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POTATO STORAGE

By W. R. PHILLIPS
Appendix by N. M. PARKS

HORTICULTURE DIVISION
EXPERIMENTAL FARMS SERVICE

DEPARTMENT OF AGRICULTURE
OTTAWA, ONTARIO

CONTENTS

POTATO STORAGE

W. R. Phillips

Horticulture Division, Central Experimental Farm

Potatoes are grown in practically all arable areas in Canada. The bulk of the crop, however, is grown in areas where the onset of freezing weather necessitates harvest during October or early November.

During the period from November to April outside air is cool enough to provide good storage temperatures. Thus a well-designed storage, using outside air as a means of cooling, is adequate. For longer storage mechanical refrigeration will be required during the last few months.

FUNDAMENTAL PRINCIPLES

The potato tuber is designed to hold sufficient food material to nourish the new potato plant the following spring.

Under natural conditions the tuber remains in the ground when frost kills the above-ground portion of the plant. When weather conditions again favor growth, sprouts from the eyes develop new stems, leaves and roots, the tuber supplying energy for this growth until the roots and leaves can function. Potato tubers consist mainly of an organized mass of living cells surrounded by a protective skin or coat. At several points on the surface can be seen the eyes containing the buds which will commence growth under favorable conditions.

Potato tubers consist of living tissue. This tissue is continually carrying on living functions such as respiration, metabolism and other complex chemical and physiological processes. One such function is the conversion of starch to sugars which are ultimately passed off as carbon dioxide and water—just the reverse of the process carried out by the leaves during the growing season.

These living processes are the sources of many problems in storage. First, high temperatures bring about conditions favorable for sprouting. With some exceptions the eyes will start to sprout at, or slightly above, 40°F. On the other hand lower temperatures cause sugars to accumulate, making the potatoes objectionably sweet. Another point is that in order to breathe the tuber has to be relatively porous. This means that the normal moisture (which is about 78 per cent) is likely to be lost through evaporation, when the storage air is dry. If the air is moist, however, the growth of rot organisms will be encouraged both on the tubers and in the storage structure.

Thus it is readily seen that the selection of storage conditions involves considerable compromise. Temperatures must be low enough to stop sprouting but not so low as to cause sweetening. The humidity must be sufficiently high to prevent the potatoes from shrivelling but not so high as to cause rotting. The storage operator is continually faced with the adjustment of these conditions.

TREND IN STORAGE TYPE

Probably the first type of man-made storage was "Pit Storage". It was reasoned, and probably rightly so, that since the natural home of the potato was in the soil, this would provide the best form of storage. So holes were dug

90583—2

in well-drained locations, and the potatoes were put in and covered with sufficient soil, straw and other insulating material to prevent freezing. It was found that these pits heated up, resulting in decay and excessive sprouting. Ventilation flues and manipulation of the straw insulation helped to control this temperature rise but results were not completely satisfactory. For example, if the pit was insulated to prevent freezing at −20°F. and the weather suddenly changed to 35°F. for several days, heating would develop in spite of the ventilators. In consequence pits are not now generally recommended.

Fig. 1. A typical storage pit. These are not satisfactory for potatoes chiefly because of fluctuating temperatures during the storage period.

The next step in potato storages was the use of underground structures or cellars, still employed to some extent. These cellars may be equipped with a ventilator flue and air inlet ducts. By watching the inside temperature, air ventilation can be controlled to a point where good storage conditions are obtained. The chief difficulty with this type of storage is accessibility. It is somewhat difficult getting the potatoes in and out, particularly where large quantities are involved.

To avoid this, potato storages were built above ground or a compromise was made by digging into a bank. The above-ground or exposed portion had to be insulated to compensate for the insulating effect of the soil in the completely underground storage.

Fig. 2. A bank type storage. The above ground portion is of wood with concrete below ground.

Fig. 3. A bank type storage—cement block type of construction.

Later developments included properly engineered ventilators to provide adequate ventilation. These have been more recently displaced with fans where electric power is available. Other changes have involved refinements in temperature control, bin arrangement, loading devices and other mechanical equipment as well as a newer conception of insulation.

The use of mechanical refrigeration involves an added expenditure which is not usually justified during the time of year when cooling can be done by outside temperatures. Mechanical refrigeration is of definite advantage, however, in the spring and early summer when potatoes are held for the maximum storage period.

STORAGE CONSTRUCTION

It is now possible to obtain detailed plans and specifications through the Canadian Farm Building Plan Service. The procedure is to first obtain the catalogue on Farm Storage Buildings from your Provincial Department of Agriculture. Instructions for obtaining plans shown in this catalogue are outlined therein.

Convenience for loading and dispatch are usually the first considerations in choosing a location or site. Although closeness to the production fields is desirable the matter of winter transport during the shipping season, convenience to other farm buildings and accessibility to the workers needed for grading and other operations are perhaps more important.

