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SOME RECENT DEVELOPMENTS IN FERTILISER PACKAGING AND SUBSEQUENT HANDLING

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INTRODUCTION

In 1966 S.A.I. undertook an investigation into packaging and loading, aimed at evaluation of up to date equipment and its suitability for S.A.I., together with consideration of improvements in operational methods then obtaining.

This paper describes some of the changes made, particularly in regard to new packaging machinery, and the benefits obtained to date.

EXISTING INSTALLATION

The fertiliser packaging plants in S.A.I. were originally designed to provide a loading service direct from the packing line to a waiting vehicle, with provision made for palletising should the need arise.

At Leith, the largest of the plants, and the one to which for simplicity the remarks in this paper are confined, there is a bulk storage warehouse with a top capacity of 40,000 tons. Four different grade fertilisers are stored, all ammonium nitrate based, and dry air is circulated through the store to keep the moisture content of the air below the level at which the fertiliser would be affected. The material is extracted by electrically powered bulldozer and conveyed by belt conveyors over a scalping screen and dust extraction system to multiple hoppers enclosed in a heated building above the bagging house. In all there are 8-40 ton hoppers arranged in two lines of two and one line of four.

In the bagging plant, which is also heated, and has its own dust extraction system, there were until recently three 60 tons/hour twin-spout bagging lines handling 1 cwt (51 Kilo) open mouth 700 gauge polythene sacks. On each line the weighing machines, bagging spouts and bagging operators' platform were mounted on a travelling trolley which traversed under the 40 ton hoppers so that on two lines there was a choice of two products and on the third a choice of four products. Weighed bulk product could also be supplied from two of the lines. After filling and sealing, the bagged product was carried away by conveyor belt and shuttle conveyor direct to a waiting vehicle. A diagram of one packing line is shown in Fig. 1.

Each 40 Ton hopper supplied material to 4 weighing machines which were arranged in pairs so that two machines fed each packing spout. The spouts were oval in shape and the bag was held in place by means of pneumatically operated clamps.

When the bagging operator pressed a foot pedal, the bag clamps came against the spout and held the bag while material was discharged from the weighing machine down a chute and into the bag. The release of the bag from the spout and the refilling of the weighing machine was automatic and occurred simultaneously with the re-closing of the emptied weighpan discharge door.

Although the two machines feeding each spout were electrically sequenced to discharge alternatively, the operator on the downstream side of the filling line had to arrange that his filled bags dropped between those coming from the first spout. Bags from both spouts were fed through a band sealer by one operator and after sealing were conveyed direct to the waiting vehicle.

The output of each weighing machine was 5 x 1 cwt. (51 Kilos) weighments per minute, so that the top output of the packing line was 60 t.p.h. employing two operators for bagging and one for sealing. The weighing machines are shown in Fig. 2, and the spouts in Fig. 3.

From October to January, in the main, only one line was operated while during the high demand period between February and May, all lines were manned, sometimes on a two shift basis, with weekend overtime being worked when required. The outloading capability of the direct packing lines was supplemented by fork trucks working from fairly small palletised stocks.

SOME CONSIDERATIONS INDICATING THE NEED FOR A CHANGE IN METHODS

While direct loading from the packing plant is the method which involves least labour in the immediate operation, the attempt to follow large fluctuations in demand, as experienced at Leith, and as illustrated in Fig.4 can lead to under-utilisation of equipment and low overall performance in terms of tons per hour from the operators. During the period of greatest demand, the outloading capability can be under severe strain, and employment of a fairly large temporary labour force, which has to be trained each year, can cause many problems.

The use of multiple lines, necessary for direct loading, also increases maintenance and replacement costs, and makes the economic use of new packaging equipment less likely because of under-utilisation of capital.

Partly for the above reasons, and partly because a projected throughput increase of 50% was expected, which would have had to come in any case from palletised stock, it was decided to eliminate the system of direct loading and to have one line operating on a multi-shift basis, packing at a constant rate to palletised stock.

The decision to make the change was also influenced by labour and other savings, which were predicted if certain new packaging equipment were installed.

A study of packaging equipment available in 1966 led us to the following conclusions: -

1) That fully automatic polythene bag filling and sealing machines were not, at that time, at a satisfactory stage of development for S.A.I. to consider their use.

2) That weighing machines were available which would allow single spout output of 60 t.p.h. on 1 cwt. bags, with a more consistently accurate weighment performance than we could obtain from our existing, lower output machines.

3) That an operator would be able to apply sacks to a bagging spout of a suitable shape at rates peaking up to 50 t.p.h.

4) That vibration of granular fertiliser in polythene bags before sealing would produce a firmer pack, which would be more easily handled and stowed, and would also allow a slightly smaller bag to be used.

5) That we should continue to use band sealing, but that we would modify the seal so that only the bottom half was cooled, leaving the top half to cool naturally and so give a much stronger long-term seal. (A technique of sealing which is the subject of patent applications by British Visqueen Ltd., the Belgian application having been granted as Belgian Patent No 689,411.)

6) That, as all the product was to be palletised, some form of mechanical assistance in palletising would be necessary. Since none of the proprietary palletising machines then available were felt to be suitable, it would be necessary to develop a machine to meet our requirements.

7) That by using a slightly smaller sack (made possible by vibration) altering the length/breadth ratio and allowing the bags to project approximately 3" beyond the pallet, we could increase the load on our standard 5'0" x 4'0" (1.5M x 1.2M) pallet from 30 to 42 cwts., (1.52 to 2.13 tonnes) a saving of approximately 30% on the number of pallets required.

8) That inter-store deliveries should be despatched on pallets.

9) That for deliveries direct to farms we would develop a system of mechanical depalletising of unit loads.

New equipment

The equipment finally chosen and installed was as follows:-

2 - Electro-pneumatic weighing machines each capable of 10 weighments per minute.
1 - Bagging spout capable of taking 20 bags per minute.
1 - Bag Vibrator
1 - Band sealer (existing but modified for double seal).
1 - Semi-automatic Palletiser
2 - Depalletising Combs.
1 - Multi-bladed Fork Lift Truck.

The new weighing machine can be seen in Fig. 5., and the delivery chute, bagging spout, vibrator and sealer in Fig.6. Fig.7., is a line diagram of the new installation.

The sequence of operation is very similar to that described for our earlier bagging lines, the main difference being that the discharge of the weighing machine and the closing of the spout to grip the bag is triggered by the back of the operator's hand as he applies the bag to the spout, and of course only one spout is used where before we required two.

WEIGHING

The weighers are of British manufacture and, as previously stated, deliver 10 weighments per minute per machine so that we can now feed to one spout at twice the previous rate.
The weighers do not have the same heavy mechanical parts as the earlier model and consequently the reduction in inertia allows for faster movement. Improved features include the more extensive use of pneumatic cylinders including a pneumatically operated weighbeam lock, and the disposition of most of the electrics and pneumatics in a dust free annulus round the product inlet.
We have found in practice that these machines have operated consistently to within 2 oz.(56 grammes) of their setting of 2 oz.(56 grammes) above 1 cwt. (51 Kilos) with much less need for re-calibration than their predecessors.

BAGGING SPOUT

The new bagging spout is of German manufacture and differs from our earlier spouts in that instead of the clamps moving in to grip the bag against a stationary spout opening, it is the spout which opens against two stationary clamps. The opening and closing movement of the spout is rather like the action of the bird's beak. The main advantage of this is that the area over which the empty bag has to be placed is very much smaller and therefore the speed of the operator is increased. Other features which we consider to be of advantage are that dust extraction takes place inside the spout mouth and that the spout grips the bag fairly closely all round, so dust contamination of the seal area is reduced. Also, the fact that the spout clamps remain stationary and do not spring out towards the operators face is preferred by the operators.
The spout can be seen in the photograph (Fig.8).

