International Fertilizer Industry Association

ISMA* Technical Conference

Wiesbaden, Germany

11-15 September 1961

**In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).*

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
TECHNICAL COMMITTEE · COMITE DES TECHNICIENS

FILE COPY.

LE/61/50
Received: 22nd June, 1961

CONFIDENTIAL

TECHNICAL MEETINGS - WIESBADEN

This paper will be presented at the Technical Meetings in Wiesbaden from September 11th to 15th, 1961. It must not be published prior to that date, and in any case it must not be published without the permission of the author.

SUPPRESSION OF DUST IN FERTILISER RAW MATERIALS AND GRANULAR PRODUCTS

by

F. J. Harris and T. Craig
Scottish Agricultural Industries Ltd.

1. INTRODUCTION

Both the raw material and the finished products of the fertiliser industry are normally inherently of a dusty nature. Scottish Agricultural Industries Limited has spent some considerable effort in trying to minimise the problems associated with handling such materials. The main reasons are as follows:-

a) The dusts are often corrosive and, in consequence, give rise to severe problems with steelwork inside plants.

b) Unless considerable time and money is to be spent in cleaning, then the general appearance of plants handling these materials is dirty, and in damp weather, the hygroscopic nature of the dusts tends to cause slipperiness on floors and, as such, creates a hazard.

c) Even under dry conditions in large bulk stores and in conveyor tunnels, dust problems can be such that they can cause serious discomfort to personnel employed on those locations even though there is no evidence of there being a health hazard.

d) Finally, there is the loss of material inevitably associated with dust.

Some aspects of the problem can be effectively dealt with by conventional dust collecting equipment. Where, however, very long ducts would be involved or the material falls from a considerable height on to a pile, this method is not practical. This paper deals with measures tried in our Company to deal with the difficult cases by various means of suppressing the dust rather than attempting to collect it. These means include (i) reducing the dustiness of the raw material by wetting; (ii) controlling the fall of material: (iii) making the finished product inherently less dustyand (iv) treating the surface of the finished product.

The problems associated with handling the raw material on the one hand and the product on the other, are, in general, quite different, and for the purposes of this paper a rough division has been drawn at this point.

2. HANDLING RAW MATERIAL

2.1. At the Leith Works of Scottish Agricultural Industries Limited a belt conveyor system, 1,470 ft. long and rated at up to 350 tons/hour, has been provided to handle phosphate rock, muriate of potash and sulphate of ammonia from ship to store. The first conveyor is located in a tunnel alongside the unloading berth and it connects to a series

-continued-

of conveyors housed in enclosed gantries which pass overhead to the main storage building in the works. Dust arises from each transfer point despite the provision of special chutes and, with certain materials, reaches serious proportions, particularly in the tunnel. Sulphur is presently handled from the dock to store by tipper lorries, as it is considered unsafe to handle on the conveyor system without effective dust suppression.

In an endeavour to obtain effective dust suppression, semi-scale trials with water containing wetting agents sprayed on the dusty materials were carried out. From these tests it appeared that 1½% by weight of treated water was required for effective dust suppression of Grade II sulphur, whereas 2½% of treated water was required on Grade III sulphur, 3% on Gafsa phosphate, and 3% on Florida phosphate for the same effect. Following these tests, experimental spraying equipment was fitted to the 350 tons/hour conveying system mentioned above, and preliminary tests have indicated that substantial dust suppression can be obtained on Nauru phosphate by the addition of 1½% of treated water. Plant conditions determine, however, that due to frothing in the sulphur melter in the case of sulphur, and humidity in the grinder circuits in the case of Nauru phosphate, the addition of moisture to the extent required for effective dust suppression is unacceptable. Thus, unless further tests show that much lower percentages of water are adequate, this method of suppression is not likely to prove practicable.

2.2. In the raw material store, a shuttle conveyor discharges from approximately 40 ft. above floor level and if material is allowed a free fall over this height, severe dust evolution takes place. This difficulty is overcome by the provision of fixed open top chutes as shown in Fig. I. When filling an empty store, the shuttle is positioned to discharge onto the fixed chute. The material slides down the chute to form a cone at the base of the chute, and when the apex of the cone reaches the chute, there is no further free drop, but instead, an overspill from the sides of the chute. When the apex of the cone reaches its maximum height, the shuttle conveyor is slowly moved, keeping the apex of material level along the length of the store. Thus, at all times, the free fall is minimised and consequent reduction in dust formation obtained.

3. HANDLING PRODUCT/

-continued-

3. HANDLING PRODUCT

3.1. Granular C.C.F. Fertiliser at Leith is stored in a number of 5,000 ton and 2,500 ton bays and recovered to an underground conveyor handling at a rate of 230 tons/hour. It is necessary to feed from any one of the bays on to the recovery conveyor and for this purpose a chute as shown on Fig. 2. is used which limits the drop of material on to the belt. When material is not required, the balance weight actuates the pivoted chute, closing off the flow, and raises the tip of the chute above the level of material placed on the conveyor by a chute on another storage bay. The pivoted chutes are actuated by an electric thruster, controlled from the bagging plant.

3.2. Incorporated in the conveying system from the C.C.F. granular fertiliser store to the packing plant, is an aspirator for removing dust from the product. The dust recovered by this system is in the region of 0.6% by weight of the material handled. The recovered dust is discharged into an 8-ton capacity silo with a pneumatic system mounted on a trailer. When full, the trailer is conveyed to the granulation plant where the dust is pneumatically discharged to a storage hopper for re-incorporation into the product.

