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PROCESS FOR OBTAINING NEW REACTION PRODUCTS OF  
PHOSPHORIC ACID, UREA AND AMMONIA, AND THEIR  
APPLICATIONS IN THE FERTILISER INDUSTRY

By

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Most polyphosphate based liquid fertilisers manufactured from wet process phosphoric acid can only be kept for a limited time, because after some months of storage, a slight deposit is found at the bottom of the storage tanks. Trials carried out at our Research Laboratory showed that the formation of this deposit is directly related to the amount of various impurities in the phosphoric acid used, particularly the fluorine and magnesium content. Defluorination of phosphoric acid to be used for polyphosphate based liquid fertiliser manufacture can be achieved by heating and concentration, but even partial elimination of the other impurities involves problems which are difficult to resolve from the industrial point of view.

Our idea was to achieve wet process phosphoric acid purification by crystallising the  $P_2O_5$  at the stage of practically pure urea phosphate and to use these crystals to make polyphosphate based liquid fertiliser. This led us to develop a process for the manufacture of highly concentrated liquid and/or solid fertilisers based on ammonium polyphosphate and urea. This process makes simultaneous use of the purification resulting from the crystallisation of the urea phosphate and the action of ammoniation and condensation of the crystals obtained.

Our operating method combines the chemical reactions between phosphoric acid, urea and ammonia in such a way that the thermal balance is in surplus, enabling the process to function within an autothermal system.

The details of the process are as follows:

Manufacture of Urea Phosphate

Urea phosphate is a crystalline compound obtained by reaction between phosphoric acid and urea in stoichiometric proportion by the reaction:



The reaction is exothermal, releasing 53 K.cal. per kg of pure crystalline urea phosphate. The urea phosphate is water soluble, and its solubility increases with temperature. Consequently, the operating efficiency of the process of crystallisation or manufacture of crystalline urea phosphate is a function of the amount of water in the reaction medium and the evaporation temperature of the crystal slurry. To obtain a high crystallisation yield during manufacture one should use a concentrated phosphoric acid (50-53 per cent  $\text{P}_2\text{O}_5$ ) and solid urea, cooling the crystal slurry before evaporation to a low temperature.

Depending on circumstances, it is possible to use urea solution at  $100^\circ\text{C}$  containing 88 per cent by weight of urea but the introduction of water into the reaction medium will naturally reduce the crystallisation yield and increase the volume of mother liquor produced, unless the manufacturing plant has a low pressure evaporator. Moreover, in order to maintain sufficient fluidity in the reaction medium consistent with effective agitation during the reaction forming the urea phosphate, and to obtain a good separation between the crystals and the mother liquor by evaporation, our process requires the recycling of about three-quarters of the volume of the mother liquor produced in the reaction vessel.

Some plants may comprise a vacuum evaporator to reduce the volume of mother liquor in circulation or an apparatus for double crystallisation under low pressure.

We chose the simplest crystallisation process requiring a minimum of apparatus:

- a reaction vessel with agitator:
- a crystallisation tank with agitator and cooling equipment:
- a continuous vertical axis centrifuge.

The reaction vessel is used in the formation of urea phosphate by reaction between phosphoric acid and urea with release of heat.

In our process, we also introduce a volume of mother liquor equal to double the volume of phosphoric acid used to ensure suitable viscosity in the reaction slurry and a liquid phase/solid phase ratio of between 2.2 and 2.5 needed for good centrifugal crystal separation in our equipment. This liquid phase/solid phase weight

ratio may be modified in relation to the type of industrial equipment chosen for centrifugation.

Contact time is 15-25 minutes, the reaction is exothermal and the temperature of the reaction medium rises by about 10°C.

The crystallisation tank is used for de-supersaturation of the previously obtained slurry. The crystals grow and are then separated from the mother liquor by centrifugation. The crystals are well formed (orthorhombic system), white and sized between 100 and 750µ.

The compositions of the crystals and the mother liquor as determined by analysis, for manufacture from wet process phosphoric acid (51-53 per cent P<sub>2</sub>O<sub>5</sub>) and prilled urea (46 per cent N) are given in Table 1.

