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RECOMMENDATIONS FOR ONION PRODUCTION, CULTURAL PRACTICES, HARVESTING, & STORAGE IN HONDURAS

by

A.M. DESSERT

Prepared for the
U.S. Agency for International Development
Honduras

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EXECUTIVE SUMMARY

The U.S. Agency for International Development Mission in Tegucigalpa, Honduras requested (cable Tegucigalpa 14305) that the Postharvest Institute for Perishables provide short term assistance on ways to improve onion production, cultural practices, harvesting and storage in Honduras. In response to the request, a private consultant, Mr. A. M. Dessert, spent the period 5 to 16 February 1985 in Honduras reviewing all of the onion management practices and preparing recommendations for their improvement.

The onion production in Honduras is low, both in terms of acres in production and yields per acre. Both could be increased significantly. There are several areas in the country where this could be accomplished, viz., Choluteca, Comayagua, Santa Rose de Capon, Ocatepeque Valley and San Pedro Sula.

There are numerous varieties of onions that should be tested in Honduras for improved yields and storage qualities, as well as offering potentials for different markets, both domestic and export. Those varieties are discussed in the report.

Also recommended and discussed are improved management of planting dates, planting systems, land preparation, fertilization practices, irrigation practices, weed control measures, harvesting methods, storage systems, and marketing systems for onions in Honduras.

A recommendation is made also that a few appropriate people from Honduras study onion production in the U.S. in order to form the nucleus of an extension system.

RECOMMENDATIONS FOR ONION PRODUCTION, CULTURAL PRACTICES, HARVESTING, & STORAGE IN HONDURAS

INTRODUCTION

Onions are one of the most important vegetables in the diets of almost all people. They are cooked in many different ways. They can be eaten raw, or mixed with other vegetables to make sauces. There are many publications about the value of onions, and as the cultural practices improve throughout the world, the total consumption of onion is constantly increasing. The onion used as a spice in dishes can add zest to a very bland diet. If produced properly, it can be a very inexpensive food.

Onions are classified into two major groups, short-day varieties and long-day varieties. There are some varieties that will fit in between these two which are called intermediate, however, they are not a large class. In Honduras the short-day variety is grown almost exclusively. They should try some of the earlier of the intermediate varieties as they will store longer. In general, the short-day varieties are very sweet or low in solids and do not store well. There are some exceptions to these, namely the Creole class and Creole type hybrids that are high in solids and will store quite a while under proper conditions.

In Honduras the number of acres grown per the population is very low, and there should be considerably more onions produced for the number of people in this country. The production per acre at this time is also very low, which could be changed immensely in a very short time. This could be brought about by improved cultural practices.

I will be reporting on the different areas that I think could grow onions, the uses and names of new varieties to be tried, a trial method, and then suggested production changes which will be a must if Honduras is going to be successful in producing a fair yield per acre, supplying its internal needs, and then looking towards the export of onions. We will also touch on storage, a little bit on the marketing, and the need for a great deal of extension work.

The trip to Honduras was my first visit, and it was a very interesting and enlightening two weeks. It would not have been possible without the help of Julio Barahona who works for the Extension Service in the Department of Natural Resources.

DESCRIPTION OF AREAS AND GROWING CONDITIONS

During the week of traveling throughout Honduras we visited most of the areas where they grow onions. It is my opinion that they could grow a successful crop of onions in almost any area that we visited.

South Coast Area. I visited down through Choluteca and stopped off in an area called Nacuone on the way down there. Here was the largest single planting of onions that I saw in Honduras. It was on fairly good soil, and it looked like an excellent crop of onions could be grown there. They were a little bit late this year, as the grower obtained the ground late and it had been in cotton. I had the feeling that everybody thought that this area was too hot to grow onions. Nevertheless, I believe that onions can be grown anywhere cantaloupes and similar crops can be produced. This would be a very good area to produce onions if they put their seed beds in early and grow some of the longer-growing varieties that would mature into larger bulbs and could be dried down, topped, and put in sacks.

The area around the Escuela Agricola Panamericana (E.A.P.) in Zamorano is another area where they can grow good onions. Dr. Alfredo Montes had some good trials growing on beds at the University. Further on, about another hour and a half, around the area called Jamastran, is an area where onions can be grown, as they are growing tobacco and other crops. It looked to me like it would be a natural area for good onion production.

Comayagua Valley. This is an excellent area for onions, and in total there are probably more onions growing in this area but by very small farmers. This would be an excellent area to put in the project, as the Experimental Station is there. The people who are interested in onions could help with the extension work and get the onions grown in the proper cultural condition for storage.

Santa Rosa de Capon. This area is another area that is high in the mountains and could grow good onions. I definitely think that here there is a need to select the right variety to get the maximum yield. Here again there is an experimental station that is interested in doing a variety of trial work.

Ocatepeque Valley. This area is right near the El Salvador border and had some very fine land. It appeared to be ideal growing conditions for onions, and they had enough water that they could set up to increase the acreage of onions considerably.

San Pedro Sula. This is another area that I think could grow a lot of onions. There is a great deal of land there that is good deep land, and there is more machinery around that could work the ground properly. This area has not grown too many onions, as they think it is too wet. I think there could be a large production of onions in this area if the plants could get started during the wet season and transplanted as soon as the dry season starts. The amount of land available to grow vegetable crops in this area could be expanded immensely, rotated, and not have to be growing onions after onions year after year.

VARIETIES IN USE AND NEED FOR TRIAL WORK

There are basically four varieties used in Honduras today. The largest varieties being used are Red Creole, Grano 502 PRR, Yellow Granex PRR, and Crystal Wax. I would suggest the following be used to replace these varieties or trials put out to see how they would do.

Red Creole

1. Red Creole PRR. This is a larger, darker color, more resistant onion.

2. Red Grano PRR. Larger and a little earlier than the Red Creole and should increase the yield immensely. It is not a storage onion.

3. F-1 Tropicana. Half Red Creole, and it is definitely larger, earlier, more resistant, and is a pretty good onion to store.

4. Red Ace. A very early onion. Plants would have to be started early. It is not very large, but is larger than Red Creole. It has very dark color and is quite hard and could be stored a little while, but since it is so early it should not be grown to go into storage.

5. Red Granex. Considerably larger than the Red Creole, will bulb down very nicely, is darker color, and stores pretty well.

6. Hybrid Red Commander. Quite large and could be a very good onion if grown to proper size. It might be shipped to the American market during the months of January, February and March.

7. Red Burgundy PRR. This is very large, semi-flat, and dark color. This is one that could increase the yield but should not be grown for storage.

8. Regal. This is another early intermediate red that might store well. It could have high production, but for later harvest just before the rainy season starts.

Yellow Granex PRR

1. Texstar. This is earlier and is a very productive onion. It would be good for the main crop season for getting good bulb size and shipping within the interior of the country.

2. Special 38. This is quite a bit larger, quite early, and would be a good storage onion if it will mature in late April.

3. F-1 Hybrid Goldrush. Quite a bit earlier than Yellow Granex, the same size, and would be planted for the very first part of the harvest.

4. F-1 Granex 33. Earlier, a little smaller than the regular Yellow Granex, but has had good performance records all through Central America.

5. Y1000. This is a new open pollinated variety that is early, makes a large round bulb, and could prove to be a very good onion for Honduras.

Crystal Wax and White Granex

1. Robust. Earlier, larger, and more disease resistant. Could produce good large white onions for early harvest in Honduras and for export to the U.S. during the months of January and February.

2. F-1 Hybrid Early Supreme. It is even larger and firmer than the Robust. It is another one that has done very well in Mexico and could be exported. It is exported to the United States from Mexico during the months of January and February.

3. Majestic. About the same size as Crystal Wax but a little deeper. It has much more foliar resistance and would probably come off a little earlier. It would be good for early white onions for consumption within the country.

4. F-1 Tampico. This is very early. The season could be started with this one because it should be earlier than anything else except for White Express.

5. White Express. Very similar to Tampico but a little firmer and maybe a few days earlier.

6. White Grano, Open Pollinated PRR. This is a large open pollinated PRR variety. It is about twice the size of Crystal Wax and could increase yields immensely for the white consumption. It should not be considered for export.

7. Paradise. An early intermediate white; however, it has high solids and it might store better and be used for production at the tail end of the season to put in storage.

502 Grano PRR Group

1. Colossal. This is a very large 502 Grano type, a little later in maturing, and could be used as one of the main onions for harvest in late March and April.

2. Texas 1015. It is very similar to Colossal, might store a little better, and could be a good one for the main crop.

3. Glory PRR. This is an early intermediate type, but it is larger and later. It should make a bulb in Honduras, and if it does, it would store better than any of the above.

4. Yellow Creole. This is like Red Creole but yellow. It is one of the hardest and highest solid onions in the short-day classes. It will be larger than the Red Creole and could be stored a considerable length of time.

5. F-1 Golden. This is a half Yellow Creole hybrid, earlier than Creole, but makes a larger bulb. It has a very beautiful skin color and a thicker skin than anything else in these classes.

NEED FOR TRIALS AND NEW VARIETIES

During my travels throughout Honduras I did not find in any area any onions that I would call well matured and well cured. That is why we have to do immense trial work in search for the right varieties for the right time of harvest during the year. What we have to try to do is to get an earlier variety so we can start harvesting in November. If we can plant in the rainy season, the plants will not be affected as much by leaf or foliar diseases when they are small as when they get older. On the other end of the growing cycle we have to see if we can get onions that we can mature right before the real heavy rainy season starts. This part of the onion crop could be grown to full maturity. That is, we should make sure the bulbs are well cured and have some dry skin on the outside, and then these should be put in storage. There is a possibility that we can grow some varieties right through the rainy period and sell them fresh, as they are selling them now with the tops on. This way we would then have a harvest period stretching from November through June, and we would only have to store through July, August, September, and October. This is why the trials are so important, and someone in Honduras has to follow through, after we send all the seed samples down there, to make sure that the different people in the different areas are getting them tried at the

different times throughout the year.

SUGGESTED PRODUCTION CHANGES IN GROWING OF ONIONS

A. Seed Beds. There should be a great deal of work done on learning how to grow good seed beds. They are doing a good job at the present time, however, where the work needs to be done is a method of sheltering the seed bed from the heavy rains. Get them started during the rainy season so that there are plants to transplant early, such as August and September and then again in October. This could be done under some type of shade, using banana leaves or something similar to protect the seed bed from the real heavy rains until they are established.

B. Land Work. In almost every location I did not feel the land was being worked deep enough to start. The land should be worked by being plowed, chiseled, or subsoiled at least 12-14 inches deep. It should then be disced a couple of times, landplaned or smoothed out as much as possible, and then some preplant fertilizer applied and some beds made. We will go into the bed making a little later.

Onions are considered a shallow root crop, however, they will go down 24-30 inches if there is moisture that deep. In the early stage it is advisable to let them reach down. Almost in all cases where onions are growing in Honduras they are on a flat surface and the roots are not more than two, or possibly three inches deep. In a good crop of onions it should not be possible to pull the onion out without breaking it off. That is how strong the root system should be. This was not seen in Honduras in any area. The roots were all just parallel with the ground.

C. Fertilization. I really believe that the fertilizer should be applied before the beds are made. Then when the beds are made most of the fertilizer is folded right into the bed. It has been recommended before to use a three way mixture, such as 15-15-15, about 300 pounds per acre, and I would recommend this. I think we might be better off with a little

higher mixture of phosphate and eliminating any additional phosphate in the sidedressings. I would suggest that all land be tested to see if potash is needed because, as one person in my tour told me that he is finding that there was plenty of available potash in the soil when it was tested. They have a good set up for testing soil for available fertilizer, both at the university and at the experimental station at San Pedro Sula.

It is very important that pre-fertilizer is applied, so that when the transplants are put in there is some available nitrogen, potash, and phosphate for these plants to start as early and vigorously as possible. They would probably be sidedressed again in about three to five weeks and then sometime between the seventh and the tenth week, mostly with nitrate. It is very important when sidedressing that it be put off to the side of the row of plants but down into the soil. Do not just spread it in the middle of the furrow, particularly if using urea because in 24 hours the sunlight can destroy about 50% of the urea. It has to be covered, and to make a large onion, I would suggest that between 60 and 75 units of nitrate be applied at each sidedressing.

It is important, if the soil has been tested and found to be short of potash, that potash be applied and also maybe a little additional in the initial fertilization before seeding. If it is short, it is a good practice to apply a little extra potash in the last sidedressing, as this seems to make onions firm up, store and ship better. This would be extremely important on the onions for storage.

D. Installing Beds. It is very important that beds are installed so as to get the onions out of the water and be irrigating down a furrow. Beds can be made in unison, two plows, three plows, four plows, or five plows, and should be uniform.

I am enclosing pictures of our bed making machine, or what we call the lister, our bed shapers after the beds are made, and our sled or planters that go over the beds after they are shaped with the planter on it.

It would be a great advantage if one of the natural resource organizations could purchase some equipment and in one area do some of the basic ground work, such as making the beds, shaping the beds, and then eventually having as a planter that could be used later for direct seeding. I would probably think that the Comayagua Valley would be the place to start.

Once people see what they could do by getting their onions on beds, I think everybody in the country would eventually switch over. Some of the advantages of having onions on beds is that there is more air movement than trying to have a six to eight foot wide planting of onions every four inches. The farmers will also definitely get a larger size in a more mature onion, better quality, and easier to irrigate once the crop is set up. It is also easier for weed control. Enclosed are some pictures of the lister that makes the beds.

The beds could be so advantageous that after a few years the people will be wanting to direct seed. This has been worked out in Mexico where they were always transplanting and now they are direct seeding. Larger yields are achieved with direct seeding, and it is an earlier and less expensive crop.

E. Weed Control. In the last few years many chemicals have come out that are really helping in weed control in onions. I know labor is very inexpensive there, however, some of these controls that can be used are fairly inexpensive. Here again there can be a larger crop with actually less expense in it if some type of weed control is used, particularly in the early stage. If farmers are working their ground, putting in beds, and planning to transplant, they could spread Treflan or some similar chemical on top of the ground. List the ground up or make the beds and spray the Treflan working it in with the lilliston.

This will provide good weed control for the transplants in the early stage. Treflan is a very inexpensive herbicide used in cotton and soybeans.

Dacthal also is a very good herbicide on onions and can be used particularly for direct seeding, even in a seed bed. Seed can be planted, sprayed over with Dacthal, then watered. It does not have to be worked into the ground. It is a little more expensive, but it does stop most of the weeds; and might be used in the seed beds or starting to grow onions from direct seeding. The seed should be planted, the beds sprayed with Dacthal, and then the soil should be sub-irrigated. This will give very good weed control.

Two very good herbicides that have come out in the last few years for grass control are Post and Fusilade. They can be applied after the grass has come up. It will take about four weeks for complete kill of all the existing grass, however, they work very well on most grasses. They are not very effective on nutgrass. There has been some work done on nutgrass in Mexico with the use of Bueno 6 or MSMA. It will kill the nutgrass if sprayed right on the bad patches without a wetting agent, and it doesn't seem to hurt the onions. The temperature has to be around 80^{0} in the daytime to have this work fairly well.

Another good herbicide is Goal. It does a good job on a lot of broadleaves and will kill some grasses in the early stage. It also lasts for quite a while after it is applied. In other words, it will kill some of the existing weeds that are up and will not allow new ones to sprout for about six to eight weeks. Goal can not be used on onions until they are about six to eight weeks old, until they get a little wax on their leaves so it doesn't adhere to the onions when it is sprayed on.

There has been a great deal of work done and written on weed control for onions. This weed control work should be demonstrated to the growers at the different experiment stations along with the variety trials.

F. Irrigation. Irrigation is applying the correct amount of water on a crop at the right time. If the ground is worked deeper and the crop is on beds, quite a bit less water will be needed. In the first transplanting, if the crop is on a bed, it can be sub-irrigated until it gets wet to the middle of the bed, whether on 20-inch or 40-inch beds with double lines. Get it wet and then leave it alone from two to five weeks, depending on how much moisture the soil will hold. The soil will be in good shape, it won't crack or dry, there is a lot of moisture for the onion plant, and it will make the roots go down with the moisture.

In the early stage, onions do not need very much water, as they do not have much of a top to evaporate the moisture. As the crop gets big and the tops get tall, they have to be irrigated more frequently; however, never get them too wet. Keep them growing at all times and make sure that the roots are in good condition.

G. Harvesting. Harvesting for onions that will be put in a sack or storage should be done after the tops have started to go down about 50%. This won't always hold true, as there might be a shortage for the very first onions, and people will be taking them a little earlier.

One of the best things to do when harvesting the short-day onions is windrow them and let them sit in the field before the tops are cut off. This is just simply laying down rows of onions, one on top of the other so that the tops shade the bulbs, and leaving them there six to ten days. This helps the onion to perfect its outer skin, which is one of the best storage mechanisms. It will also fill out any irregular hollows or bumps, i.e. smooth them out, and they get a very good shine.

Harvesting will be done in one or two ways. Either bring the onions in to storage with the tops, string them up, and let them store; or cut the tops and roots off, put them in burlap bags, let them sit another four or five days in the field, (as long as there is no threat of rain) cure down, and then take them to storage.

If thinking of the American or export market there should be some type of onion grading equipment so that sizing is done very accurately. Onions for export are usually sized in about four or five groups. Usually from 2 to 2 7/8 inches, 3 to 3 1/2 inches, 3 1/2 to 4 inches, 4 to 5 inches, and then anything over 5 inches in diameter.

There is also a good market in the United States which could stand the additional transportation costs of Honduras' onions for boiler onions. These would be white onions that are planted closer together, still in rows, on beds, and only making about an inch in diameter.

H. Storage. There are many ways to store onions. I will enclose some information on how to build drying equipment and refrigerated storage, however, I think it will be a long time before we get to refrigerated storage in Honduras. I would suggest, at this time, that we use the local buildings in the areas onions are grown. Hang them from the tops, just about the way tobacco is cured. I think they will store three months this way.

There is a lot of work being done on how to make simple storage in Panama. When it is finished and tried we should make sure copies get sent to Honduras. There is no sense redoing this work. These are simple sheds with sun collectors, dryers, and other items that Dr. Mark Gaskill is working on.

If, in a couple of years, the production of onions is a good enough state of art in Honduras to try to ship to other countries, particularly the United States, the product will have to be a very well cured, dry onion for shipment. The onion will have to be free from roots, have a small neck, and no flat spots on it larger than a quarter. In other words, do not grow them too close together and have flat sides. The onions also should have a dry outside skin, with some of the skin breaking off and shedding during transit.

In tropical areas this onion would probably have to go over some type of dryer during periods of unexpected rain. If the weather is hot and dry the dryer will not be needed, but in the rainy areas there should probably be one dryer set up to handle a thousand or so bags a day of onions coming out of the field. There will be some drawings of these dryers enclosed. They are in constant use in Texas during their early season, particularly if there is an unexpected rain.

I. Marketing. The marketing of onions in Honduras is mostly done along the roadsides and in the major markets. If onions are grown that can be stored, it will be necessary to have some type of a central marketing set up so that the supermarkets and people who sell onions and other goods in the markets can buy them.

If we are successful in producing good yields of onions per acre, it will be necessary to be careful of not bankrupting the little farmer who is only growing a hectare or less of onions and trying to make a living. Onions are basically too expensive at this time in Honduras for the average person. They need to be put on the market at a less expensive price so more consumption will take place. I would caution about trying to go into the production of too many onions in the first few years so as not to disrupt a social life style.

EXTENSION WORK

All through this report I have mentioned that there is not a good set up for experimental stations, universities and private sectors in the country. I think these people have to be coordinated and get a big job done in a relatively short time. It will be necessary for them to prove to the farmers in the country that they can grown onions if they use a new system and grow good quality onions.

Here again, I highly recommend sending one or two people from Honduras to

see how onions are harvested, how they are grown, and what they can expect. The best time would be, as I stated before, around the first of May. I think what they could learn in a week's time would benefit their entire country.

I also believe that if we could get a couple of their people will versed in how the onions are grown and what to expect, that it would be better than sending experts down there.

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The storage and handling of onions

APPENDIX I

INTRODUCTION

Common name	Onion
Botanical name	*Allium cepa* L.
Family	Alliaceae
Other names	Bulb onion, Cebolla, Cebolla cabezona, Cebolla huevo, Oignon

The edible portion of the onion is the bulb which consists of fleshy swollen leaf bases on a small flattened basal stem. It has a natural period of dormancy, which varies with cultivar and storage conditions, but it will eventually produce roots, leaves and flowers.

HARVESTING

For long-term storage bulbs should be allowed to mature fully in the field. Maturity is judged to be when the junction between the bulbs and the green leaves becomes soft and the tops bend over. Storage losses of the bulbs at this maturity are normally lower than those harvested before the tops collapse (Stow, 1975). Hand-harvesting

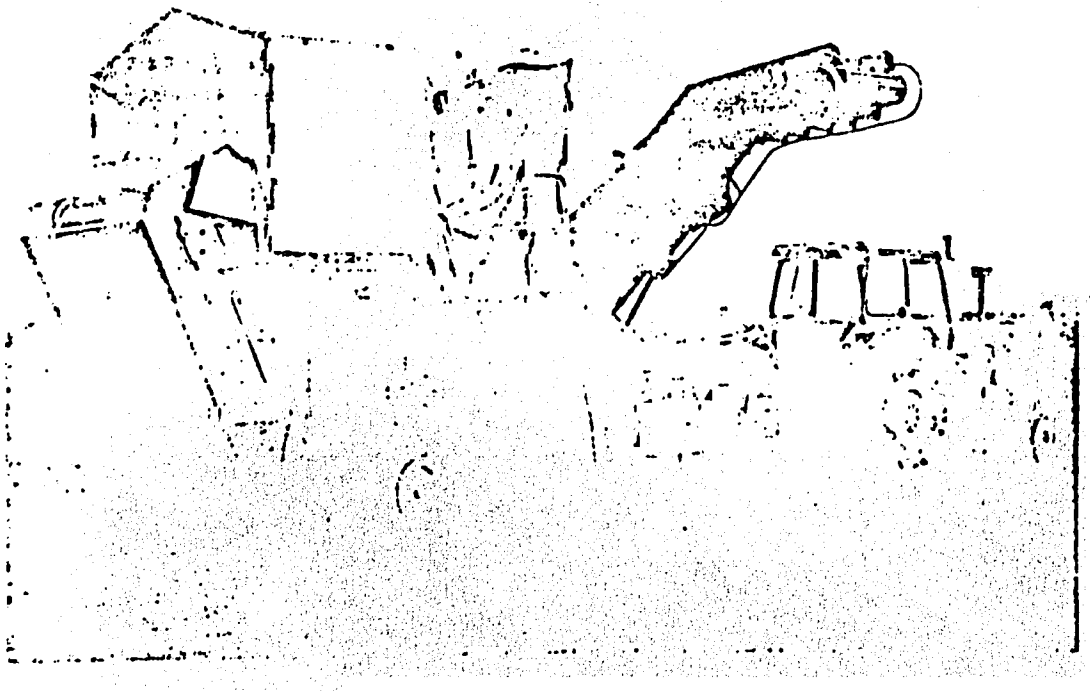

Plate 1

Commercial potato harvester adapted for onion harvesting. Bulbs are loaded directly into a trailer by the adjustable elevator

the tops by hand.

Mechanical harvesting is commonly used and a variety of machines is available. Potato digging machines can be used which cut the roots just below the bulbs and pick them up on a chain conveyor (Plate 1). Other machines are available which can dig the plants from the ground, cut off the leaves and load the bulbs into a trailer.

FIELD HANDLING

Traditionally onions are dried by leaving them in rows in the field directly after harvesting. This is called 'windrowing', and they are laid out in such a way that the leaves of one row of onions cover the bulbs of the next row. This is especially important in the tropics where direct exposure of the bulbs to the sun will damage them. With this method there must be a rain-free period to dry the bulbs. Skin staining can occur during field drying which may reduce the marketable grade of the bulbs. Onions may also be harvested into shallow trays which are then stacked at the side of the field to dry (Plate 2). In certain countries the bulbs are tied together in groups by plaiting the tops, which are then hung over poles in sheds to dry.