4. REDUCTION IN DUSTINESS OF THE PRODUCT.

4.1. Composition of the Dust

Fertiliser granules are generally produced by agglomerating a number of crystalline salts, namely potassium chloride, superphosphate or ammonium phosphate, together with an additional nitrogen source such as ammonium sulphate or nitrate. During granulation, partial solution occurs, and, in the subsequent drying, the salts that have been in solution crystallise and can produce very fine particles. Drying occurs by diffusion of water from the centre to the surface of the granules. This water is saturated with salts which tend to be deposited as fine crystals on the surface of the granules as the water evaporates. Those fine crystals can then be rubbed off, creating dust wherever attrition occurs. Analysis of the dust shows that there is an increased proportion of phosphate compared with the fertiliser being produced. For example, the average figures obtained from the analysis of six samples of dust, produced when 12:12:18 fertiliser was being made, gave a composition 12.6:19.8:13.7. Of the components present in such fertilisers, monammonium phosphate has the highest solubility at the drying temperature, thus the theory mentioned above accounts for the increase in P_2O_5 content of the dust.

-continued-

Observations both on the full plant scale and in the laboratory had shown that the efficient removal of dust from product as normally produced had no lasting effect.

There were two ways of tackling the problem, either (a) to modify the process by which the granules were made so that they were inherently less dusty, for example high recycles coupled with a layering technique could be used and possibly produce harder and more dense granules, or alternatively, incorporate some material during the granulating stage which would give the desired result: or (b) treat the surface of the finished product granules so that they are either less prone to dust formation, or, alternatively, cause dust particles that are formed to tend to re-adhere to treated surfaces.

The largest plant at which dust was giving trouble was producing ammonium phosphate-based fertiliser. There is no cooler in the system and product is conveyed to store at temperatures within the range 65-80°C, thus any method of treatment must be at least as effective when treating hot granules as when treating them cold. Preliminary experiments showed that the hot granules were likely to be the more difficult to treat and, further, it was likely that any treatment that was effective for the hot granules would largely retain its effect when they cooled. For this reason, the subsequent experimental work was done on hot granules.

Experimental work quickly showed that a reduction of the amount of dust in the atmosphere by a factor of 2 as judged by gravimetric results had little effect on the general appearance, and a factor of at least 4 is generally necessary to produce a really distinct visual change.

4.2. Measurement of Dustiness

So that the improvement achieved by using a given technique could be evaluated, it was necessary to have some means of measuring the dustiness of a fertiliser.

A large number of methods were tried; these ranged from a fluidisation technique to passing gas through fixed and rotating beds of fertiliser, various gas velocities and temperatures, etc. were used. The main difficulties encountered were in finding a method which would give reproducible results and also results which were capable of correlation with the effects obtained on the full-scale process.

The technique eventually found most successful was among the simplest tried and was as follows:-

-continued-

4.2.1. Equipment Used for Measurement. For the control determination a 15 lb. sample is placed in the 2' drum (shown in Fig. 4) and the drum is rotated for 10 minutes during which the temperature is raised to 80°C. by the application of external heat. After 15 minutes from the start of the test a cover is placed on the drum and rolling is continued for a further 15 minutes. With the drum rotating, a sample of the atmosphere inside the drum is drawn off through a hole in the cover and passed through a soxhlet extraction thimble (33 mm. x 80 mm. double thickness) which has been previously dried and weighed. (The gas rate used is approximately 3 cu. metres/hr. and the time of sampling arranged so that the weight of dust collected is 0.5-1.0 g.) This is the "blank" test. The drum is then emptied, brushed out and air blown through to remove residual dust.

15 lb. of the test sample are now introduced into the drum and rotated for 10 minutes during which the temperature is raised to 80°C. At this point the additive (if any is being used) is sprayed on to the rolling bed (with a "scent spray" type of applicator) and this is completed within 5 minutes. (If no additive is used the procedure is exactly as for the control sample above.) The cover is now placed over the mouth of the drum and, after 15 minutes, a sample of dust is extracted under exactly the same conditions as in the control test.

The two samples of dust are dried and weighed and the dust reduction factor is expressed as the ratio of their two weights.

Before carrying out any further tests it is necessary to clean the drum thoroughly, and it has been found most convenient to do this by putting 15-20 lb. of fertiliser into the drum and letting it rotate for about an hour before carrying out the brushing out and air blowing procedure. This is to ensure the complete removal of any additive which may have adhered to the drum walls and which might affect the next control determination.

Using this technique, a large number of tests were done on granules either made by a modified production method or by surface treatment after production.

4.3. Effect of P_2O_5 Source on Dustiness

One of the first aspects studied was a comparison of fertilisers, both ammonium phosphate and superphosphate based fertilisers, in which the original P_2O_5 was derived from Nauru and Morocco rocks. On comparable finished fertilisers there was no appreciable difference in dustiness or in dust composition between granules irrespective

-continued-

of the P_2O_5 source. This lack of difference was borne out by chemical, X-ray and microscopic examination of both the dust generated and in the general structure and build up of the granules.

4.4. Effect of Production changes on Product Dustiness

The process variables which could have an effect on the dustiness and which could be fairly readily changed were as follows:

i) changing the size of the various solid constituents fed to the process,

ii) working the process with a higher or lower recycle with variation in drying temperature,

iii) raising or reducing the proportion of ammonia combined with phosphoric acid.

4.4.1. Effect of Changing the Particle Size of the Raw Materials The particle size of both the potassium chloride and ammonium sulphate fed to the process were changed within as wide limits as possible, consistent with the production of well formed granules and without crystals of chloride or sulphate passing through the process into the product.

Variation of the ammonium sulphate had little effect, but the use of coarse crystal potash did give some improvement, the amount of dust measured and determined gravimetrically being only about 35% of that obtained when using the normal fine material. In spite of this result, there was only a limited visual change in dustiness.

4.4.2. Effect of Changing the Recycle Ratio and Drying Temperature. It was hoped that, by increasing the proportion of material recycled in the Dorr type ammonium phosphate based process, the formation of the smoother, more dense granules so produced would be less dusty. Further, with this technique, lower drying temperatures can be used, and it was hoped that this would lead to less rapid evaporation and the consequent formation of larger crystallites which would, in turn, be more resistant to abrasion.

The disadvantage of this system is that it tends to restrict the output of a plant owing to the large amount of materials which have to be recycled.

Even when the recycle was increased to about 5 to 6:1 (i.e. the ratio of recycle to product removed from the system) and a coarse grade of potassium chloride was used, there was no really marked visual change in the dustiness of the product.