TABLE 1

Composition of the Crystals and the Mother Liquor

	Crystals per cent	Mother Liquor per cent
P <sub>2</sub> O <sub>5</sub> :	44.30 - 44.40	21.50 - 22.40
N :	17.35 - 17.50	7.63 - 8.80
F :	0.060- 0.070	0.70 - 0.80
Fe :	0.064- 0.073	1.15 - 1.25
Al :	0.030- 0.040	0.37 - 0.46
Mg :	0.017- 0.022	0.29 - 0.33
Ca :	0.002	0.03 - 0.04
SO <sub>4</sub> :	0.170	2.50 - 4.76
Si :	less than 100 ppm	0.03 - 0.04

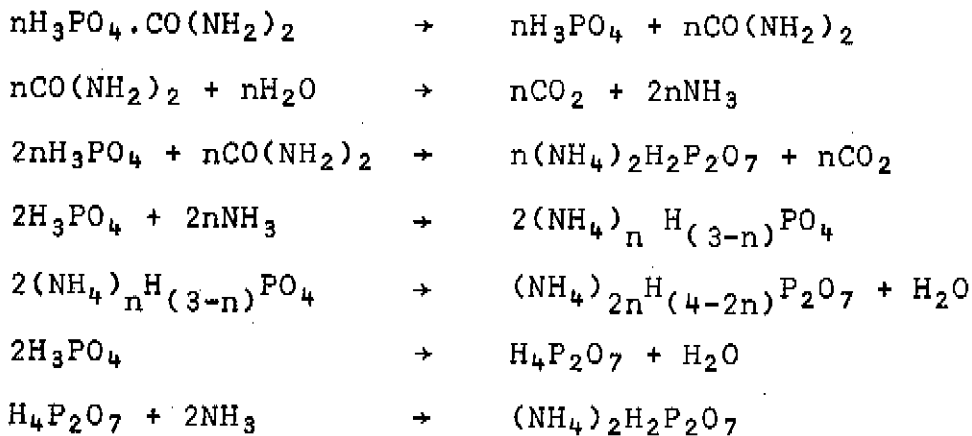
These figures are given for a production with urea phosphate crystallisation yield of 80 per cent in relation to total P<sub>2</sub>O<sub>5</sub> in the wet phosphoric acid used.

The mother liquor remaining after separation of the urea phosphate crystals consists of solutions saturated at evaporation temperature, containing all the impurities from the wet phosphoric acid. It is sent to the fertiliser plant where it is used in the manufacture of a binary urea-ammonium phosphate fertiliser or, after addition of other fertiliser materials, a ternary fertiliser.

A production flow sheet relating to the production of one ton of centrifugal urea phosphate is shown in Figure 1.

### Manufacture of Fertilisers Based on Urea-Ammonium Polyphosphate

Urea phosphate is an additive compound and behaves in chemical reactions like a mixture of phosphoric acid and urea. During ammoniation of this product, depending on the degree of ammoniation and the operating temperature, the following reactions can occur either partially or totally:



Reactions during the ammoniation of ortho- and pyrophosphoric acid are strongly exothermal, whilst the reactions during urea decomposition and polymerisation of the phosphoric molecule are endothermal. It may be noted that, according to our operating methods, the overall heat balance is positive for condensation reactions stopping at the first order and practically at ammonium pyrophosphate. The non-ortho  $\text{P}_2\text{O}_5$ /total  $\text{P}_2\text{O}_5$  ratio of the product is 65-70 per cent.

The polyphosphate manufacturing equipment is extremely simple and functions in an auto-thermal system. It consists essentially of an ammoniation vessel with an agitator, and a polyphosphate synthesis pipe. Ammoniation of the urea phosphate is achieved by injectors at two places, inside the ammoniation vessel and at the entry of the synthesis pipe.

The crystalline urea phosphate is introduced into the above vessel, also called a melt tank, and it is partially ammoniated until the product is transformed from the solid to the liquid state by means of the heat evolved from the partial neutralisation of the phosphoric acid.