We had estimated that the operator would be able to apply bags to the spout at rates up to 17 per minute, where previously we had been restricted to about 11 per minute. In fact we now find that the operator can peak up to 20 bags per minute, and can sustain an average rate of 17 per minute over an hour. We are therefore getting virtually the same output from one operator that previously we got from two.

VIBRATION OF BAGGED FERTILISER

The vibrator which we installed is shown in Figs 8 and 9, and is patented by a British Company.
It is fitted directly below the bagging spout and is as can be seen, a high metal box, open at both ends, and mounted on angled spring plates. The box vibrates in the vertical plane at an angle determined by the spring plates, and it is driven by an electric motor through an eccentric shaft.
The angular vibration created conveys the filled bag at the same time as the material is being consolidated, and delivers the bag on to a belt conveyor which is fitted with two stationary vertical sides. The vertical sides to the band conveyor are necessary to retain the width of the bag while sealing, in order to avoid damage to the seal.

We have found that the bag produced by the vibrator is of a better shape, has almost no air entrapped after sealing, is more easily handled and makes neater stows than the unvibrated bag.

The question of whether vibration of granular fertiliser before sealing will allow smaller bags to be used has engendered a great deal of discussion. We have found that, by using a wider vibrator than the manufacturers produce as standard, we can make polythene savings of approximately 5%. We can only speak of our own experience of course, since bulk density and granule size and shape largely determine the reduction in volume obtained.

Having for the purpose of polythene saving produced a package thicker (9") than we eventually require, we have then to reduce this thickness before palletising. We find that this occurs naturally in the process of conveying the bag in the horizontal position, but to ensure that the process is completed we have fitted a short length of conveyor belt with 'rapper' idlers which in effect vibrate the bag in the horizontal as opposed to the vertical position. The rapper idlers are standard parallel idlers to which has been welded 4 strips of ¼" (6mm) round rod. The conversion cost is minimal and we find them to be quite effective. The idlers can be seen in the photograph (Fig.10).

SEALING

The modifications which we made to the band sealer are the subject of patent applications by British Visqueen Ltd., already referred to. Originally, the seal which is effected by heater blocks behind a moving coated steel band, was cooled across the whole area by means of water cooled blocks operating across the full depth of the seal.

It is of course necessary to cool the seal quickly so that it will withstand the pressure of material when the bag is tipped on to its face for conveying to the loading point. This cooling does, however, weaken the polythene in the seal area to about 60% of the strength of the virgin film.

The modification made to the sealer was to alter the cooling blocks so that only the lower part of the seal is force cooled, leaving the top part as a completely relaxed seal. The strength of the relaxed or uncooled part of the seal is then about 90% of the virgin film on uncontaminated polythene. The lower, cooled seal now operates in the short term to prevent material opening the seal and the top, relaxed, section gives a stronger long-term seal. The relaxed seal will hold effectively in marginally dusty conditions where previously the seal was ineffective, but without fuller experience we can make no comment as to its success under conditions of heavy dust contamination of the polythene.

The use of the double seal, together with more effective dust extraction at the bagging spout at our Leith plant eliminated faulty seals due to dust contamination.

PALLETISING, STORING AND DEPALLETISING

What has been described up to this point is standard manufacturer's equipment, much of which will already be known to many fertiliser manufacturers, but the semi-automatic palletiser and the depalletiser now considered have only recently been developed. The depalletiser in fact is still undergoing trials at the time of writing.

PALLETISING

The basic design requirements which were set for the palletiser were that it had to be as simple and as robust as possible, and that since, to the best of our knowledge, all palletisers on the market needed an attendant, we would give the operator a certain amount of work to do, in order to reduce the complexity of the machine . We had the palletiser made for us by a Scottish Company.

We were agreeably surprised that the palletiser, which is after all a prototype machine, worked efficiently almost from installation. Modifications have certainly been made, but almost all of these have been concerned with improving the output of the machine.

The palletiser is shown in Fig. 11.

It consists of three main units: An upper level on to which the bags are received and manually assembled, a raising and lowering mechanism for the pallet, and a chain conveyor for transporting the empty and filled pallets.

The bags arrive from the bagging unit down an aerated slide(9) onto a short rubber belt (10) controlled by a foot pedal on the operators platform (21). The operator arranges the layer of bags on the forming table (1). Then, stopping the belt conveyor, he transfers the layer of bags by means of pusher plates (6) actuated by pneumatic rams (17) to the aerated stripping table (2) where the forward movement of the layer is arrested by a backplate (7). The two transverse edges of the layer are now parallel and the other two faces are squared by compressing the layer between side plates (8) and (6a) by the forward movement of (6a), actuated automatically by pneumatic rams (11), and at the same time rams (17) retract to their original position. The operator then depresses a foot pedal on the platform and the table (2) retracts towards the back of the machine by means of pneumatic ram (18), depositing the layer of bags which is held in horizontal position by plates 8, 7, and 6a, onto the empty pallet (12). The pallet with the layer of bags is then lowered to a position determined by a series of sensing devices, at which point the lowering is automatically stopped and the stripping table returns to its original position. At the same time as this is happening, the operator is assembling a fresh layer of bags on table (1).

This sequence is repeated until the required number of layers has been deposited on the pallet when automatically the pallet is lowered until it rests on the chain conveyor (4). At this point provided an empty pallet is placed on the conveyor, the full pallet is automatically moved out to the end of the conveyor, and the empty one moved in and raised to the filling position.

It can be seen that the machine has no pallet magazine and storage for only one filled pallet, although storage for both full and empty pallets could be easily fitted. Our philosophy here was that the fork truck should be used as an extension of the machine and if the driver knows he has to be at the machine at a certain time he will be there. So far we have found this to be a perfectly satisfactory arrangement.

The palletiser has 20 connected Horse Power and uses approximately 12. h.p. at 60 tons per hour, including flotation and compressed air. The maximum output of the machine illustrated is 70 tons per hour palletising 7 x 1 cwt. bags per layer and 6 layers per pallet.

To the time of writing we have palletised approximately 25,000 tons and mechanical breakdowns have so far amounted to less than 5% of running time, with longest breakdown being of 4 hours duration.

Electrically the machine has been made as simple as possible, but interlocking has been provided so that the stripping table will not close while bags obstruct the ultrasonic sensors; the conveyor will only run if the scissors lift is in the fully closed position, there is an empty pallet on one end on the conveyor, and no full pallet on the other.

Safety devices are also fitted so that the machine can be quickly isolated both electrically and pneumatically from almost any point. Where switches are located, they are easily accessible and robust in construction. Tubular heaters are fitted at three points under the conveyor to keep a warm draught of air over the switches.

Since we consider that in order to sustain the line output of 60 t.p.h. we would require three men for hand palletising, the semi-automatic palletiser gives a saving of four men on two shifts.

Patent cover for the palletiser has been applied for by Scottish Agricultural Industries Limited.

STORAGE

As previously mentioned, we are now able to place 7 bags per layer on a pallet instead of 5, thus allowing 42 cwts. per pallet. In stow it is possible to store 4 or 5 pallets high so that we can have a 10½ ton column of fertiliser on approximately the same area as previously held 7½ tons.

Both our pallet and storage utilisation is therefore considerably improved. In the photograph (Fig 12) a 30 cwt. and a 42 cwt. pallet are seen side by side, and in Fig. 13 a stow of 42 cwt. pallets.

Our standard pallet can be seen in Fig. 14.

Fork truck capacity is also increased by about 40% since if the truck is heavy enough to lift the increased weight, each trip moves 42 cwt. instead of 30 cwt. We are now considering the possibility of putting 49 cwt. on a pallet, thus increasing fork truck capacity even further, and further reducing the number of pallets required. Since, for reasons of stability, our trucks (8,000lb. lift) would only be able to lift this increased load 4 pallets high, this would mean a slight reduction in storage utilisation, but the other factors mentioned could well outweigh this disadvantage.