-continued-

4.4.3. Effect of Changing the proportion of Ammonia Combined with Phosphoric Acid. In monammonium phosphate, the N:P ratio is 1:1. It was found that, by varying this ratio between 0.9:1 and 1.1:1, it was possible, on a laboratory scale, to modify the crystal habit of the ammonium phosphate from long needles to crystals of low aspect ratio . Small scale experiments were done, but owing, it is believed, to impurities in the system, probably in the phosphoric acid being used, the crystals were always very small and no improvement in reduced dustiness was obtained.

4.5. Effect of Additives on Dustiness

With the lack of effect obtained from the methods described under 4.4. above, it was necessary to approach the problem from a different angle and the one chosen was to add some material to the finished granules as soon after screening as possible. Such additives could function in a variety of ways, for example, they could put a complete envelope around the granule, they could cover and diffuse into the surface of the granule and so modify surface physical properties, or they could only partially cover the surface and remain as sticky patches to which dust would adhere.

The criteria for such an additive was as follows:

i) It must be effective at low concentration, preferably less than 1% by weight of the fertiliser.

ii) The cost would have to be competitive with a mechanical system of venting.

iii) Its method of application must be simple.

iv) It must have no bad effects on the fertiliser, mechanically or agronomically.

v) It must be capable of use on a hot (up to 85°C) material and retain its effect as the fertiliser cooled.

vi) Any hydrocarbon used must have a sufficiently low vapour pressure under the conditions of use to avoid flash point troubles or health hazard.

4.5.1. Preliminary Tests. At this stage, a large number of preliminary tests were done and they included, among the most promising additives, solutions of carboxy methyl celluloses, the long chain fatty amines, molasses, mineral, vegetable and animal oils, some polymerised oils with a wide range of viscosities and oil/wax solutions and oil/tar solutions. The tests applied included:

a) application to hot granules followed by dissection of the granules to find the extent of penetration;

-continued-

b) setting tests on treated granules to find out whether the additive would affect the relative humidity of the air in contact with them;

c) effect of additives on the mechanical properties of granules, in particular their hardness and flow properties to find out, for example, whether they retained the original angle of repose; and,

d) whether the additive would tend to confer any unpleasant smell to the granule.

As a result of these tests and bearing in mind the criteria mentioned above, it was decided that the best solution to the problem was that of partial coverage of the granule surface leaving adhesive patches to which dust would stick.

The advantages of this were as follows:

a) Ease of application. It was unnecessary to ensure complete coverage of each granule.

b) The amount of additive required was small, and consequently, cost was reduced and bad side effects minimised.

c) There was less risk of changing the mechanical properties of the Granule. It is interesting in this connection to note that there was some evidence, that, when an additive was used which covered the surface of the granule and diffused inwards, water was displaced, the relative humidity above the fertiliser increased and some setting could result.

Tests showed that fertiliser granules at about 80°C are strong absorbents and some "thick" additive was required to prevent this occurring; the best results were obtained with heavy oils, and, for reasons incompletely understood, viscosity of the oil at the working temperature was not necessarily a good guide to its dust suppressing properties. Indeed an oil with a viscosity of 260 Redwood seconds at 90°C was less good than one of 190 seconds at the same temperature. Further, oils which incorporated petroleum jelly, paraffin waxes or compounds such as Glyceryl monostearate, were no improvement over a fairly heavy cylinder oil which contained no additives of any sort.

4.6. Chosen Additive

The additive eventually chosen was a heavy cylinder oil which contained no modifiers and care was taken to ensure the absence of trace elements. Its properties were as follows:

-continued-

Specific gravity	0.960
Viscosity at 60°C	1150 Redwood sec.
" " 92°C	190 " "
Closed flash point	260°C

The oil was applied not as a continuous coating over the surface of the granules but to form discontinuous globules.

For the first full scale tests, the method of addition was as follows: The oil was preheated to about 90°C and sprayed through a paint spray gun using compressed air for atomisation. The spray gun was directed at the curtain of granules as they fell from the conveyor collecting the product from the screening process on to a transverse conveyor. From this second conveyor the material fell into a collecting storage hopper, was discharged to a bulk rail truck, and from there, via another series of three conveyor belts until it was discharged on to the main bulk storage piles. These features are mentioned to show that the only mixing the granules received after treatment was during their direct transfer from conveyor to conveyor, or conveyor to hopper.

The effectiveness of the treatment when 0.25% by weight of the oil was applied can be seen from the results of tests in which the atmosphere was sampled at dusty points in the bulk store. The figures quoted are not indicative of general conditions in the store, but were chosen bad places since they would show up most effectively the improvements to be obtained.

Sample Position No.	Dust concentration gm./M^3	
	untreated fert.	treated fert.
1	0.23	0.03
2	0.44	0.05
3	0.17	0.05

In all cases the effect of the treatment had a marked visual effect and, although the results obtained were by no means perfect, they were sufficient to permit relatively comfortable working conditions at all points in the conveying system and in the bulk store.

4.7. Present Method of Treatment and Results Obtained

The oil is stored in a 1,600 gallon storage tank is pre-heated by the L.P. steam coil on the tank offtake, filtered and pumped by

-continued-

one of two positive displacement pumps to an H.P. steam heater which heats the oil up to 80/90°C. The oil circuit is arranged so that a continuous circulation takes place from pump to spray point and back to the suction side of the pump, while the amount of oil sprayed is controlled by a small horizontal valve. A by-passvalve is fitted and this can be operated manually or by a flap resting on the product band. As long as there is product on the belt conveyor, this flap keeps the valve open. Oil is sprayed on the product at the head of the main product conveyor, just as it falls off into the chute leading to the shuttle conveyor offtake and discharge hoppers. A flow diagram of the system used is shown on Fig. 5. The actual spray has an oil pressure atomising jet of the type used for burning fuel oil.

