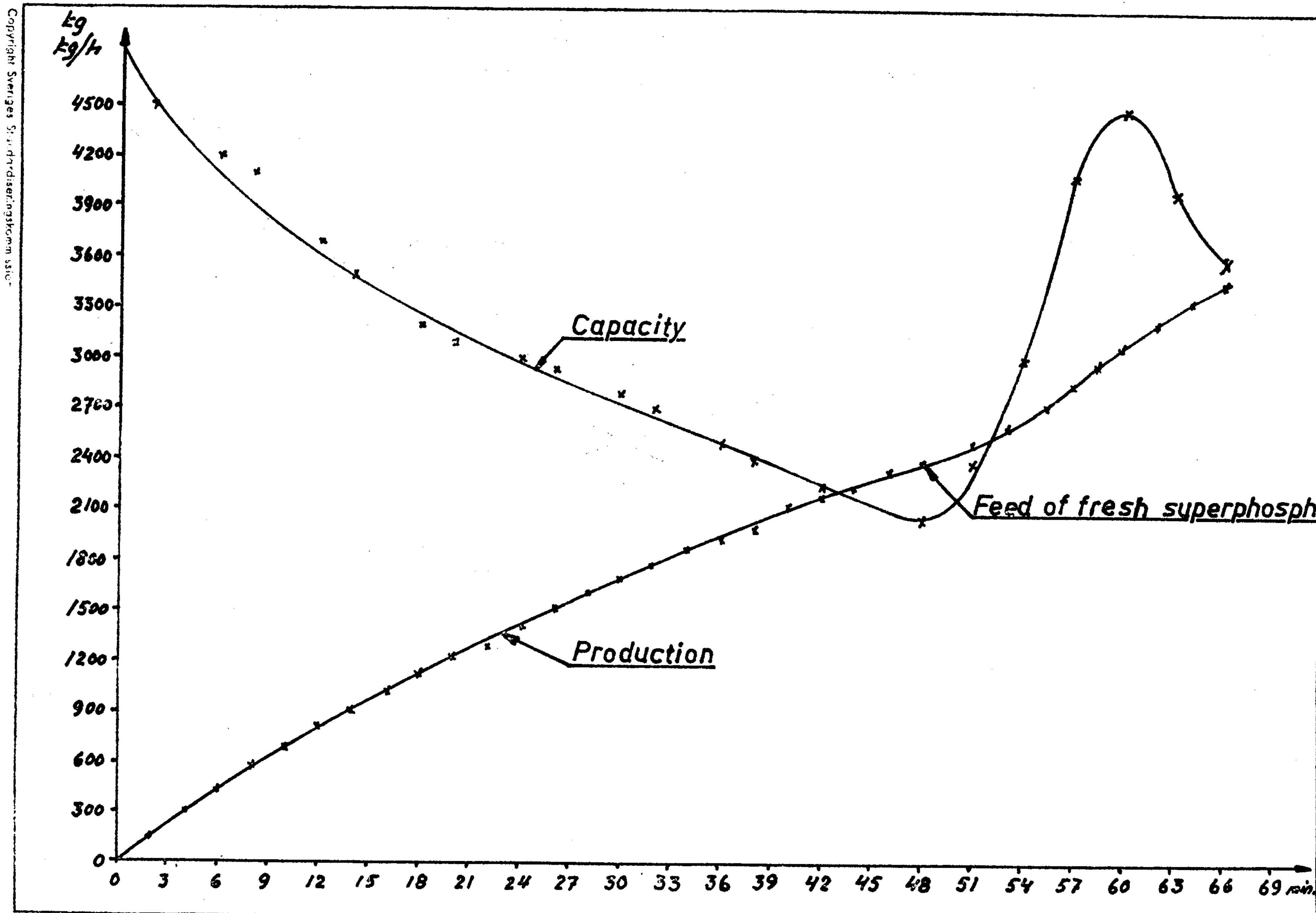

kg
kg/h
4500
4200
3900
3600
3300
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
63
66
69 min.
Capacity
Feed of fresh superphosphate.
Production