DEPALLETISING

An examination of mechanical palletless loading equipment in 1966 revealed that the only suitable system available was the skid-board, but as this would have involved replacing all our existing pallets and modifying all the fork trucks in the Company, we decided not to adopt the system, but instead to investigate the possibility of developing some technique of loading where the conventional timber pallet could still be used. To this end we have designed a piece of equipment which we call a 'Depalletising Comb', which is a device for separating the load from the pallet so that the load may be placed on the vehicle without the pallet.

Patent cover for this has been applied for by Scottish Agricultural Industries Limited.

Fig 15 shows the comb and the multi-bladed fork truck used to transfer the load to the waiting truck.

As can be seen, the concept is simple, consisting of a raising and lowering device on which is mounted a series of vertical blocks. The loaded pallet is placed by conventional fork truck on to a static angle iron frame and positioned by the vertical sides of the angle. After the truck has withdrawn, the comb is raised so that the vertical blocks rise through the spaces between the pallet boards, thus supporting and lifting the load clear of the pallet. The multi-bladed truck moves in at right angles, lifts the load clear of the comb, and places it on the platform of the waiting lorry. The truck then moves back at the same speed as a pusher behind the blades is moved forward, thus depositing the load on the lorry. At the same time a fresh pallet is being brought forward to another comb adjacent to the first one, from which the empty pallet is then removed. The only special provision which has to be made is that the pallets must be jig made so that the pallet boards and stringers are always in the same position.

With our standard pallet there is $\frac{5}{8}$" clearance on each side between the boards and the vertical fingers of the comb, so that some missalignment is permissible.

This unit is still being developed, so that we can only estimate its output, but we consider that an average of 80/100 tons per hour may be possible, depending of course, on the weight of the unit load.

FUTURE DEVELOPMENTS

As to the future, we are watching with interest the progress being made in automatic bag filling and sealing equipment and also in the efforts being made to produce a lower priced polythene valved sack. We are also aware of the possibility of a reduction in bag weight, perhaps to 100 lbs or less and all our new equipment can be readily altered should this change occur.

ACKNOWLEDGEMENTS

The author wishes to thank the Directors of Scottish Agricultural Industries for permission to publish this paper.