The product becomes a paste at  $80^\circ\text{C}$  and liquid at  $85-90^\circ\text{C}$ ,

whilst the melting temperature of the non-ammoniated urea phosphate produced from wet phosphoric acid is  $113^{\circ}\text{C}$ . In continuous operation a temperature of  $100-110^{\circ}\text{C}$  is maintained within the melt tank solely by means of ammoniation of urea phosphate. The ammoniated liquid product is then introduced into a synthesis pipe, at the entry of which it undergoes a final ammoniation by means of an ammonia injector. Within this column occur the reactions of urea decomposition, condensation of the phosphoric molecule and neutralisation of the ortho- and polyphosphoric acid. The temperature of the product, which is roughly  $110^{\circ}\text{C}$  at the synthesis pipe entry, rises to about  $155^{\circ}\text{C}$  at the exit.

The product is a foamy substance which, according to its use - manufacture of solid or liquid fertilisers - is treated differently. When it is used for liquid fertilisers, the foam coming from the synthesis pipe is conveyed to a dissolution tank where the necessary water is added to obtain the desired grade. The dissolution tank is equipped with an agitator, a small absorption column for the gases released, a water inlet, an ammonia inlet to regulate the pH, and possibly a phosphoric acid inlet and a recycle pump. A steam ejector situated at the top of the small gas absorption column evacuates the incondensables. The recycle pump continuously extracts the liquid fertiliser at the base of the tank and sends it back to the upper part after passing it through an external cooler and the small gas absorption column. The polyphosphate liquor within the dissolution tank is thus maintained at a temperature of  $50-60^{\circ}\text{C}$ . Finally, the liquid fertiliser which is sent to storage passes through a pH meter.

The liquid fertilisers thus obtained contain 15-17 per cent N (by weight) and 27-31 per cent  $\text{P}_2\text{O}_5$ , or 20-22 g/litre N and 36.8-40.8 g/litre  $\text{P}_2\text{O}_5$ . This may be compared with the 10-11 per cent N and 34-37 per cent  $\text{P}_2\text{O}_5$  in solutions of ammonium polyphosphate. The liquid is clear, almost colourless and perfectly stable over time, because it contains practically no impurities. The filtration of liquid polyphosphates after manufacture, which is necessary when wet process phosphoric acid is used, is not required in our process.

Depending on the formulation, density at  $20^{\circ}\text{C}$  varies between 1340 and 1360, the pH 1/10 varies from 6.3 to 6.9 and the temperature at the start of crystallisation is between  $-8^{\circ}\text{C}$  and  $0^{\circ}\text{C}$ . The N/ $\text{P}_2\text{O}_5$  weight ratio in these liquids varies from 0.52 to 0.55. Figure 2 indicates the use of raw materials in the production of one tonne of urea-ammonium polyphosphate of 16.5 per cent N and 30 per cent  $\text{P}_2\text{O}_5$ .

When polyphosphate liquor is to be stored in winter or in cold countries, the temperature of crystallisation can be reduced by decreasing the  $N/P_2O_5$  weight ratio to between 0.46 and 0.47. Liquors are then obtained with temperatures of crystallisation beginning at  $-15^{\circ}C$ .

Thus by feeding wet phosphoric acid into the polyphosphate dissolution tank, one reduces the urea content of the fertiliser and obtains a liquor with 14 per cent N - 30 per cent  $P_2O_5$  by weight which crystallises at a temperature lower than  $-15^{\circ}C$ . The rate of condensation of the polyphosphate is quite adequate to sequester the impurities introduced by the extra phosphoric acid.

When manufacture of solid urea-ammonium polyphosphate is desired, the foam emerging from the synthesis pipe described previously is vigorously stirred and granulated in an apparatus similar to that indicated in publications of the TVA relating to the granulation of solid polyphosphates. The fertiliser obtained is a mixture of ammonium orthophosphate, ammonium polyphosphate and urea, containing 23-25 per cent total N and 45-47 per cent total  $P_2O_5$  with a condensation rate of about 60 per cent.

The urea-ammonium polyphosphate emerging from the synthesis pipe is supplemented by the amount of urea needed to give the slurry an  $N/P_2O_5$  weight ratio of 1. After granulation this slurry gives a binary fertiliser of 30 per cent N - 30 per cent  $P_2O_5$ . As indicated above, potassium chloride can be added to the slurry and, after granulation, this gives a fertiliser of roughly 20 per cent N - 20 per cent  $P_2O_5$  - 20 per cent  $K_2O$ .