Fig. 5

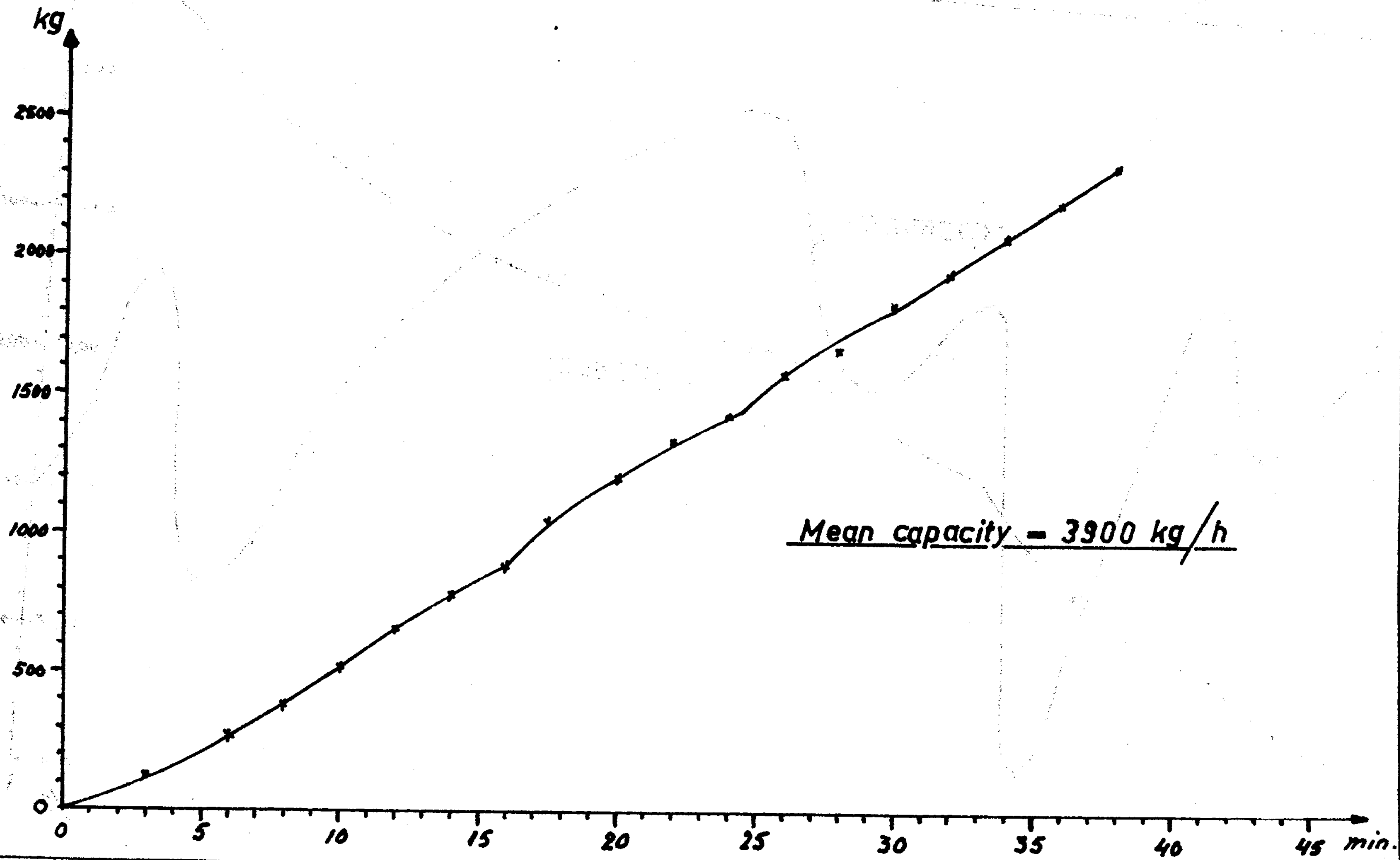

kg
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
35
40
45
min.
Mean capacity = 3900 kg/h