Figure I ORIGINAL BAGGING INSTALLATION ATELIER D'ENSACHAGE INITIAL

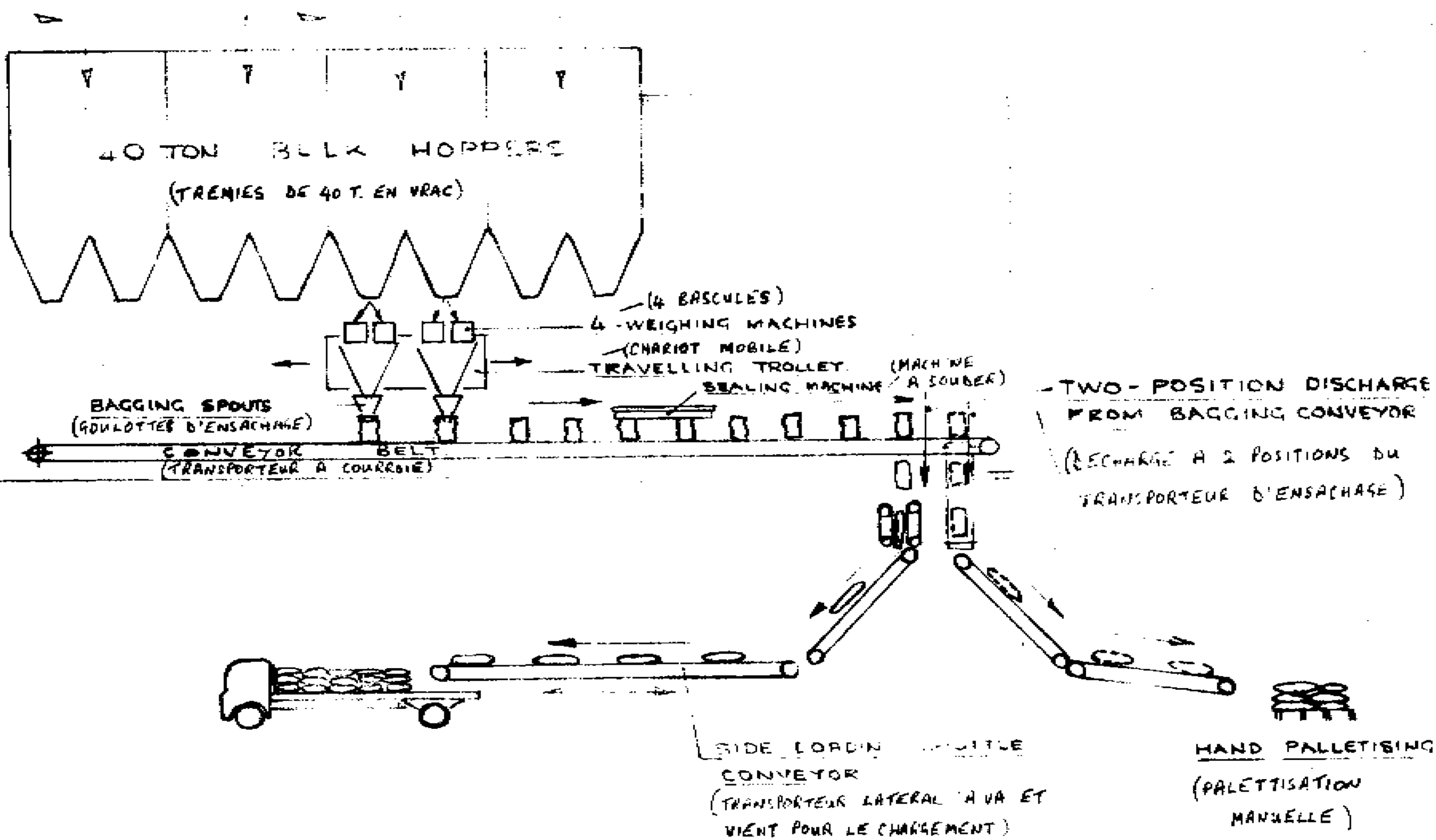

Figure 2

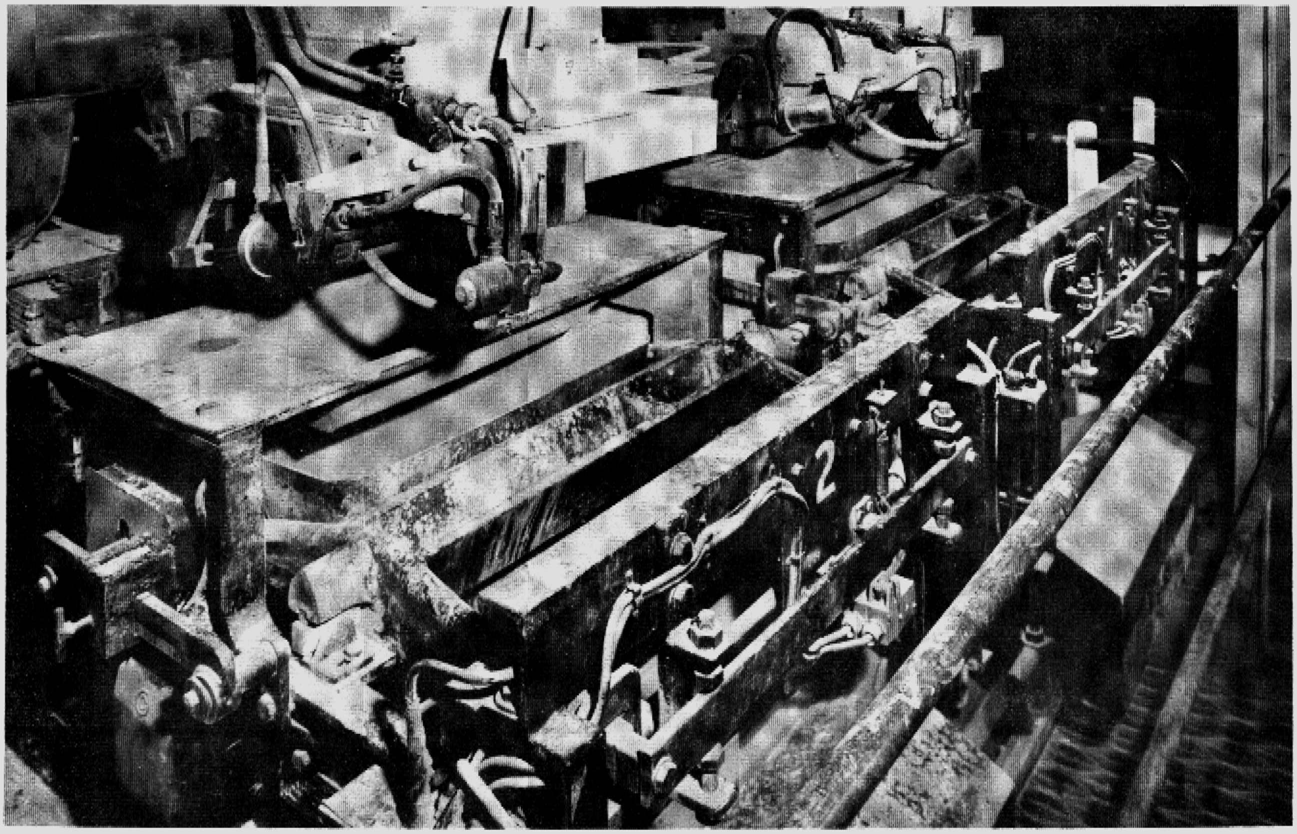

Figure 3

Figure 4

WEEKLY DESPATCH OF BAGGED FERTILISERS SHOWN AS A PERCENTAGE OF MAXIMUM WEEK

