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Fundamentals of Seed Drying

B. Campbell

FUNDAMENTALS OF SEED DRYING

Bowen Campbell [1/]

As all of you know, I am sure, the artificial drying of seed is a necessity in many cases and is a worth while operation in a good many other cases. In discussing the fundamentals of seed drying, I will skip most of the theory of drying as I am sure this could be better discussed by the professors and scientists at Mississippi State University. Suffice it to say that in an air dryer, whether natural air or heated air is used, the rule of thumb is that it takes about 1,000 BTU to evaporate a pound of moisture. There is no way to get around this basic drying fact. Varied and intricate designs of driers have been devised with no appreciable benefits. Infra-red radiation, high frequency radiation, vacuum and freeze drying have been tried but it requires heat energy to evaporate the moisture. Therefore, the dryer design should be made as simple and straight forward as possible.

The air in a heated air dryer has two functions; one of which is to supply this 1,000 BTU of heat for evaporating the moisture and the other is a vehicle for transporting the moisture away from the seed being dried and exhausting it into the atmosphere. Even in natural air drying this 1,000 BTU per pound of moisture evaporated is supplied by the air. In picking up the moisture from the seed the air is actually cooled in dry bulb temperature down to near the dew point and is exhausted from the drying bin a few degrees cooler than the temperature at which it entered the bin.

For any variety of seed or grain there is an equilibrium between moisture content and relative humidity of surrounding air. See Figure #1. For 12% Corn this is about 55% relative humidity. Heated air dryers speed up the drying over natural air drying because the relative humidity of the air is reduced below this equilibrium point by raising the temperature. The lower the relative humidity of the drying air the greater the difference from the equilibrium relative humidity and the faster the drying.

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ADSORBED MOISTURE IN EQUILIBRIUM WITH AIR OF VARIOUS HUMIDITIES AT ROOM TEMPERATURE (APPROXIMATELY 77F)

	Moisture content (wet basis), in percent							Authority
Relative humidity (percent)	15	30	45	60	75	90	100	
Barley	6.0	8.4	10.0	12.1	14.4	19.5	26.8	C&F
Buckwheat	6.7	9.1	10.8	12.7	15.0	19.1	24.5	C&F
Corn, shelled, YD	6.4	8.4	10.5	12.9	14.8	19.1	23.8	C&F
Corn, shelled, WD	6.6	8.4	10.4	12.9	14.7	18.9	24.6	C&F
Corn, shelled, Pop	6.8	8.5	9.8	12.2	13.6	18.3	23.0	C&F
Flaxseed	4.4	5.6	6.3	7.9	10.0	15.2	21.4	C&F
Oats	5.7	8.0	9.6	11.8	13.8	18.5	24.1	C&F
Rice, rough	5.6	7.9	9.8	11.8	14.0	17.6	-	K&A
Rice, undermilled	5.9	8.6	10.7	12.8	14.6	18.4	-	K&A
Rice, polished	6.6	9.2	11.3	13.4	15.6	18.8	-	K&A
Rye	7.0	8.7	10.5	12.2	14.8	20.6	26.7	C&F
Sorghum	6.4	8.6	10.5	12.0	15.2	18.8	21.9	C,R&F
Soybeans	-	6.2	7.4	9.7	13.2	-	-	R&G
Wheat, white	6.7	8.6	9.9	11.8	15.0	19.7	26.3	C&F
Wheat, Durum	6.6	8.5	10.0	11.5	14.1	19.3	26.6	C&F
Wheat, soft red winter	6.3	8.6	10.6	11.9	14.6	19.7	25.6	C&F
Wheat, hard red winter	6.4	8.5	10.5	12.5	14.6	20.1	25.3	C&F
Wheat, hard red spring	6.8	8.5	10.1	11.8	14.8	19.7	25.0	C&F

(C&F) Coleman & Fellows. Hygroscopic moisture in cereal grains. Cereal Chem., vol.II, pp.275-287, Sept. 1925. (Moisture content determined by water-oven method.)

(C,R&F) Coleman, Rothgeb & Fellows. Respiration of sorghum grains. USDA Tech. Bul. 100, Nov.,1928. (Moisture determined by vacuum-oven method.)