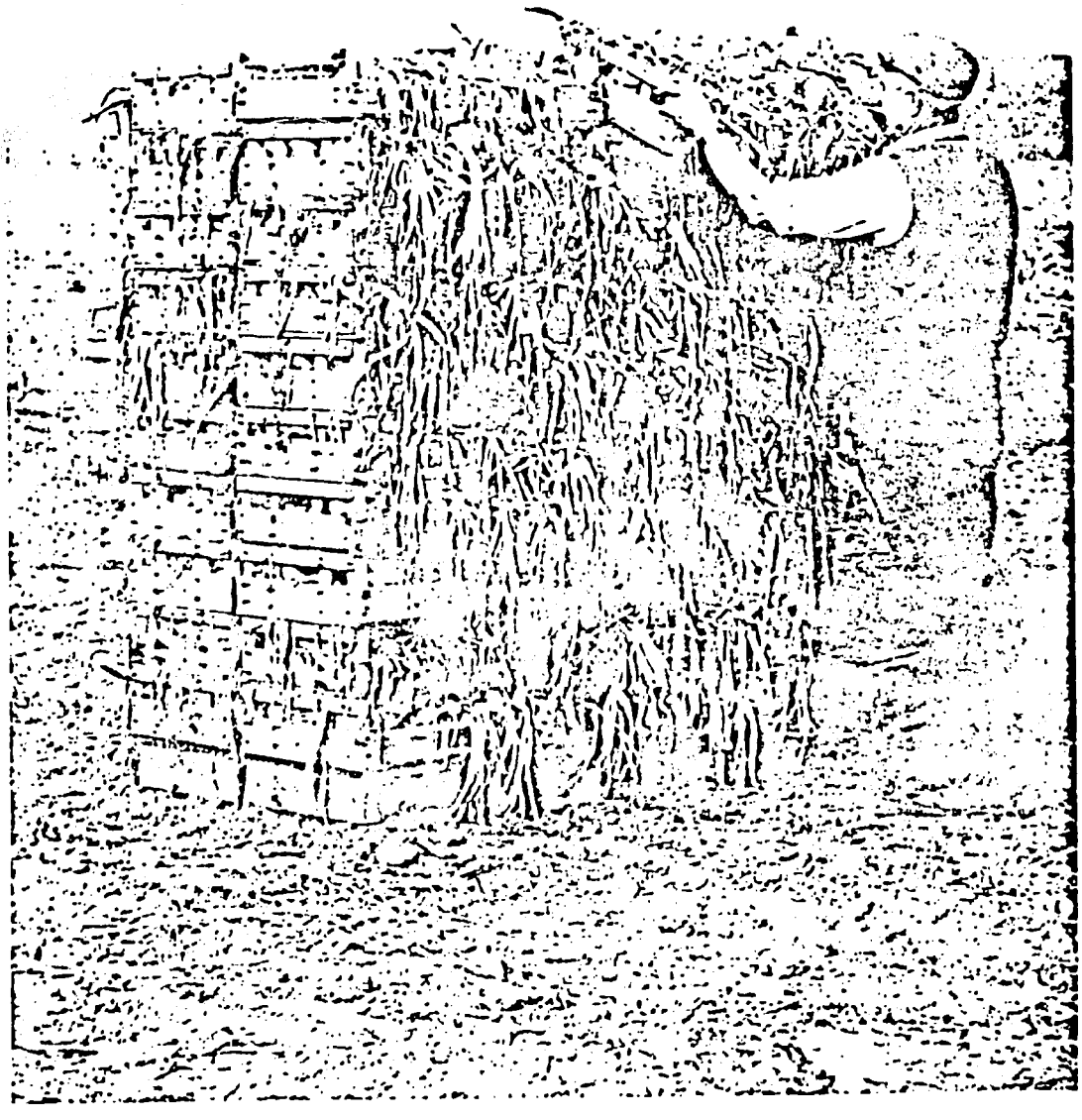

Plate 2
Bulbs may be stacked in trays to dry in the field in Britain. The top tray is usually covered with a waterproof sheet

The purpose of drying is to remove excess moisture from the outer skin and neck of the bulb. This is normally achieved with weight losses of 3--5% (Thompson *et al.*, 1972). If carried out correctly it helps reduce infection by diseases and organisms; and minimises shrinkage caused by removing moisture from the interior of the bulb. This can be achieved naturally, as described in the previous section, by field drying. In countries where field drying is a problem, bulbs may be artificially dried either in a special drier or when they are loaded into the store. This method is commonly used where crops are bulk stored but it can also be applied to bulk bins, bags or boxes. The method is to pass air rapidly through the mass of bulbs until the outer scales are dry and the necks are dry and tight. In Britain, commercial drying is carried out at 30–35°C, and less than 75% relative humidity (r.h.), with an air flow of $7m^3$/tonne/minute (Shipway, 1978). Other recommendations used, based on experimental, or semi-commercial observations, are for 46°C and 70–80% r.h. for 16 hours (Thompson *et al.*, 1972); or 70–80% r.h. with air at 15°C for 4 days then 27°C for about 10 days (Whitwell, 1970). If the relative humidity falls below 60%, excessive water loss can occur and the outer scales will split (Bleasdale *et al.*, 1969).

STORAGE

Various simple methods of storage are used. These may date back for generations and have been developed and refined. Examples of these include mud or straw cottages in the Sudan (Plates 3 and 4). These have a latted wooden stage inside on which the bulbs are piled up to about 1 m deep (Plate 5). They are constructed in such a way that they are ventilated by the prevailing wind passing through them. After 4 or 5 months storage by this method only 50–60% of the bulbs were marketable (Musa *et al.*, 1973). In Britain, windbreaks are still used to a small extent for onion storage (Plate 6). These are made in the field from a wooden base which allows a space below the onion stack. Stakes are driven into the ground around the wooden base and chicken wire is stretched between the stakes to a height of 1–1.5 m. Onions are placed within this cage, topped with loose straw and then covered with polyethylene sheets, which are tied down and weighted with bricks. The windbreak should be built with its longest axis at right angles to the prevailing

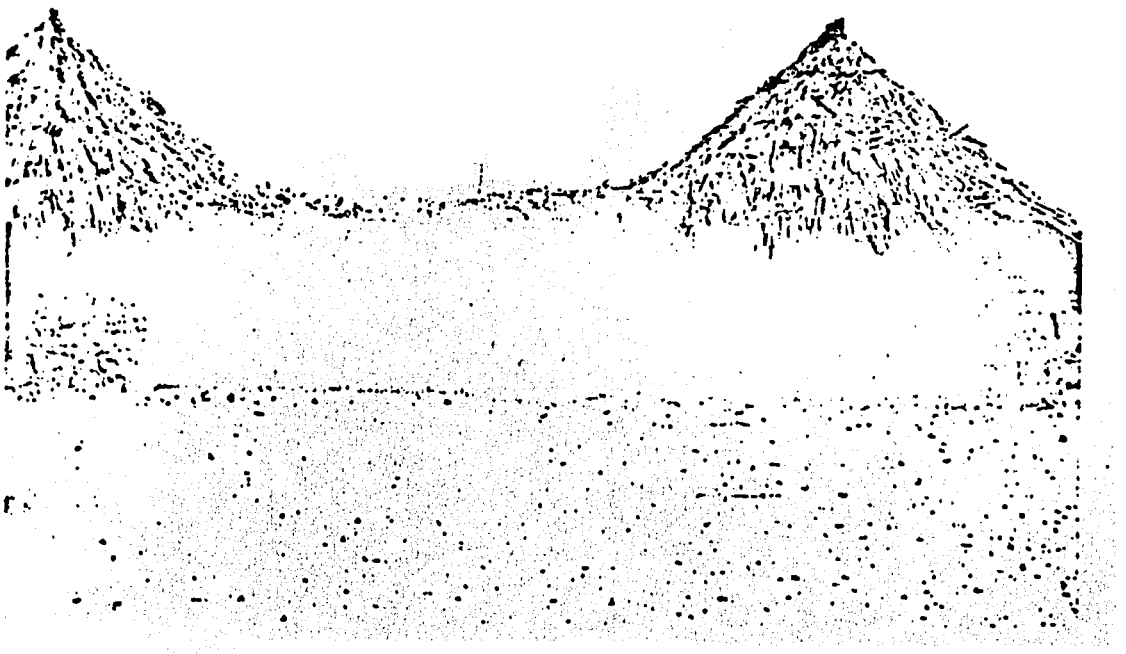

Plate 3
Onion store made from dung, mud and straw in the Sudan

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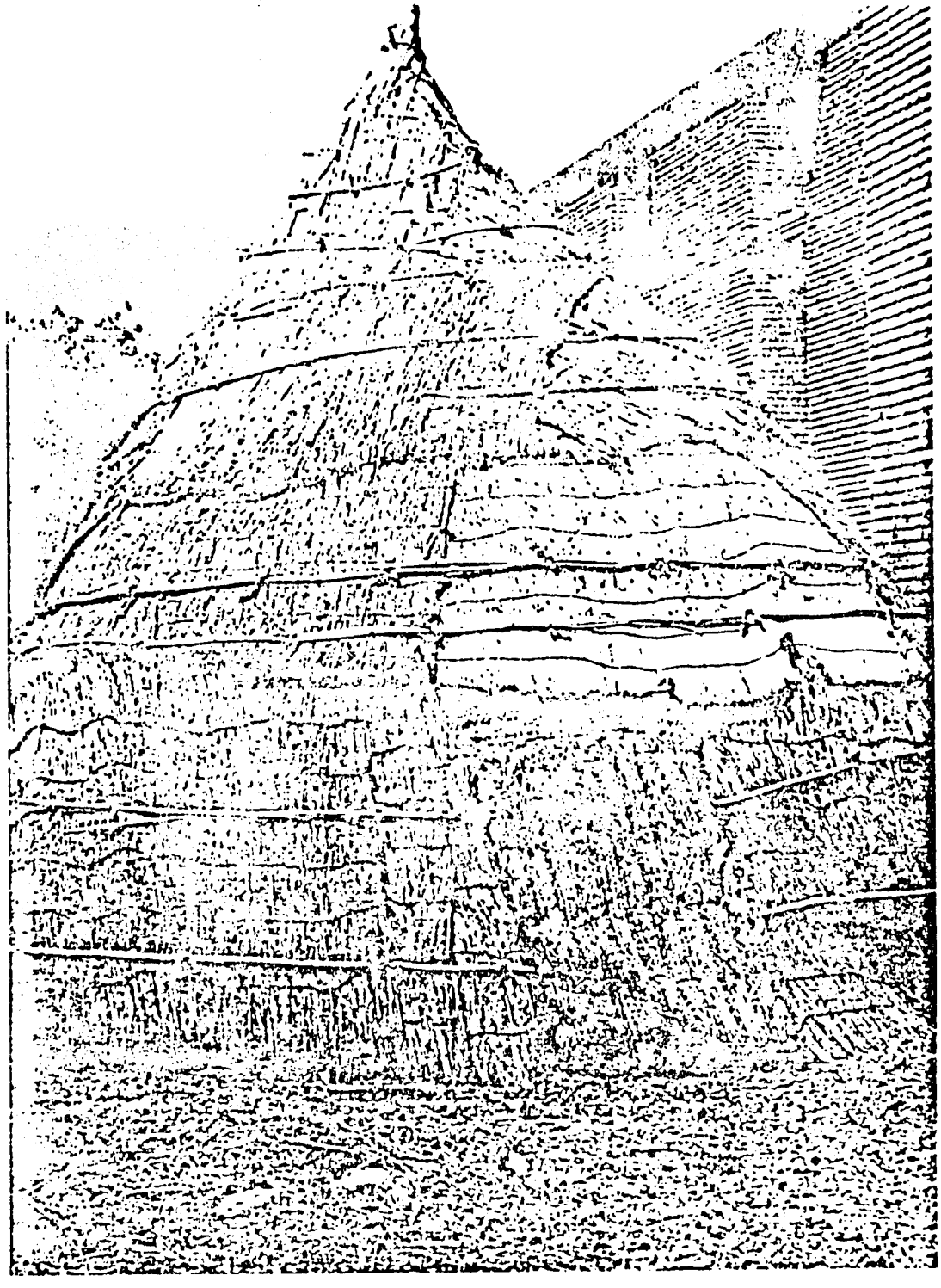

Plate 4
Onion store made from straw in the Sudan

wind. In Korea, square straw cottages are built on upright poles driven into the ground. Nails are driven into the poles and bunches of onions, plaited together by their tops, are suspended from these nails.

For large-scale commercial storage onions are usually stored under refrigeration, the most commonly recommended conditions being 0°C with 70–75% r.h. High humidities will cause development of roots in storage and promote rotting. Higher temperatures will result in sprouting and encourage *Botrytis* rots. Other recommendations have been published, as follows:

(i) - 3°C and 85–90% r.h. for 5–7 months (Wardlaw, 1937; Fedyuk, 1977).
(ii) - 2 to - 0.6°C and 75–80% r.h. for 6 months (Superba) (Udry, 1972).
(iii) - 3 to 0°C and 70–75% r.h. for 6 months (Anon, 1967).
(iv) - 0.6°C and 78–81% r.h. for 6–7 months (Wardlaw, 1937).

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Plate 5
Inside view of Sudanese onion store showing bulbs stacked on a simple bamboo structure

Plate 6
'Windbrake' onion store used occasionally in Britain

(v) 0°C and 75–85% r.h. for 6 months (Shipway, 1978).
(vi) 0°C and 65–70% r.h. for 6–8 months (Globe), 1–2 months (Bermuda) (Lutz and Hardenburg, 1968).
(vii) 0°C and 70–75% r.h. for 20–24 weeks with 16.3% loss (red) (Pantastico, 1975).
(viii) 1°C and 87% r.h. (Whitwell, 1969).
(ix) 1.1°C and 70–75% r.h. for 16–20 weeks with 14.2% loss (white) (Pantastico, 1975).

Some of these are the results of experiments designed to test the extremes of conditions which can be tolerated by onions whilst others may apply to varieties peculiar to certain localities.

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Plate 7
Bulbs stacked in shallow trays in a refrigerated store

Bulbs freeze below -3°C (Kolesnik and Ogneva, 1969). Storage at temperatures between 1°C and about 25°C resulted in sprouting (Stow, 1975). High temperature storage in the order of 20–30°C has been studied but the high level of desiccation and rots suffered by the bulbs, means it would probably be uneconomic for long periods (Musa *et al.*, 1973; Stow, 1975). Bulbs are stored either in boxes (Plate 7) net bags (Plate 8), bulk bins (Plate 9) or loose bulk (Plate 10). The problem with the first three types of container is that if they are too large, air tends to circulate around rather than through them and the respiration of the bulbs results in a warm, humid environment in the centre of the container, giving rise to decay or sprouting. Also, in large stores the capital investment in boxes may be very high. In bulk storage the bulbs are stacked directly onto the store floor to a depth of about 3 m. Air is forced through the stack either from ducts set in the floor of the store (Plate 10), or, where these are not available, through ducting laid on the floor of the store (Plate 11).

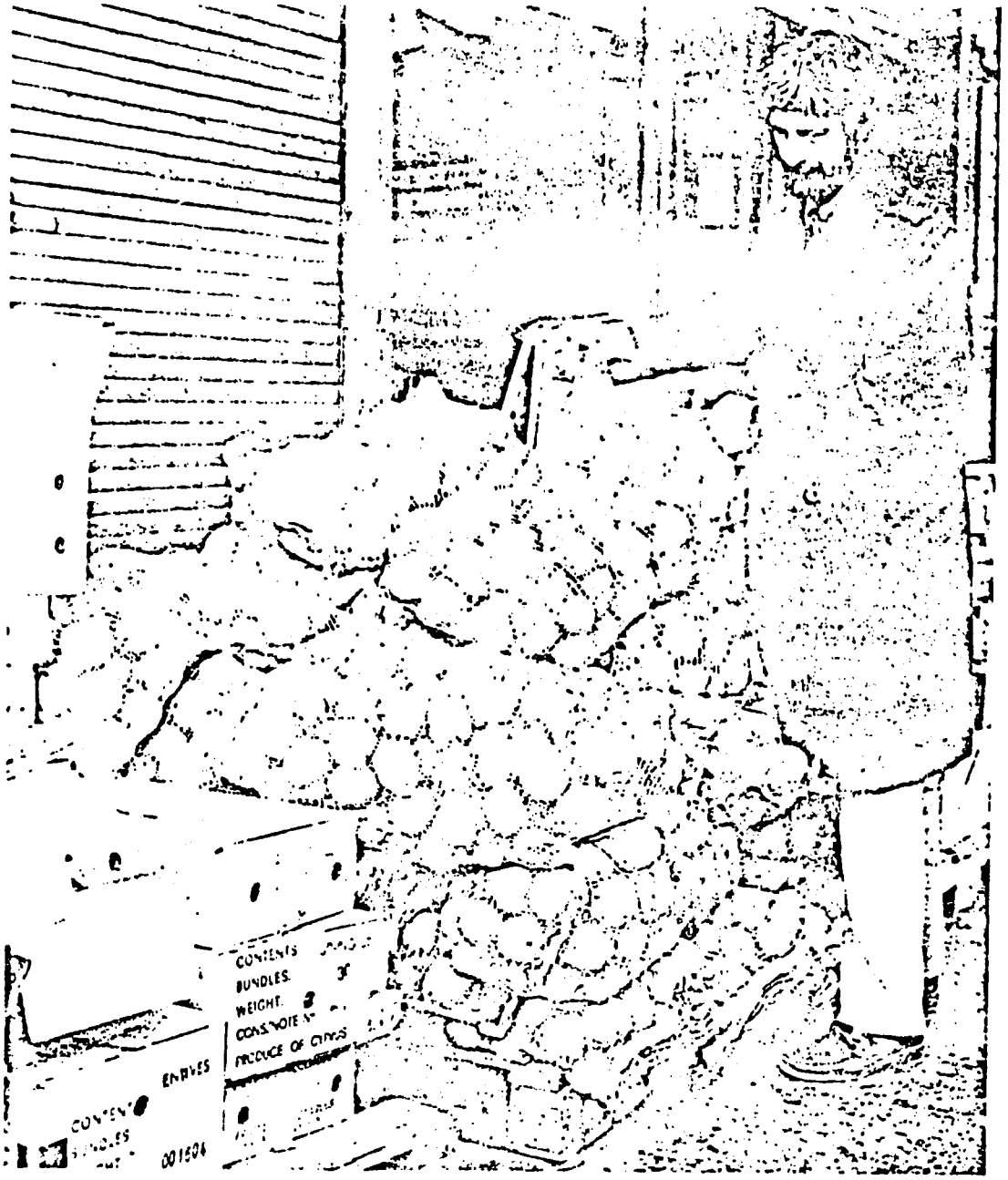

Plate 8
Bulbs packed in net bags for marketing

The ducts may be made of welded steel mesh or wood and are spaced at about 1 m between centres. Air is passed through these ducts at about 2–3 m^3/tonne/minute.

Air ventilated stores have been tried experimentally. These involve a differential thermostat which switches on the fan to blow air into the store when the outside temperature is lower than the store temperature. These can be used in place of, or as a supplement to, mechanical refrigeration depending on the ambient climate.

In the field the bulbs can be transferred in loose bulk directly from the mechanical harvester to a trailer running alongside it (Plate 1) in which they are then taken to the store entrance and tipped into a hopper. They are quality graded as they pass along conveyor belts from the hopper (Plate 12) to an elevator which stacks them directly on to the floor of the store (Plate 10). Bulbs are damaged by a drop of 30 cm onto a hard surface (Isenberg, 1965) therefore care must be taken to restrict the height of fall during all the handling operations

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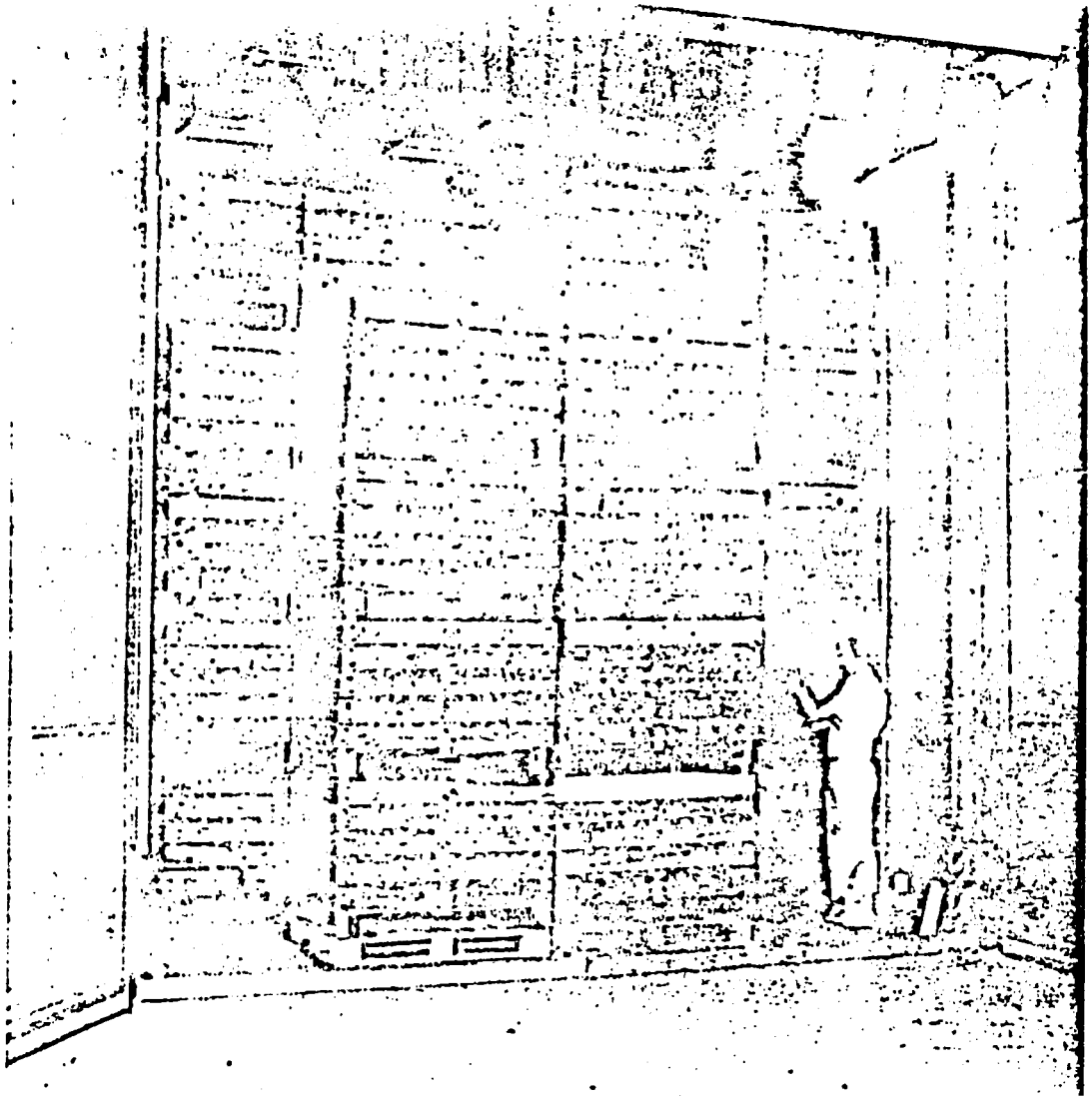

Plate 9
Bulbs in pallet boxes in a refrigerated store

CULTIVARS

The various cultivars tend to assume the same relative position for storage quality regardless of storage conditions. Poor keeping cultivars generally have a low dry matter content, low soluble solids, low pungency and a high rate of water loss especially in the period immediately after harvest (Thompson *et al.*, 1972). This results in softening and shrivelling. Such cultivars are frequently more susceptible to storage rots (Magruder *et al.*, 1941). Examples of cultivars which show high storage losses are Italian Red and the various Early Grano types. Cultivars which store well include the Creole types, Australian Brown, Pukekohe Langkeeper, Mako, Southport Globe types, and many Denvers cultivars. Giza 6 was developed in Egypt to produce well under hot dry conditions and to withstand rough handling and long distance shipment. In the Sudan the cultivar Wad Ramli is stored for several months in hot ambient conditions (Musa *et al.*, 1973).