LIVRAISONS HEBDOMADAIRES D'ENGRAIS EN SAC EN POURCENTAGE DE SEMAINE MAXIMUM

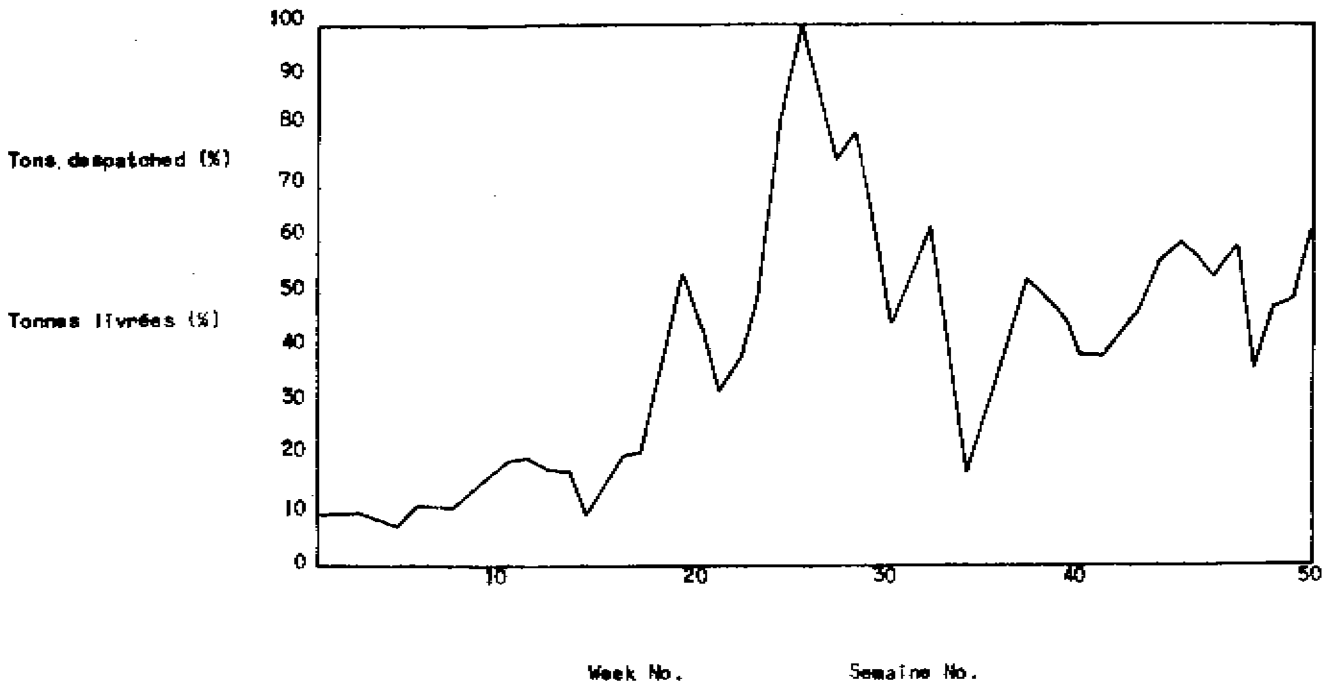

Figure 5

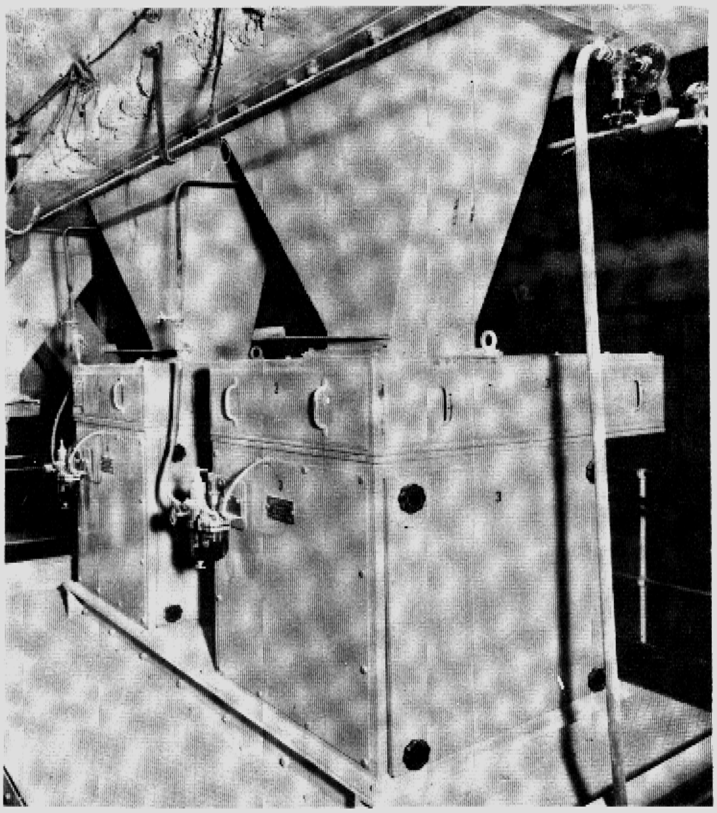

Figure 6