The designed spraying rate is 0.25% oil based on the weight of product. The spraying rate is determined by relating the spraying pressure to the product rate on the conveyor. A series of measurements have been made to determine thespraying rate for the various pressures. The attached graph, Fig. 6, summarises these results. At present only one spray head is used and this limits the oil addition to a maximum of 0.2% when the production rate is at peak, but it is intended to fit an additional spray head to enable this limit to be raised to 0.4%, as it has been determined that for certain products a spray quantity of 0.2% is not sufficient to ensure the desired degree of dust suppression.

The spray system gives very little trouble and an operator has only to check and record the spray pressure once an hour. During start up in cold weather, troubles occasionally arise due to the viscosity of the cold oil causing the pumps to cut out. At present, the pumping lines are not steam jacketted.

4.8. Operating Cost

The cost of oil spraying including oil, maintenance, and depreciation is approximately 2.3 shillings per ton of CCF when spraying at the level of 0.25% by weight.

4.9. Effect of Dust Suppression

The dust nuisance in the C.C.F. bulk store has been considerably reduced. If, for any reason, oil spraying is stopped, the dust conditions worsen noticeably within a very short period of time. Material which has been in store for a few months, gives rise to dust on extraction, as the oil as a whole has apparently been largely absorbed by the granules, but the dust is still appreciably less than without oil spraying.

-continued-

4.10. Effect on Conveyor Belting

At one time it was feared that oil spraying would have a serious effect on the condition of the conveyor belts. This has, fortunately, not proved to be true, as we have now been oil spraying the product for over two years and so far it has not been necessary to replace any conveyor belting. Severe distortion has, however, occurred on some conveyor belts in that they become convex due to swelling, but this was overcome by turning the belts at the annual shut-down in June, 1960. Since then, the belts have operated satisfactorily. The belts affected were: a) the product belt on the granular C.C.F. fertiliser plant which is made from Butyl rubber and terylene, and deals with granules at 80/100°C. The oil spraying is done at the top of this belt and this sometimes is accidentally sprayed with oil; b) the main intake conveyor at the bulk store. As the store is approximately half a mile from the plant, the material is transported by road or rail. This belt, in natural rubber, has not such an arduous duty as the plant product belt.

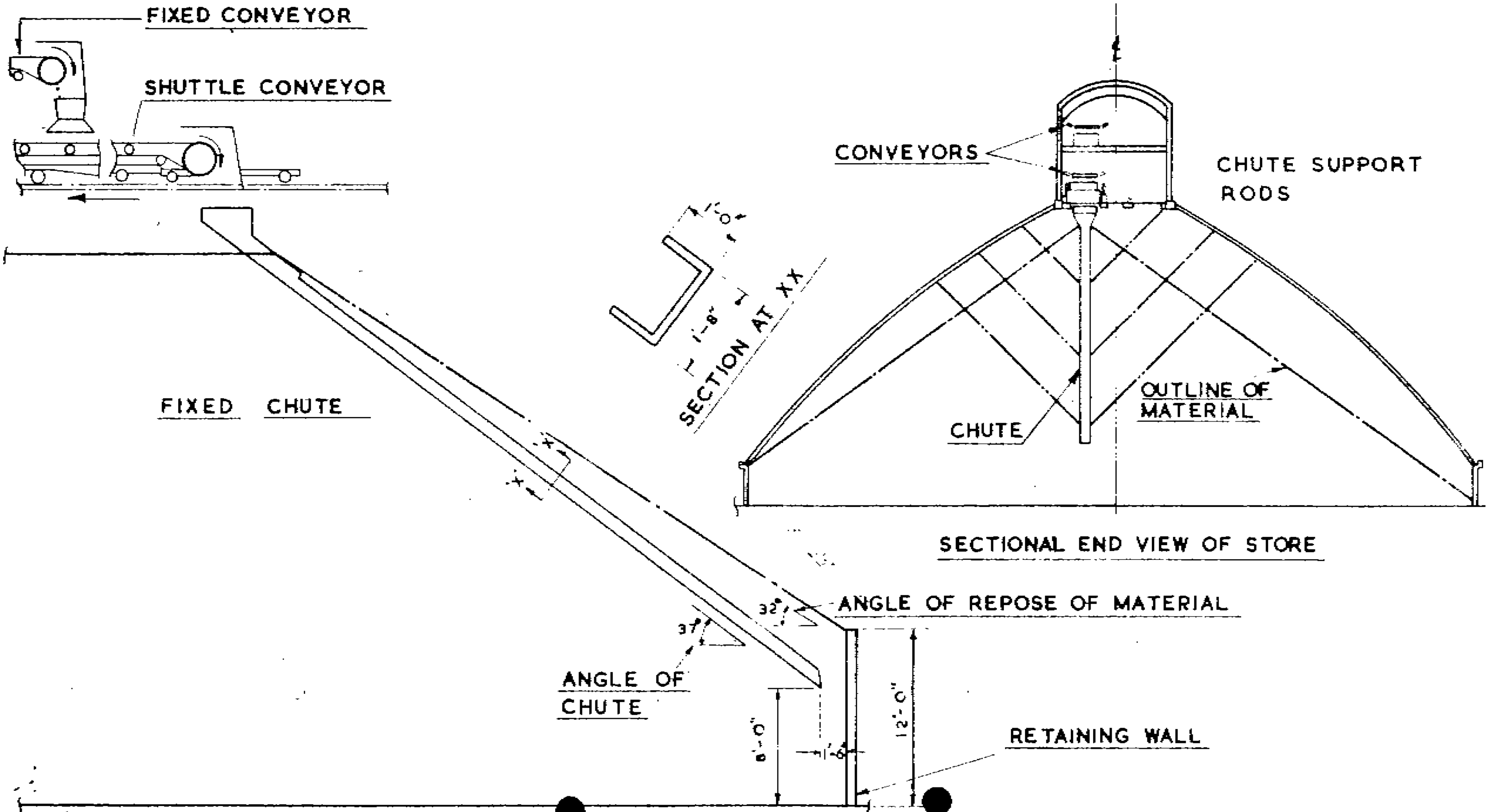
4.11. Conclusions

Oil spraying of C.C.F. granules with 0.2% - 0.3% mineral oil has effectively reduced the dust nuisance at the bulk store. Some conveyor belting has suffered distortion due to the effect of the oil, but this is much less than had been expected.