As in the erection of any building, water drainage is important. A poorly drained location involves extra expense in the way of sump pumps and other drainage devices. A high site in well-drained soil is therefore advantageous, provided it meets other requirements. A tile at footing level around the building leading into a good drain-off is insurance against water trouble on any site.

In the selection of building materials it should be remembered that wood construction when exposed to underground soil can only be regarded as temporary. Cinder block, tile or terra cotta blocks are frequently used but they have a tendency to crack at the joints, resulting in a break in the building seal. The most satisfactory construction material for the under portions of the storage exposed to soil is concrete or properly laid masonry.

The above-ground structure can be of any material that meets the requirements of good building practice. Since concrete is a poor insulator the usual practice is to have the above-ground or exposed parts of the storage made of hollow block or lumber.

Insulation

Insulation Properties

The prime reason for installing insulation is to reduce heat transfer. Insulation prevents the rapid escape of heat during the winter, thus avoiding damage by low temperature; it also keeps out heat during warm weather.

Attempts to control temperature in a storage oppose the natural tendency of the inner part of the building to adjust itself to the outside temperatures. For example, if a reading of 38°F. is wanted in the storage the temperature will proceed to rise when the outside temperature is above 38°F. and will drop when the temperature is below this point. Insulation does not stop this heat transfer but merely slows it down.

Any material will slow down heat transfer because a definite length of time is required for heat to pass through a given substance. The term "insulator" is applied to substances that are particularly effective for this purpose. Thus when heat takes a long time to pass through a substance that substance is an insulator.

The rate of heat transfer is measured in different ways. From a practical standpoint the simplest way is to select a standard insulator and compare other materials with it. Corkboard is usually selected as a standard, since this is the best known of the common insulating materials. The following list gives the approximate number of inches in thickness of various materials that are required to provide the same insulation effect as one inch of corkboard. (Based on A.S.R.E. K value rating of .28.)

Asbestos (packed)	5″	Rock Wool	1″
Asbestos (loose)	4″	Sawdust	2.1″
Corkboard	1″	Pine across grain	3″
Eel grass	1.1″	Wool	0.9″
Fir along grain	8.5″	Bricks	13″
Fir across grain	3.3″	Concrete	19″
Glass wool	1″	Sphagnum moss	1″
Oak (hardwood across grain)	4″ - 6″	Redwood bark	1.1″
		Wheat straw	0.9″
Oak (hardwood along grain)	8″ -10″	Soil dry	3.6″
		Soil wet	36″
Peat (dry dust)	2″	Cinder concrete	8.5″
Planer shavings	1.5″	Snow	0.6″-0.85″

These figures should be regarded as approximate because such things as moisture content, density, and method of installation, have a profound influence on the insulation value. To illustrate, dry soil is a fairly good insulator whereas, if wet, it has only one-tenth the insulation properties of the dry soil. If the figures for asbestos are consulted it will be seen that tight packing reduces the insulation properties. Density of packing is not always a direct relationship. There is usually an optimum density below or above which the insulation effectiveness decreases.

Installation

Soil acts as the main form of insulation in underground storage. In a well-drained location where the soil can be maintained in a reasonably dry state, three feet is sufficient. When measuring this distance it should be kept in mind that the three feet should be from any part of the structure to the outside air. If the soil is reasonably dry this would be equivalent to 3 to 4 in. of cork-board, which by modern standards is considered to be good insulation.

Another important factor to consider in below-ground storages is that in the winter time the ground can be regarded as a source of heat. At a depth of twelve feet or lower, soil temperature is in the neighbourhood of 40°F. and the variation is very slight. If the banking around the storage is well spread out from the building more heat will be obtained from this source, helping materially in frost control.

In underground storages, there is bound to be a portion of the structure above ground, whether it be a loading port, vestibule, the upper portion of the wall, or a complete upper storey. This offers one of the most difficult problems in insulation. This is because underground materials such as concrete are poor insulators, and because soil as an insulator is applied on the outside of the building whereas most insulators are applied to the inner surfaces.

For a completely underground storage or root cellar with a vestibule it is a good idea to construct this vestibule with cinder concrete or cinder block to reduce heat losses. An alternative is to make a complete break between the point of attachment of the vestibule walls and the storage walls. Another compromise is to make the vestibule of wood, regarding this portion of the structure as temporary. In some instances cedar logs have had a fairly long life buried in soil.

If the upper portion of the wall is above ground this should be insulated on the inside. The equivalent of four inches of corkboard should be used, where the wall is exposed. This is tapered off by gradually reducing the thickness to a point at least three feet below the upper soil level. If shavings or loose fill insulation is used, allowance for settling should be made.

When calculating for the thickness of loose fill insulating materials it is customary to increase the thickness by at least 50 per cent to allow for the deficiencies of loose fill as compared with board-type insulators.

Stud contact should be avoided when using loose fill insulation in the walls. This is best done by using the staggered stud system. By this method each alternate stud is set back sufficiently to provide space for the insulation required, making two rows of studs instead of one. (See Fig. 4).