(R&G) Ramstad & Geddes. The respiration and storage behavior of soybeans. Univ. Minn. Tech. Bul. 156, June, 1942. (Moisture determined by vacuum-oven method.)

(K&A) Karen & Adams. Hygroscopic equilibrium of rice and rice fractions. Cereal Chem., vol. XXVI, pp. 1-12, Jan., 1949. (Moisture determined by forced-draft air-oven method.)

Figure #1

Seed is especially hard to dry because the drying temperature is limited to 110°F. or there about for fear of damage to the germination and therefore, the relative humidity of the drying air cannot be reduced as low as it is in high temperature commercial grain dryers. All of you who have seed dryers have experienced the slow drying on hot humid afternoons. It can be shown on a psychometric chart that the humidity of the heated air may be as high as 50% after being heated to 110°F, which will only, after a long time, dry seed down to the 12% moisture content required. Some drying, of course, will be done in the bins where the moisture content of the seed is relatively high because the relative humidity at equilibrium is possibly 90 or 95%, if the moisture of the seed is as high as 25 or 30%.

I would like to discuss hybrid seed corn drying as that is the field in which I have had the most experience, but the principles involved apply to other kinds of seed. Seed corn is dried on the ear for reasons you know better than I. A few growers are shelling before drying but tests are indicating that the vigor and viability of the seed corn is adversely effected. The design of hybrid seed corn drying plants is not an exact science from an engineering point of view. Certainly there are many known facts and formulas to be applied, but there remains a considerable quantity of practical design information that is constantly changing. Dryer design can be said to be more of an art than a science. In 35 years of working with the seed corn industry I have been in the fortunate position to grow up with and observe the evolutionary changes. As a result, drying plant and equipment design today is very different from the early plants, and very much better, I might add. Some of you remember the drying equipment used 30 or 35 years ago when gas as a fuel was not often available and practically every drying plant used fuel oil. The burners were very crude and hard to adjust, the temperature was regulated manually by turning the fire a little higher or a little lower and there were practically no safety controls except a high temperature limit. The burners were manually lighted with a torch. Today most dryers burn gas with electric ignition, automatic temperature control and safety controls that may go to the other extreme of being a little complicated causing nuisance shut downs.

The fans have evolved from the original squirrel cage blowers that considerably overloaded the motors easily under some conditions of low static pressure. They were lacking in ability to build up the static pressures that we use today.

The bin construction has certainly improved to permanent type, fire proof, air tight, construction with self cleaning floors and more or less self leveling in filling. The material handling equipment for filling and emptying the bins works almost to perfection now. I know of one plant where the capacity of about 10,000 bushels per 24 hours in which two women handle the filling and emptying of the drying bins.

Some of the variables that defy analysis for design purposes are the wide ranges of temperature and humidity of the air during the drying season affecting the drying rate, expecially since the temperature rise is rather small under some conditions such as warm afternoons and high humidities. There is a wide variation in the moisture content of the corn put into the drying bins, some as high as 40% early in the season down to 25% or lower towards the finish.

There is a wide variation in the number of bins that are filled at any one time which is influenced by the weather and the ability of management to make the best use of drying bins available. It is quite customary as soon as it is decided to pick seed corn that all of the bins in the building are filled with very high moisture corn and the equipment has to be capable of drying it before mold and bacteria growth cause damage. This requires high capacity equipment and the design must be a compromise to give operating efficiency during normal operation of the drying plant. On the other side of the operation we have seen instances during the drying season when the bins become completely empty due to weather that prevents picking of the seed corn.

The air resistance through a bin of corn varies considerably with a type of corn. The high percentage of single cross hybrid seed corn being produced today packs into the bin rather tightly making it necessary to provide a higher static pressure than was the case a few years ago. The single crosses, in addition, are usually picked at high moisture content to prevent field losses on account of the high value of this type seed corn and this adds to the drying problem.

The tendency, therefore, in drying plant design is to go to larger motors, higher static pressures and high air volumes for any given bin. There are also lesser variables such as the fact that some hybrids have larger cobs that hold moisture and you can probably think of a half dozen other variables.