#### Use of Mother Liquor After Urea Phosphate Manufacture

Depending on its water content, the mother liquor is either directly ammoniated or ammoniated after concentration and then fed into a classic granulation plant to produce a binary urea-ammonium phosphate fertiliser, or with the addition of other fertiliser materials, a high-analysis NPK fertiliser.

Working with mother liquor from the centrifuge of phosphate crystals at  $50^{\circ}C$ , with a grade of 12.2 per cent N and 31.5 per cent  $P_2O_5$  and containing all the impurities from the wet phosphoric acid used, we have obtained a slurry after direct ammoniation, which, following granulation with recycled fines, gives an NP fertiliser as follows:

Total N	: 24.77%	Total P <sub>2</sub> O <sub>5</sub>	: 36.82%
Urea N	: 12.82%	Water & citrate	
Ammoniacal N	: 11.95%	sol., P <sub>2</sub> O <sub>5</sub>	: 36.16%
		Water soluble P <sub>2</sub> O <sub>5</sub>	: 34.96%

We have also added potassium chloride and urea to the granulation of this slurry and have obtained an NPK fertiliser as follows:

19 per cent N - 19 per cent P<sub>2</sub>O<sub>5</sub> - 19 per cent K<sub>2</sub>O

Using mother liquor from the centrifuge of urea phosphate crystals at 18°C, containing 8.82 per cent N and 21.47 per cent P<sub>2</sub>O<sub>5</sub>, we concentrated it to 29 per cent P<sub>2</sub>O<sub>5</sub> and then ammoniated it. The slurry thus obtained, after granulation with recycled fines, gives fertiliser of the following composition:

Total N	: 21.61%	Total P <sub>2</sub> O <sub>5</sub>	: 35.58%
Urea N	: 10.38%	Water & citrate	
Ammoniacal N	: 11.23%	sol. P <sub>2</sub> O <sub>5</sub>	: 35.38%
		Water soluble P <sub>2</sub> O <sub>5</sub>	: 29.81%

The difference between the water solubility and water and citrate solubility of the P<sub>2</sub>O<sub>5</sub> in the latter product compared with the former one results from the high iron and aluminium phosphate content of the mother liquor used.

In addition, these mother liquors can be used as a supplementary raw material for the manufacture of granular NP or NPK urea-based fertilisers of all grades. Finally, they can also serve as a basic raw material for the manufacture of suspension fertilisers.

## CONCLUSIONS

The use of urea as a straight nitrogen fertiliser is long established, but technical progress in the industrial manufacture of urea, the proliferation of production units and their ever-increasing size pose the problem of creating markets for this product in the production of high-analysis complex fertilisers. Relatively recent research (Nitrogen No.66, July/August 1970) has resulted in associating urea with the manufacture of NP fertilisers with 28 per cent N - 28 per cent P<sub>2</sub>O<sub>5</sub> or, if KCl is introduced during granulation, NPK fertilisers with 19 per cent N - 19 per cent P<sub>2</sub>O<sub>5</sub> - 19 per cent K<sub>2</sub>O.

The use of urea with phosphoric acid to form urea phosphate results in a new industrial product which,



in itself, provides an excellent, non-hygroscopic, fairly highly concentrated fertiliser (17 per cent N - 44 per cent  $P_2O_5$ ) but which can also serve as an intermediate material for the manufacture of other, more highly concentrated polyphosphate-based fertilisers.

Our manufacturing process offers the manufacture of liquid fertilisers based on urea and ammonium polyphosphate which are clear and stable over time, containing 15-17 per cent N and 27-31 per cent  $P_2O_5$ ; and solid fertilisers containing 23-25 per cent N and 45-47 per cent  $P_2O_5$ . By adding supplementary urea or urea and potassium chloride during granulation of the solid fertiliser, a product is obtained containing 30 per cent N - 30 per cent  $P_2O_5$  or 20 per cent N - 20 per cent  $P_2O_5$  - 20 per cent  $K_2O$ .