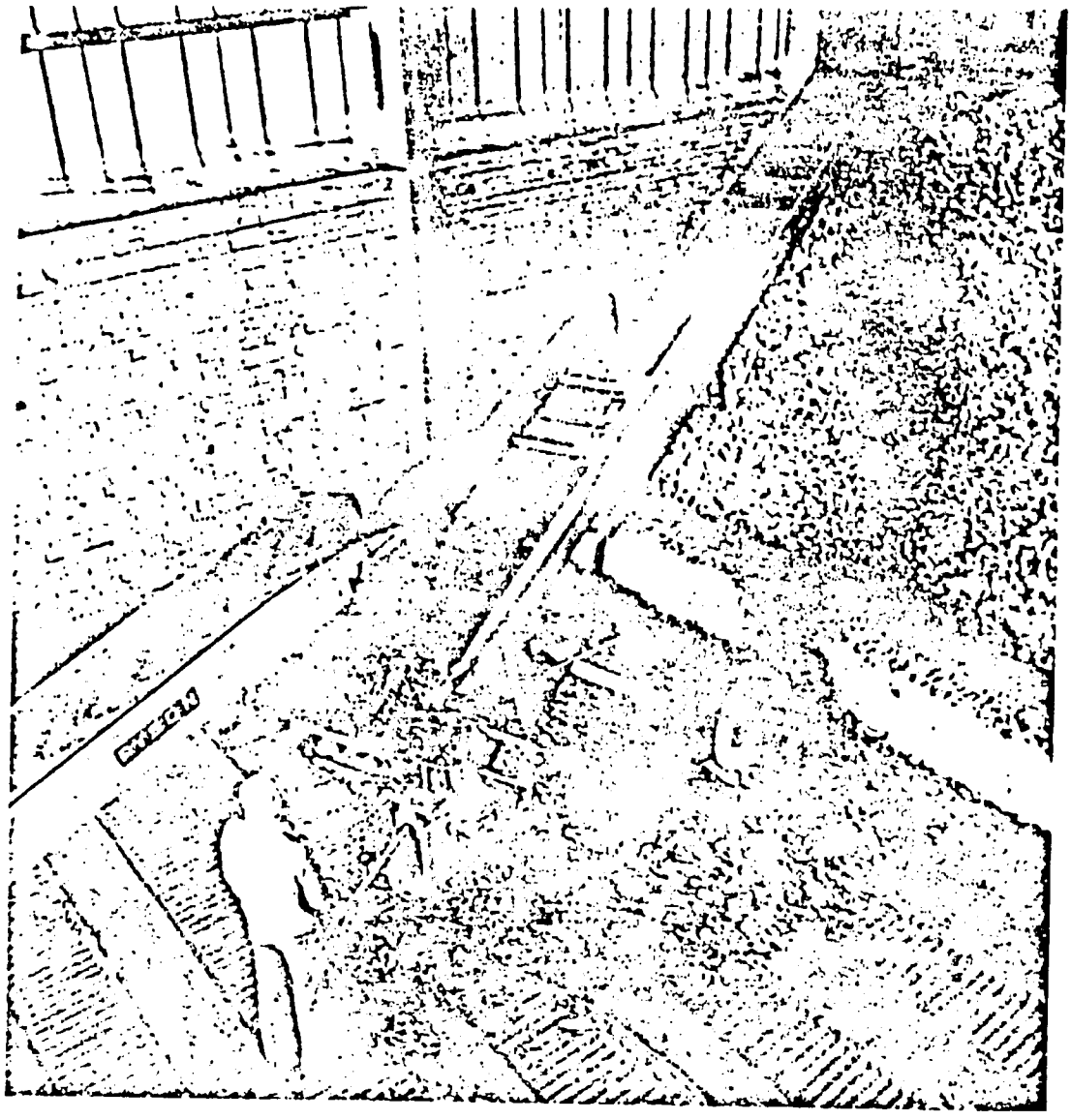

Plate 10
Bulbs being loaded into a bulk onion store

SPROUT SUPPRESSION

Various chemicals and gamma irradiation have been shown to prevent sprouting of onions during storage (Thompson *et al.*, 1972). The most commonly used chemical is maleic hydrazide (MH), which is applied to the onions as a foliar spray in the field before harvest. It may be applied at the rate of 5.4 litres of 36% active ingredient preparation in about 600 litres of water per hectare (Thompson *et al.*, 1972). This is generally done when 30–50% of the tops have fallen over, but in any particular situation the exact time and rate of application should be strictly in accordance with the manufacturer's recommendation. The use of MH is governed by legislation in several countries and this must be consulted before it is used.

PACKING

The conventional package for onions is a net bag, typically 750 mm long and 500 mm wide holding 25 kg (Plate 8). Most nets are produced by knitting together one of the principal yarns (cotton or polyethylene tape). The knitted fabric may be formed into a bag as part of the knitting process or by seaming using rolled seams and under-sewing. Usually a draw string is incorporated at the mouth of the bag to

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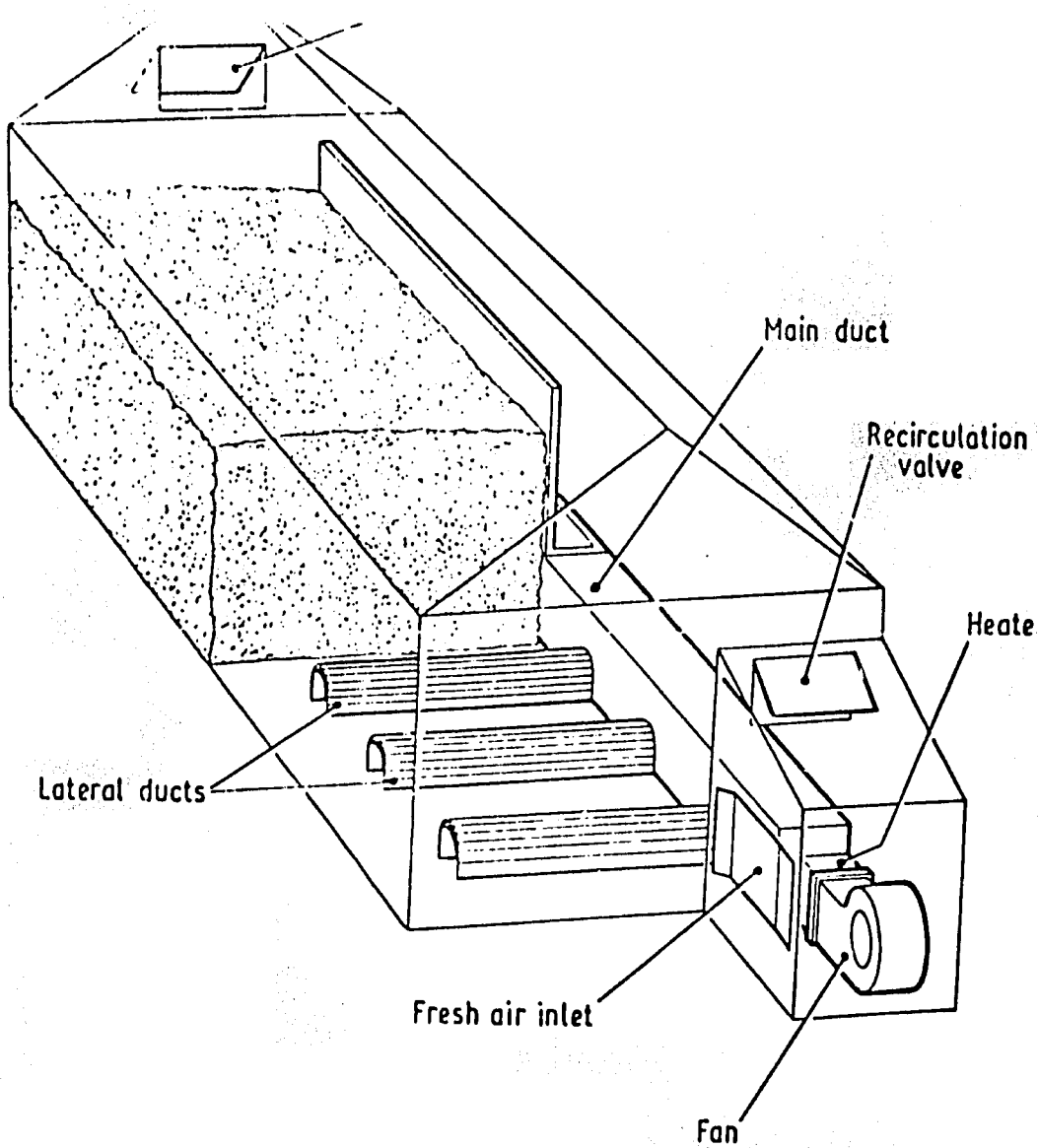

Plate 11
Typical layout for on-floor drier and store for onions

facilitate closure. Bags can also be made from tubular extruded plastic net, normally of high density polyethylene, or from a light-weight hessian fabric. Red or orange fabrics are customary to enhance the appearance of the onions. A printed label may be bonded around the middle of the bag to enable brand identification and other information to be attached. Net and jute sacks are light-weight and allow good ventilation.

DISEASES

Neck rot/Grey mould: *Botrytis allii* Munn (also *B. byssoidea* Walker and *B. squamose* Walker)

The disease may develop at any point of the bulb, but it is most common on the damaged neck tissues. Affected areas develop a brown soft rot followed by a dense cover of grey/green powdery spores.

This storage disease is widespread where onions are grown. The infection is seed-borne and evidence suggests there is no bulb to bulb transmission during storage (Maude and Presley, 1977). Good control of the disease has been achieved by dusting seeds before planting with benomyl at a rate of 1 g active material per

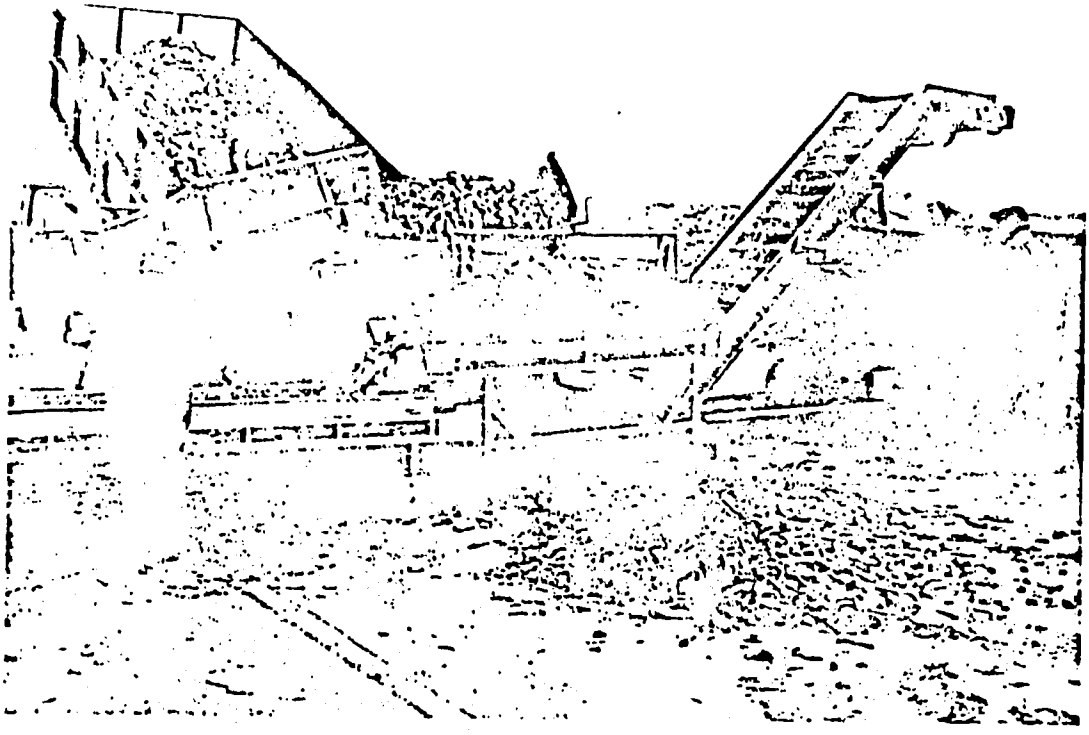

Plate 12
Bulbs being unloaded from a trailer directly after harvest. They are tipped into a hopper, passed over a chain conveyor which separates out dirt and undersized bulbs, then along a conveyor to the elevator shown in Plate 10.

kg of seed. This seed treatment should preferably be carried out by the seed merchant as soon as possible after harvesting.

Basal bulb rot: *Fusarium oxysporum* Schlecht ex Fr.

This is a soil-borne disease which can affect onions at any stage of development and causes death of seedlings (Walker and Tims, 1924). It is essentially a disease of warm climates. If the roots and basal plate of the growing bulbs become affected at a late stage of development, infected bulbs which show no external symptoms may be put into store. Where they are stored at ambient temperatures, bulbs will quickly develop a soft semi-watery rot and eventually become desiccated empty shells.

An effective field treatment to control this disease has not been devised. Experimentally, dipping the seeds in a suspension of benomyl (1 000 ppm) for 15 minutes has given a degree of control. The fungus is believed to survive from season to season in the field on weed hosts. Holding the bulbs under refrigeration at 0–1°C inhibits the development of basal rot in storage.

Black mould: *Aspergillus niger* Van Tiegh

This disease is characterized by the appearance, during storage, of black powdery spore masses on the outer scales of the bulbs, especially along the vascular strands of veins.

Although the disease may be severe locally it is not generally devastating enough to warrant special control measures. White onions are somewhat less susceptible than coloured varieties and the disease is controlled when onions are kept in cold storage at 0–1°C.

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APPENDIX II

INFORMACION DE INTERES CON RELACION AL SECADO DE LA CEBOLLA

Esta información se refiere a las facilidades (construcciones) requeridas para el secado, almacenaje y clasificación de las cebollas. Tradicionalmente, la cebolla se deposita en edificios con ventilación adecuada y depositada sobre una tarima entablillada sobre el piso en un cobertizo abierto al frente.

Otra forma de secado consiste en dejar secar la cebolla en estantes protegidos de la lluvia y a través de los cuales el aire pueda soplar y circular libremente.

Los métodos modernos de cultivos y cosecha, con frecuencia a gran escala requieren diferentes formas de secado.

Las cebollas cosechadas son traídas dentro de los almacenes o edificios después de estar algún tiempo puestos a secar en montones o hileras en el campo.

El espacio de tiempo que sigue a la cosecha variará de acuerdo a varios factores como son: las condiciones de la propia cosecha, época, tiempo de levantada y otros, pero es importante que la cosecha entre tan limpia y sana como sea posible.

Antes que cualquier forma de almacenaje sea intentada, la cebolla debe ser secada y para eso la <u>ventilación forzada</u> será necesaria. Los principios del secado estan descritos e ilustrados conjuntamente con algunas alternativas en los planos en uso actualmente.

En la mayoría de los casos, el almacenaje continúa en el mismo lugar donde

la cosecha ha sido secada sin futuro movimiento hasta el momento de su venta. En otros casos no obstante, se puede proveer almacenaje aparte si esta condición existe.

Aún cuando se ilustran varios diseños de construcciones para almacenaje, debe recordarse que el método seleccionado deberá estar relacionado con el sistema de secado empleado, el período de tiempo en que la cosecha es mantenida en la finca, el número de lotes diferentes y métodos de distribución.

Los edificios para propósitos separados de secado y almacenaje son tratados individualmente por razones de claridad y se ven algunos ejemplos de planos completos en relación con la materia de clasificación y despacho. Varias alternativas se dan a los diseñadores y pueden ser modificados o seleccionados a conveniencia.

El aspecto económico de los edificios o facilidades para la cebolla no se discute en esta información pues se asume que antes que se tome una decisión para su construcción se haga un estudio de factibilidad previo para asegurar el mejor uso de todos los recursos.

Secado: Esta bien establecido que si las cebollas se han secado bien en el campo, antes de depositarla en el edificio, el proceso inicial de secado puede ser completado en tres días ventilando la cosecha a razón de 250 pies cúbicos de aire por minuto por tonelada, tomando más tiempo cuando la cosecha es húmeda. Durante el secado será normalmente necesario calentar el aire ventilado y en fases posteriores la recirculaciónes es también necesaria.

Secado a granel:

Se pueden describir 3 métodos que se ilustran:

donde la clasificación se lleva a cabo en el mismo edifico del almacenaie. pero ambas situaciones se encuentran en la práctica. Si la cebolla es empacada en sacos de malla y se va a mantener un tiempo largo en el local, los sacos pueden colocarse en la parte atrás del mismo y en lugar ventilado para mantener la cebolla en buenas condiciones.

Cuando los operadores u obreros estan trabajando es importante porveer condiciones confortables lo cual envuelve el hecho de que los locales deben estar aislados y frescos. Las fig. 10 y 11 ilustran lo que podría ser un local ideal para las operaciones aunque se pueden hacer cambios para adaptarlos a las condiciones locales.

Datos de interés-

1.- La cebolla seca ocupa un volumen de 70 pies cúbicos (2 M^3 aproximadamente) por tonelada.

2.- La cebolla húmeda con la coronilla ocupa un volumen de 110 pies cúbicos (3.1 M^3 aproximadamente) por tonelada.

3.- La máxima altura a que se puede apilar o amontontonar la cebolla es de 10 pies (3.M. aproximadamente).

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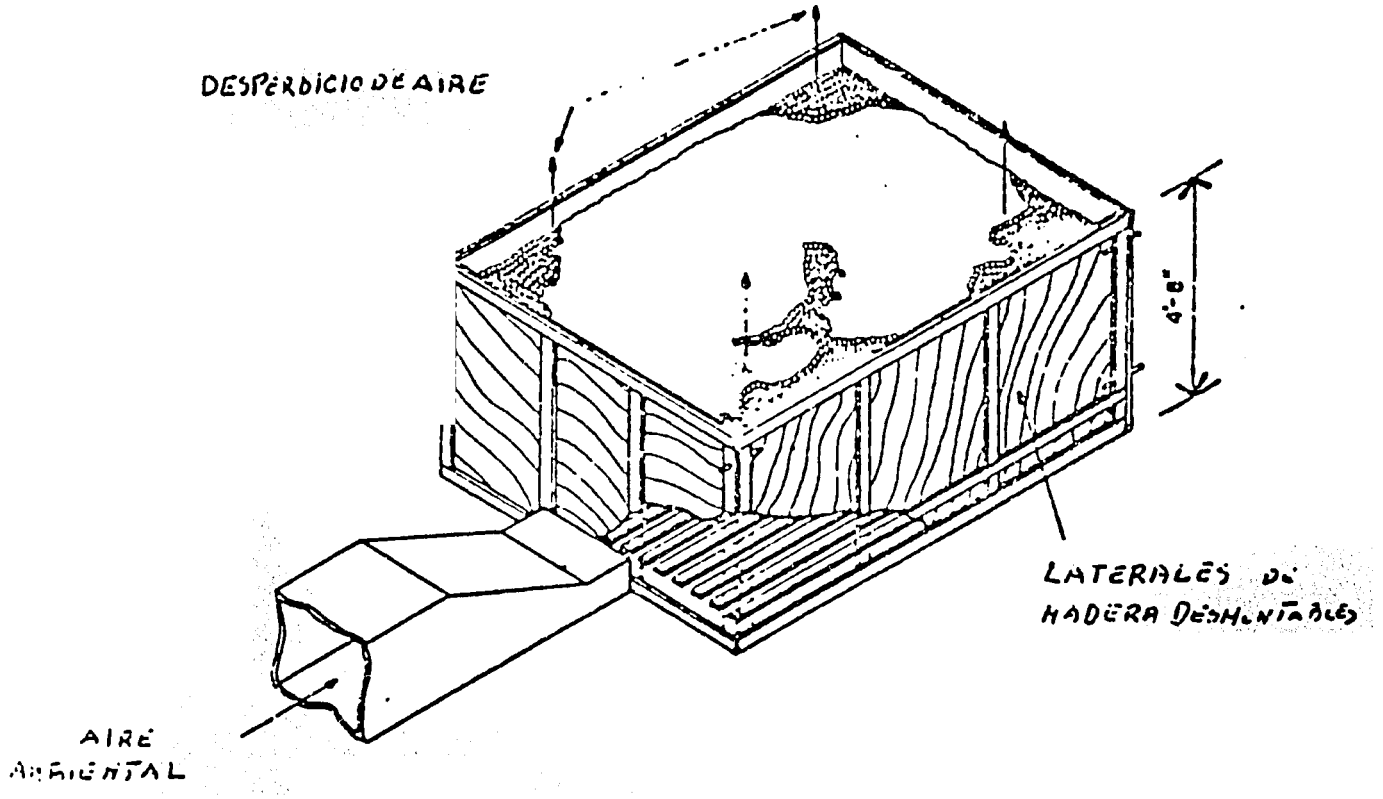