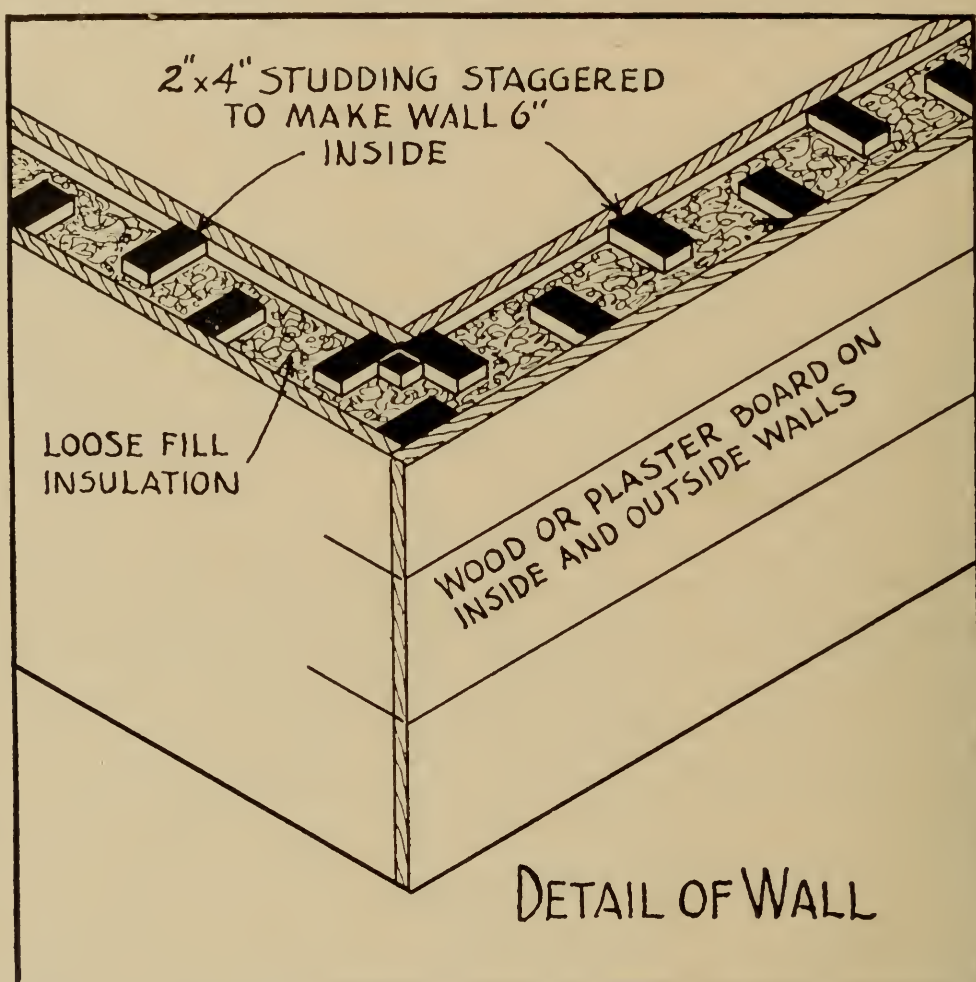

Fig. 4. An example of staggered studding. Note that alternate studs are offset, thus avoiding any stud touching both inner and outer surface.

The roof or ceiling should be insulated in such a way that ceiling and wall insulation is continuous. If board-type insulation is used, the join can be effected by an overlap type of jointing. For loose fill insulates the join is best effected by arching in the upper corners where ceiling and wall members meet. A drop type ceiling is often used. (Fig. 5).

Frequently storages are built completely above ground. Insulation of such structure is identical with that of the above-ground portion of side-hill or bank storage, except for the floor portion.

The floor in above-ground storage does not get the advantage of ground heat. For that reason it must be insulated to prevent freezing during the winter. A board-type insulation laid on a concrete floor is the most satisfactory. This should be mopped on with hot asphalt and covered with a ½- to 2-inch cement finishing coat. This insulation should be extended up the side wall to meet the wall insulation.