DISCUSSION

MR. M. GITTENAIT (Générale Des Engrais, France):  
The paper we have the honour of presenting to you covers a process for the manufacture of urea phosphate and urea-ammonium polyphosphate, products which may be used equally well as soil fertilisers and as a basic raw material for the manufacture of mineral concentrates to enrich the foodstuff or the feed rations of ruminants. Urea phosphate is a crystallised compound containing 62% phosphoric acid and 38% urea by weight, and titrating 17.72% urea nitrogen and 44.9% P<sub>2</sub>O<sub>5</sub>. Its balance of fertilising matter is of the same type as that of diammonium phosphate 18-48. Fertilising tests carried out with urea phosphate have given excellent crop results, but the industrial development of this product has been impeded by the high price of urea. Technological progress in the industrial manufacture of urea over the last ten years, and the multiplication of production units, as well as their ever-increasing size, has resulted in an appreciable reduction in price and a search for new outlets. Moreover, the use of urea phosphate as a solid phospho-nitrogenous fertiliser may represent one of these outlets, although its purity and high urea nitrogen content, which is equivalent to 700 g. crude proteic matter per kilo of product, make it equally suitable for the preparation of foodstuffs for ruminants and for the preparation of mineral fodder supplements, particularly for the ensilage of maize. Urea phosphate may also be used as raw material for the manufacture of the ammonium polyphosphates which are currently widely used in the liquid fertiliser industry. When the ammonium polyphosphates are pure and associated with urea, they may represent a first class product to supplement solid or liquid feeds intended for ruminants. And the purpose of our paper is in fact an original manufacturing process for such products. Under the present procedure, polyphosphate based liquid fertilisers, made from wet-process phosphoric acid, can be kept only for a limited time, since after some months of storage a slight deposit is generally noted at the bottom of the storage tanks. Tests carried out in our research laboratory showed that the formation of these deposits was directly connected with the content of various impurities in the original phosphoric acid, particularly fluorine and magnesium. Defluorination of phosphoric acid which is to be used for the manufacture of polyphosphate based liquid fertilisers may be carried

out by heating and concentration. But the elimination, even on a partial basis, of the other impurities poses problems which are difficult to solve from the industrial point of view. We had the idea of purifying the wet process phosphoric acid by crystallising the  $P_2O_5$  in the state of practically pure urea phosphate and using these crystals to make polyphosphate-based liquid fertilisers. Our process makes use both of the purification resulting from crystallisation of the urea phosphate, and the action of ammoniation and condensation of the crystals obtained. Our operating method combines the chemical reactions between phosphoric acid, urea and ammonia in such a way that the thermal balance is in surplus, which enables the process devised to operate within an autothermal system. We have described this process in our paper, and will add details during the discussion. In conclusion, our personal view is that our process has the following advantages: elimination of any purification and concentration of the phosphoric acid used for the preparation of polyphosphate-based liquid fertilisers; an autothermal process which does not require any external contribution of calories for the condensation of the phosphoric molecule, low thermal regime, which reduces corrosion of the manufacturing equipment, simple manufacturing equipment, elimination of filtration of liquid fertilisers on manufacture, direct production of ammonium polyphosphate based liquid fertilisers having a better balance from the point of view of distribution of fertilising elements. The traditional solutions are 10-34; we obtain 16-30.

MR. A. GAMERO BRIONES (S.A. Cros, Spain):

There is no doubt that the problem of the slow precipitation, over a period of time, of the polyphosphate based liquid fertilisers requires a solution. The slow hydrolysis of the polymer seems to be the result, according to the latest papers and our own experience, of catalysis of the process by the quantities of magnesium ions contained in the original phosphoric acid, and possibly by other impurities such as fluorine, iron, aluminium etc. As is well known, precipitates have been found which answer more or less to the composition of a multiple pyrophosphate of magnesium, aluminium, ammonium, fluorine etc. Under these conditions the ideal solution would be to find an inhibitor of the catalytic action of the magnesium, possibly reinforced by the presence of fluorine. At the same time efforts could be made to eliminate

undesirable impurities from the wet process phosphoric acid.