FIG. 1 SECADO EN BANDEJAS POCO PROFUNDAS

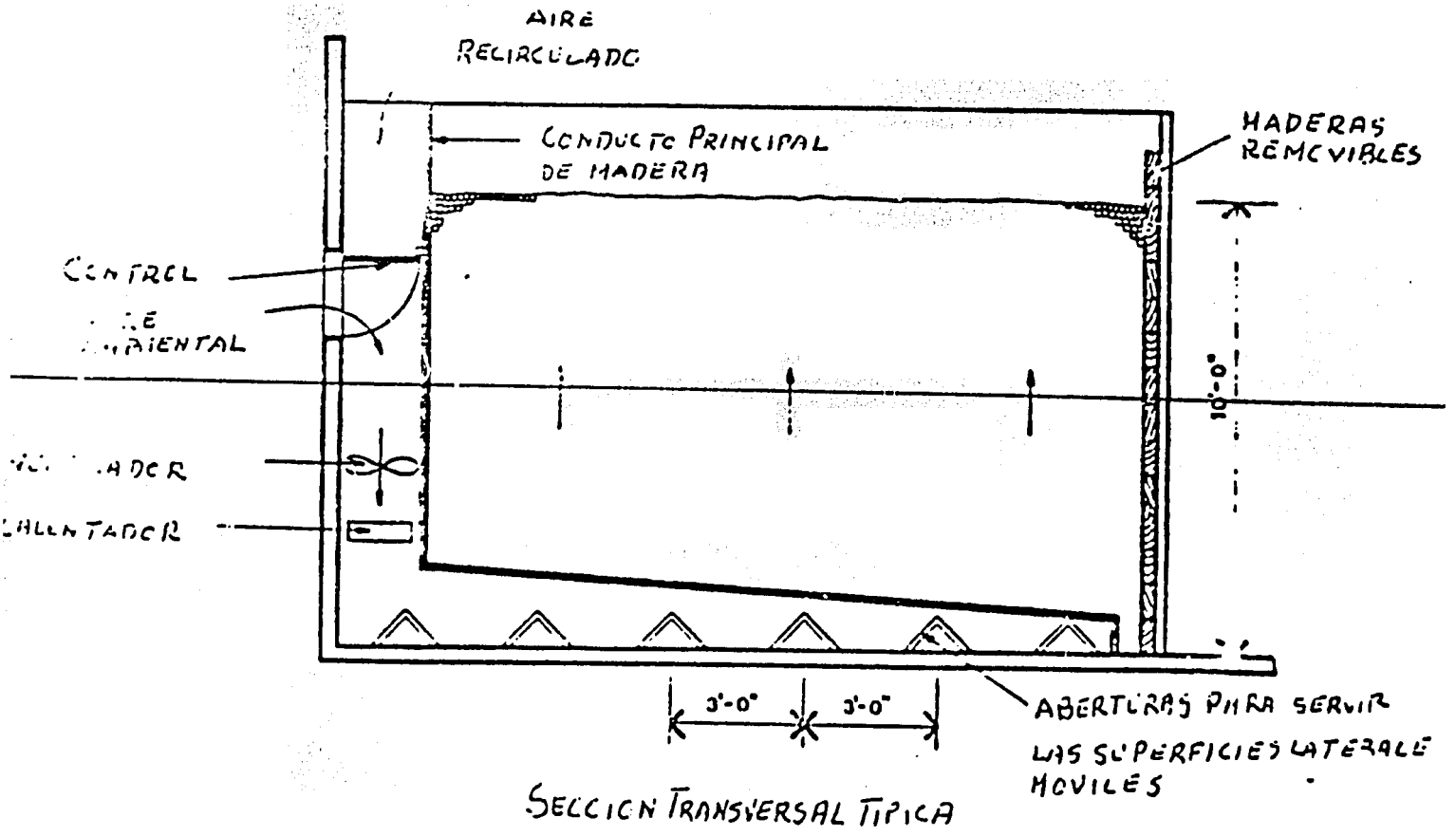


FIG. 2. SECADO EN DEPOSITOS

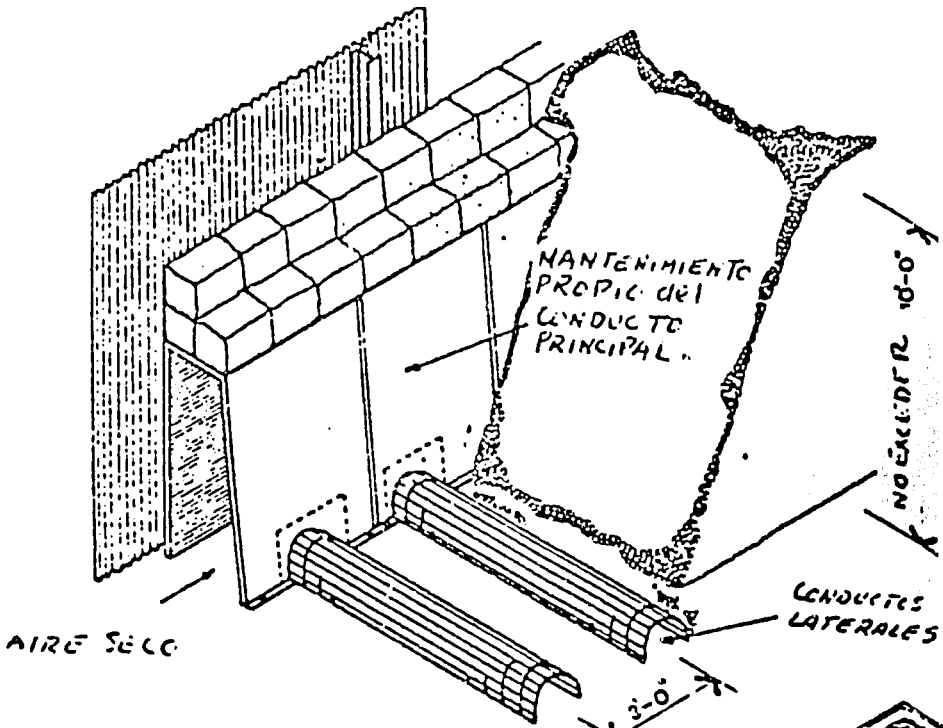


FIG. 3. SECADO EN EL SUELO EN EDIFICIOS EXISTENTES

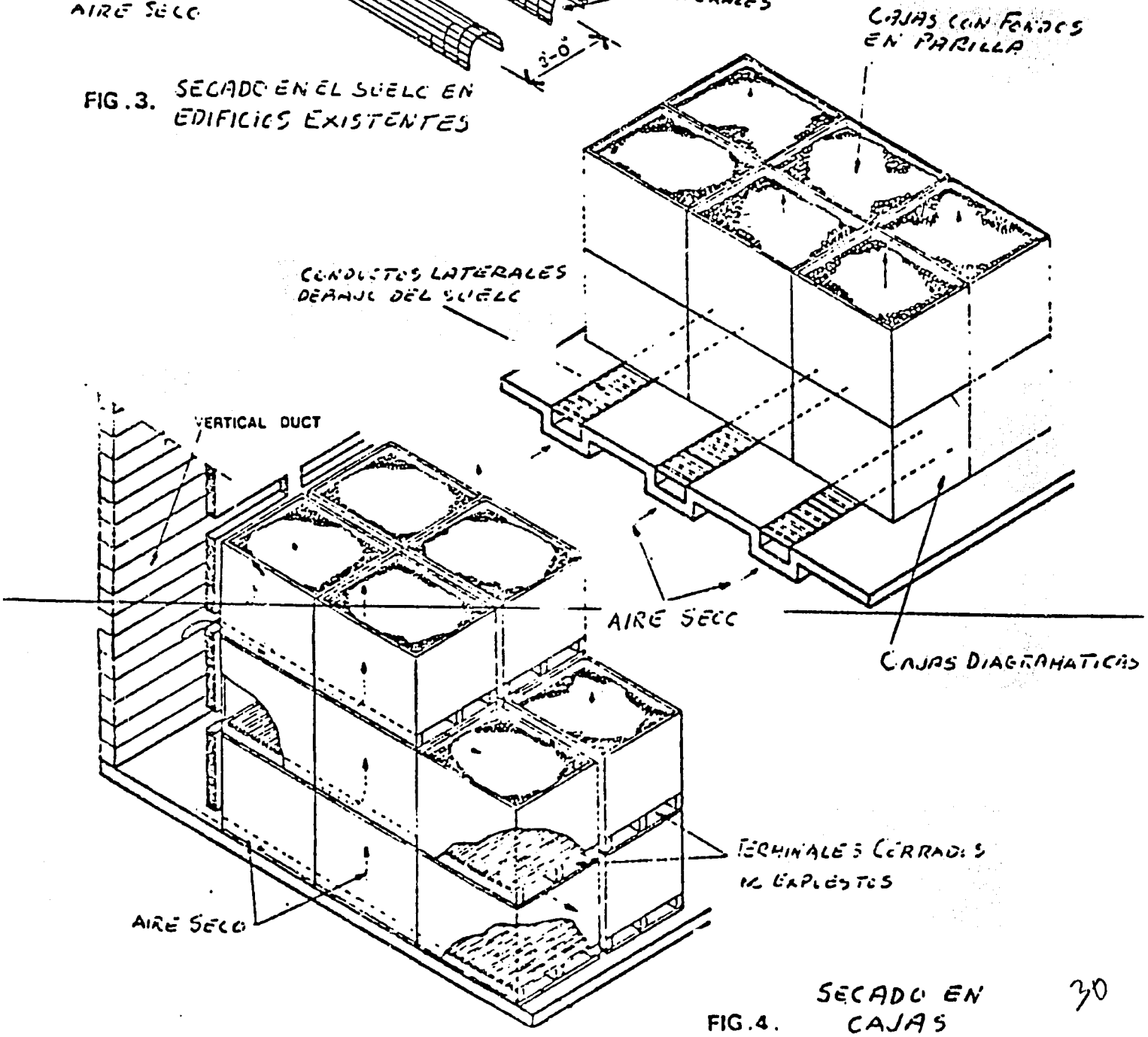
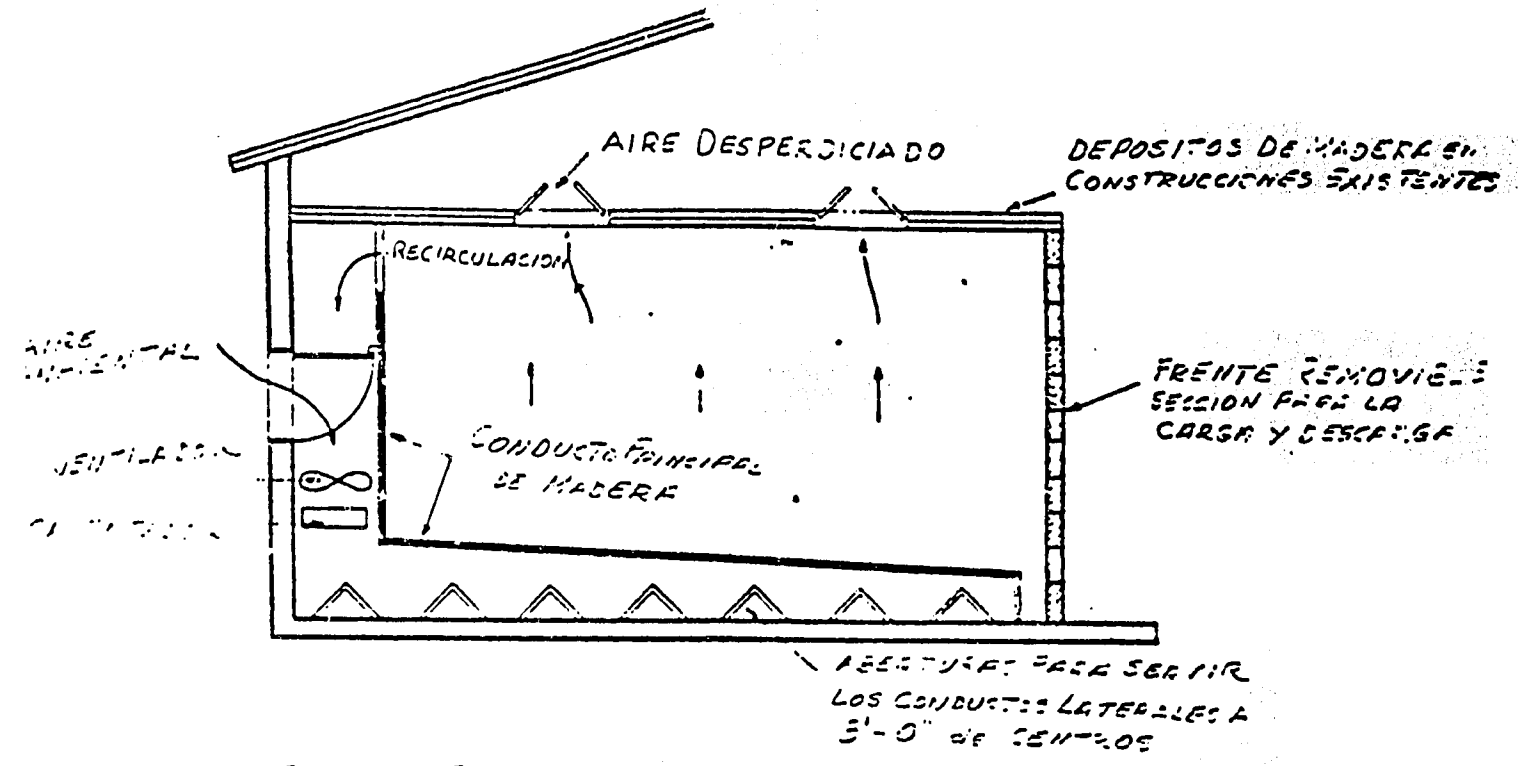
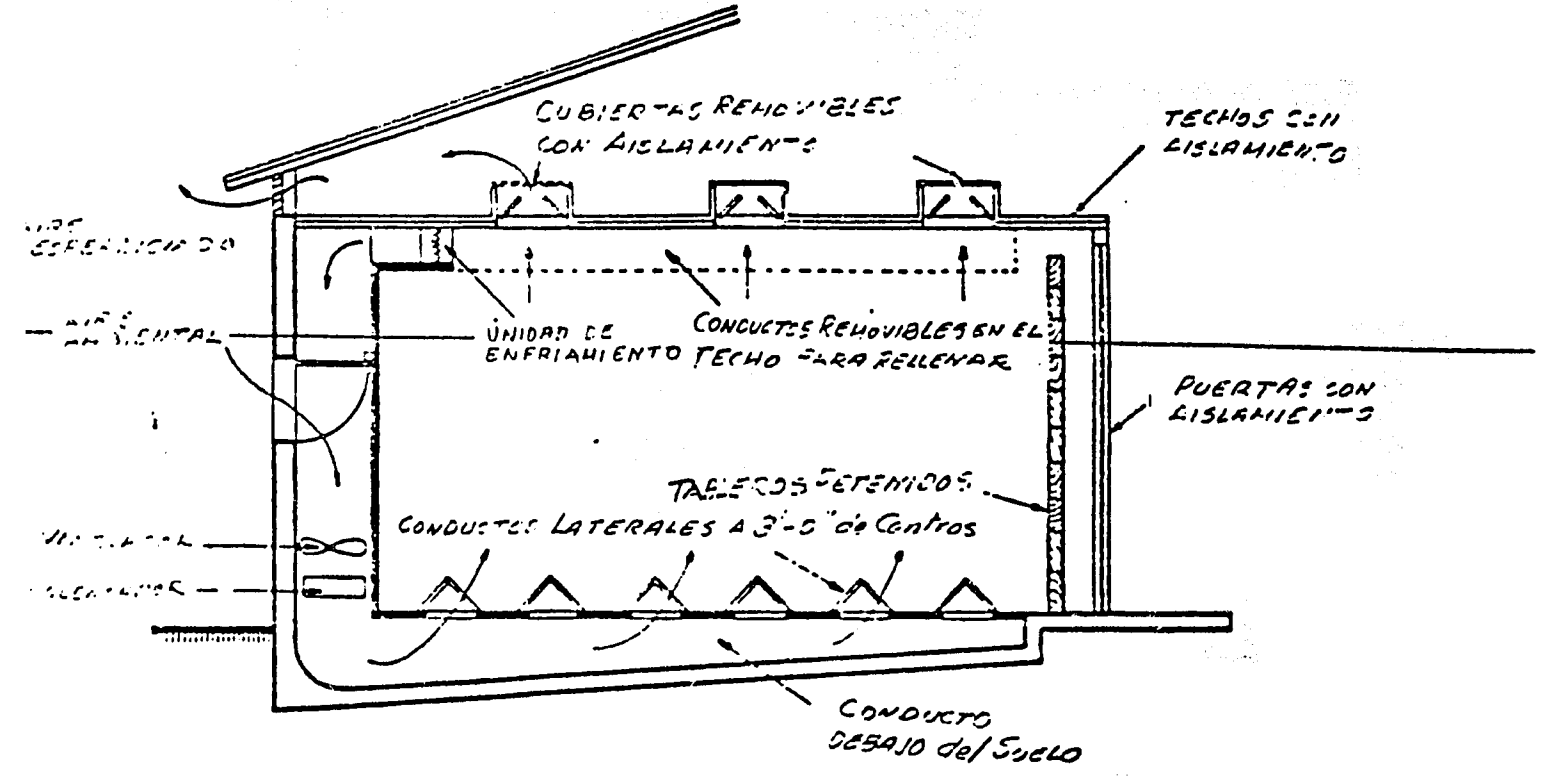


FIG. 4. SECADO EN CAJAS



SECCIÓN TRANSVERSAL ALMACENAMIENTO CONTINUO EN DEPOSITOS



SECCION TRANSVERSAL ALMACENAMIENTO CONTINUO EN COMPARTIMIENTOS

FIG. 5 ALMACENAMIENTO EN DEPOSITOS Y COMPARTIMIENTOS

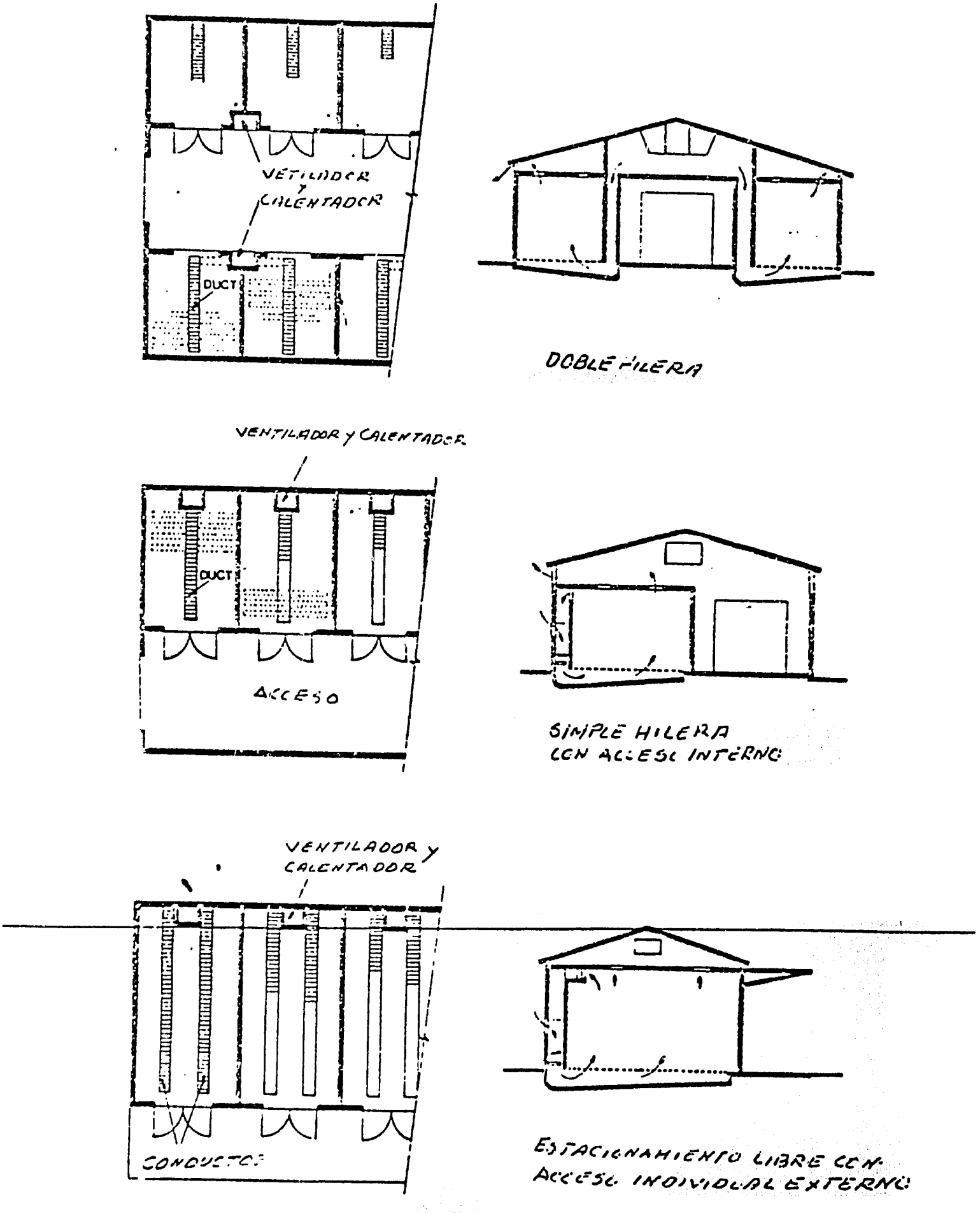
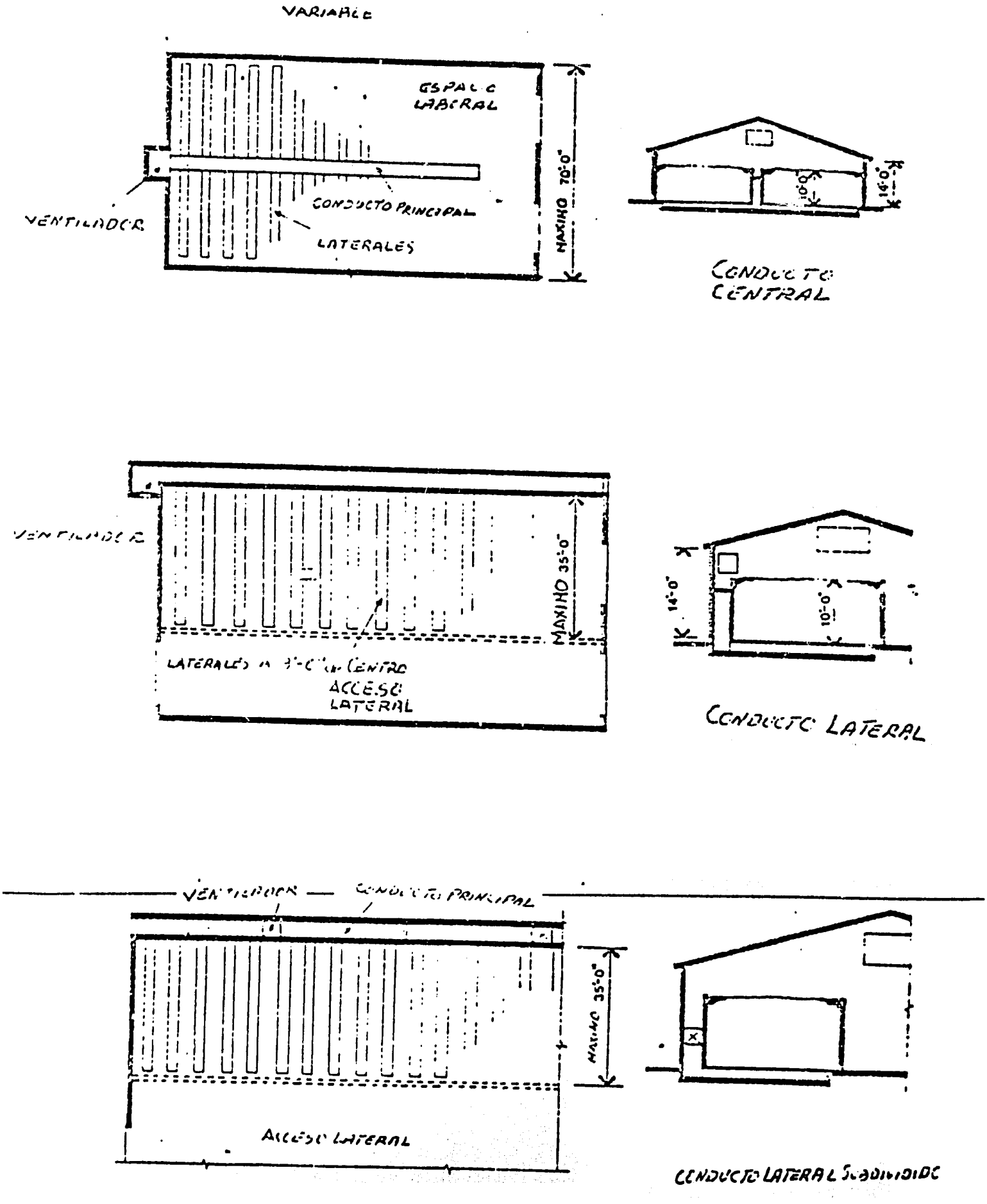
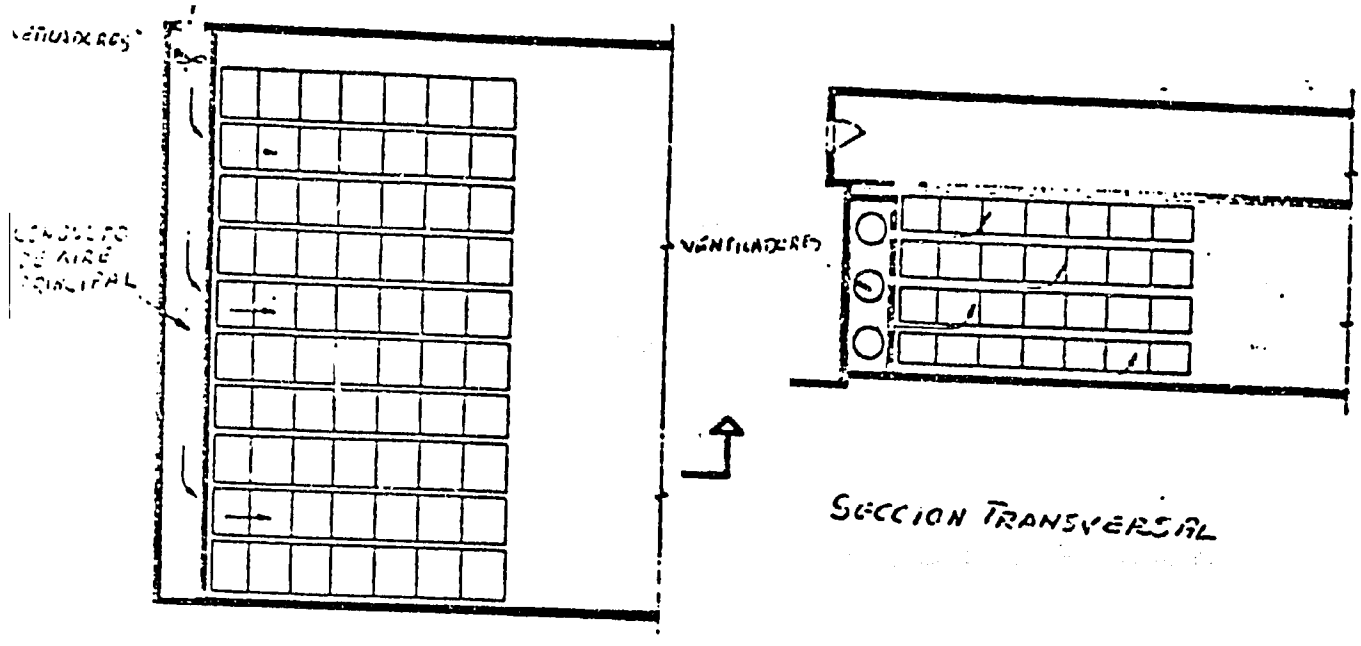


FIG. 6. ALTERNATIVAS PARA ALMACENAMIENTO EN COMPARTIMIENTOS

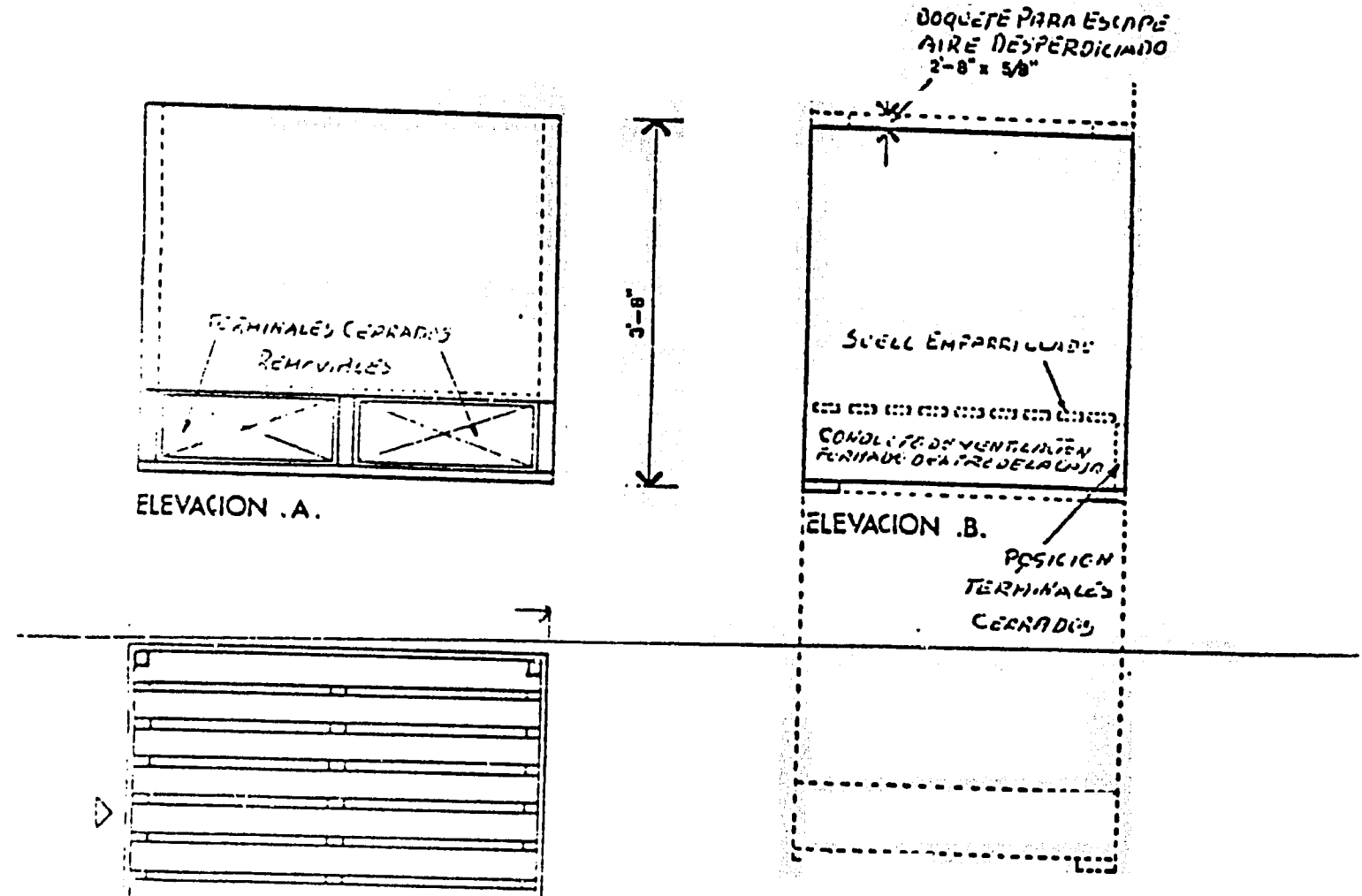


ALTERNATIVAS PARA EL SISTEMA

FIG. 7



PLANO



ELEVACION .A.