A seed drying plant can be designed with any number of bins depending upon the number of different varieties that it will handle, the ease of filling and emptying and so forth, but it should have enough bins so that an orderly rotation of the use of the bins can be accomplished.

Drying plants are usually designed so that each bin will dry in about 72 hours. Using the data shown in Figure #2, a chart should be prepared indicating how deep to put the seed corn in the bins for the various original moisture contents so that there will be about the same amount of moisture to evaporate from that bin whether it goes in originally at 35% or higher, or, later in the season goes in 25% or lower. The manager of the drying operation can then anticipate that the bin will dry in 72 hours and rotate the use of them accordingly. This drying time for a bin seems to be desired by the industry as it is well within the time that will get the seed corn dry before mold and bacteria action has begun to cause any damage to the germination. This also works out to be the most economical use of the drying bins and drying equipment.

No seed drying plant can be designed for 100% operating efficiency. Heated air drying plants instead of requiring a 1000 BTU/lb. of moisture evaporated may require 2000 or 3000 or more BTU/lb. of moisture evaporated due to the fact the heated air that supplies the heat for evaporating the moisture and carrying it away carries with it, when exhausted from the drying bins, a considerable amount of heat. The efficiency of the drying plant design has to be a compromise, taking into consideration the original investment in the drying bin building itself and the relation of the air handling and heating equipment with the operating costs for fuel and power. It is a pretty complex problem to arrive at the best solution, taking into the account the wide range in different type of building cost, power and fuel costs.

Figure #2

Approximate amount of water in ear corn, when harvested at different percentages of moisture content of the kernels

Kernel moisture content (percent)	Amount of water in a bushel of ear corn		
	In kernels (pounds)	In cobs (pounds)	Total (pounds)
35	25.5	12.4	37.9
30	20.3	9.9	30.2
28	18.4	8.8	27.2
26	16.6	7.8	24.4
24	14.9	6.7	21.6
22	13.3	5.5	18.8
20	11.8	4.4	16.2
18	10.4	3.2	13.6
16	9.0	2.1	11.1
14	7.7	1.4	9.1
12	6.5	0.9	7.4
10	5.3	0.5	5.8

*A bushel of ear corn is defined here as the quantity that will yield 56 pounds of shelled corn at 15.5 percent moisture.

Drying of seed corn is being done in crib type structures, round steel bins with perforated floors, multiple round bins, steel or concrete stave/silo types or drying bin structures of frame construction, pole construction, prefabricated steel, masonry construction, poured concrete structures and tilt up concrete structures. Typically drying costs run about as follows:

Depreciation and interest on the drying bins	14¢/bu.
Power	2
Fuel, natural gas	4
Labor	7
	27¢/bu.

The cheaper structures are probably not economical because of higher depreciation rates, higher fire insurance rates, and less operating efficiencies. However, less capital investment is sometimes a necessity and any of the above types of construction can be used in the design of an effective seed drying plant. The best type of construction and design of your plant should be worked out with your consulting engineer and contractor.

There are two basic designs of drying plants consisting of continuous flow dryers or batch dryers. Seed drying has not in general worked out well with a continuous flow dryer due to the necessity of keeping individual varieties and batches separate. At one time it seemed the sorghum seed industry could use the continuous flow dryer to good advantage but the trend is now to batch type dryers very similar to the design of the hybrid seed corn plants. The drying bins are built with the same type of loping floors, filling and emptying conveyors and heated air drying equipment. The sorghum seed is put in the bins to a uniform depth of about 30 inches. If a continuous flow dryer is advisable in some instances for seed it should be designed for counter flow.

There are two further types of dryers, namely; counter flow and con-current or parallel flow. The con-current or parallel flow is being tried in commercial dryers sacrificing operating efficiency for high capacity using high drying temperatures, but our study of it so far does not indicate it would be the huge success its sponsors hoped, and we feel sure it has no application at all in seed drying.