Such efforts, particularly those designed to introduce modifications to the wet process phosphoric acid technology, in order to adjust it to PK fertiliser production, are already known. Some make it possible to obtain technically pure products, including phosphoric acid.

The idea of using the production of urea phosphate crystals as a base material for possible polymerisation is ingenious and well worth consideration. Obviously the impurities will thus be eliminated, not only those which are troublesome, but also those which do not cause the slow precipitation of the liquid fertilisers.

A price must, however, be paid. The technology becomes complicated with the stages of crystallisation, washing and centrifuging. The problem of movement of a large volume of mother liquor arises. As Mr. Gittenait rightly notes, there is the problem of finding a use for the effluent mother liquor. Difficulties arise in this connection which lead us to put a number of questions.

1. The process, as described, seems to be feasible technologically. Is it equally feasible economically ?
  - a) Has the process been tested on pilot plant or industrial scale ?
  - b) Could you advance some economic data or analysis, showing for example the increase in liquid NPK price as compared to the same liquid NPK with impurities as obtained by conventional methods ?
2. It seems that one of the consequences of trying to maintain the process autothermal is that a part of the urea present remains unreacted.
  - a) How can we control the  $\text{NH}_3$ /urea ratio in polyphosphate ?  
How can we control the total amount of urea ?
  - b) What is the risk of obtaining in appreciable quantities, undesirable products from urea decomposition, such as biuret, etc. ?

3. You give temperature data. Could you offer similar data for residence time and its connection with the degree of polymerisation? Residence time can also affect the  $\text{NH}_3$ /urea ratio.
4. Can you describe with more detail the  $\text{NH}_3$  injection system to the reactors?
5. Many of the industrial possibilities of the process lie in finding an economical use for the effluent mother liquors. Both production and recycle of mother liquors are considerable. Can you advance flow data as well as data on the economical incidence of this aspect of the process?

MR. GITTENAIT: The process described was tested on a batch basis in a laboratory, and continuously on pilot scale. The scale of the pilot test was 2 tonnes/day, and the results of the laboratory tests were fully confirmed by the operation of the works pilot plant. From the economic viewpoint, a urea-ammonium polyphosphate obtained with our process, with equal total nitrogen and  $\text{P}_2\text{O}_5$  content, in comparison with an ammonium polyphosphate obtained by the traditional process from phosphoric acid and ammonia, will be slightly dearer, since ammonia is cheaper than urea, but we have the advantage of obtaining an absolutely clear polyphosphate liquor which can be used equally well as fertiliser or animal feed, with a content of nitric nitrogen, i.e. crude proteic matter, which is far from negligible. In our opinion, our process may represent a certain outlet in the developing countries and even in others for utilisation of the urea which is beginning to be manufactured in units with very high production capacities. The ammonia/urea ratio can easily be controlled. The urea is used only in the form of crystallised urea phosphate, which is introduced on a batch basis by an accurate distributor, while the ammonia is measured by a flow meter. If a watch is kept on the regularity of the supply of these two raw materials, the ammonia/urea ratio in the polyphosphate remains constant.

The residence time of our polyphosphate slurry in the reaction tube is very short, and the decomposition of the urea present is only partial. Under these conditions, we did not note the presence of undesirable products, but if the urea ammonium polyphosphate slurry were kept for a long enough time