Fig. 6

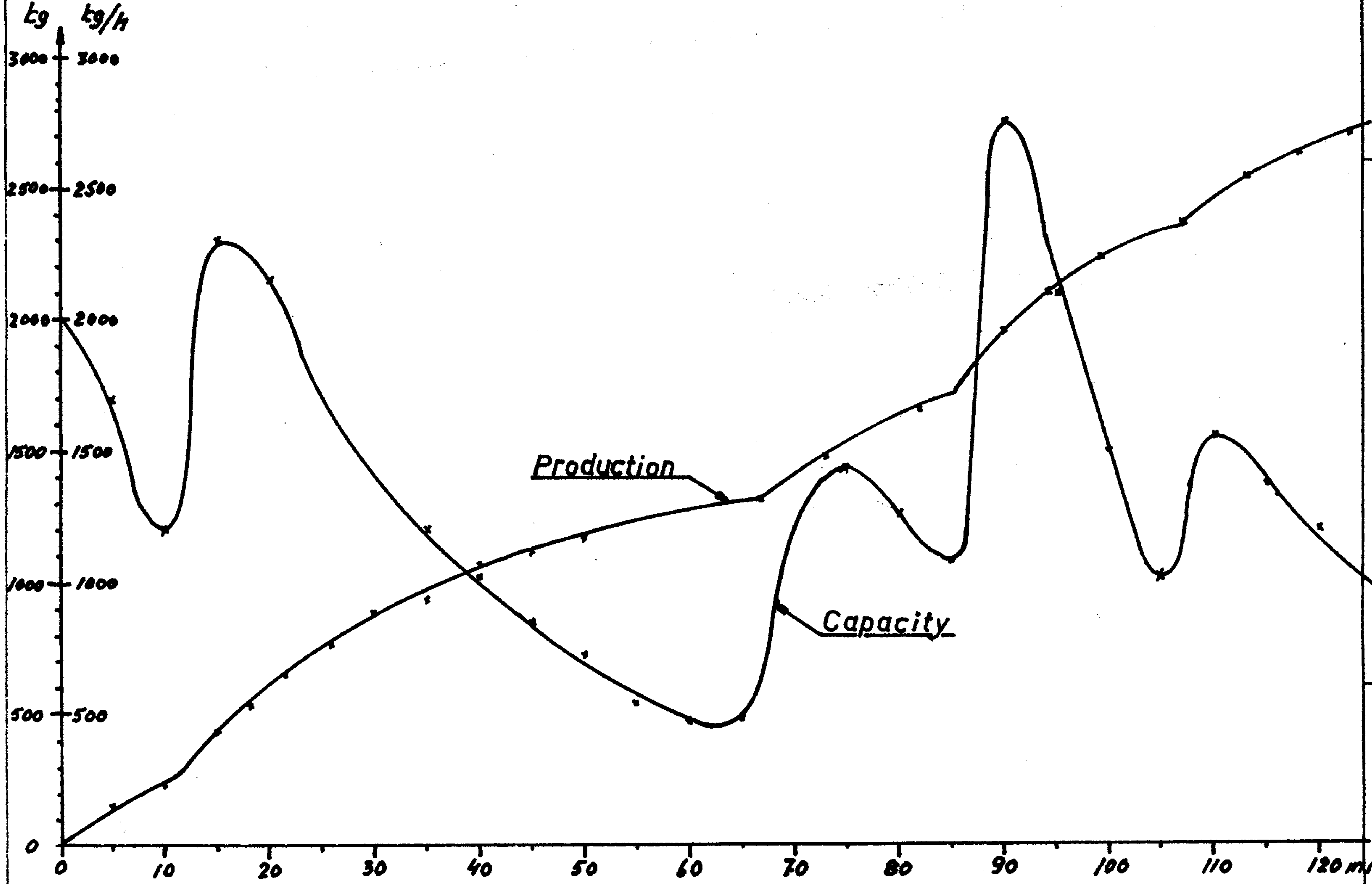

kg
kg/h
3000
3000
2500
2500
2000
2000
1500
1500
1000
1000
500
500
0
0
10
20
30
40
50
60
70
80
90
100
110
120 min.
Production
Capacity