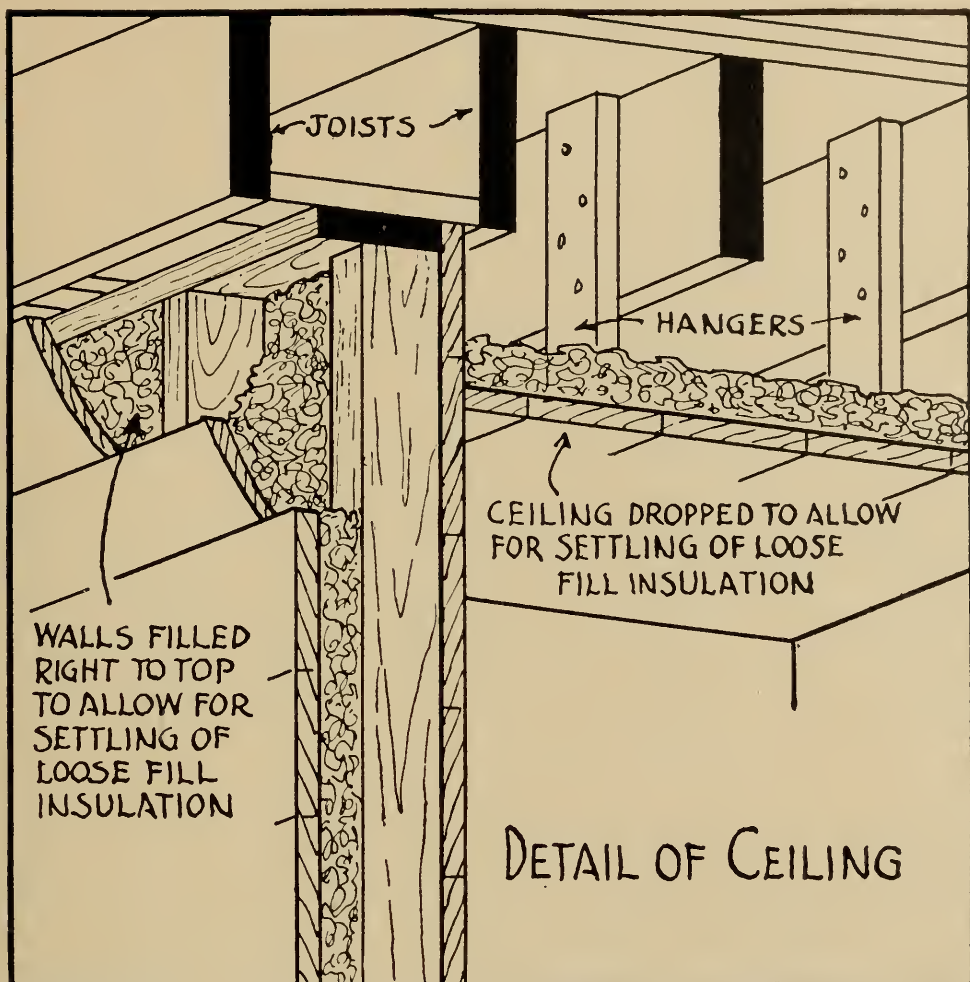

Fig. 5. Application of loose fill insulation to ceiling area. Note hangers to prevent joist contact and provide more space.

Moisture Barriers

Reference has been made to the importance of keeping the insulation dry. Beyond loss of insulation effect there is also the obvious disadvantage of rotting and ultimate disintegration when the insulating material becomes wet. Moisture barriers must be installed to maintain the orginal dryness of the insulation.

High humidities are necessary for maintaining the potatoes in good storage condition. When moist air comes in contact with a cold surface, condensation or "sweating" takes place. In a properly insulated storage the walls and ceiling will be warm, making it possible to maintain high humidities without moisture forming on the inner surface.

If moist storage air is allowed to percolate into or through the insulation, moisture will form when this air reaches colder areas. This means that at some point between the inner and outer wall, moisture will be deposited. The consequence will be that the value of the insulation will be reduced allowing more heat to escape. This in turn causes more condensate until the whole inner wall becomes wet and soggy.

The obvious control is to seal off the inner or warmer surface on the insulated wall or ceiling. This must be a good air-tight seal. The most practical types of seals or moisture barriers are bitumen compounds or papers treated with bitumen. A thorough job must be done and it is often wise to exaggerate the recommendations of the manufacturer. The life and effectiveness of the insulation depends on this moisture barrier.

Bin Construction

Potatoes can be stored directly on the soil. However, a slatted floor with an air space under the bin is more satisfactory. The slat spacing should be one-quarter to three-eighths inch. Wider spacing will not increase the air movement and may cause damage to the tubers.

The tubers should not come in contact with an outside wall. A slatted false wall allowing a one- to two-inch space for air movement will make a satisfactory back-stop to the bin.

The partition between the bins can be of similar slatted construction. However, a two-inch space between bins aids in air movement. Thus the slats can be nailed to both sides of studding forming the partition wall between the bins.

The front of the bin should be constructed so as to make the potatoes accessible. Heavy planks inserted in guide slots so that they can be pried up and removed assists in unloading. If an individual slot for each plank is made at a slight angle, any one of the front planks can be removed independently.

Some potato storage operators prefer to have bin walls built on what are known as "stub-walls". These are simply concrete curbs about 24 inches high. The top has a width of about four inches and forms a sill for the partition. This keeps the wooden partition of the structure well off the ground and so controls dry rot.

Ventilation

It is important that the ventilation equipment be properly designed and installed since the temperature of the storage depends on it. This applies to either natural or forced draft. Proper insulation will aid in the effectiveness and control of ventilation. However, the capacity of the ventilator must be increased if the storage is well insulated. Storage operators sometimes condemn insulation on this account. Usually the trouble results from insulation having been added to a storage equipped with inadequate ventilation. Naturally the ventilation system would be overtaxed under these circumstances.