at a temperature of 130-150° cyanuric acid might perhaps form, even if in low quantity. This is not the case with our process. From the viewpoint of polymerisation rate, under our operating conditions with the thermal regime as described, i.e. 110° in the urea phosphate melt tank, and 155° at the outlet from the reaction tube, the polymerisation rate varies between 65 and 70%. No special profile was produced for the ammonia injectors and we did not experience any difficulty in the pilot operation. I am sorry that I have no slides, but I can show you a diagram if you wish. On the basis of the process described in our paper for the manufacture of urea phosphate, there is in fact a problem of use of the mother liquor. Utilisation of this liquor is essential, and the outlet is the manufacture of solid and liquid fertilisers and suspensions, and use as a soil conditioner in association with an alkaline silicate. We indicated in our paper several fairly concentrated fertiliser formulations which we have succeeded in making from this mother liquor, but it can be introduced as a contributory raw material for the manufacture of urea-based binary, ternary and all grades of granulated fertilisers; finally it may be used as a basic raw material for the manufacture of liquid fertilisers or suspensions. We also sought other outlets; we had the idea of using the urea phosphate mother liquor to acidify solutions of sodium silicate or potassium silicate used in soil treatment in order to obtain silicic acid gels which are both soil conditioners and fertilisers. We found that these gels had a better performance and better keeping properties than those obtained from phosphoric acid and alkaline silicate, which we attribute to the presence of the impurities more commonly known as ferral phosphate. We treated with these gels samples of soils of varying structure, and obtained favourable results as regards circulation and storage of water in such soil. We secured an increase in permeability of very clayey soils and an increase in the water retention capacity in the case of quartz-rich or sandy soils. These soil conditioners are currently being tested in the field. We may expect a major outlet for these gels in improving the structure of glasshouse soils and in horticulture. I may add that, apart from animal feeding, other outlets have been found for urea phosphate. It has been found that urea phosphate is also an efficient cleaning product, for in an aqueous solution it acts like phosphoric acid. It has the advantage over liquid phosphoric detergents of presentation in solid form with a very high P<sub>2</sub>O<sub>5</sub> content. In addition, the components of urea phosphate i.e. phosphoric acid

and urea, are accepted by the Fraud Control office for cleaning of equipment which may come in contact with foodstuffs. An outlet may thus be envisaged in dairies and breweries. A further outlet may be contemplated as a firefighting product. The use of ammonium phosphate in combating forest fires in the USSR, USA and Canada is known, as is the use of this product in powder mixtures for fire extinguishers. And urea phosphate offers, in comparison with ammonium phosphate, the advantage of giving off a very large amount of CO<sub>2</sub> through combustion which would contribute to fire extinguishing. Moreover, comparison with sodium bicarbonate, another product used in the composition of extinguisher mixtures, is also very favourable, since the thermal decomposition of urea phosphate absorbs a large quantity of calories while giving off more CO<sub>2</sub>. To our knowledge, no study has so far been undertaken along these lines and we consider that application tests should be organised by a competent body or specialised service of various applications of urea-ammonium polyphosphate for use in fireproofing wood and textiles.

MR. J. FROCHEN (Compagnie Francaise de l'Azote, France): Could Mr. Gittenait tell us whether the sequestering capacity of the TPA obtained is comparable with that obtained by simple ammoniation ?

MR. GITTENAIT: In my opinion the sequestering capacity is at least equal to that obtained by ammoniation.

MR. FROCHEN: Is that the result of experience or just an estimate ?

MR. GITTENAIT: No, because I tried introducing impurities into these solutions, since I tried using the mother liquor itself in order to find an outlet for it, and in fact it sequesters very well.

PROFESSOR J. ANSIAUX (I.S.M.A.): You mentioned animal foodstuffs as an outlet for your product. Normally the supplement is given in urea or mono-calcium phosphate. Is your product cheaper, does it allow for the same combinations, and are you taking into account a contribution of necessary calcium in the same proportion as that required by the livestock diet ?

MR. GITTENAIT: Urea phosphate is a pure product, rich in nitrogen and phosphorus and very suitable as a raw material for the preparation of supplementary foodstuffs for the feeding of ruminants, the preparation of mineral fodder supplements, in particular the ensilage of maize. The high acidity of this salt lends itself readily to neutralisation by bases such as calcium, sodium, potassium, ammonium, and the exothermal nature of the reaction means that mineral concentrates can be obtained directly in dry, powder form. These mineral concentrates, rich in phosphorus, calcium and urea nitrogen, form nutritive supplements which can be used to enrich the food or rations allocated to ruminants. In addition, when these mineral supplements are made from urea phosphate, cane or beet molasses, by-products of the manufacture of sugar, can be added to give energising food, rich in phosphorus and calcium, with a nitrogen content equal to or approaching that of the best cakes. Moreover, liquid urea-ammonium polyphosphate, titrating 16% nitrogen and 30%  $P_2O_5$ , either alone or in association with molasses, is equally suited to the enrichment of the feed rations of ruminants. We were able to compare various feeds which we tested with breeders, and we found an average weight gain of 1.6 kg to 1.9 kg per day. We think this represents a valuable food.