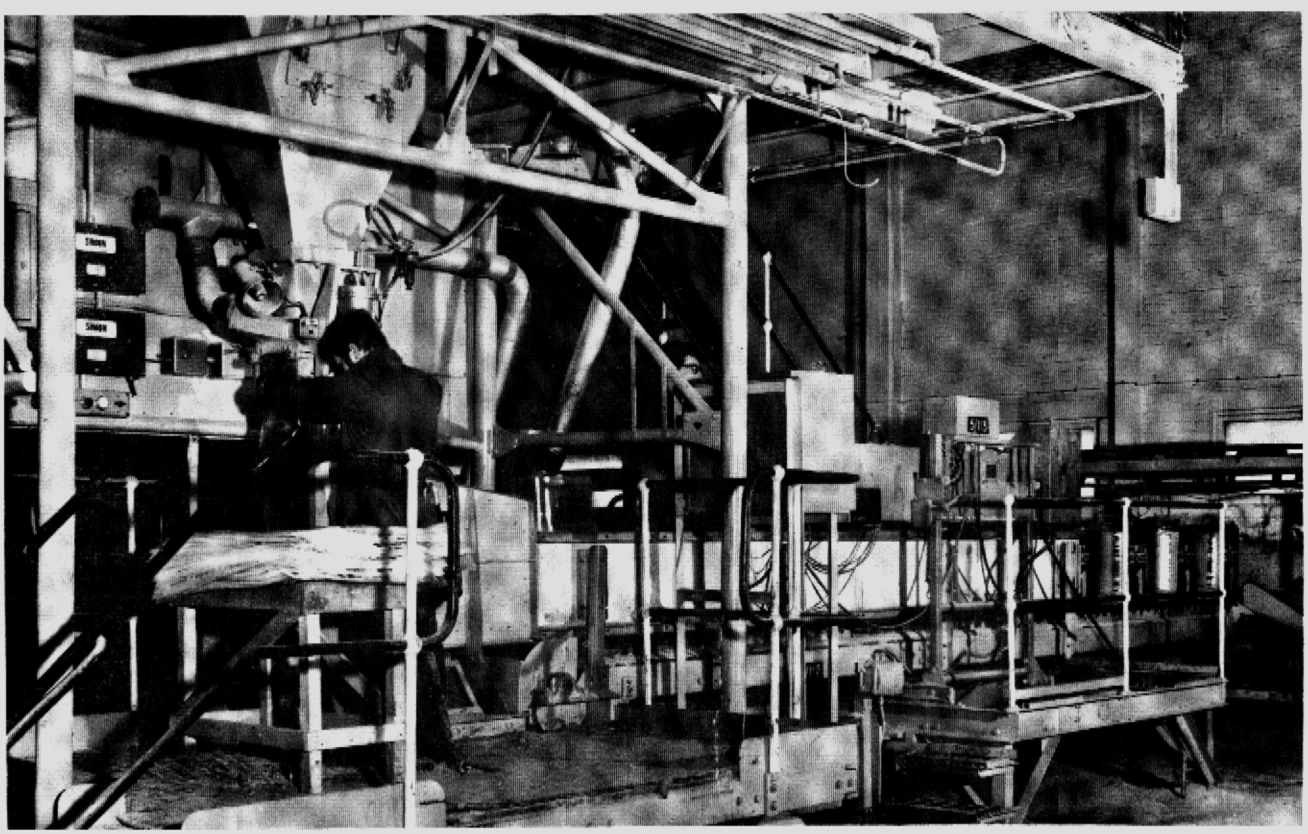

FIGURE 7 NEW BAGGING INSTALLATION NOUVEL ATELIER D'ENSACHAGE

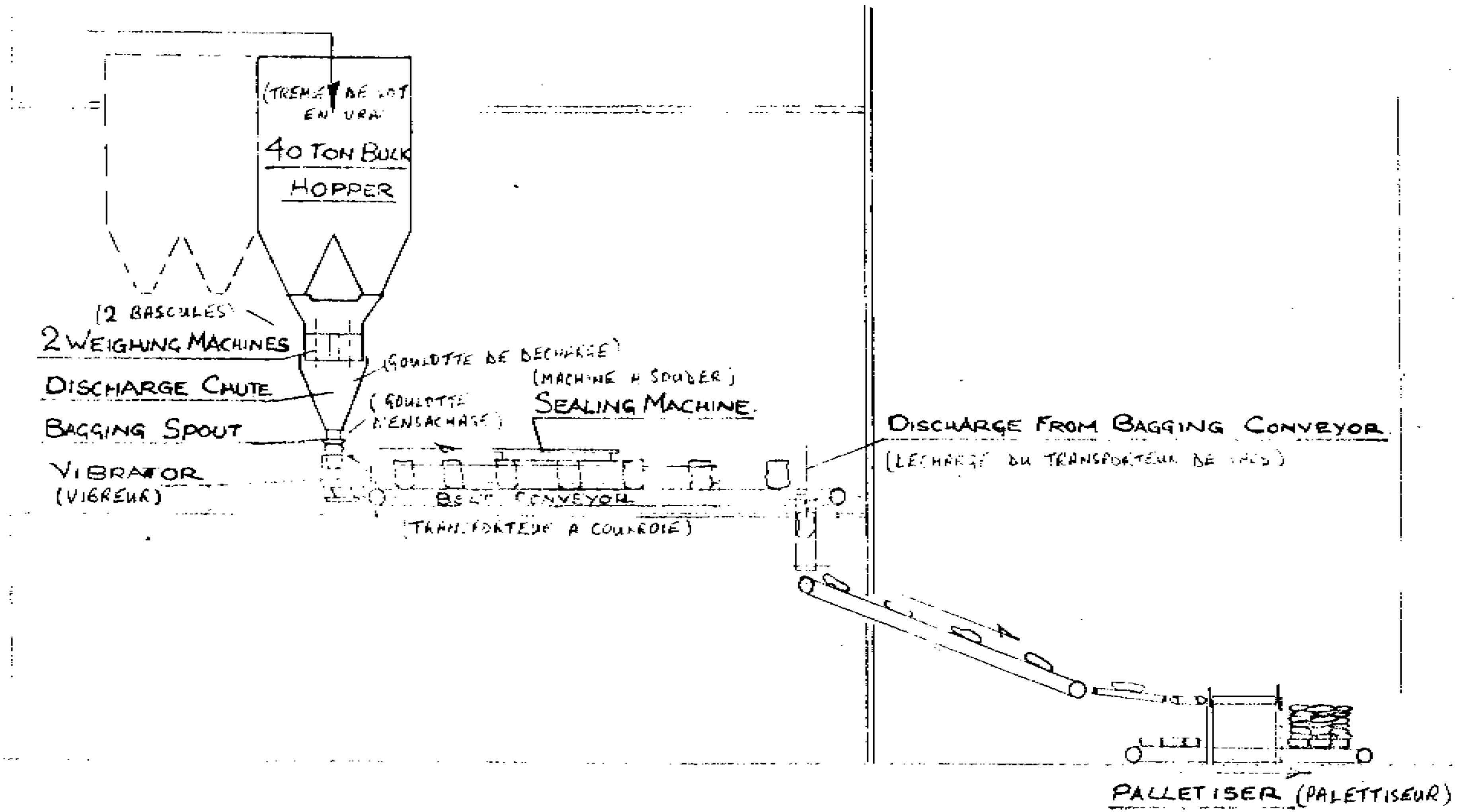

Figure 8

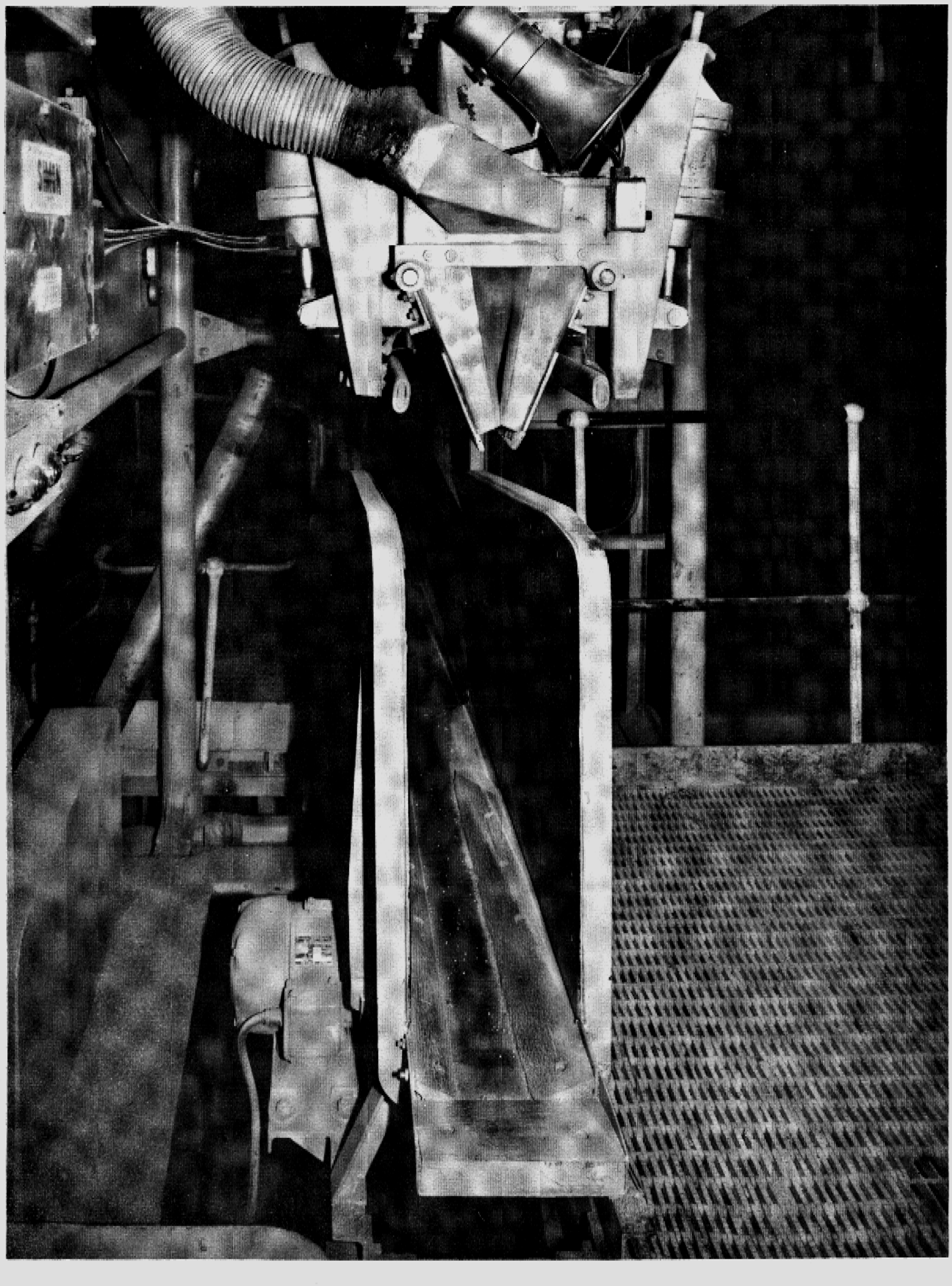

Figure 9

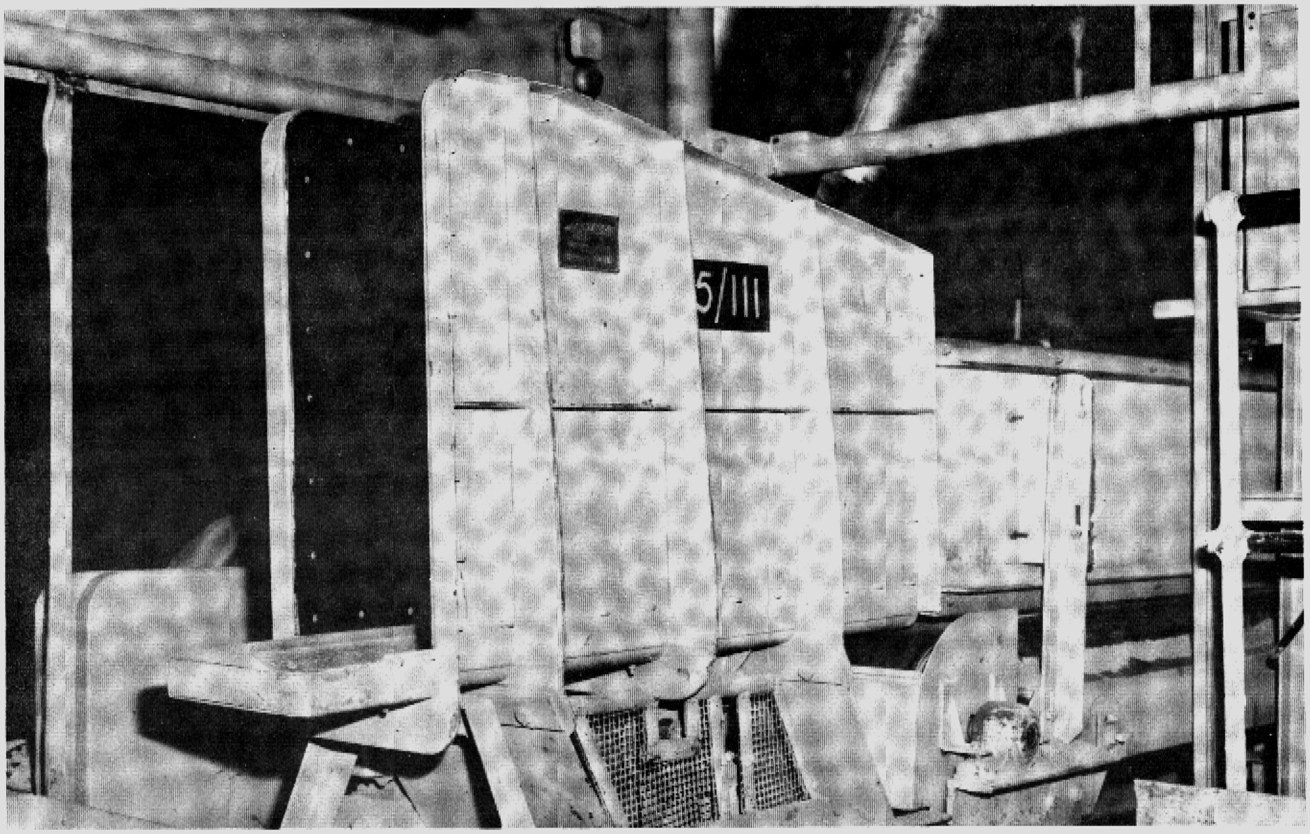