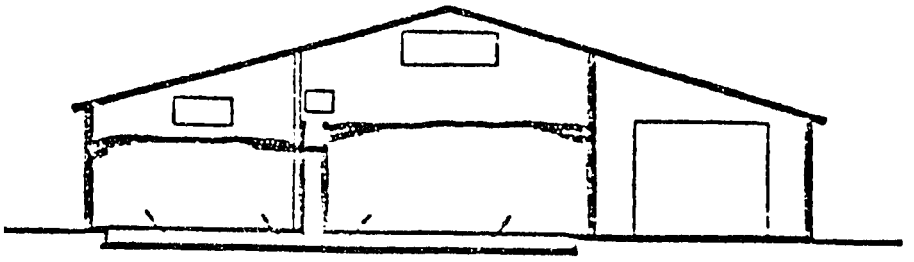
ELEVACION .B.

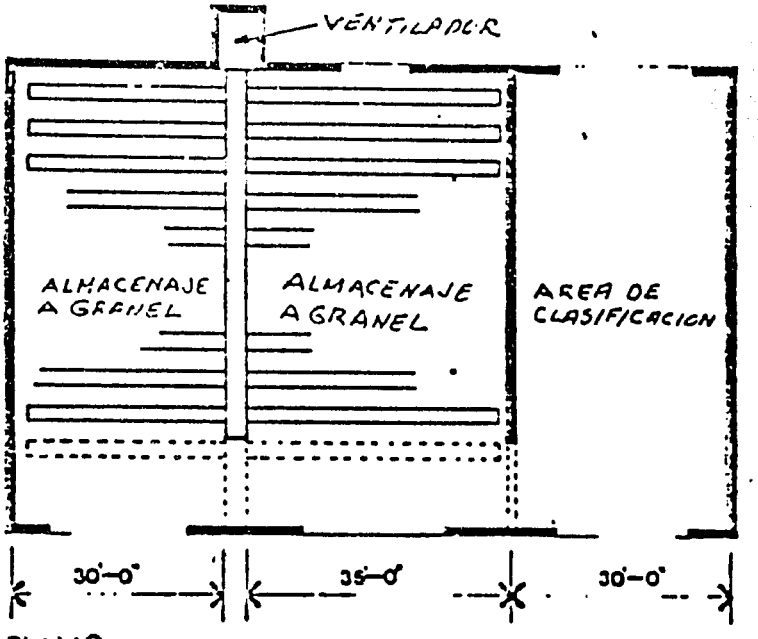
PLANO

A

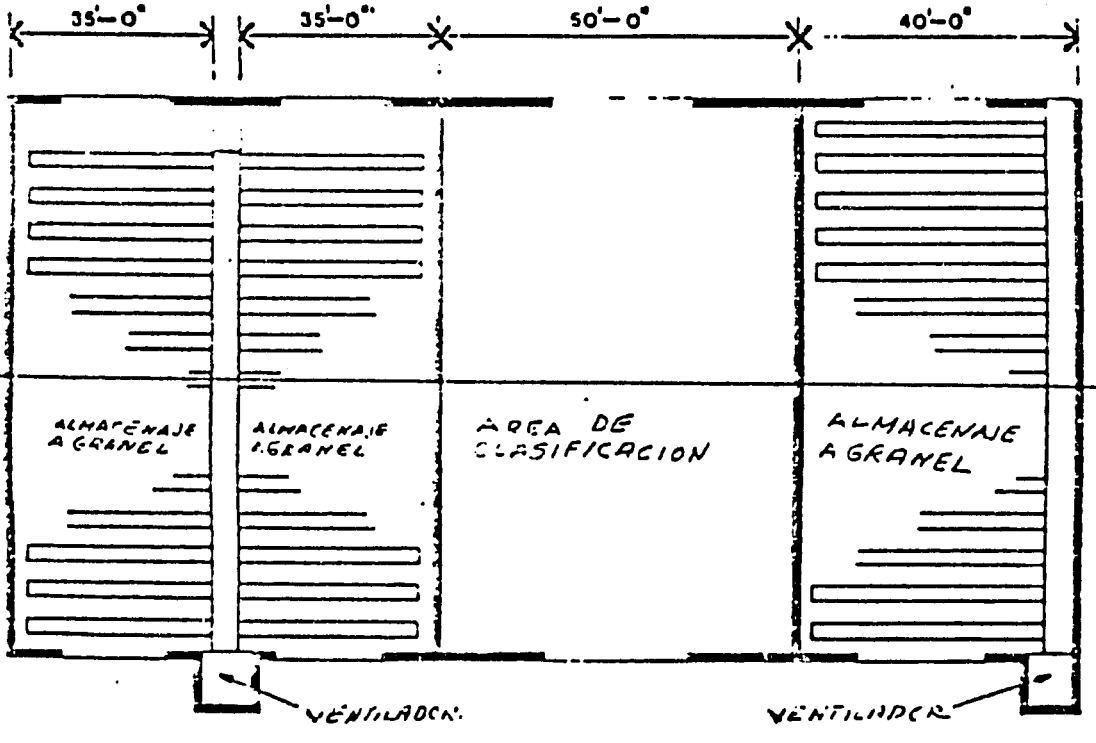
DETALLES ALMACENAMIENTO

CONSTRUCCION DE CAJAS



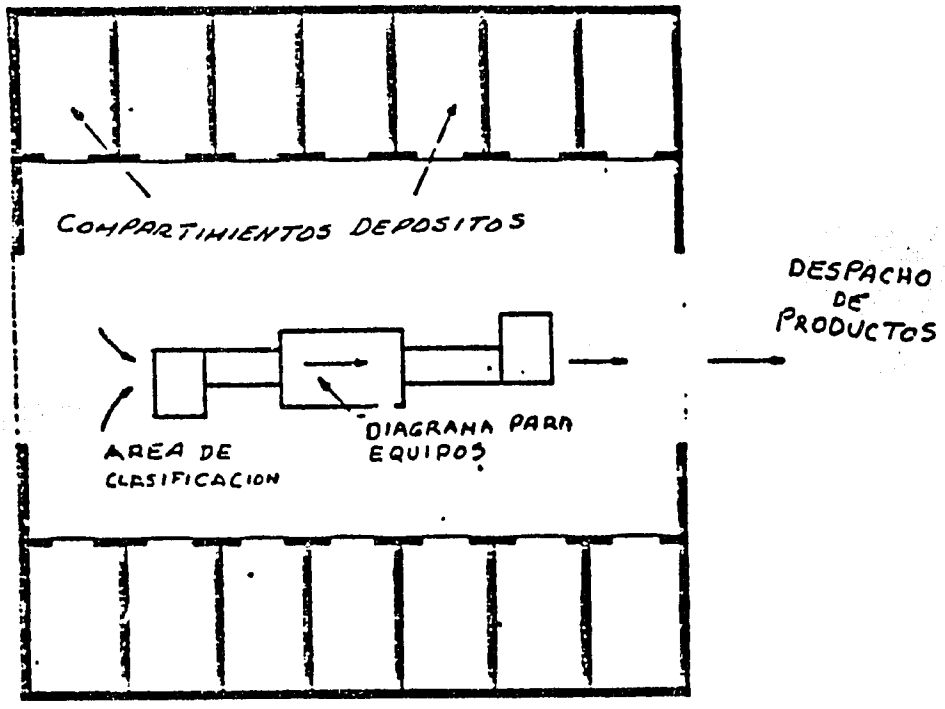


PLANO

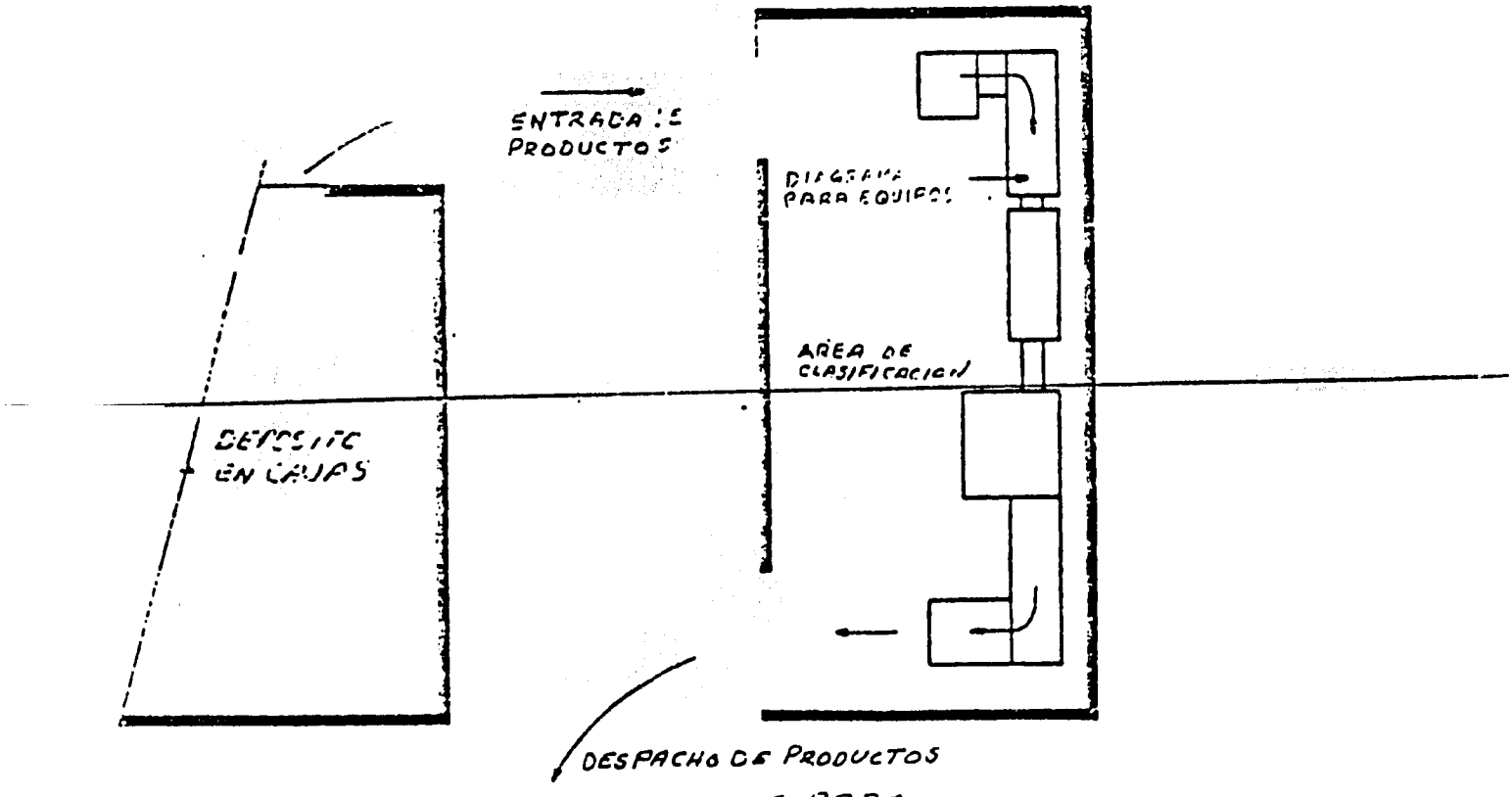


PLANO

FIG .10. ALTERNATIVAS PARA LA CLASIFICACION Y DESPACHO DE PRODUCTOS EN EL ALMACENAJE SOBRE EL SUELO



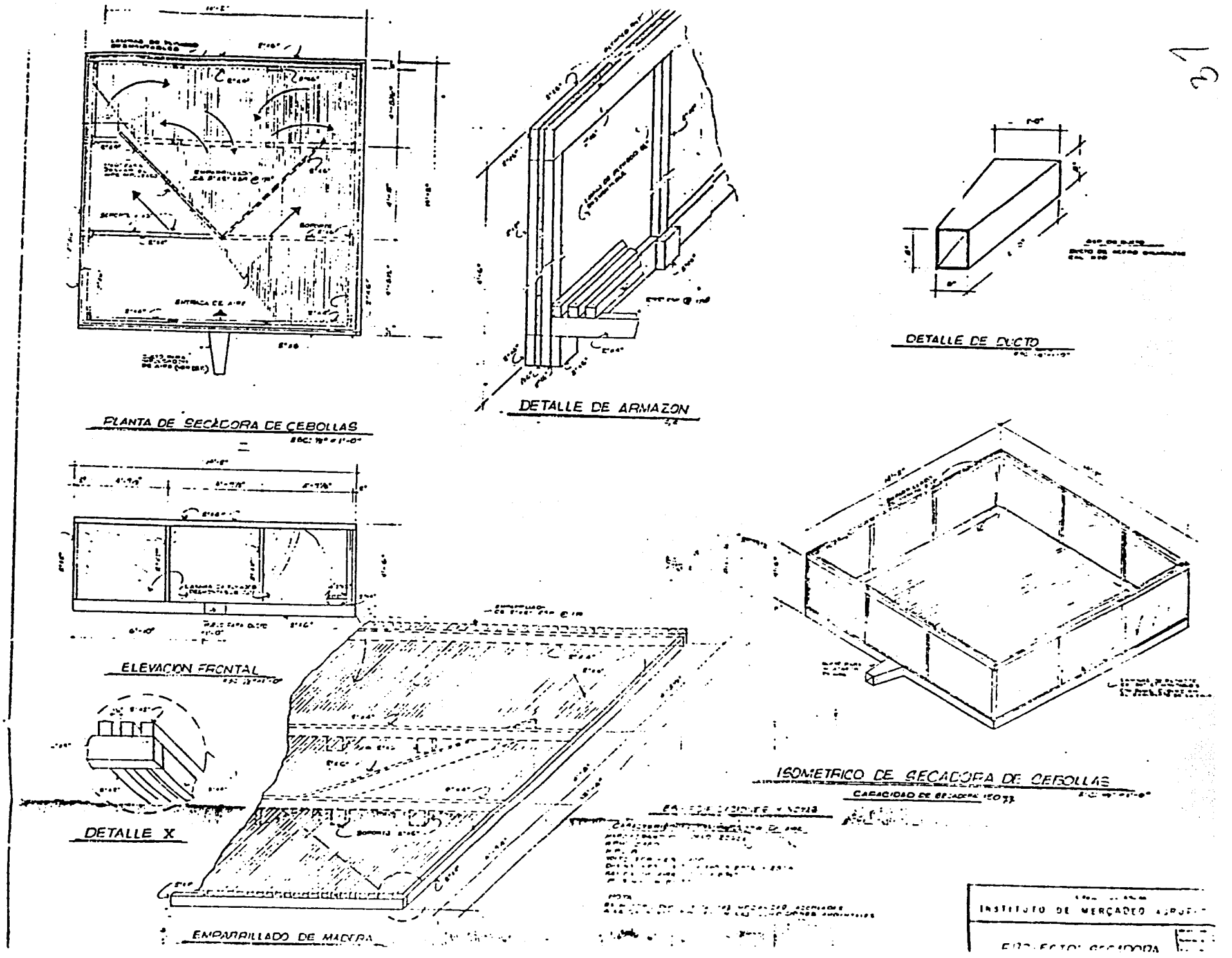
AREA DE CLASIFICACION INTERNA



EDIFICIOS SEPARADOS PARA ALMACENAJE Y CLASIFICACION

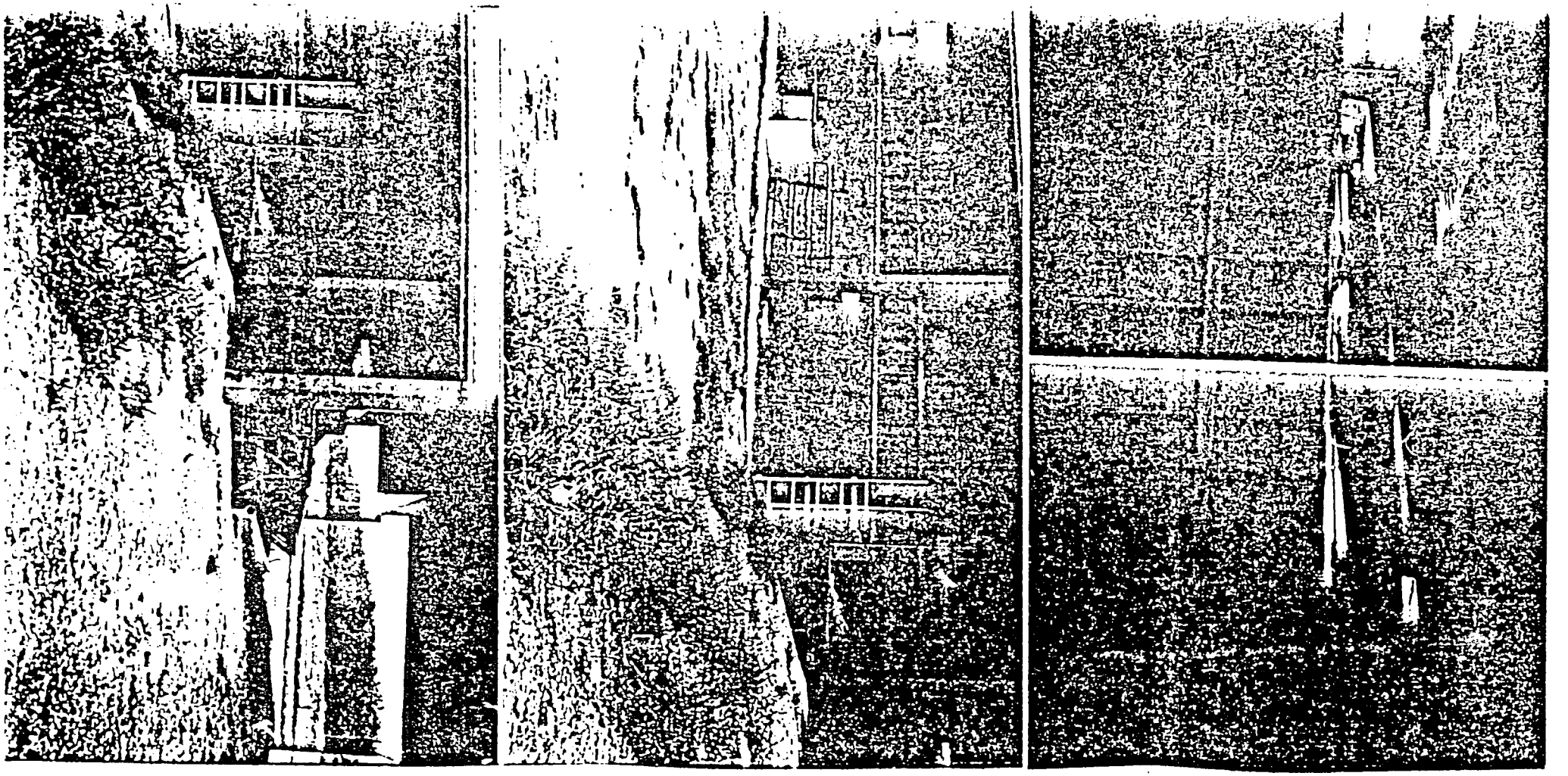
PLANOS PARA CLASIFICACION Y DESPACHO DE PRODUCTOS

FIG . 11.


PLANTA DE SECADORA DE CEBOLLAS
DETALLE DE ARMAZON
DETALLE DE DUCTO
ELEVACION FRONTAL
DETALLE X
EMPARRILLADO DE MADERA
ISOMETRICO DE SECADORA DE CEBOLLAS
INSTITUTO DE MERCADEO

APPENDIX III

PICTURES OF DRYERS AND SOME OF THE EQUIPMENT USED IN THE DRYERS IN TEXAS.



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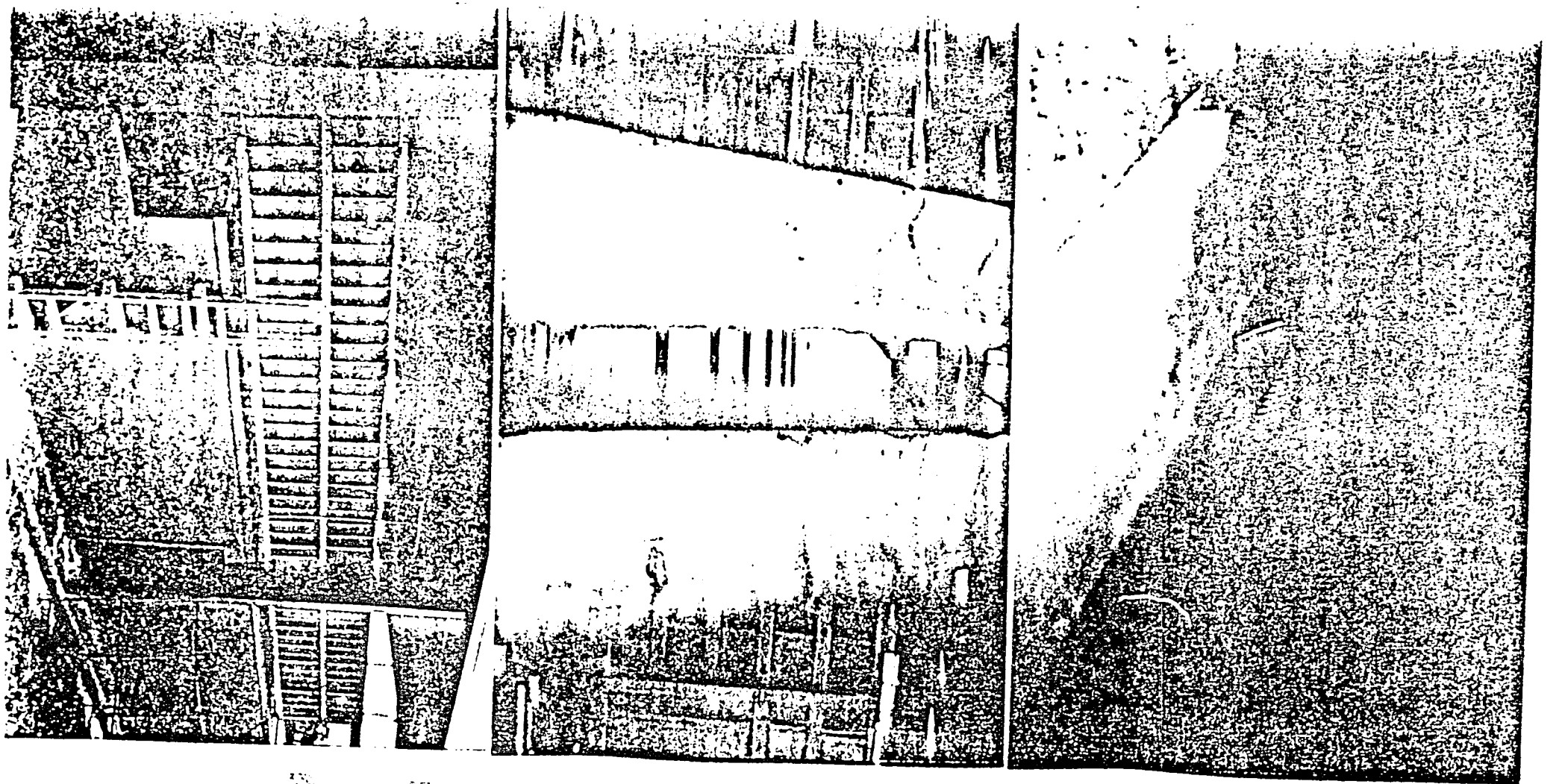

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HELIFOIL®

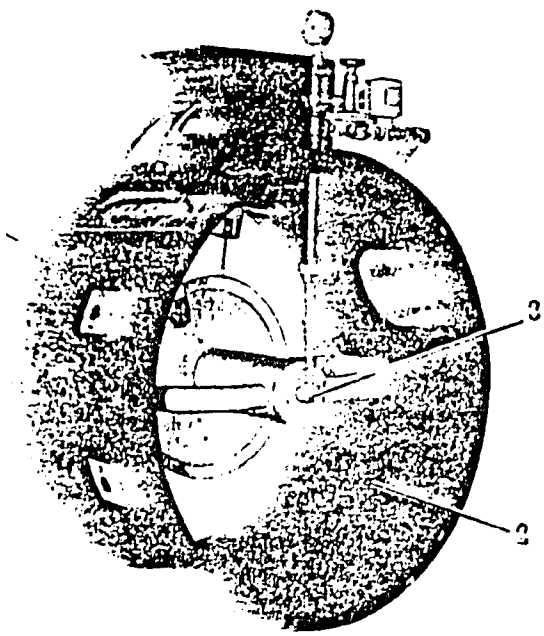
DEPENDABLE PRODUCTS THROUGH RESEARCH

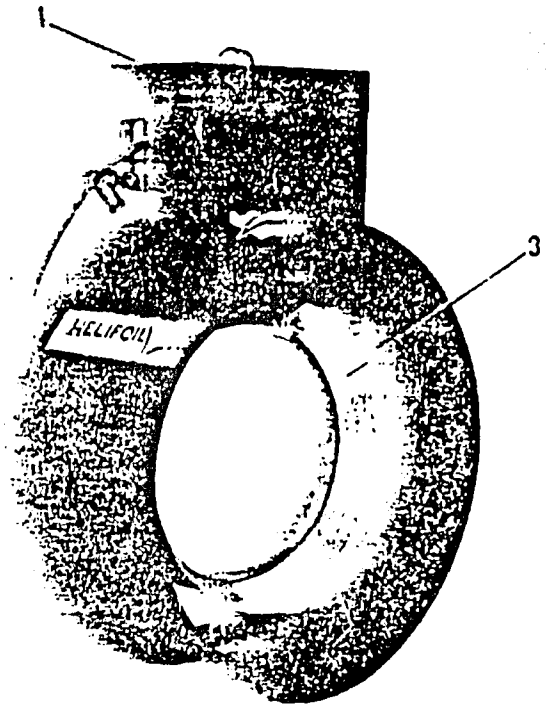
APPENDIX IV

SPLIT BURNER UNIT ADAPTS TO ANY DRYER FAN UNIT

Burner Units come in 24" and 26" diameters. Special adapters for other diameters of Dryer Housings.