Natural Draft Systems

The theory of ventilating by natural draft whether it be ventilator stack or flue is that warm air, being lighter than cold air, rises. Advantage is taken of the fact that there is a temperature difference between the storage and the outside air. When this temperature difference is great, as it would be in cold weather, the draft or change of air is great. Unfortunately, when ventilation is required to cool the storage in the fall the temperature difference is slight making poor draft. Likewise when the outside air is warmer than the storage, as may occur in the spring, a reverse or down draft may be created.

Other factors influencing the amount of draft are the height and width of the ventilator. The higher and wider the ventilator the greater is the volume of air removed. Since these factors are controllable it is just a question of making the ventilator sufficiently high and wide to compensate for weather conditions producing the poorest draft.

At least three changes of air per hour are required for good cooling. That is, for every 1,000 cubic feet of empty storage space, at least 3,000 cubic feet of air must be removed through the flue every hour. With the temperature 5 degrees lower outside than inside and the top of the flue 20 feet higher than the storage floor, the cross sectional area of the flue should be 144 square inches (1′ x 1′).

Flue size for each 1,000 cubic feet of storage space is shown below:

Top of flue 20′ from floor—1.0 square foot
Top of flue 25′ from floor—0.8 square foot
Top of flue 30′ from floor—0.7 square foot
Top of flue 40′ from floor—0.6 square foot

Forced Air Systems

The simplest and most effective form of ventilation is by the use of an electric fan. The previous discussion indicates that ventilation by natural draft is almost entirely dependent on weather conditions. When sufficient ventilator size and other precautions are incorporated to allow for ample ventilation when natural draft is poor, it is frequently found that the fan system can be installed at less expense. Another advantage of fan or forced ventilation is that this system lends itself to automatic control.

The first requirement for forced ventilation is available electric power. Having electricity, the next consideration is selection of the proper type of fan. Frequently the ventilation system is rendered completely inadequate by the use of an improper type of fan. A blower or wheel type fan is usually most satisfactory. These are designed to operate under static pressure.

An ordinary type propeller fan (some propeller fans are designed to operate under pressure) may be capable of circulating the desired amount of air when running free. If the same fan has to push air through a duct it will be found that its efficiency will fall off almost entirely.

Pressure is measured as inches of water by a water gauge (W.G.) and the static pressure in most storage layouts exceeds one inch W.G. Hence the basic requirements for a fan are that it be capable of handling 100 c.f.m. (cubic feet per minute) for each thousand cubic feet of storage space at one inch W.G. If the manufacturer will guarantee to meet these specifications the fan will do a satisfactory job.

The fan should be placed in an accessible location and as close to the most convenient discharge point as possible. The discharge port should be of the same dimensions as, or slightly larger than, the fan discharge. A louvre-type damper should be located in the discharge line. This type of damper closes automatically when the fan is not operating, thus preventing uncontrolled ventilation. Care should be taken to have this damper located where it is protected from frost. Moisture freezing on the individual louvres will interfere with their opening freely.

The suction side of the fan may be left open in a small storage. If the fan has to draw air from a longer distance than 20 feet a duct should be installed. This can be made from standard furnace pipe. It is better if adjustable openings are made every six to ten feet to ensure that approximately the same amount of air is drawn from all parts of the storage. A good location for such a duct is over the bins so that warm air is withdrawn as it rises from the potatoes.

Controls

Whether natural or forced draft ventilation is used some form of control must be maintained. If hand control is employed it is just a question of watching both storage and outside temperatures. For this purpose at least one reliable thermometer should be located inside the storage. A thermometer located outside in the shade and not too close to buildings is also necessary.

The dampers are opened by hand when temperature reduction is necessary. Care should be taken to observe the outside temperature; if above that of the storage it is obvious that opening the ventilator will have no effect on temperature reduction. In fact, an increase of temperature may result.

The forced air system lends itself to automatic control. In its simplest form this merely consists of starting the fan motor by thermostats. Such an instrument is simply a switch which is closed when the temperature rises to a predetermined level. If, for example, the thermostat is set for 40°F. the fan will continue to run so long as the storage temperature is 40°F. or higher and will shut off only when it falls below 40°F.

This means that although outside temperatures may be 50°F. or higher the fan will run if the storage is 45°F. resulting in a warming rather than a cooling effect. This can be overcome by (1) a dual thermostat or, (2) a differential thermostat.

Dual Thermostat.—This consists of having two thermostats wired in series so that both have to be closed (on contact) to start the fan motor. One of these is placed in the storage and is set to operate at the desired storage temperature. The other is placed so that the bulb is influenced by outside temperatures. A convenient location for the thermostat is in the vestibule of the storage. The bulb extension should be carried through the wall to the outside and shaded from the sun. It should be noted that this latter thermostat operates in a reverse manner to the storage thermostat.