Counter flow means the product, seed to be dried, flows in the opposite direction from the drying medium, heated air, giving the highest efficiency. This means that the entering heated air comes first in contact with the driest seed and as the air progresses through the dryer it picks up moisture and loses temperature. It contacts higher and higher moisture content seed until, on being exhausted, it is passing over the coolest and the highest moisture seed just being brought in from the field that needs to be warmed to start the drying process and has surface moisture present which can be quickly and easily evaporated. The air is then exhausted at a relatively high humidity and low temperature, resulting in the highest efficiency.

Since continuous flow dryers are not suitable for most seed drying operations, an approximation of this counter flow principle can be accomplished by using a two-pass system in which the high temperature drying air is first directed through the bins containing the more nearly dry corn. This then picks up only a small amount of the moisture it is capable of holding and loses only a small portion of its heat. It is then transferred and exhausted through one of the more nearly freshly filled bins that needs to be warmed up and surface moisture is available for being evaporated. This makes a little more complicated drying procedure but is well worth it, as in our opinion it adds about 25% to the drying capacity of a given size drying plant and reduces the fuel cost considerably, although it adds something to the power cost. Below are some illustrations of this type of design.

This two-pass design also has an advantage in that there is some added protection to the germination of the seed. Seed is more susceptable to damage from high drying air temperatures when the moisture content is high, and less susceptable to this damage when the moisture content is low. Therefore, only the nearly dried seed is subject to a possible 110 or 115 degree drying air temperature and the high moisture seed is exposed to drying air at 80 or 90 degrees or less.

Another common design of seed drying plants is a single-pass arrangement with the capability of reversing the air direction through the various bins occasionally to obtain uniform drying. In the single-pass system, you can realize that when the bin is first filled, the drying air first comes through the bin and is exhausted, nearly saturated, but towards the end of the drying cycle the air is being exhausted without having picked up very much moisture and not having given up much of its heat so that it has considerable drying potential being wasted. This method of drying has only about 80% of the efficiency and capacity of the two-pass system.

A third type of drying plant design is a single-pass system with no provision for reversing air direction, and the drying of the seed is probably several percentage points too low where the air enters the bin, usually the bottom of the bin, and several percentage points too high where the air leaves the bin. The operator then depends on the blending of the seed to equalize the moisture content. There problably is some damage to the rough ears in shelling and we estimate that such a plant is about 75% of the capacity and efficiency of the two-pass system.

Below are some photographs of seed drying plants. The bins are of different types of construction and the drying equipment in some cases is portable equipment on skids which has the advantage that the unit is factory run and tested and comes ready simply to put in place and connect up the power and fuel lines.

The stationary drying equipment is quite often built into a steel building and some of the plants have drying equipment at each end. This is due to the fact that it is not practical to go above a certain motor, blower or burner size. In fact, costs start to rise disproportionately and it is cheaper and more flexible to use two units.

Drawings for building drying bins to get the best possible drying results are presented at the end of this article. These drawings are worked out on a basis of good balance between the investment in the bins, the investment in the drying equipment and the operating efficiency.

The first drawing is of a small size drying plant using the two-pass system with a small portable drying unit. This portable drying unit, and in a good many of the stationary drying equipment buildings, is elevated enough so that the fresh air can be brought up thru the unit from the bottom. The advantage of this arrangement is that the wind effect on the distribution of fresh air over the burner has very little effect; therefore, a very even and uniform drying air temperature is obtained. The screens on the fresh intake are not being continually plugged with husks and other foreign material. In addition the line burner can be spread out over the area of the fresh air intake and the heat from the burner has a good chance of getting well mixed with the air in traveling from the burner to the blower intakes and then is further mixed in passing through the blower. A good uniform temperature is essential for good safe seed drying.

The second drawing shows another small two-pass system used for foundation seed and therefore, has smaller bins and more of them. It illustrates a sloping roof with enclosed top conveyor.

Drawings three and four illustrate another two-pass drying system of eight bins, and you will notice these drawings are more in detail as it was structurally designed. They are good illustrations of a frame building. Buildings built of something more permanent and fireproof are preferable but, with careful design, and a few precautions a frame building can be entirely practical.