FULLY AUTOMATIC





SHARE THESE FEATURES:

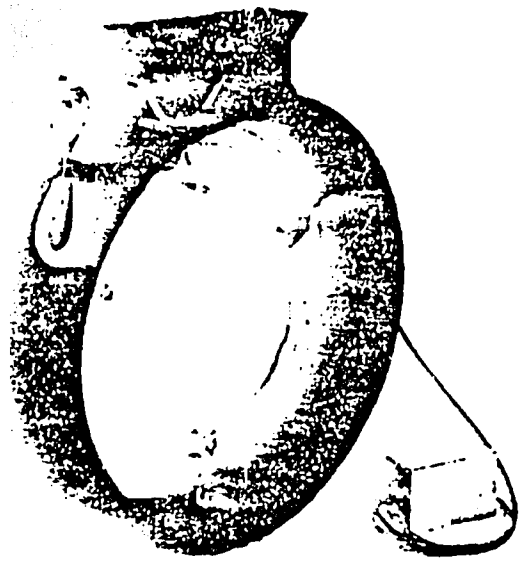
- Rugged heavy gauge steel fill feeder housing
- New process enamel coating for longer lasting finish.
- Choice of either the Gun-type Burner or the Ring-type with Spun-Steel Flame Spreader
- Temperature compensated automatic water control system with electronic burner ignition.

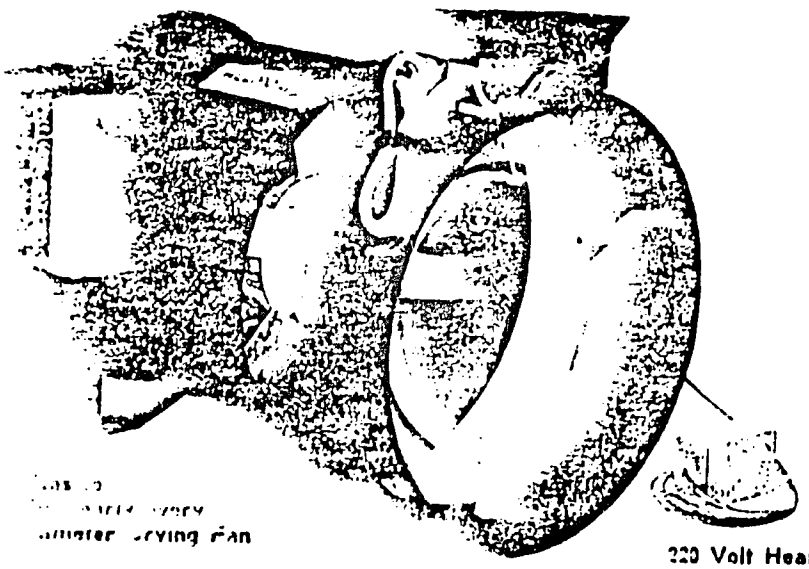
Burner Controls and Safety Devices

- Power switch to disconnect power to burner control system.
- Humidistat switch to provide either automatic or manual burner control.
- Adjustable pressure regulator for more accurate pressure regulation.
- Solenoid valve (5 year coil guarantee) and regulator both designed to operate at tank pressures (same), thereby eliminating the need for a tank heater and allowing the use of a smaller supply line.
- Manual reset high limit switch to shut down system in case debris blocks fan intake or in case of blower failure.
- Automatic continuous electronic ignition for maximum safety and convenience.
- Low temperature flame rod to sense flame and no-flame conditions.
- The temperature compensated time delay switch has two functions:
  1. Initial firing switch.
  2. To shut down burner control system in case of burner misfire.
- Power for heater is connected to motor side of magnetic switch to insure burner shut down automatically when motor is shut off.

HELIFOIL™

ELECTRIC HUMIDITY CONTROLLER





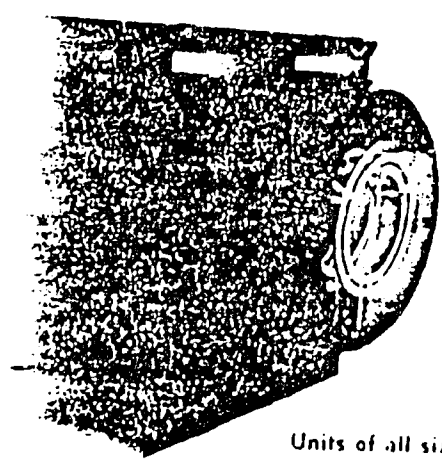
Electric Heat coils are Humidistat controlled to add a few degrees of heat only when outdoor Relative Humidity is high, reducing the moisture in the air. Now you can Natural Air Dry grain under adverse weather conditions

ECONOMICALLY!

220 Volt Heating Elements

Electric Heat Drying offers the advantage of filling the bin as fast as you desire without regard to the previous grain in the bin being dried. Will not over dry the grain layers of grain.

LEADERS IN LOW TEMPERATURE DRYING



Units of all sizes for centrifugal applications

MS

Middle State Manufacturing Co. Inc.

DEPENDABLE PRODUCTS THROUGH RESEARCH

P.O. Box 788 COLUMBUS NEBRASKA 68601

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AXIAL FANS

1750 RPM FANS

MODEL	PART NO	LIST PRICE	HP	DIA	PHASE	VOLT	WT
*TF16-1.5-1	174-1-0022	507.15	1.5	16"	1	230	50
*TF16-1.5-3	174-1-0023	502.95	1.5	16"	3	230/460	63
*TF18-3-1	174-1-0024	675.15	3	18"	1	230	145
*TF18-3-3	174-1-0025	656.25	3	18"	3	230/460	150
**TF38-7.5-3	100-1-0193	2759.00	7.5	38"	3	230/460	250
**TF38-15-3	100-1-0194	3115.00	15	38"	3	230/460	285
**TF38-20-3	100-1-0195	3342.00	20	38"	3	230/460	313
**TF38-25-3	100-1-0196	3592.00	25	38"	3	230/460	413

*Units include: Heavy gauge steel housing with angle ring both ends, cast aluminum blade, totally enclosed motor, heavy steel screen guard and tapered bushing.

**Same as * except has open-drip proof motor. Also includes magnetic starter with electric line heater strips pre-wired at factory. Motors have internal thermal protection.

All units enamel painted. Available in hot-dipped galvanized. Contact Middle State Manufacturing for galvanized prices.

All fans are factory tested under static pressure and inspected for correct amperage draw and proper blade balance.

All units shipped in cartons.

HEATERS

GAS FIRED FOR AXIAL FANS

MODEL	PART NO	LIST PRICE	DIA	FUEL	BTU	WT
HTFG-IV-24	104-1-0149	829.05	24"	Liq. Prop.	500,000-2,000,000	85
HTFG-VP-24	104-1-0228	540.75	24"	Vap. Prop.	500,000-2,000,000	70
HTFG-IV-MV-24	104-1-0153	1072.65	24"	Liq. Prop.	500,000-2,000,000	90
HTFG-VP-MV-24	104-1-0230	784.35	24"	Vap. Prop.	500,000-2,000,000	75
HTFG-NG-24	104-1-0150	624.75	24"	Nat. Gas	500,000-1,500,000	70
HTFG-NG-MV-24	104-1-0154	868.35	24"	Nat. Gas	500,000-1,500,000	75
HTFG-IV-26	104-1-0151	941.25	26"	Liq. Prop.	500,000-2,000,000	90
HTFG-VP-26	104-1-0229	575.40	26"	Vap. Prop.	500,000-2,000,000	75
HTFG-IV-MV-26	104-1-0155	1185.45	26"	Liq. Prop.	500,000-2,000,000	95
HTFG-VP-MV-26	104-1-0231	819.90	26"	Vap. Prop.	500,000-2,000,000	80
HTFG-NG-26	104-1-0152	653.10	26"	Nat. Gas	500,000-1,700,000	75
HTFG-NG-MV-26	104-1-0156	896.00	26"	Nat. Gas	500,000-1,700,000	80
HTFG-IV-MV-38	104-1-0001	1609.00	38"	Liq. Prop.	500,000-2,000,000	100
HTFG-NG-MV-38	104-1-0002	1309.00	38"	Nat. Gas	500,000-1,700,000	110

Units include: Heavy gauge steel housing, angle ring on each end, gun burner with combustion air tubes, 1/2" plumbing, 17" target, air straighteners, propane 5/32 orifice (additional orifice sizes are available), pressure regulator, pressure gauge, solenoid valve, flame sensor, air switch, gas strainer, and test light.

Units enamel painted. Available in hot dipped galvanized. Contact Middle State Manufacturing for galvanized prices.

115 Volt heater controls must be interlocked to the fan through the fan's magnetic starter.

IV models include liquid and vapor solenoid valves plus liquid propane vaporizer.

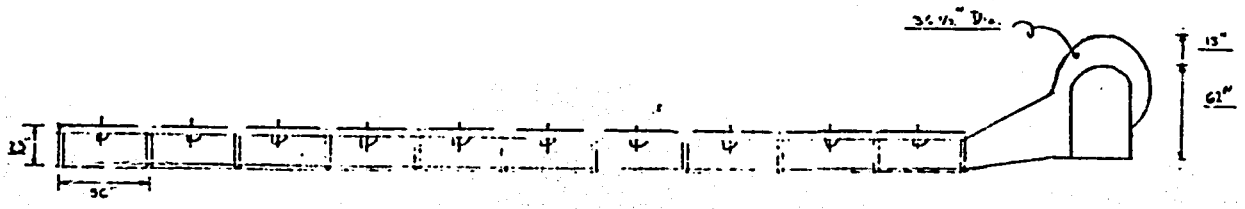
MV models include factory installed modulating valve.

NG burners require an upstream regulator (supplied by gas company) installed within 10' of the burner and 3 lbs. continuous minimum gas pressure.

Downstream high limit (manual reset) is supplied with all burners. Instructions for installation are in the Instruction Manual supplied with the burner.

All units shipped in cartons.

All gas heaters are factory tested to assure field performance.



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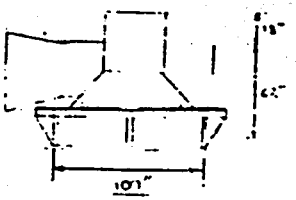

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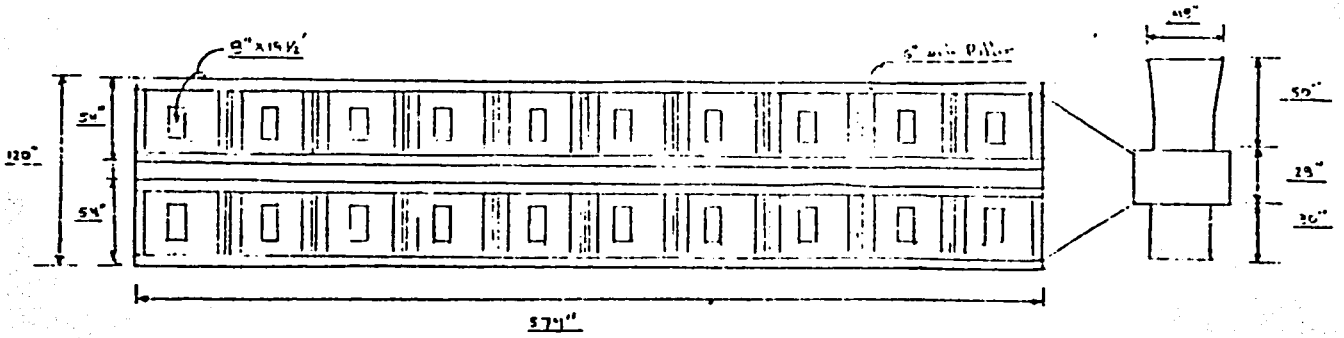


PLAN

BLOWER SPECIFICATION :

WHEEL DIA 36 1/2"

BLOWER 425 RPM

17,400 CFM AT 3" SP

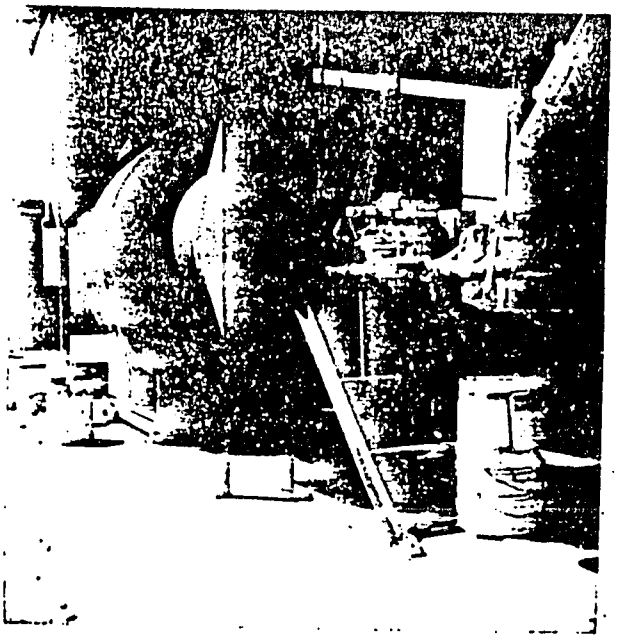
BOX SPECIFICATION

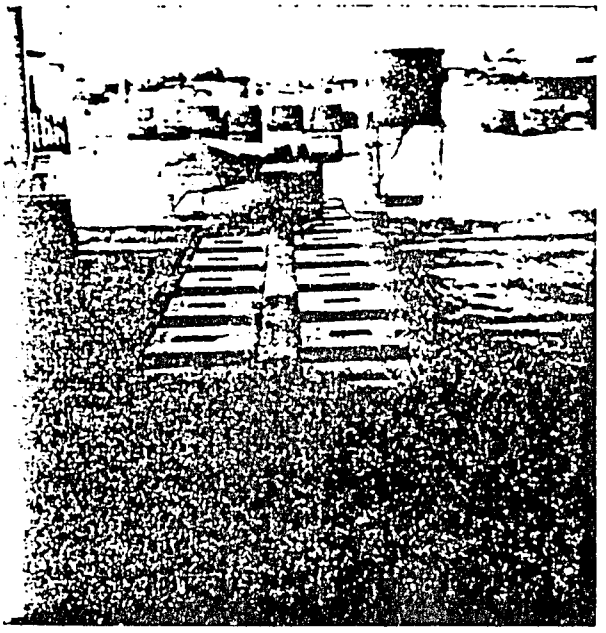
VOL 1100 CU FT

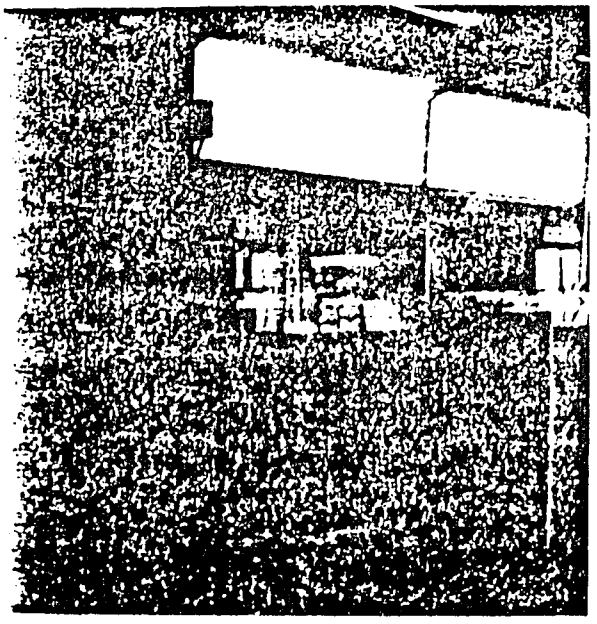
BOXES CAN BE
1 OT 3 TO 4 HIGH

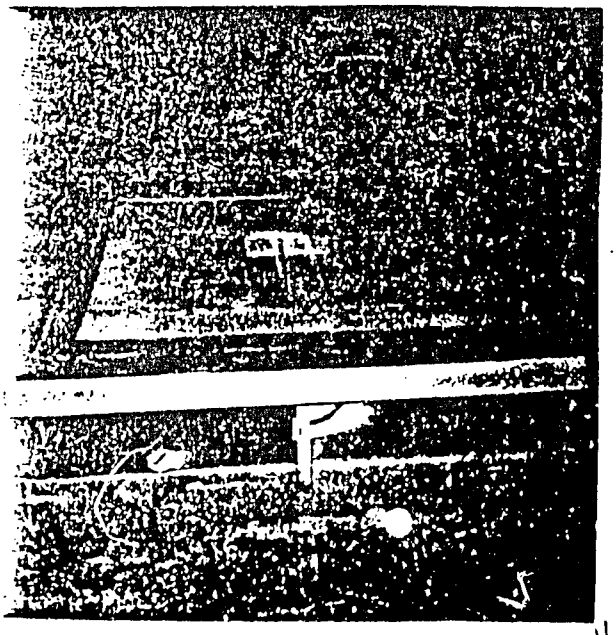
ACME SPEED CO
... DECK

Best Available Document









JOHN CALANDRI FARMS
42016 IVESGROVE DRIVE
LANCASTER, CA 93534

APPENDIX VI

March 07, 1984

Archie Desert
Arco Seed Company
P. O. Box 181
El Centro, CA 92244-0181

Dear Archie,

Art Caston asked me to prepare some photos for your trip to Panama and I hope these will be adequate. We also hope you are enjoying your visit and are learning much.

To begin with the secret to storing onions is the quality that goes into the storage facility. If bad onions go in, poor quality onions come out. Sorting is of the utmost importance.

Next we feel temperature and relative humidity must be controlled very closely. (see additional articles). Also air movement must always be maintained to circulate cold air into potential "hot" spots.

The inclosed photos show our coils (#1). There are 6 per 10,000 sq. feet, displacing 582,000 B.T.U.'s per hour. There are many other types and sizes. Each operator needs to know his specific needs. I might add there are other types of cooling systems used throughout the United States and Canada, but I'm sorry to say I'm not familiar with them. The Department of Agriculture in Canada could assist you. I believe the Directors name is Mat Valk. Each area must investigate the most economical methods.

Photo #2 shows how we "rack" the onions. You can see they are all palletized anywhere from 36 to 40 sacks per pallet. Some parts of the United States store onions in bins and some in bulk piles. Both of these methods are successful. Especially if the onions are to be regraded. It is a much less expensive method. We stack ours 3 tiers high. Note there are air aisles between each pallet.

Pictures 3 thru 7 are just other views of product in racks. Photo #8 is a top view looking over total room. Coils are well above product to prevent freezer burn and promote air circulation.

Hope these help you out. Enjoy your stay.

Sincerely,
John A. Calandri
John A. Calandri

ity of strawberry plants, bare-root rose bushes and certain other nursery stock in storage. Strawberry plants can be stored up to 10 months in polyethylene-lined crates.

NUTS

See Chapter 27.

ONIONS

A comparatively low relative humidity is essential in the successful storage of onions. At higher humidities in which most other vegetables keep best, onions are disposed to root growth and decay and at too high a temperature sprouting is encouraged. Therefore, a storage temperature of 32 F with a relative humidity of 70–75% is recommended to keep them dormant. Onions in cold storage are usually held in 50 lb mesh sacks which are best piled in pairs laid crosswise of each other in stacks five or six sacks high. The stacks are set on dunnage strips to allow air passage beneath and spaced a few inches apart to allow further air circulation. *Onion sets* require practically the same temperature and humidity conditions as onions, but since they are smaller in size they tend to pack more solidly. They are handled in approximately 25 lb bags and should be stacked to allow the maximum of air circulation.

ORANGES

See Chapter 25.

PAPAYAS

Papayas should be ripened at 78–86 F to a firm ripe condition before shipment or storage. This usually requires one to six days. The best shipping or storage temperature is 45 F and the fruit should keep for two to three weeks without undue decay. *Anthracnose* is the principal decay of stored papayas.

PEACHES

Peaches can be stored for only short periods. However, if well matured but not overripe, they can be held at 31 to 32 F for two to four weeks. Deterioration is marked by loss of flavor and bright natural color and by browning of the flesh, especially around the pit. This deterioration occurs much more rapidly at 36 to 40 F than at 31 or 32 F.

PEARS

See Chapter 24.

POPCORN

Popcorn should be stored at 32–40 F and at a relative humidity of about 85%. For optimum popping condition a moisture content of about 13.5% is desirable. The above relative humidity should maintain about this amount of moisture.

PLUMS AND FRESH PRUNES

Plums and fresh prunes are not stored extensively and are not adapted to long storage. *Abundance, Wild Goose*, and varieties of the *Damson* type store l than the softer-fleshed plums, such as *Santa Beauty, Wickson* and *Duarte*. If held longer about three to four weeks, even at 32 F all var become too ripe for commercial handling and somewhat in flavor. Italian prunes, if held lc than about three weeks, are likely to develop int breakdown as well as abnormal odor and flavor. much confidence should not be placed on the ap ance and condition of the fruit while it is in sto as more deterioration, decay, shriveling, and int browning may take place within three days removal from storage than during the whole sto period.

POTATOES

Early crop potatoes are usually not stored ex during congested periods. They should be consid as perishable and not be expected to keep as we as long as late crop tubers. Refrigerated storag 50 F following a curing period of a few days at 80 F is recommended. If early crop potatoes ar be used for chipping or french frying a storage t perature of 70 F is recommended.

Late crop potatoes should keep in sound dorm condition at 40 F for five to eight months. A temp ture below this is not desirable except for seed st for late planting. For this purpose 38 F is best. 40 F or below Irish potatoes tend to become sw For ordinary table use potatoes from 40 F are sa factory but they probably will be unsatisfactory chipping or french frying without being desugared conditioned at about 70 F for one to three we previous to use. Potatoes will remain dormant at 5 for from two to four months, and since tubers fr this temperature are more desirable for both table and processing than those from 40 F it is reco mended that late crop potatoes for use within fo months be stored at 50 F and those for later use 40 F. All potatoes should be stored in the dark. Th should not be kept in the same room with fruits, nu eggs or dairy products because of the objection flavor they may impart.

POULTRY

Frozen poultry should be stored at 0 F to −10 with the temperature maintained as constant possible. Temperatures of from −20 to −40 F a desirable for the actual freezing operation. Und optimum conditions, broilers, fryers and roaste (New York dressed) can be held without appreciab deterioration for six to nine months. Ready-to-co chickens packed in institutional packs with goo quality liners should remain in satisfactory conditio for 9–10 months, and similar classes of birds in vidually wrapped in film should hold up in stora for 12–16 months. Improper handling during a of the processing operations could materially red these safe storage times.