Control of temperature by this system is maintained by setting the adjustment on the outside thermostat at or slightly below the storage temperature as indicated by the storage thermometer. For example, the storage temperature may be 50°F. by the thermometer. If the outside thermostat is set at 50°F. then no ventilation will take place until the outside air goes down to 50°F. or lower. As the storage temperature drops the adjustment on the outside thermostat has to be changed accordingly.

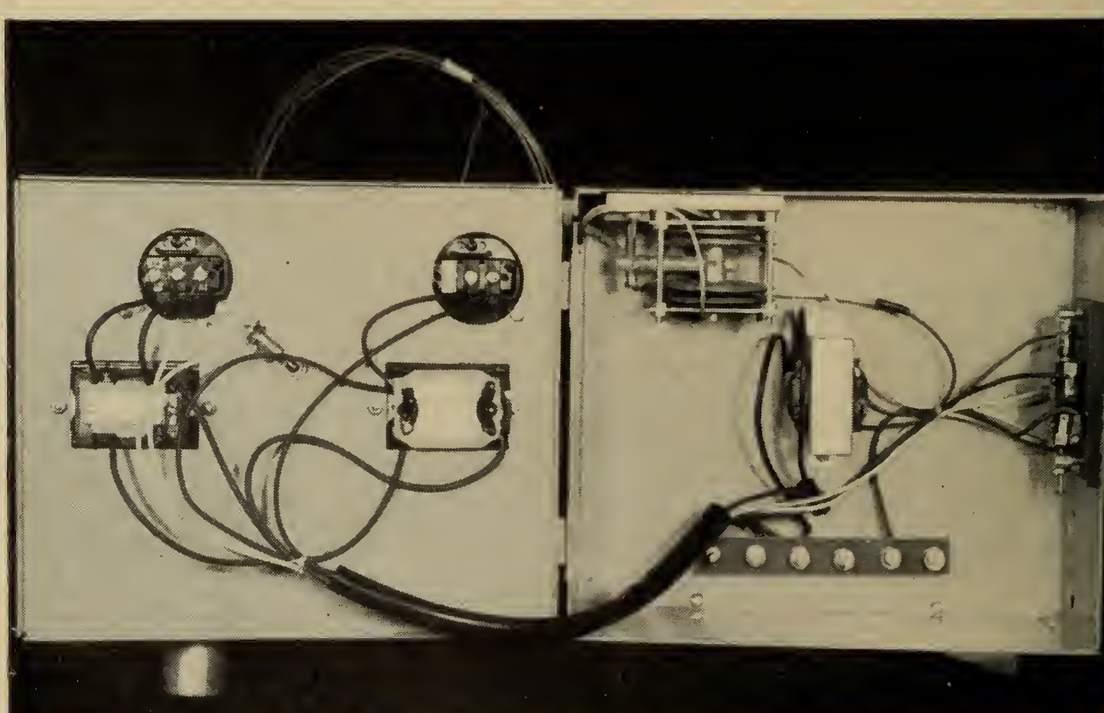

Fig. 6. Control box opened to show temperature control equipment. Note bellows in upper left hand part of box for the control of a differential thermostat. (Courtesy of the Department of Horticulture, Ontario Agricultural College, Guelph, Ontario.)

Differential Thermostat.—In order to overcome this latter difficulty the Department of Horticulture, Ontario Agricultural College, Guelph, have developed what is known as a differential thermostat. This automatically stops the ventilation fan when outside temperatures are higher than storage temperatures. (*See* Fig. 6).

Storage Air Circulation

The terms circulation and ventilation are often confused. Circulation is the movement of air within the storage whereas ventilation involves the exchange of air from outside to the storage.

To promote circulation some engineers suggest forming flues within the storage walls. A space is formed between the inner sheathing and the outer wall. This space is open to the storage at both the top and bottom. Warm air entering at the top meets the outer wall and is cooled, thus setting up a continuous down draft. This cooler air falls to the lowest point of the wall and regains entrance to the storage by various forms of ducts. A gutter or trough is usually located at a point where the condensate can be collected and drained away.

One objection to this form of air circulation is that it is uncontrollable. Condensation and cooling will continue throughout the winter when not needed or at times when it may even be harmful.

If the inner walls are so constructed that there is an air space between the potatoes and the outside wall, it is sufficient. Even when the outside wall is well insulated there is danger of frosting the potatoes if they are allowed to touch this wall.

Having an air space at the bottom of the bins is helpful in aiding air circulation. A three- or four-inch space under a slatted floor permits better air movement throughout the potatoes, keeping moisture and temperature conditions uniform throughout the pile.

Air circulation can be maintained more readily by the use of forced air than by the natural draft system. Diagrams showing both systems are included in the catalogue of plans for Fruit and Vegetable Storages and Equipment, published by the Canadian Farm Building Plan Service.

Heating

Heating is a feature of storage operation which is more abused than used. A stove may be installed merely as an emergency measure, but in practice it is used either for the comfort of the workers or to make up for the deficiencies of insulation. The net result is that the storage operator is slowly dehydrating his potatoes, throwing away many dollars in the form of weight loss.