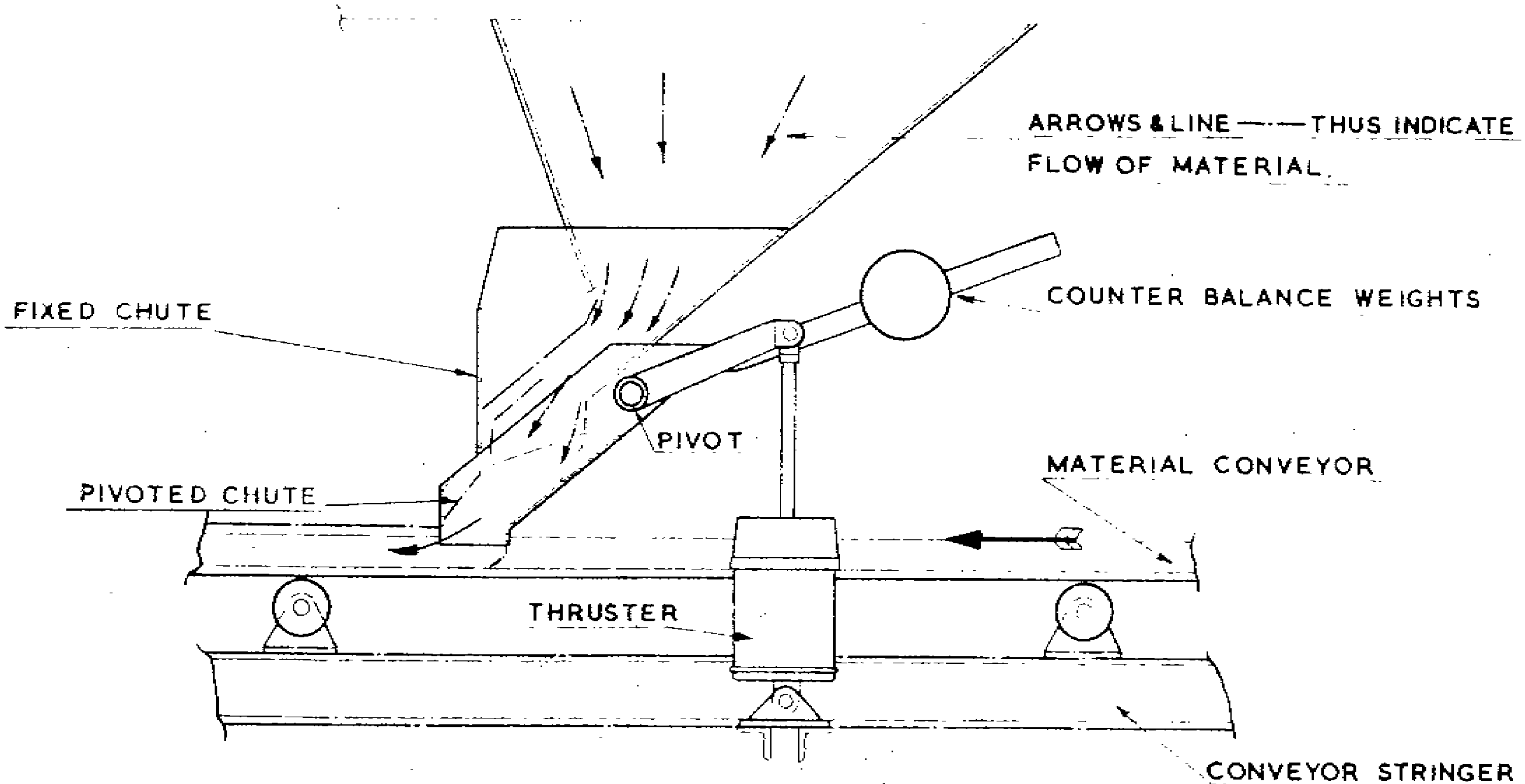
Acknowledgements

In conclusion we wish to express our thanks to the Directors of Scottish Agricultural Industries for permission to present this paper, and to those of our colleagues who have assisted in its preparation.

TC/FJH/NCR



FIXED CONVEYOR
SHUTTLE CONVEYOR
FIXED CHUTE
X
X
SECTION AT XX
1'-0"
1'-8"
32°
ANGLE OF REPOSE OF MATERIAL
37°
ANGLE OF CHUTE
8'-0"
1'-6"
12'-0"
RETAINING WALL
CONVEYORS
CHUTE SUPPORT RODS
OUTLINE OF MATERIAL
CHUTE
SECTIONAL END VIEW OF STORE



ARROWS & LINE —·— THUS INDICATE
FLOW OF MATERIAL.
COUNTER BALANCE WEIGHTS
FIXED CHUTE
PIVOT
MATERIAL CONVEYOR
PIVOTED CHUTE
THRUSTER
CONVEYOR STRINGER