Figure 10

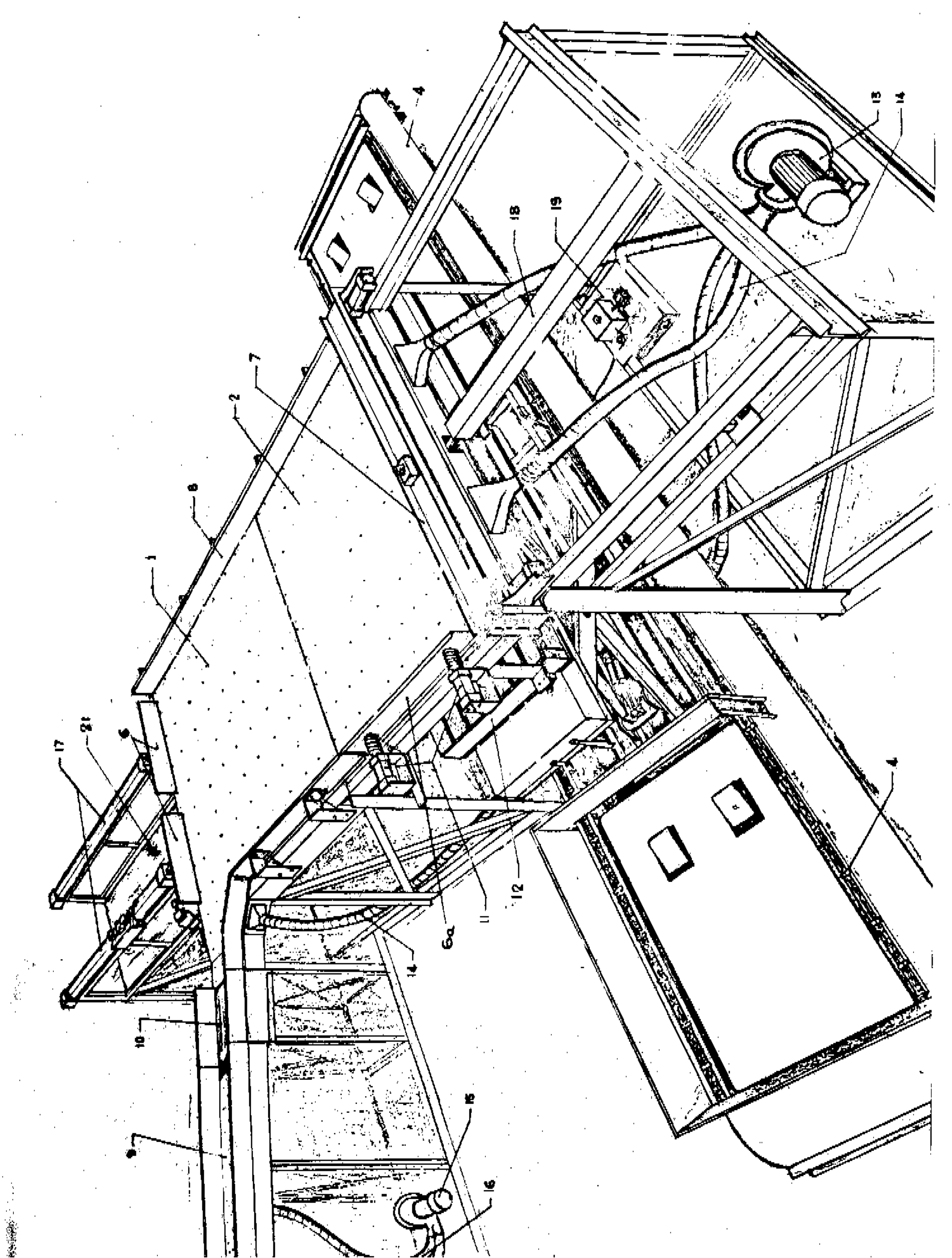
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Figure 12

30 cwt ↘ 42 cwt ↙

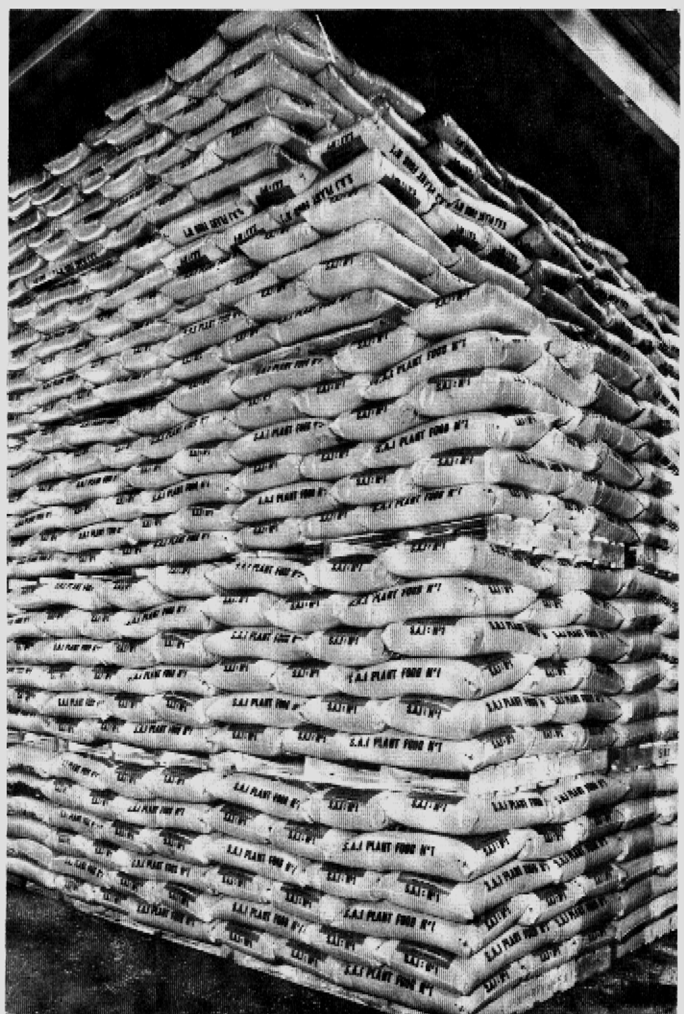
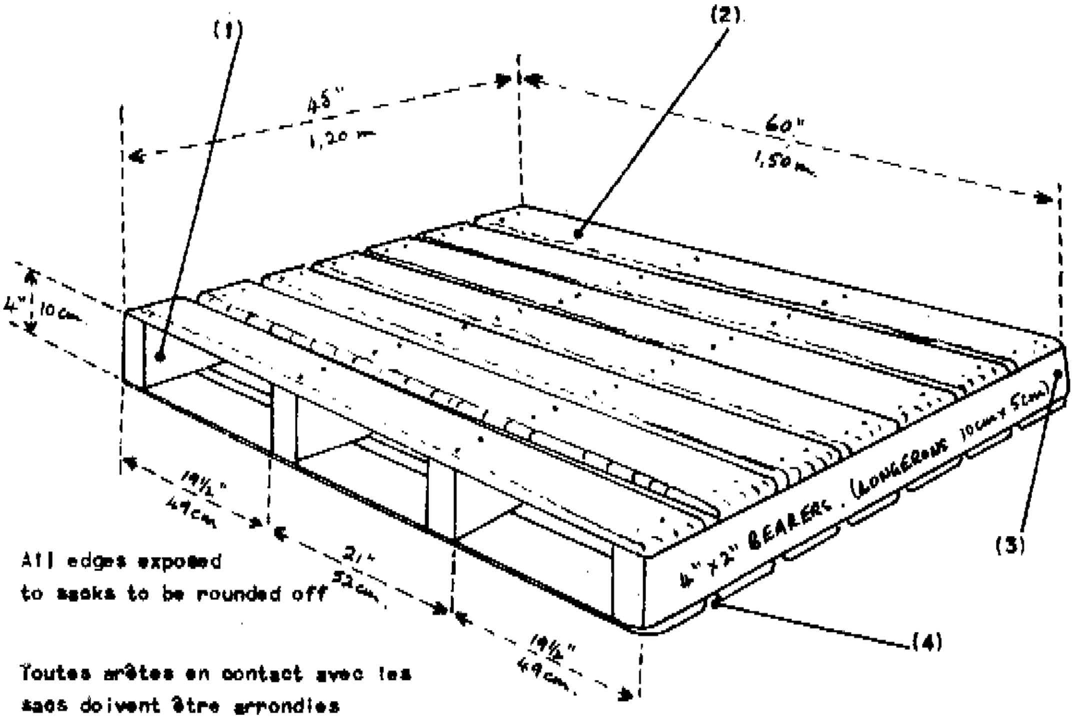