A well-insulated storage, provided it is well filled, should not require heat even in the most severe weather. The potatoes generate heat and if the insulation prevents this heat from being lost too rapidly, safe temperatures will be maintained. It may happen, however, that the storage is only partially filled during severe winter weather, and temperatures may drop to a dangerous level. Under these circumstances there is no alternative but to provide sufficient heat to prevent loss.

The working space or grading room should be separate from the storage. An insulated wall will prevent the storage from being warmed up and will provide comfort for workers. Frequently, too, a heated room is necessary to warm the potatoes before shipment. If heat is required in the storage it can be blown in from the grading room by means of a fan.

Electrical heating can also be provided in the storage room by placing an element on the suction side of a circulating fan. This can even be controlled by a thermostat making contact when the storage temperatures drop to a predetermined point. This is usually set in the neighbourhood of 34°F. for potatoes.

STORAGE DISORDERS

Most of the disorders arising in storages are a consequence of growing conditions. Such things as blight, fusarium rot, etc. are a result of these diseases existing in the field. Others more directly associated with storage conditions will be mentioned here.

Molds

High moisture conditions are conducive to the growth of molds and also to bacterial rot. For this reason wet conditions should be avoided. As mentioned previously one function of insulation is to keep warm walls and ceilings that would otherwise be cold and wet.

Bruises and cuts caused by rough handling provide entry for molds and rots. Unfortunately, when such rots gain headway, they spread to adjacent potatoes with possible serious loss. The logical control is careful handling and the avoidance of excessive moisture.

Low Temperature Disorders

Potatoes behave abnormally at temperatures below 50°F. The first and most common indication of this abnormal condition is sweetening. This is brought about by the accumulation of sugars. At temperatures down to 40°F. this is barely noticeable except with potatoes used for crisps, chips or French fries. Below 40°F. the sweetening over a period of time may become objectionable. At 30°F. to 32°F., sweetening is almost immediately perceptible.

Another expression of abnormal conditions is low-temperature breakdown. This requires about six weeks at least at 32°F. and longer periods at 36°F. Some varieties are more susceptible than others with Katahdin probably the worst offender. Irish Cobbler is also susceptible while Green Mountain is highly resistant. The injury takes the form of a reddish brown or mahogany colored breakdown area in the flesh.

Freezing can also be classified as a low-temperature disorder. Actual freezing does not take place unless the temperature goes below 28°F. When the frozen tissue thaws out it is soft and watery and the potato has a musty odor. Freezing should not be confused with low-temperature breakdown or other low-temperature injuries.

Light Injury

As in the field, exposure to light in storage causes the potatoes to become green and bitter to taste. When eaten, such potatoes cause digestive upsets or may even be toxic. To prevent the greening of potatoes, prolonged exposure to sunlight, even diffused, should be avoided.

Sprouting

Sprouting is a natural phenomenon rather than a storage disorder. Nevertheless as far as the storage operator is concerned sprouting is the most serious form of deterioration. Sprouting produces an immediate loss in tuber weight and nutrient content. In addition, when the sprouts become long, matting occurs, causing an air seal and resulting in excessive heating and suffocation.

A temperature of 38°F. is required to keep potatoes dormant. At 40°F. slight swelling of buds is followed by sprouting at the extreme limits of storage life. Temperatures above 40°F. can be tolerated for only a few months.

STORAGE OPERATION

A good storage manager will see that the storage building and ventilation system is in good condition well in advance of the potato harvest. During the warm summer weather the storage should be well ventilated to dry out the insulation and timbers.

Timbers and other parts of the wooden structure should be thoroughly examined for weakness. If dangerously weak, such structure should be repaired or replaced. By such precautions the building will be maintained without serious damage.

The walls and floors should be thoroughly cleaned. Spoiled potatoes and other debris should be removed. This should be followed by a thorough spray with a good fungicide. Chlorate compounds are quite satisfactory. The main thing is to use a fungicide that will not leave a residual harmful odor. Formaldehyde is dangerous on this account particularly if it penetrates the earthern floor of the storage. The whole inside surface can be sprayed with a lime and copper sulphate spray (bordeaux). This keeps the building fresh.

Loading

Cleaning and repairing should be completed before harvest starts. Once loading operations commence the storage operator has no time for anything else. The essential features in loading are speed with careful handling and the elimination of damaged and diseased tubers.

Potatoes usually arrive in barrels. These can be rolled, or placed on conveyors, to the bins, Elevators are commonly used for moving from ground floor to basement.

In smaller storages loading chutes are used. These can be made of sacking as shown in Fig. 7, or standard loading chutes made of canvas can be purchased. When starting to fill the bin a man should control the outlet of the chute so that the potatoes do not suffer from direct drop.