Fig. 7

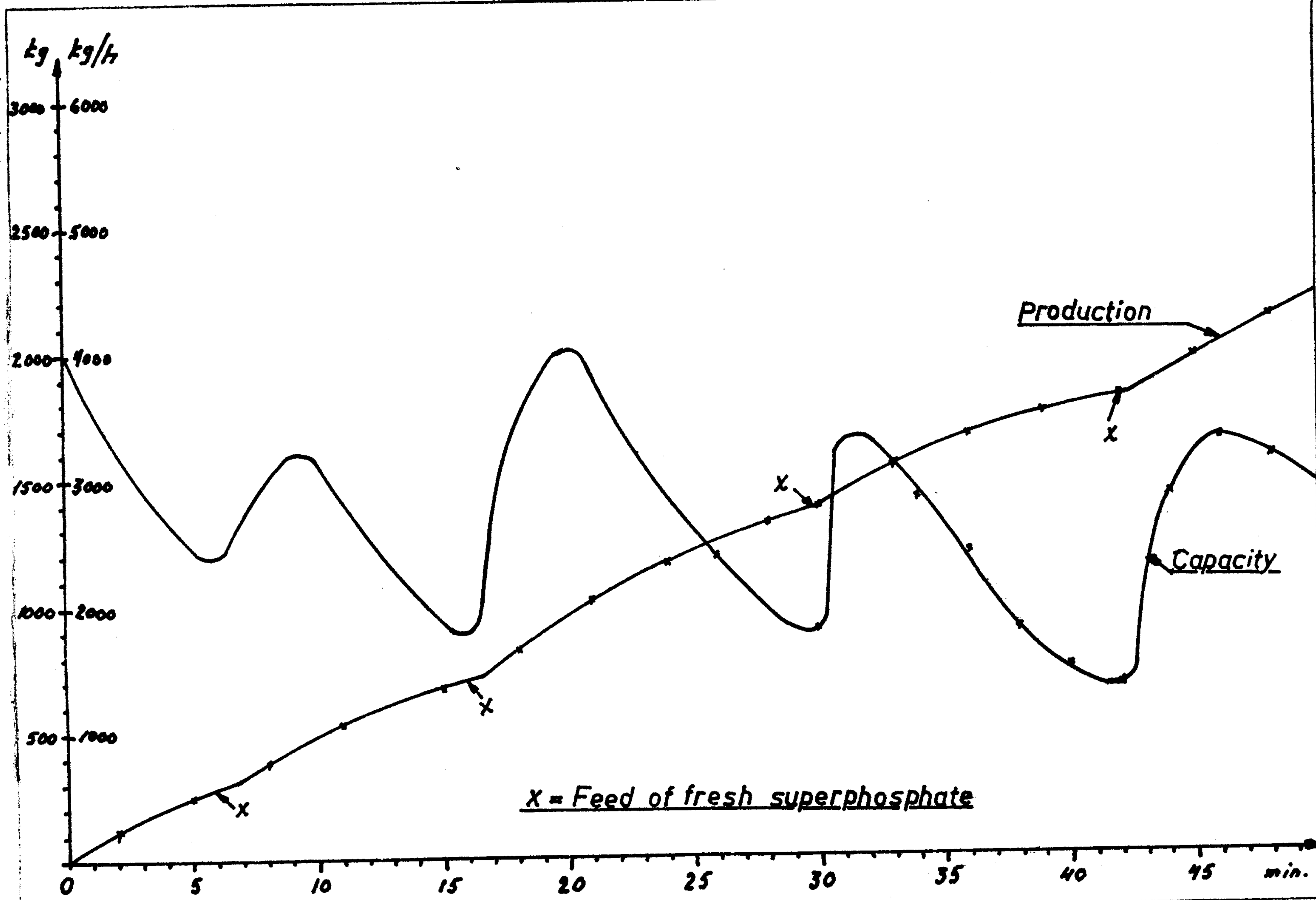

kg
kg/h
3000
6000
2500
5000
2000
4000
1500
3000
1000
2000
500
1000
0
5
10
15
20
25
30
35
40
45
min.
Production
Capacity
X
X = Feed of fresh superphosphate

Fig. 8