FIG. 2

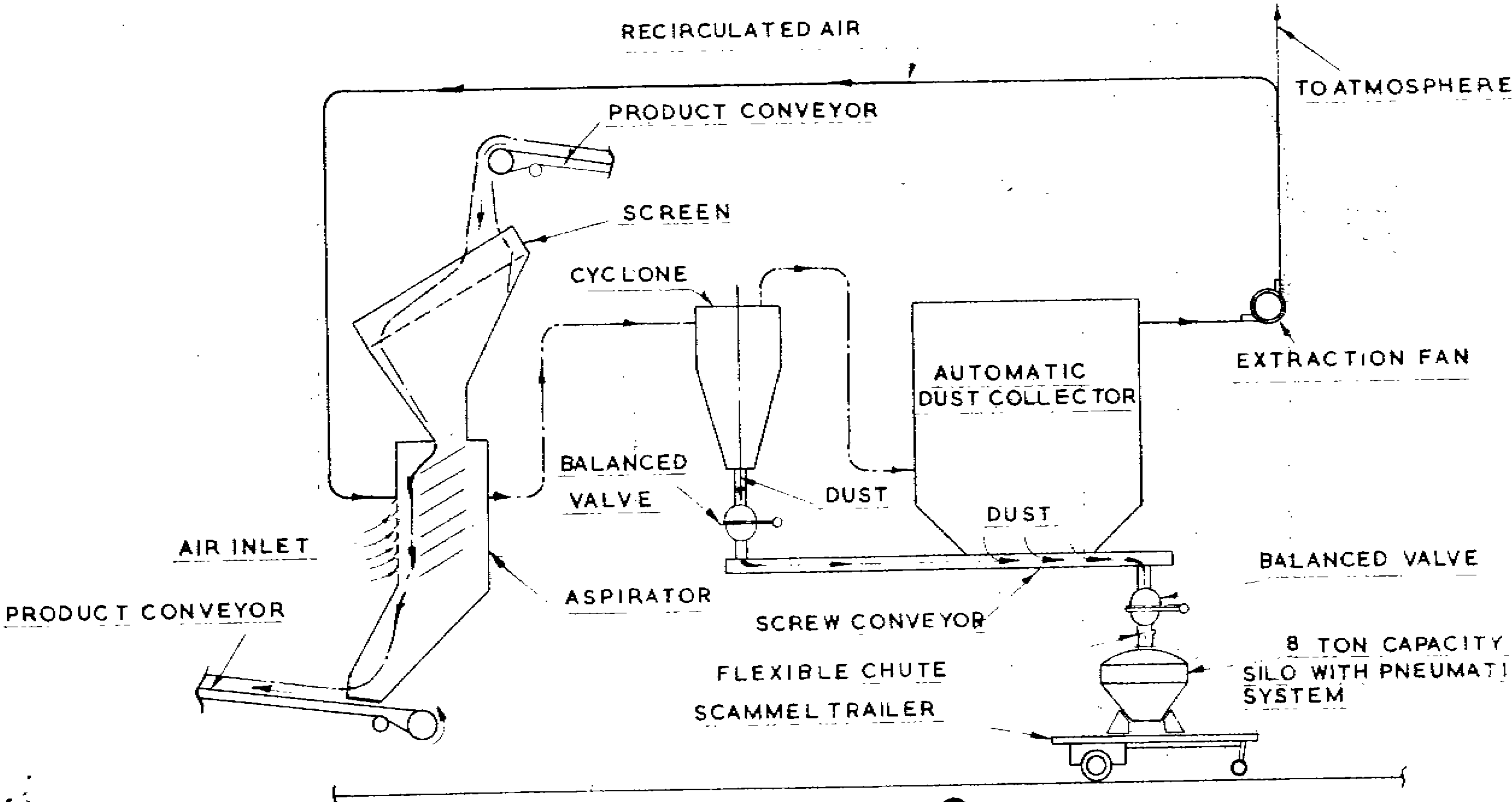
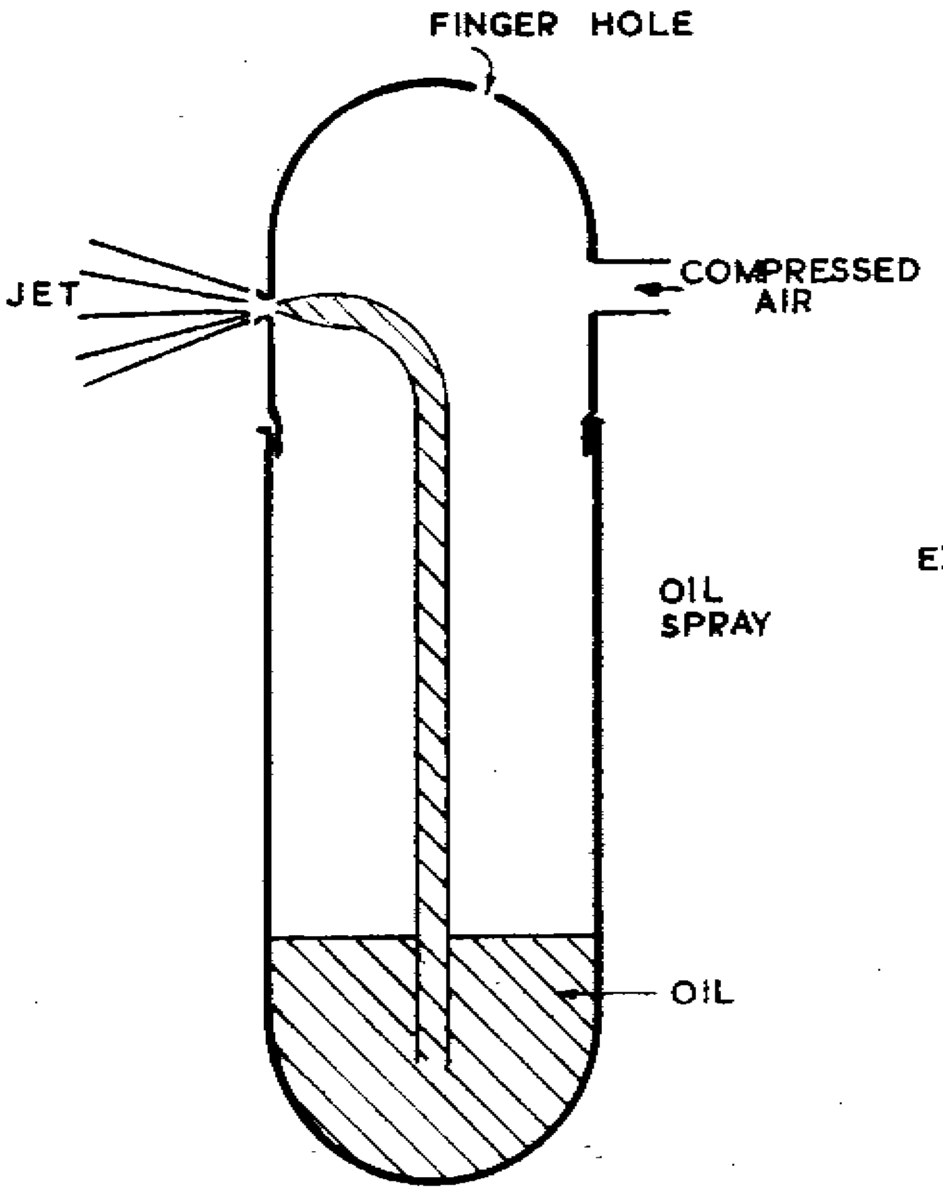