Careful inspection of potatoes should be made both in the field and on arrival at the storage. Only sound, disease-free potatoes should be placed in bins intended for long storage. If there is a large percentage of unmarketable potatoes they should be graded out immediately. Frequently grading operations interfere with loading and it usually works out better from the labor distribution standpoint to grade later in the storage season.

The bins should be filled to a height which permits at least 18 inches head space. This space between the top of the potatoes and the ceiling permits the circulation of air, helping to maintain uniform temperatures.

Curing

All potatoes should be held for a period of from ten days to two weeks at a temperature of 60°F. This curing period allows wounds to callus and the skin to toughen.

Storage

Following the curing period the temperature is reduced to 38°F. This procedure will, of necessity, be rather slow. The large bulk of potatoes and relatively warm weather early in the storage period usually means that at least several weeks are required to reduce the temperature.

For short storage 50° to 55°F. would be satisfactory. As mentioned previously, sugars which are detrimental to quality accumulate at lower temperatures. The practical basis for temperature control is to hold at 38°F. to prevent sprout development. If the potatoes are to be consumed before sprout-

Fig. 7. Potato loading chute made of jute sacking for the prevention of bruising.

ing, they may be held at higher temperatures. Another point to keep in mind is that holding for long intervals in the fall at higher temperatures will result in early sprouting in the spring, when the storage temperatures rise to 40°F. or higher.

Potatoes destined for chip manufacture should be given special consideration. A very slight increase in sugars will produce a dark low-quality product. Thus it is very important that such potatoes be held at higher temperatures than those for the general market.

Once the temperature is down it is just a question of controlling the ventilation to hold the temperature at 38°F. Air circulation within the storage should be employed if temperatures show variation from point to point. This will also reduce any condensate that may be present on cold surfaces.

During severely cold weather the temperature may be satisfactory without ventilation. This may cause the accumulation of gases harmful to the potatoes. A good test is to light a match and if it goes out the storage should be ventilated slightly. In a well-insulated storage needing frequent ventilation for temperature control, gas accumulation is not a problem.

Another difficulty is that temperatures may drop below the desired level with the ventilators closed. This is more likely to happen if the storage is only partially filled. If the temperature drops dangerously low it will be necessary to apply heat. This can be done with an electrical element, stove or by blowing in warm air from the packing room. Heat should be applied only as a last resort. If it is necessary to apply heat for a prolonged period, steps should be taken to increase the insulation the following year. Heating desiccates the potatoes causing considerable weight loss.

It is wise also to examine the potatoes from time to time. Blight or other disorders may be causing high financial losses during the storage season. This occurs sometimes in spite of all precautions. Nevertheless, even under the most adverse circumstances, an alert storage operator can reduce financial losses to a great extent.

APPENDIX

N. M. Parks, *Horticultural Division*

Sprout Inhibitors

Sprouting of potatoes in storage results in shrinkage, weight loss, and general deterioration of both market and cooking quality. In recent years chemicals have been discovered and methods developed whereby sprouting of potato tubers can be retarded for several months when held at temperatures higher than those considered ideal for proper storing of potatoes.

The sprout-inhibiting hormone, methyl ester of alpha naphthaleneacetic acid has been commonly used for this purpose. Experiments have shown that the same concentration of this hormone was more effective as a dust than as a spray. The chemical had very little inhibiting effect on the sprouting of potato tubers stored at 68°F. Storage temperatures of 39°F. were more effective in delaying sprouting than the many materials studied. Even a reduction in storage temperature from 68° to 55°F. was more effective in inhibiting sprouting than was the hormone treatment on potatoes stored at 68°F. If potatoes treated with this chemical are stored at high temperatures, they will sprout but at a slower rate than untreated potatoes.

The application of sprout-inhibiting materials to potato tubers on a commercial scale has always presented a problem. One method has been the impregnation of shredded paper with the chemical and the distribution of the paper through the bin at time of storing. Another method has been to spray the diluted chemical on the tubers as they are stored in the bins. The third method is dusting the chemical on the tubers when they are being stored after harvest. To apply the sprout inhibitor on a commercial scale either as a spray or dust necessitates moving the potatoes over a belt conveyor, bin loader or sorting table equipped with either a pressure mist sprayer or a dust applicator. For small quantities of potatoes stored for home use the dust application is most convenient.

Recently, considerable success has resulted from the use of maleic hydrazide as a sprout-inhibitor. Application of this material to the potato plants at a concentration of 0.25 per cent of active ingredient six weeks before harvesting retarded sprouting of potatoes held in storage for seven months at a temperature of 55°F.

From the result of this work it would appear that hormone treatment of the growing plant by spray application holds great promise as a means of inhibiting the sprouting of potatoes. The use of maleic hydrazide as a sprout inhibitor on potatoes has recently been approved by the Food and Drug Directorate, Department of National Health and Welfare. The residue tolerance of 20 p.p.m. of maleic hydrazide is permitted for potatoes. The effective amount of maleic hydrazide recommended for use as a sprout inhibitor on potatoes conforms to the tolerance permitted.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
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