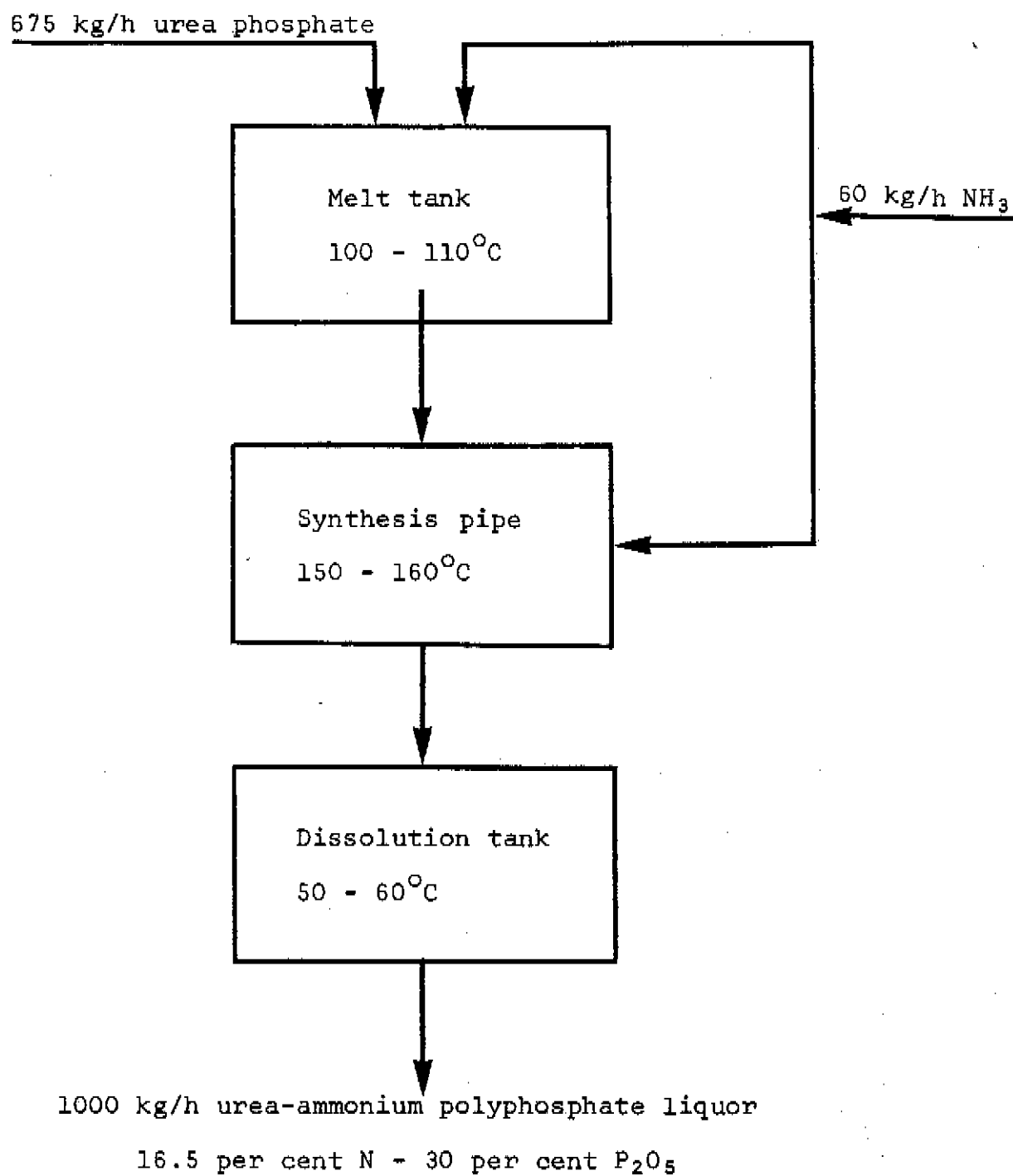


FIGURE 2

Manufacture of Urea-Ammonium Polyphosphate