When frozen poultry is held under severely fluctu ating temperatures, evaporation of moisture from th skin may be so great that it causes light-colored pockmarks to appear. Such a condition is called

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Commodity	Storage Temp, F	Relative Humidity, %	Approximate Storage Life	Water Content, %	Average Freezing Point, F	Specific Heat Above Freezing[1]	Specific Heat Below Freezing[1]	Latent Heat (Cul later Bt
Lamb—Fresh	32–34	85–90	5–12 days	60–70	28–29	0.68–0.76	0.38–0.51	86–1
Frozen	−10– 0	90–95	8–10 months	—	—	—	—	—
Livers—Frozen	−10– 0	90–95	3– 4 months	70.0	—	—	—	—
Pork—Fresh	32–34	85–90	3– 7 days	35–42	28–29	0.48–0.54	0.30–0.32	50–4
Frozen	−10– 0	90–95	4– 6 months	—	—	—	—	—
Smoked Sausage	40–45	85–90	—	—	—	—	—	—
Sausage Casings	40–45	85–90	—	—	—	—	—	—
Veal	32–34	90–95	5–10 days	70–80	28–29	0.76–0.84	0.42–0.51	100–1
Mangoes	50	85–90	2– 3 weeks	81.4	29.4	0.85	0.44	11
Melons								
Cantaloupe and Persian	45–50	85–90	1– 2 weeks	92.7	29.9	0.94	0.48	13
Honey Dew and Honey Ball	45–50	85–90	2– 4 weeks	92.6	29.8	0.94	0.48	132
Casaba	45–50	85–90	4– 6 weeks	92.7	29.9	0.94	0.48	132
Watermelons	36–40	85–90	2– 3 weeks	92.1	30.6	0.97	0.48	132
Milk, powdered	32–40	Moistureproof containers	several weeks	—	—	—	—	—
Mushrooms[1]	32–35	85–90	3– 5 days	91.1	30.0	0.93	0.47	130
Mushroom spawn								
Manure spawn	34	75–80	8 months	—	—	—	—	—
Grain spawn	32–40	75–80	2 weeks	—	—	—	—	—
Nursery stock (Table 4)	32–35	85–90	3– 6 months	—	—	—	—	—
Nuts (Chap. 27)	32–50[1]	65–75	8–12 months	3–6	—	0.22–0.25	0.21–0.22	4–8
Oil (vegetable salad)	35	—	1 year	0	—	—	—	—
Okra	50	85–95	7–10 days	89.8	28.6	0.92	0.46	128
Oleomargarine	35	60–70	1 year	15.5	—	0.32	0.25	22
Olives, fresh	45–50	85–90	4– 6 weeks	75.2	28.5	0.80	0.42	10
Onions and onion sets	32	70–75	6– 8 months	87.5	30.1	0.90	0.46	12
Oranges (Chap. 25)	32–34	85–90	8–12 weeks	87.2	28.0	0.90	0.46	12
Papayas	45	85–90	2– 3 weeks	90.8	30.1	0.82	0.47	13
Parsnips	32	90–95	2– 6 months	78.6	29.8	0.84	0.46	12
Peaches	31–32	85–90	2– 4 weeks	86.9	29.6	0.90	0.46	12
Pears (Chap. 24)	29–31	85–90	—[1]	82.7	27.7	0.86	0.45	11
Peas, green	32	85–90	1– 2 weeks	74.3	30.1	0.79	0.42	10
Peppers, sweet	45–50	85–90	8–10 days	92.4	30.5	0.94	0.47	13
Peppers, Chili (dry)	32–40	65–75	6– 9 months	12.0	30.9	0.30	0.24	1
Persimmons	30	85–90	2 months	78.2	27.5	0.84	0.43	11
Pineapples								
Mature green	50–60	85–90	3– 4 weeks	—	29.1	—	—	—
Ripe	40–45	85–90	2– 4 weeks	85.3	29.7	0.88	0.45	12
Plums, including fresh prunes	31–32	80–85	3– 4 weeks[1]	85.7	28.7	0.88	0.45	12
Pomegranates	34–35	85–90	2– 4 months	—	26.5	—	—	—
Popcorn, unpopped	32–40	85	—[1]	13.5	—	0.31	0.24	1
Potatoes								
Early crop	50–55	85–90	—[1]	—	30.0	—	—	—
Late crop	38–50[1]	85–90	—[1]	77.8	29.8	0.82	0.43	111
Poultry (Chap. 2 and 16)								
Fresh	32	—	1 week	74.0	27.0	0.79	—	10
Frozen, New York dressed	−10– 0	—	6– 9 months	—	—	—	0.37	—
Frozen, eviscerated	−10– 0	—	9–10 months	—	—	—	—	—
Pumpkins	50–55	70–75	2– 6 months	90.5	29.9	0.92	0.47	18
Quinces	31–32	85–90	2– 3 months	85.3	28.1	0.88	0.45	12
Radishes—Spring, bunched or prepackaged	32	90–95	10 days	93.6	30.1	0.95	0.48	13
Winter	32	90–95	2– 4 months	93.6	—	0.95	0.48	13
Rabbits								
Fresh	32–34	90–95	1– 5 days	—	—	—	—	—
Frozen	−10– 0	90–95	0– 6 months	—	—	—	—	—
Raspberries								
Black	31–32	85–90	7 days	80.6	29.4	0.84	0.44	12
Red	31–32	85–90	7 days	84.1	30.3	0.87	0.45	12
Frozen (red or black)	−10– 0	—	1 year	—	—	—	—	—
Rhubarb	32	90–95	2– 3 weeks	94.9	29.9	0.96	0.48	13
Rutabagas	32	90–95	2– 4 months	89.1	29.7	0.91	0.47	12
Salsify	32	90–95	2– 4 months	79.1	29.6	0.83	0.44	11
Spinach	32	90–95	10–14 days	92.7	31.3	0.94	0.48	13
Squash		—						
Acorn	45–50	75–85	4– 5 weeks	—	30.0	—	—	—
[illegible]	32–40	85–95	10–14 [illegible]	95.0	30.4	0.96	—	13
[illegible]	50[illegible]	[illegible]	[illegible]	[illegible]	29.5	[illegible]	[illegible]	[illegible]

arts on the outer ad leaves, but in severe cases all leaves. *Contr l:* There is no known control

ead, brown areas along the edges and tips of s. This is considered to be of field origin, but occa- e severity of the disease increases after harvest. eep the affected stock well-cooled and market it ter unloading to avoid secondary bacterial rots. *oft Rots* (see Table 4, Note 4).

rage is hardly used for most kinds of melons except emporarily adverse market conditions. To avoid nilling, most melons are stored at 7 to 10°C with 85

should keep at this temperature range for up to *honeydews* for two to three weeks; and *casabas* o six weeks. It is reported that these melons will be njured in eight days at temperatures as low as 0°C. s are usually given an 18- to 24-h ethylene treat- mg/kg) to obtain uniform ripening. Pulp tempera- be 21°C or above during treatment. Honeydews hature when harvested; immature melons fail to if treated with ethylene.

upes harvested at the hard stage (less than full slip) d about 15 days at 2 to 4°C. Lower temperatures chilling injury. Full-slip hard-ripe cantaloupes can a maximum of 10 to 14 days at 3 to 4°C. Canta- precooled by hydrocooling or forced air cooling, ding, or by top-icing after loading in railcars or

ions are best stored at 4 to 10°C and should keep hree weeks. Watermelons decay less at 0°C than hey tend to become pitted and have an objec- sor after one week at 0°C.

a Rot: Irregular, circular, brownish spots, with concentric rings, later covered with black n found on melons that have been chilled. *Control:* ing temperatures. If cold melons are to be held at erature, they should be so stacked that condensed il evaporate readily. Market melons promptly.

nose (*Colletotrichum*): Numerous greenish, ots with yellow centers, later sunken and covered ore masses. *Control:* Apply recommended measures.

njury: Honeydew and honeyball melons stored s or longer at temperatures of 0 to 1°C sometimes irregular, water-soaked, sticky areas in the rind. ore melons at 7 to 10°C.

rium Rot: Small black shallow spots later covered green mold. On cantaloupes, this rot is evident on hallow areas at the stem ends, or at points of con- n melons, and can be rubbed off easily. *Control:* tsures are the same as for *Alternaria rot*, above.

Rot: Brown areas on white melons; white or pink indefinite spots on green melons. Affected tissue is soft, with white or pink mold. *Control:* Avoid injuries; reduce carrying temperatures to 7°C.

thora Rot: Brown, slightly sunken areas; later ed and covered with a wet, appressed, whitish *rot.* Cull out the affected fruits during packing. s the temperatures to 7°C.

Rot: The affected melon is soft, but not soupy s in similar decay on other vegetables. Coarse ds may be demonstrated in decayed tissue. (See ote 1)

Rot (*Diplodia*): Brown, fairly firm decay usually starting at the stem end and affecting a large part of the watermelon. Black fruiting bodies develop later. *Control:* At the time of loading in cars, recut the stems and treat them with Bordeaux paste or another recommended fungicide.

Mushrooms (0°C and 90% rh)

Mushrooms are usually processed or sold in a retail market within 24 to 48 h after they are harvested. They keep in good salable condition at 0°C for five days, at 4°C for two days, and at 10°C or above for about one day. A rh of 90% is recommended during storage. While being transported or displayed, for retail sale, mushrooms should be refrigerated. Deterioration is marked by brown discoloration of the surfaces, elongation of the stalks, and opening of the veils. Black stems and open veils are correlated with dehydration.

Controlled-atmosphere storage reportedly can prolong the shelf life of mushrooms held at 10°C, if the oxygen concentration in the atmosphere is 9% or the carbon dioxide concentration is 25 to 50%.[60]

Moisture-retentive film overwraps of film caps usually are beneficial in reducing moisture loss. Treatment with a solution of salt and sodium bisulfite has been found effective in reducing discoloration.

Mushroom spawn made with rye grain deteriorates in two to three days at 21°C after it is removed from the culture bottle for delivery to the grower. It will, however, keep in good condition for two weeks when stored in well-ventilated containers at temperatures of 0 to 4°C.

During the growing period, the temperature in mushroom houses must not exceed 18°C. For summer growing in eastern Pennsylvania, about 35.2 KW of refrigeration capacity is required for each double house (with cinder block walls) containing 540 to 900 m^2 of bed space.

Okra (7 to 10°C and 90 to 95% rh)

Okra deteriorates rapidly, and normally it is stored only briefly before marketing or processing. It has a very high respiration rate at warm temperatures. Okra in good condition can be kept satisfactorily for seven to 10 days at 7 to 10°C. A rh of 90 to 95% is desirable to prevent wilting. At temperatures below 7°C, okra is subject to chilling injury, which is manifest by surface discoloration, pitting, and decay. Holding okra for three days at 0°C may cause pitting. Contact or top ice causes water spotting in two or three days at all temperatures.

Fresh okra bruises easily; blackening of the damaged areas occurs within a few hours. A bleaching type of injury may also develop when okra is held in hampers for more than 24 h without refrigeration.

Onions (0°C and 65 to 70% rh)

A comparatively low rh is essential in the successful storage of dry onions. However, humidities as high as 85% and forced air circulation have given satisfactory results. At higher humidities, at which most other vegetables keep best, onions are disposed to root growth and decay; at too high a temperature, sprouting is encouraged. Storage at 0°C with a of 65 to 70% rh is recommended to keep them dormant.

Onions should be adequately cured either in the field, in open sheds, or by artificial means before or in storage.[61, 62] The most common method of curing in northern areas is by forced ventilation in storage. Onions are considered cured when the necks are tight and the outer scales are dried until they rustle. If not cured, onions are likely to decay in storage.

Onions are stored in 22.7-kg bags, in crates, in pallet boxes that hold about 0.45 Mg of loose onions, or in bulk bins. Bags

ôles

ps are frequently stored on pallets. Bagged onions e stacked to allow proper air circulation. Modern air- rages have forced ventilation systems. Air is in- rough floor racks beneath the bins of onions. The e heated if necessary. Onions in bins are stored about ep. Soft onions at the bottom of the bin might be d in shape when stored in this manner. Onions should tored with other products that tend to absorb odors.

onions are removed from storage in warm weather, apt to sweat because of moisture condensation. This vor decay. Warming onions gradually should avoid iculty.

e northern onion-growing states, onions of the globe e generally held in common storage, since average temperatures are sufficiently low to permit common . They should not be held after early March unless they en treated with maleic hydrazide in the field to reduce growth.[62]

gerated storage is often used to hold onions for ing late in the spring. Onions to be held in cold storage be placed there immediately after curing. A tem- e of 0°C will keep onions dormant and reasonably free ecay, provided the onions are sound and well- cured stored. Sprout growth indicates too high a storage ature, poorly cured bulbs, or immature bulbs. Root indicates the relative humidity is too high.

e onions can be held for six to eight months at 0°C. r Bermuda types can usually be held at 0°C for only one months. Onions of the Spanish type are often stored; if atured, they can be held at 0°C, at least until January or ry. In California, onions of the sweet Spanish type are 0°C until April or May.

ons are damaged by freezing, which appears as water- of the scales when cut after thawing. Onions that slightly frozen may recover with little perceptible if allowed to thaw slowly and without handling.

on sets require practically the same temperature and ity conditions as onions, but since they are smaller in ey tend to pack more solidly. They are handled in ap- nately 11.3-kg bags and should be stacked to allow the num air circulation.

en onions (scallions) and green shallots are usually ted promptly after harvest. They can be stored three to eeks at 0°C with 95% rh. Crushed ice spread over the aid in supplying moisture. Packaging in polyethyl- in will also aid in preventing moisture loss. Storage life een onions at 0°C can be extended to eight weeks by ing them in perforated polyethylene bags or in waxed s and holding them in a controlled atmosphere of 1% n with 5% carbon dioxide.[63]

monia Gas Discoloration: Exposure of onions to 1% onia in air for 24 h causes the surface of yellow onions to brown, red onions to turn deep metallic black, and white s to turn greenish yellow. *Control:* Ventilate storage s as soon as possible after exposure.

cterial Soft Rot: This decay often affects one or more s in the interior of the bulb. Decayed tissue is more y than gray mold rot. (See Table 4, Note 1.)

ack Mold (Aspergillus): Black powdery spore masses on innermost scale or between outer scales. *Control:* Store s at least above 0°C and at 65% rh.

eezing Injury: A Water-soaked, grayish yellow ap- ance of the entire outer fleshy scales results from a slight injury. All scales are affected and become flabby ere injury. Opaque areas appear in affect scales. *rol:* Prevent exposure to −1°C temperatures or lower. frozen onions at 4°C.

Fusarium Bulb Rot: Semiwatery to dry decay progressing up the scales from the base. Decay usually is covered with dense, low-lying white to pinkish mold. *Control:* Do not store badly affected lots. Pull out infected bulbs in slightly affected lots. Store onions at 0°C.

Gray Mold Rot: This is the commonest type of onion decay; it usually starts at the neck, affecting all scales equally. Decay often is pinkish. (See Table 4, Note 2.) *Control:* Cure onions thoroughly. Protect them from rain. Store them at just above 0°C.

Smudge: Black blotches or aggregations of minute black or dark green dots on the outer drying scales of white onions. Under moist conditions, sunken yellow spots develop on fleshy scales. *Control:* Protect onions from rain after harvest. Store them just above 0°C.

Translucent Scale: The outer two or three scales are gray and water-soaked; as in freezing. The entire scale may not be discolored; no opaque area is noticeable. Sometimes translucent scale is found in the field. *Control:* No control is known. Store onions at 0°C after curing.

Parsley (0°C and 95% rh)

Parsley should keep one to two months at 0°C and for a somewhat shorter period at 2 to 4°C. High humidity is essential to prevent desiccation. Package icing is often beneficial.

Bacteria Soft Rot (see Table 4, Note 1).

Watery Soft Rot (see Table 4, Note 4).

Parsnips (0°C and 98 to 100% rh)

Topped parsnips have similar storage requirements to topped carrots and should keep for two to six months at 0°C. Parsnips held at 0 to 1°C for two weeks after harvest attain a sweetness and high quality equal to that of roots subjected to frosts for two months in the field. Ventilated polyethylene box or basket liners can aid in preventing moisture loss. Parsnips are not injured by slight freezing while in storage, but they should be protected from hard freezing and should be handled with great care while in a frozen condition.

Bacterial Soft Rot (see Table 4, Note 1).

Canker (Itersonilia sp.): Organism enters through fine rootlets and through injuries. The surface of the infected parsnip is first brown to reddish; later, it turns black where a depressed canker is formed. *Control:* Follow the recommended field spray program. Practice crop rotation.

Gray Mold Rot (see Table 4, Note 2).

Watery Soft Rot (see Table 4, Note 4).

Peas, Green (0°C and 95% rh)

Green peas lose part of their sugar rapidly if they are not refrigerated promptly after harvest. They should keep in salable condition one to two weeks at 0°C.[42, 64] Top icing is beneficial in maintaining freshness. Peas keep better unshelled than shelled.

Bacterial Soft Rot (see Table 4, Note 1).

Gray Mold Rot (see Table 4, Note 2).

Watery Soft Rot (see Table 4, Note 4).

Peppers, Dry Chili or Hot

Chili peppers, after drying to a moisture content of 10 to 15%, are stored in nonrefrigerated warehouses for six to nine months. The moisture content is usually low enough to prevent fungus growth. A relative humidity of 60 to 70% is desirable. Polyethylene lined bags are recommended to prevent changes in moisture content. Manufacturers of chili pepper products hold part of their supply of the raw material in cold storage at 0 to 10°C, but they prefer to grind the peppers

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Table 2 Storage Requirements and Properties of Perishable Products

Commodity	Storage Temp °C	Relative Humidity %	Approximate Storage Life[a]	Water Content %	Highest Freezing °C	Specific Heat Above Freezing[d] J/kg · °C	Specific Heat Below Freezing[d] J/kg · °C	Latent Heat[e] J/kg
				Vegetables[a]				
Artichokes								
Globe	0	95	2 weeks	84	−1.2	3.651	1.892	280.18
Jerusalem	0	90 to 95	5 months	80	−2.5[b]	3.517	1.842	266.84
Asparagus	0 to 2	95	2 to 3 weeks	93	−0.6	3.952	2.005	310.20
Beans								
Snap or Green	4 to 7	90 to 95	7 to 10 days	89	−0.7	3.818	1.955	296.86
Lima	0 to 4	90 to 95	3 to 5 days	67	−0.6	3.081	1.679	223.48
Dried	10	70	6 to 8 months	11	—	1.206	0.975	—
Beets								
Roots	0	95 to 100	4 to 6 months	88	−0.9	3.785	1.943	293.52
Bunch	0	95	10 to 14 days	—	−0.4	—	—	—
Broccoli	0	95	10 to 14 days	90	−0.6	3.852	1.968	300.20
Brussels Sprouts	0	95	3 to 5 weeks	85	−0.8	3.684	1.905	283.52
Cabbage late	0	95 to 100	5 to 6 months	92	−0.9	3.919	1.993	306.87
Carrots								
Topped—immature	0	98 to 100	4 to 6 weeks	88	−1.4	3.785	1.943	293.52
Topped-mature	0	98 to 100	5 to 9 months	88	−1.4	3.785	1.943	293.52
Cauliflower	0	95	2 to 4 weeks	92	−0.8	3.919	1.993	306.87
Celeriac	0	95 to 100	3 to 4 months	88	−0.9	3.785	1.943	293.52
Celery	0	95	1 to 2 months	94	−0.5	3.986	2.018	313.54
Collards	0	95	10 to 14 days	87	−0.8	3.751	1.930	290.19
Corn (sweet)	0	95	4 to 8 days	74	−0.6	3.316	1.767	246.83
Cucumbers	10 to 13	90 to 95	10 to 14 days	96	−0.5	4.053	2.043	320.21
Eggplant	7 to 10	90 to 95	7 to 10 days	93	−0.8	3.952	2.005	310.20
Endive (escarole)	0	95	2 to 3 weeks	93	−0.1	3.952	2.005	310.20
Frozen vegetables	−23 to −18	—	6 to 12 months	—	—	—	—	—
Garlic, dry	0	65 to 70	6 to 7 months	61	−0.8	2.880	1.604	203.46
Greens, leafy	0	95	10 to 14 days	93	−0.3	3.952	2.005	310.20
Horseradish	−1 to 0	95 to 100	10 to 12 months	75	−1.8	3.349	1.779	250.16
Leek	0	95	3 to 4 weeks	87	−0.5	3.751	1.930	290.19
Kohlrabi	0	95	2 to 4 weeks	90	−1.0	3.852	1.968	300.20
Okra, green	0	95	1 to 3 months	85	−0.7	3.684	1.905	283.52
Lettuce, head	0 to 1	95 to 100	2 to 3 weeks	95	−0.2	4.019	2.031	316.87
Mushrooms	0	90	3 to 4 days	91	−0.9	3.885	1.980	303.53
Okra	7 to 10	90 to 95	7 to 10 days	90	−1.8	3.852	1.968	300.20
Onions								
Greens	0	95	3 to 4 weeks	89	−0.9	3.818	1.955	296.86
Dry and onion sets	0	65 to 75	1 to 8 months	88	−0.8	3.785	1.943	293.52
Parsley	0	95	1 to 2 months	85	−1.1	3.684	1.905	283.52
Parsnips	0	98 to 100	4 to 6 months	79	−0.9	3.483	1.830	263.50
Peas								
Green	0	95	1 to 3 weeks	74	−0.6	3.316	1.767	246.83
Dry	0	70	6 to 8 months	12	—	1.239	0.988	—
Peppers								
Red	0 to 10	60 to 70	6 months	12	—	1.239	0.988	—
Sweet	7 to 10	90 to 95	2 to 3 weeks	92	−0.7	3.919	1.993	306.87
Potatoes								
Early	10 to 13	90	—	81	−0.6	3.550	1.855	270.18
Main crop	3 to 10	90 to 95	5 to 8 months	78	−0.7	3.450	1.817	260.17
Sweet	13 to 16	85 to 90	4 to 7 months	69	−1.3	3.148	1.704	230.15
Pumpkins	10 to 13	70 to 75	2 to 3 months	91	−0.8	3.885	1.980	303.53
Radishes								
Spring	0	95	3 to 4 weeks	95	−0.7	4.019	2.031	316.87
Winter	0	95 to 100	2 to 4 months	95	−0.7	4.019	2.031	316.87
Rhubarb	0	95	2 to 4 weeks	95	−0.9	4.019	2.031	316.87
Rutabagas	0	98 to 100	4 to 6 months	89	−1.1	3.818	1.955	296.86
Salsify	0	98 to 100	2 to 4 months	79	−1.1	3.483	1.830	263.50
Seed vegetable	0 to 10	50 to 65	10 to 12 months	7 to 15	—	1.206	0.976	036.69
Spinach	0	95	10 to 14 days	93	−0.3	3.952	2.005	310.20
Squash								
Acorn	7 to 10	70 to 75	5 to 8 weeks	—	−0.8	—	—	—
Summer	0 to 10	85 to 95	5 to 14 days	94	−0.5	3.986	2.018	313.54
Winter	10 to 13	70 to 75	4 to 6 months	85	−0.8	3.684	1.905	283.52
Tomatoes								
Mature green	13 to 21	85 to 90	1 to 3 weeks	93	−0.6	3.952	2.005	310.20
Firm ripe	7 to 10	85 to 90	4 to 7 days	94	−0.5	3.986	2.018	313.54
Turnips								
Roots	0	95	4 to 5 months	92	−1.1	3.919	1.993	306.87
Greens	0	95	10 to 14 days	90	−0.2	3.852	1.968	300.20
Watercress	0	95	3 to 4 days	93	−0.3	3.952	2.005	310.20
Yams	16	85 to 90	3 to 6 months	74	—	3.316	1.767	246.83