Figure 13

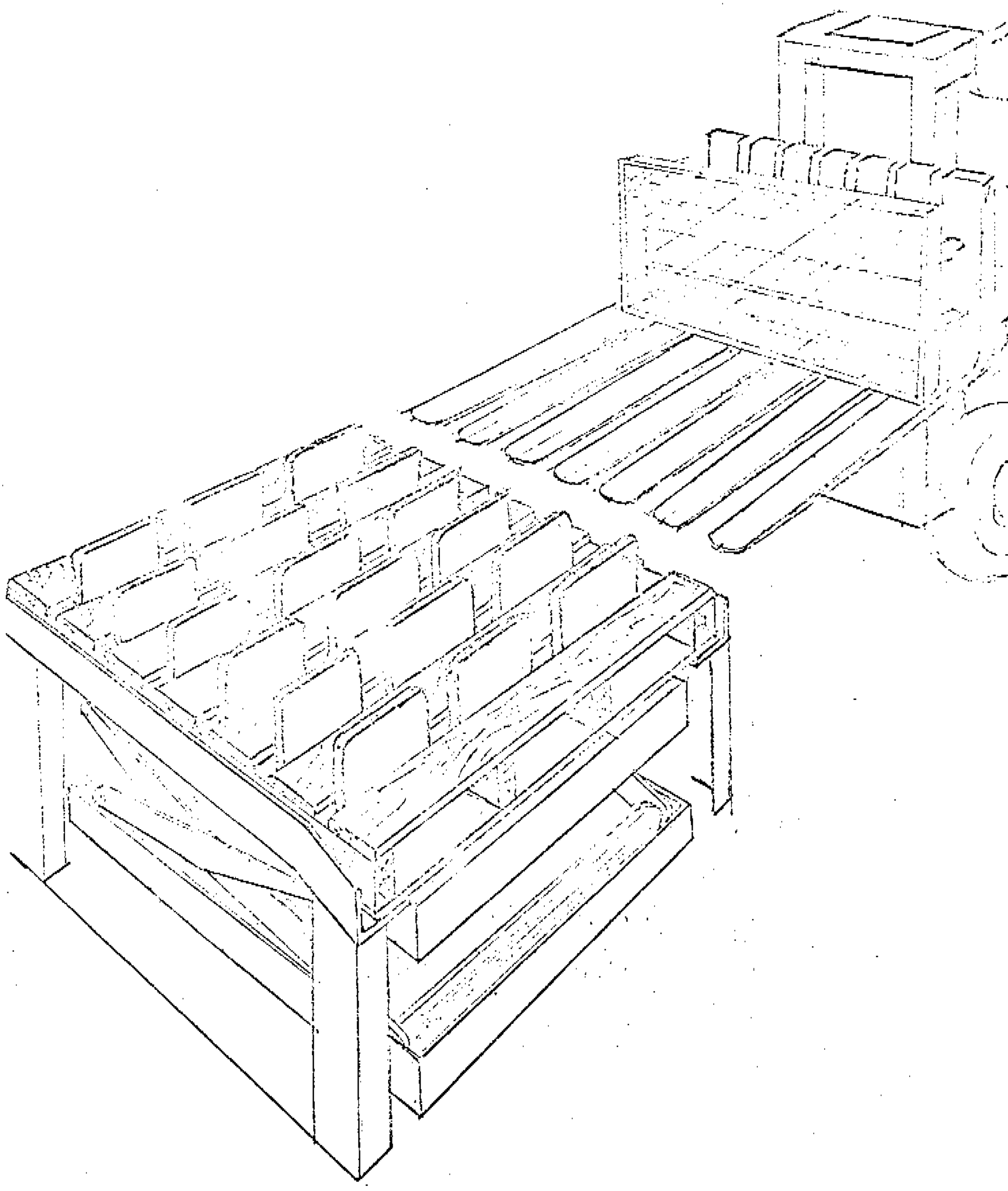
Figure 14 RECOMMENDED STANDARD 5' x 4' PALLET

PALETTE STANDARD RECOMMANDEE 1,50 x 1,20 m



(1)	Bearers 4" x 2" x 48", selected H.G.S.	- Longerons de 10 x 5 x 150 en bois résineux
(2)	Decking boards : 7-5" x 1" x 60". Selected home-grown softwood. 2-2½" x 9 A.R. nails per intersection.	Planches de recouvrement : 7-12,5 x 2,5 cm x 1,50 m en bois résineux domestique. 2 clous A.R. 6,2 cm x 9 par intersection.
(3)	Rounded off corners	Coins arrondis
(4)	Maximum gap 2 3/16"	Espace maximum 5,5 cm

FIGURE 15 DE-PALLETISING COMB



DISCUSSION

MR. MILLER (Scottish Agricultural Industries Ltd.): presented a film showing the various stages of the process described in the paper.

MR. J.J. MULKHUYSE (V.K.F. Mekog-Albatros N.V. Holland): It was with great pleasure that I accepted the invitation to open the discussion on the paper of Mr. Miller "On New Developments in Fertilizer Packaging". Although I am not an expert at all on the bagging of fertilizers, the related problems are so universal that every person in a fertilizer manufacturing company is at some time or other confronted with them and is compelled to have a closer look at this field. Mr. Miller has given us an excellent survey of the work which is done by him and his company on this subject and he has discussed several difficulties which are also experienced in my company. It is therefore very interesting to learn that the developments which take place at SAI are along the same lines which we have too. In this connection I should like to ask some questions and to make some remarks.

My first question concerns the electrically powered bulldozer. Is the type used the cause of the danger of organic contamination of the nitrate-containing fertilizer or the possible building up of carbon monoxide in the air or for reasons of maintenance? Can you indicate the capacity of this bulldozer?

The next question concerns the use of the smaller bag. Although we applied the same principle in vibrating the filled bag to get rid of some air, after 2 years of operation we have come to the conclusion that it doesn't pay to use smaller bags because of the higher percentage of breakage during transport. I must admit here that our experience is of a different type because we send a great part of our production overseas, and a lot of our bags are subject to extreme rough handling on ships and in ports and, at the same time, the greater part of our export is not palletised.

People of our forewarding department were puzzled by the fact that you succeed in placing 7 bags per layer instead of 5 on a pallet. In the meantime we have seen how you are doing it, so that has been solved, but nevertheless I should like to ask in this connection what is the bulk density of the bagged material after it is subjected to vibration and how intensely the bags are vibrated?

My third question is in connection with the remarks which are made on the sealing. Instead of one seal a double seal is made, of which the seal at the product side is normally made and cooled so that about 60% of the strength of the film is reached. The second seal is not cooled especially and you get a so called relaxed seal. In general most of the failures of seals are caused by:

a) a bad polythene film

b) a badly geared sealing machine or seal contamination of the inside of the bag by dust.

In the first of these cases a double seal gives hardly any relief because the seal at the product side would fail and tear. In the third case you will have results: although the product side seal may give way, the relaxed seal may still hold. My question is a statistical one, what percentage of failure is eliminated in this way and did you perform also experiments with the old seal with the new dust removing system as well?

Further I should like to make a remark on some new experiments which we are performing on palletising. For our export overseas and for storage in the open we cover the loaded pallet with the so called shrink film. This is a type of plastic film which shrinks when moderately heated. The result is a pallet loaded with bags which is extremely stable in handling and storage. The whole pallet can be handled as one package. I wonder if you have made experiments with this type of film and what your experiences are.

MR. MILLER: In answer to the questions I think the first one was in relation to the type of bulldozer which we use. I would say that the answer to all 3 parts of this question would be yes. There is a danger of contamination using diesel, there is also the difficulty in regard to air pollution and we find that the electric drive gives a lot less trouble and needs less maintenance. It is difficult to be precise about the output of the bulldozer since this machine normally works in a deep bin and the extraction rate when working at the top of the bin is much greater than when moving the material from the floor. If I were asked to give an average figure I would say about 200 t/hour. The second question I think was in regard to bulk density after vibration. I would expect this would be around 70 lbs per cubic foot. The intensity of the vibration is 650 cycles/minute with an amplitude of between $\frac{1}{4}$ and $\frac{3}{8}$ of an inch.

To the question regarding the percentage of failures eliminated by use of the double seal I am afraid we have no statistical information on this because the introduction of the double seal and the improvements to dust the extraction system were carried out together. I can only say that the overall result was a very significant reduction in seal failure. As to the question on shrink wrapping we have not tried this ourselves but we did look at the economics and felt that with our type of distribution, which tends to be smaller unit loads over fairly short distances, the economics were not awfully good for us.