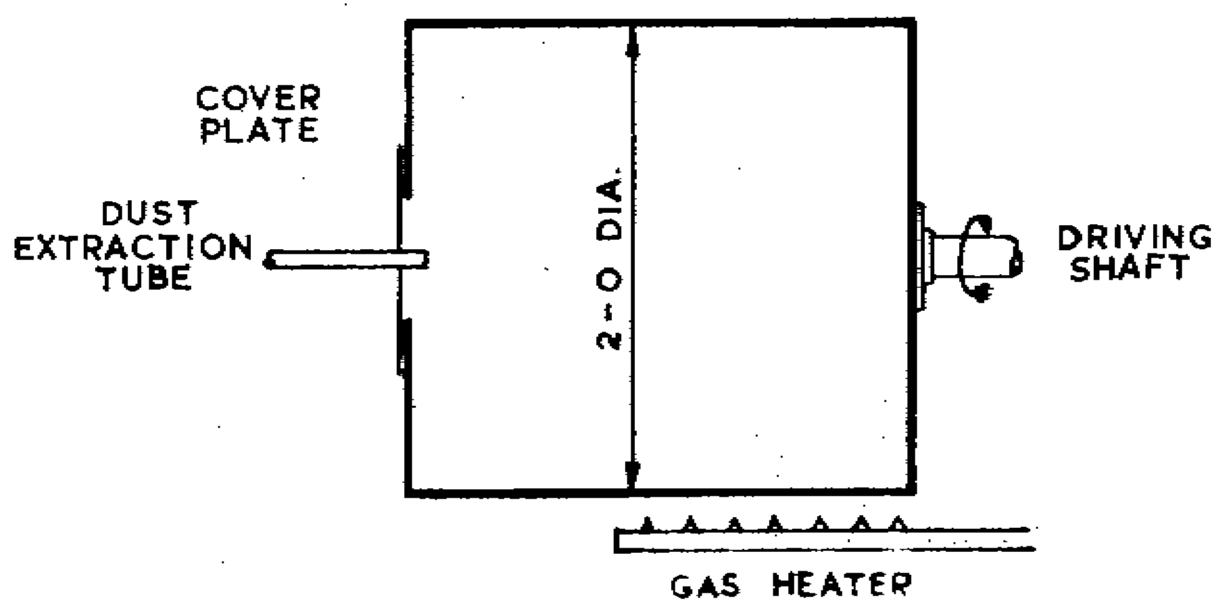
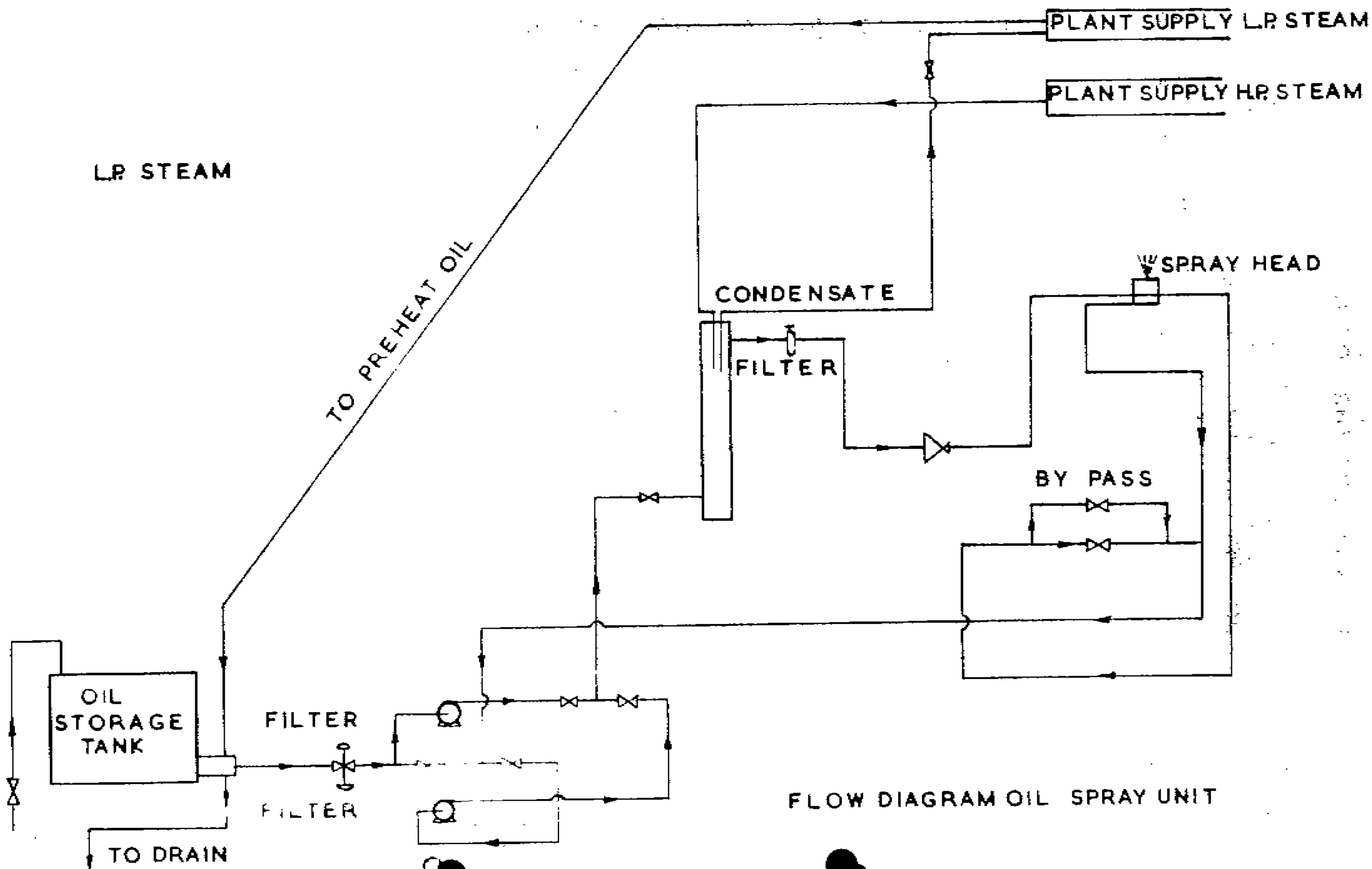