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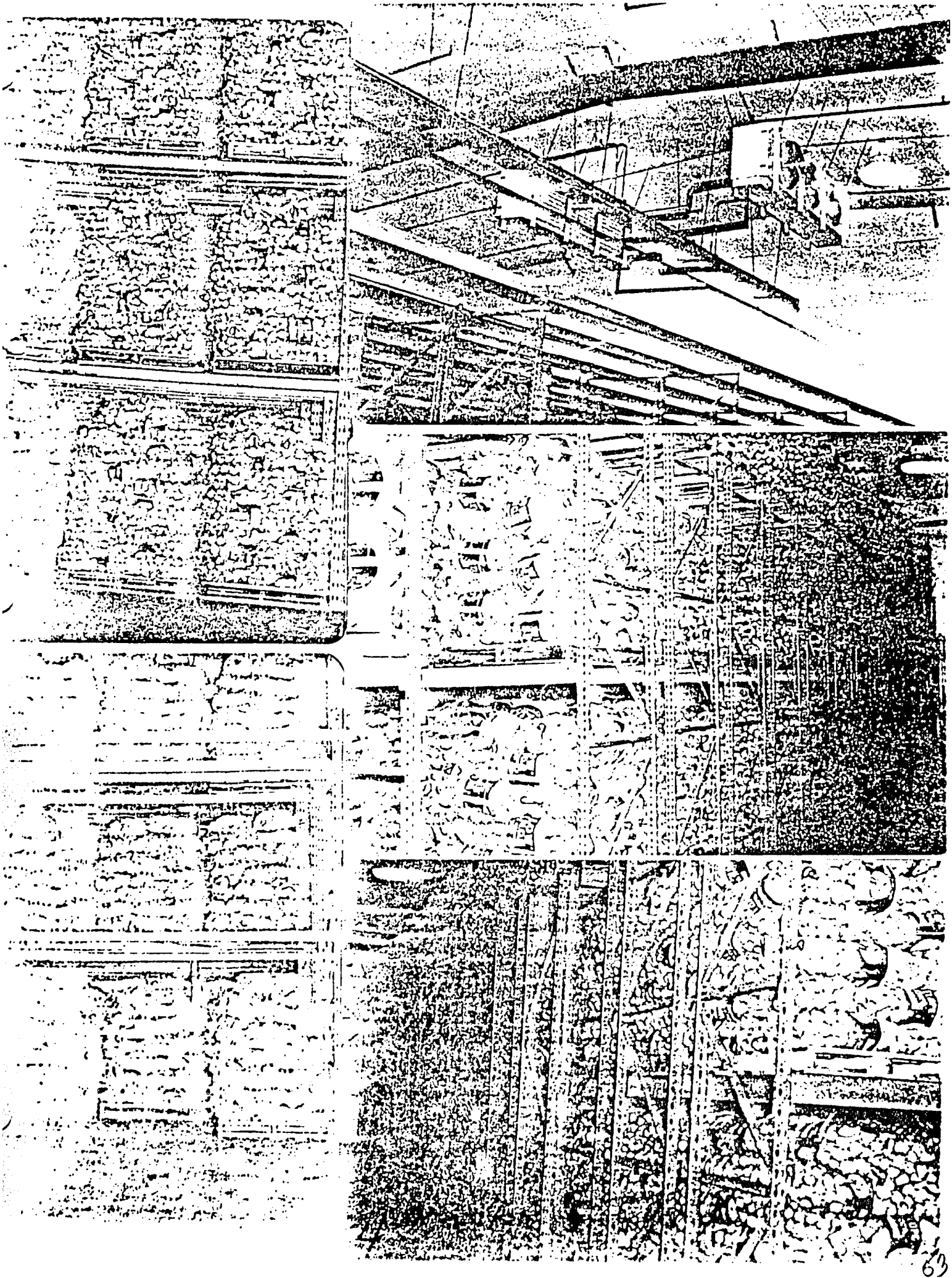

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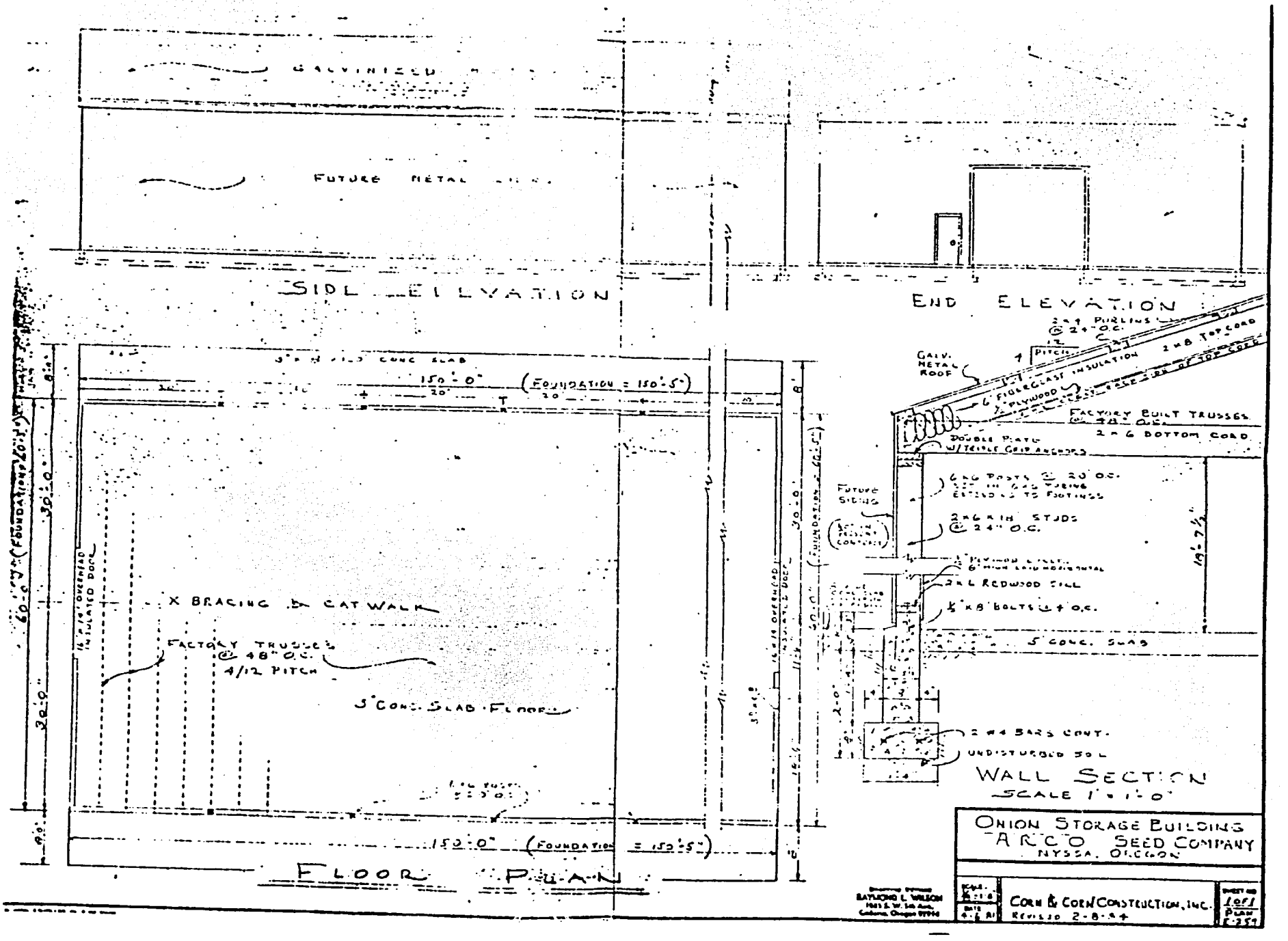
APPENDIX VII



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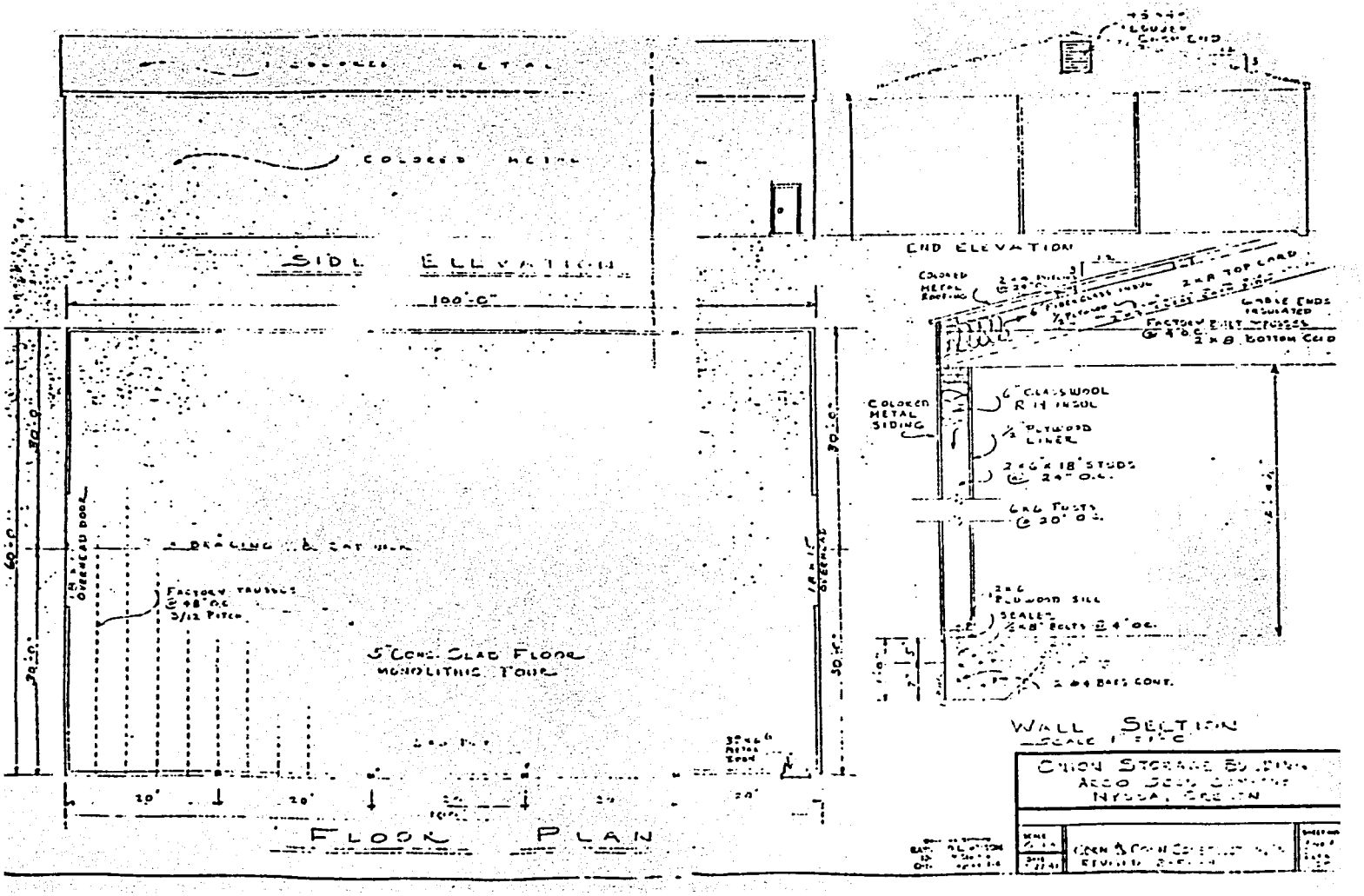
APPENDIX VIII



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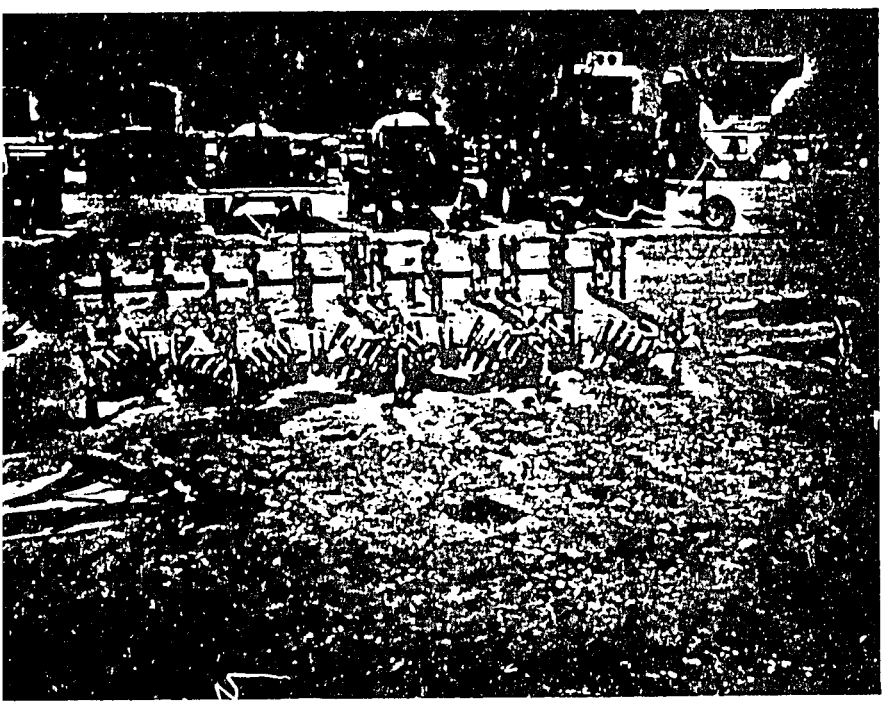
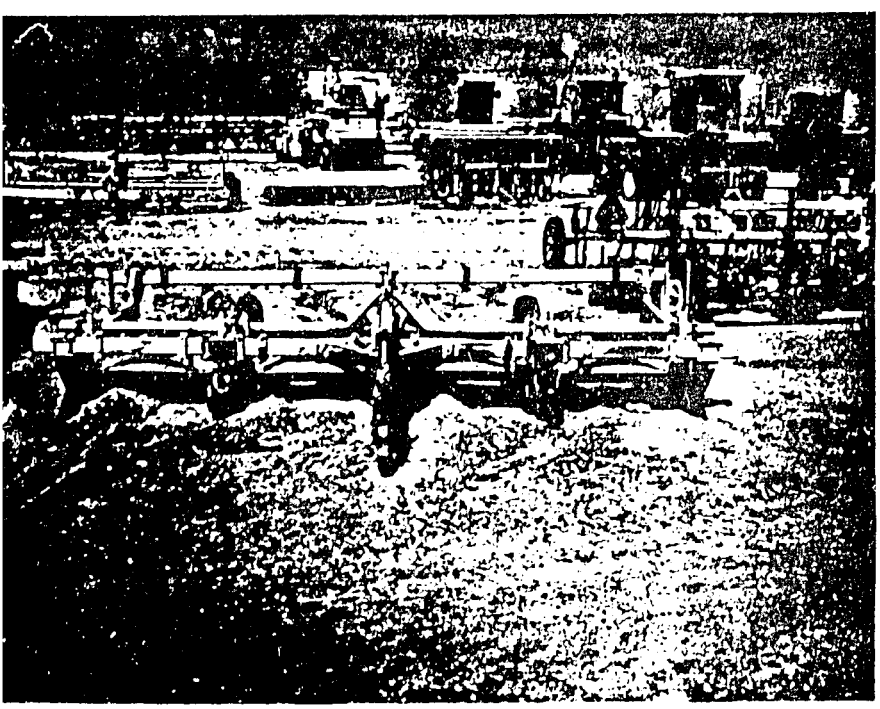
1. LISTER

This makes four beds at one time, 40" from center of furrow to next center. Notice the two outside plows are only half plows. Could make a two row lister. Beds could be 20", 30", or 40", whatever system that could be worked out best. Also see marker on the side.



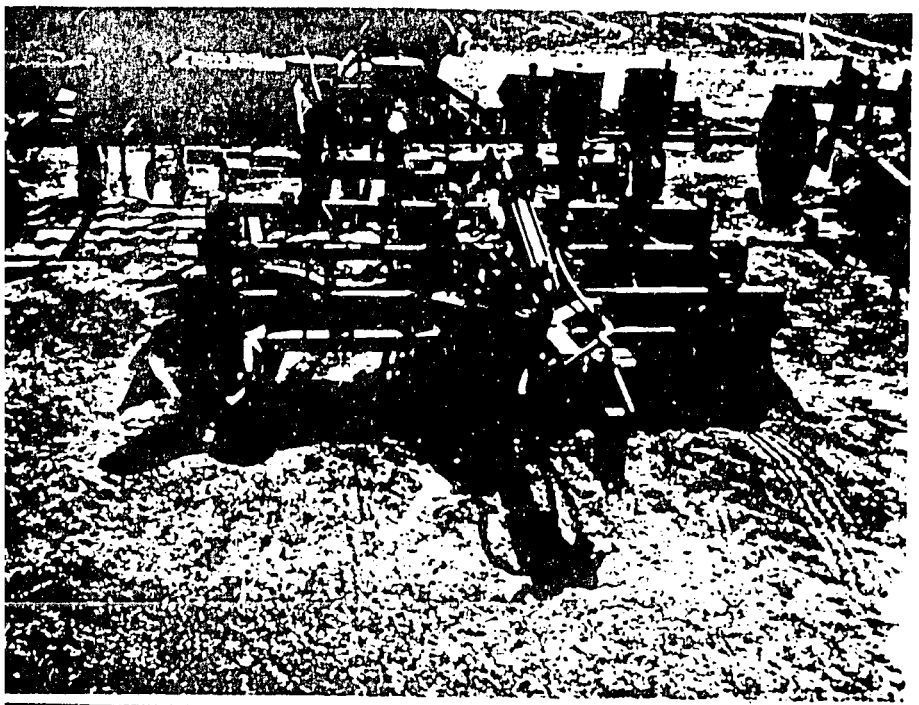
2. LILLISTON

This can be used on the bed to help break up clods, especially if beds have been pre-irrigated. This is done before shaping the bed. It helps the herbicide to be worked in the ground.



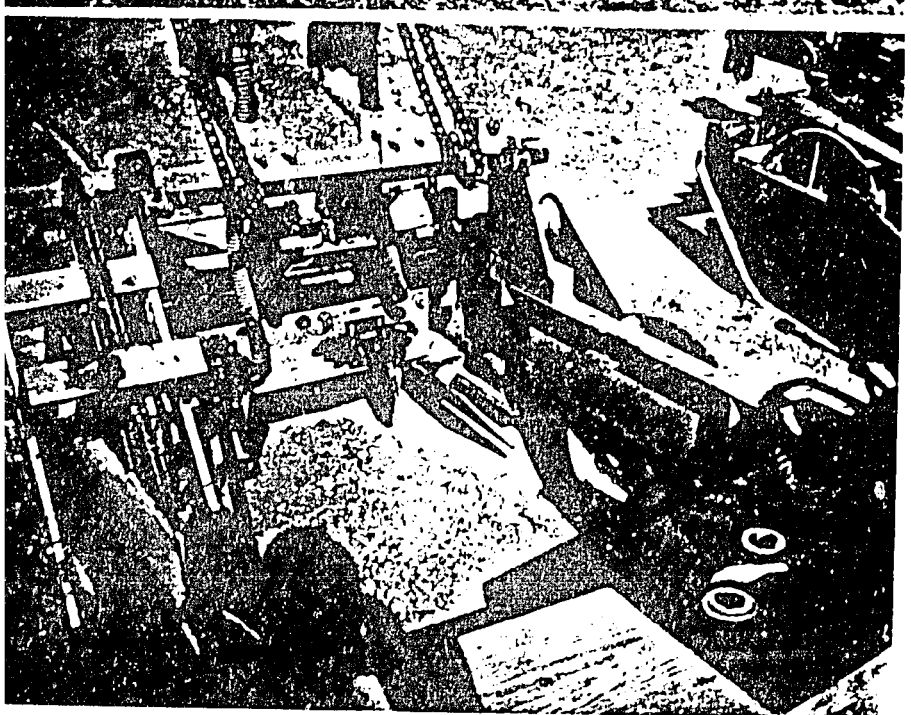
3. BED SHAPER

These can come in two row sizes and can run the planter over the bed for bed shaping.



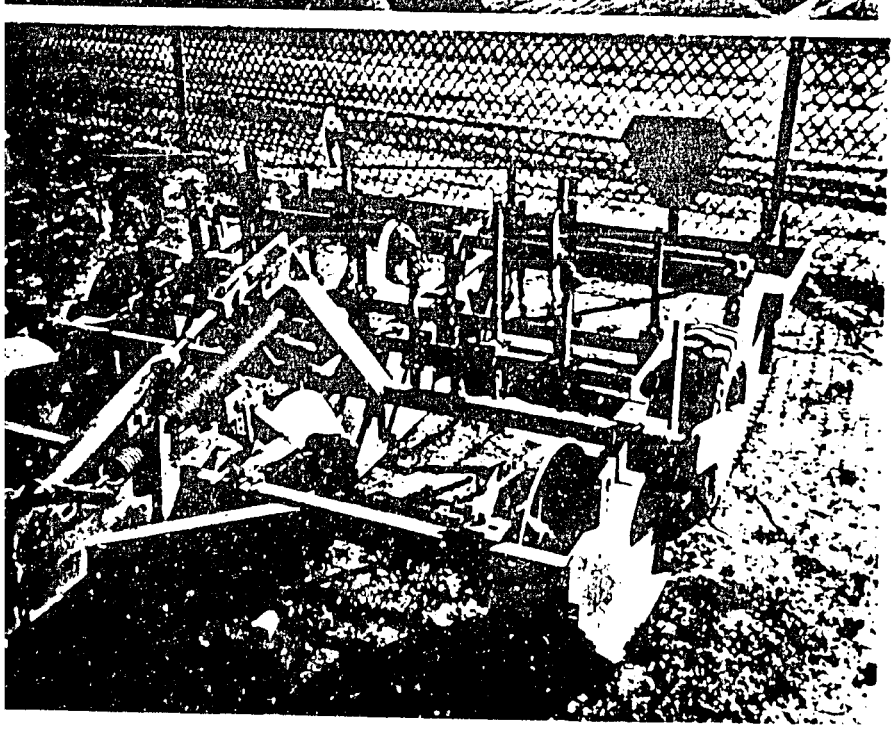
4. TWO ROW PLANTER

With junior seed planter attached. These planters are driven by ground wheel and chain.



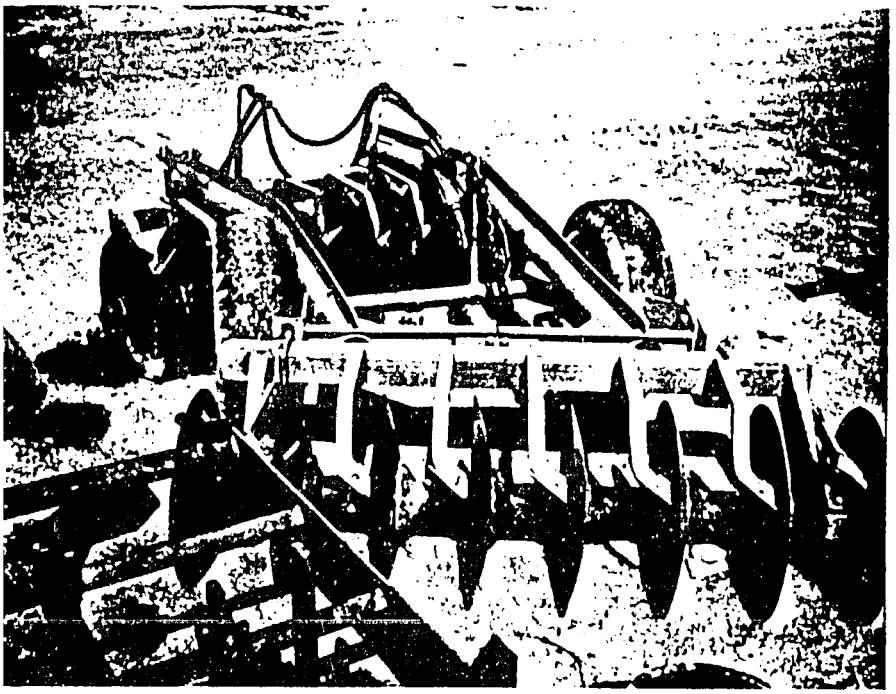
5. BACK SIDE OF PLANTER

Showing the drive mechanism and the adjustable planting shoes.



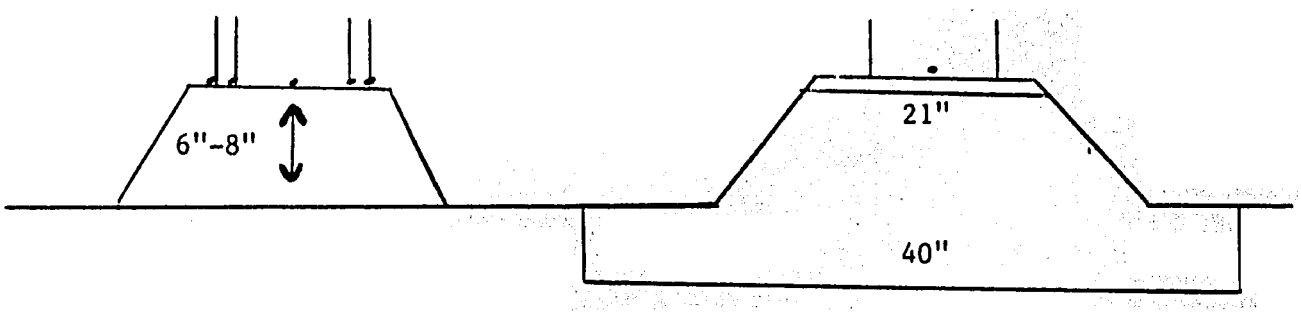
6. SEED CULTIVATOR

Showing the cones to keep the cultivator on line so that close work can be done. Also showing different bars that cultivating knives can be attached to.



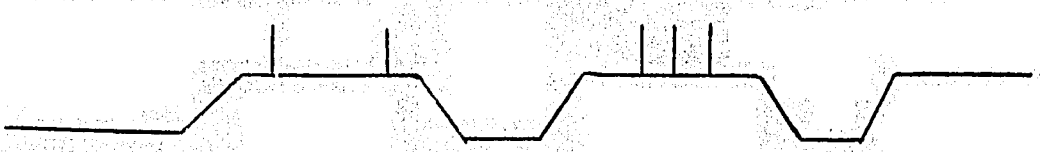
7. SMALL DISC

This can do a lot of ground work with a small tractor.



40" beds with two lines of onions on each side of bed on left bed. One line on each side on right bed. This will make larger bulbs, 4" to 5" in diameter.

20" beds. Left row - 2 rows per bed. Right row - 1 row per bed.



30" beds. Left row - 2 rows per bed. Right row - 3 rows per bed.