RECIRCULATED AIR
TO ATMOSPHERE
PRODUCT CONVEYOR
SCREEN
CYCLONE
AUTOMATIC
DUST COLLECTOR
EXTRACTION FAN
BALANCED
VALVE
DUST
DUST
AIR INLET
BALANCED VALVE
ASPIRATOR
PRODUCT CONVEYOR
SCREW CONVEYOR
8 TON CAPACITY
SILO WITH PNEUMATI
SYSTEM
FLEXIBLE CHUTE
SCAMMEL TRAILER

FIG 3

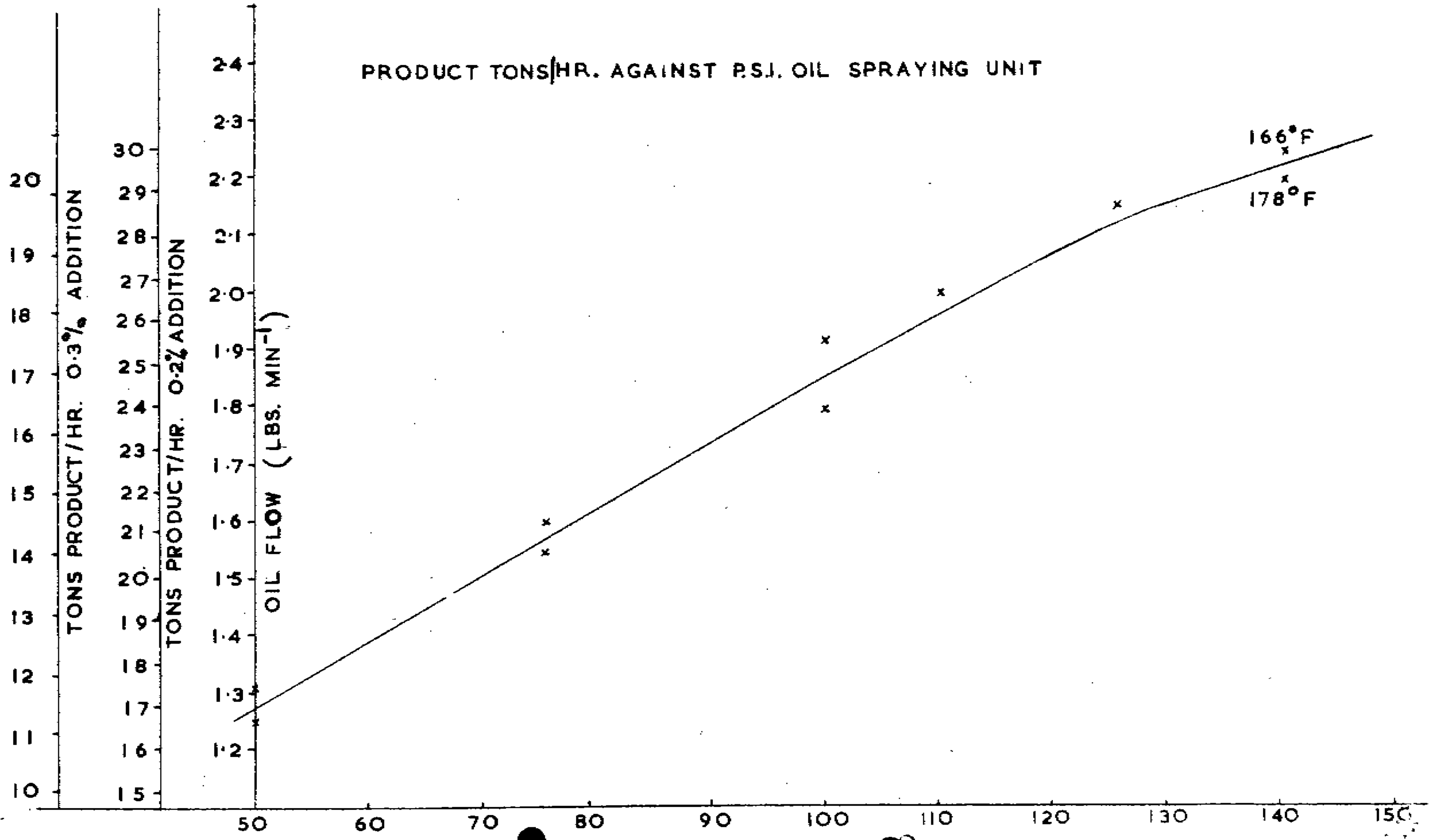

FINGER HOLE
JET
COMPRESSED AIR
OIL SPRAY
OIL


COVER PLATE
DUST EXTRACTION TUBE
2-0 DIA.
DRIVING SHAFT
GAS HEATER



FLOW DIAGRAM OIL SPRAY UNIT

FIG 5


PRODUCT TONS/HR. AGAINST P.S.I. OIL SPRAYING UNIT
TONS PRODUCT/HR. 0·3% ADDITION
TONS PRODUCT/HR. 0·2% ADDITION
OIL FLOW (LBS. MIN⁻¹)
166°F
178°F
10
11
12
13
14
15
16
17
18
19
20
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·9
2·0
2·1
2·2
2·3
2·4
50
60
70
80
90
100
110
120
130
140
150