The fifth drawing illustrates a single-pass drying system, but in which the air can be reversed to get even drying, and also illustrates the use of round bins. The lesser efficiency of a single-pass system is somewhat offset by the ability to reverse the direction and the fact that the corn can be put in these bins 14" deep.

The sixth drawing illustrates round steel bins simply blowing up through and is probably one of the cheapest ways from first cost standpoint of building a drying plant.

The seventh and eighth drawings illustrate another method of drying that may have some merit and is being used more frequently. This illustrates a two-pass pull through system in which the air is pulled into the drying plant at the ground level past the burners where it is heated and then is pulled through the bins in the rotation of sequence as desired and exhausted by the blowers finally to the atmosphere. This building was originally designed to make it possible to cool the corn before it is taken from the bin for shelling. Two of the seed drying companies who have had this type of system have duplicated the drying system after a few years use of the first one constructed. They indicate that they are getting exceptional drying capacities and efficiency, which is a little hard to explain. The most likely explanation is the fact that any leakage in building construction, and the doors in particular, is inward. Leakage air, which is normally lost completely in the normal drying plant in the pull through plant, mixes with the drying air and has some moisture carrying capacity which is useful. It is surprising how much drying capacity and efficiency is lost due to leaky building construction and poor fitting doors in drying plants. Since the leakage cannot be observed, the dryer operators are not aware of a rather significant loss.

The ninth drawing might be applicable to a good many seed processors of small seed who have many small batches. It has worked well for several hybrid seed corn growers for their parent stock and inbred drying. This might be good for all types of small seeds. The seed is put into boxes with perforated floors to an appropriate depth and these are moved by means of a fork truck and placed two or three boxes deep on each side of a central air duct. The air is blown only one way up through the drying boxes but the depth is rather shallow with the air volume high since high efficiency is not too much of a consideration. The fork trucks can be provided with a device for tipping and emptying the boxes so that the handling of this seed is rather simple with minimum amount of labor.

There is some interest in drying seed to extremely low moisture content for carry over a year or longer. Shelf life and this is a difficult problem. For instance, on a 50°F. day with 50% relative humidity, if the drying air is heated to 110°F., the relative humidity is reduced only to about 15% which leaves no spread from the approximate 15% equilibrium relative humidity for 6% moisture seed for bringing the moisture content of the seed down. If the seed can be dried down at harvest to a reasonable low moisture content, such as 10 or 12% for storage, it can be dried on down to a very low moisture percentage at some later time when the outdoor temperature is 32°F. or below, because then, by heating the air to 110°F., the relative humidity can be reduced to 7 or 8%. There is a spread between this and the 15% approximate equilibrium relative humidity for 6% moisture content seed.

Another alternative is to dehumidify the air either chemically or with a reverse refrigeration cycle, and then the complete drying to a very low moisture percentage can be done at harvest in drying bins. Another alternative is to dry the seed in storage over a long period of time by keeping it in a room in which the atmosphere in the room is dehumidified.

We might discuss for a minute the various fuels and their relative cost. Natural gas is ordinarily the cheapest and best fuel. LP gas may require vaporizing of the liquid from the tank and is probably the most expensive fuel. Fuel oil is in between, and with the proper fuel oil burning equipment, causes very little difficulty. To get a rough check of the comparative fuel cost, simply figure the cost of a therm which is 100,000 BTU and in the average seed plant location, natural gas can be purchased for 5 or 6¢ a therm, fuel oil for 9 or 10¢ a therm, and LP gas for 12 or 13¢ a therm.

The burner controls that you need for seed drying equipment consists of the following and I'll try to list them in the order of their importance:

1. An air flow air pressure switch that will assure that the blower is delivering somewhere near its full air volume before the burner can be operated, or if the volume should fail during operation, the burner will automatically shut off. This is the most important safety control on the burner. Even with the gas supply valve wide open and unlighted there is so much dilution of the gas with the air being handled that it does not form an explosive mixture. Those of you who have drying equipment know that with the blower running you can open the gas valve and some minutes later ignite the gas burner with a nice smooth ignition of the burner without any puff or trouble.

2. The burner should be wired in electrically so that the burner cannot possibly operate unless the blower motor is energized.

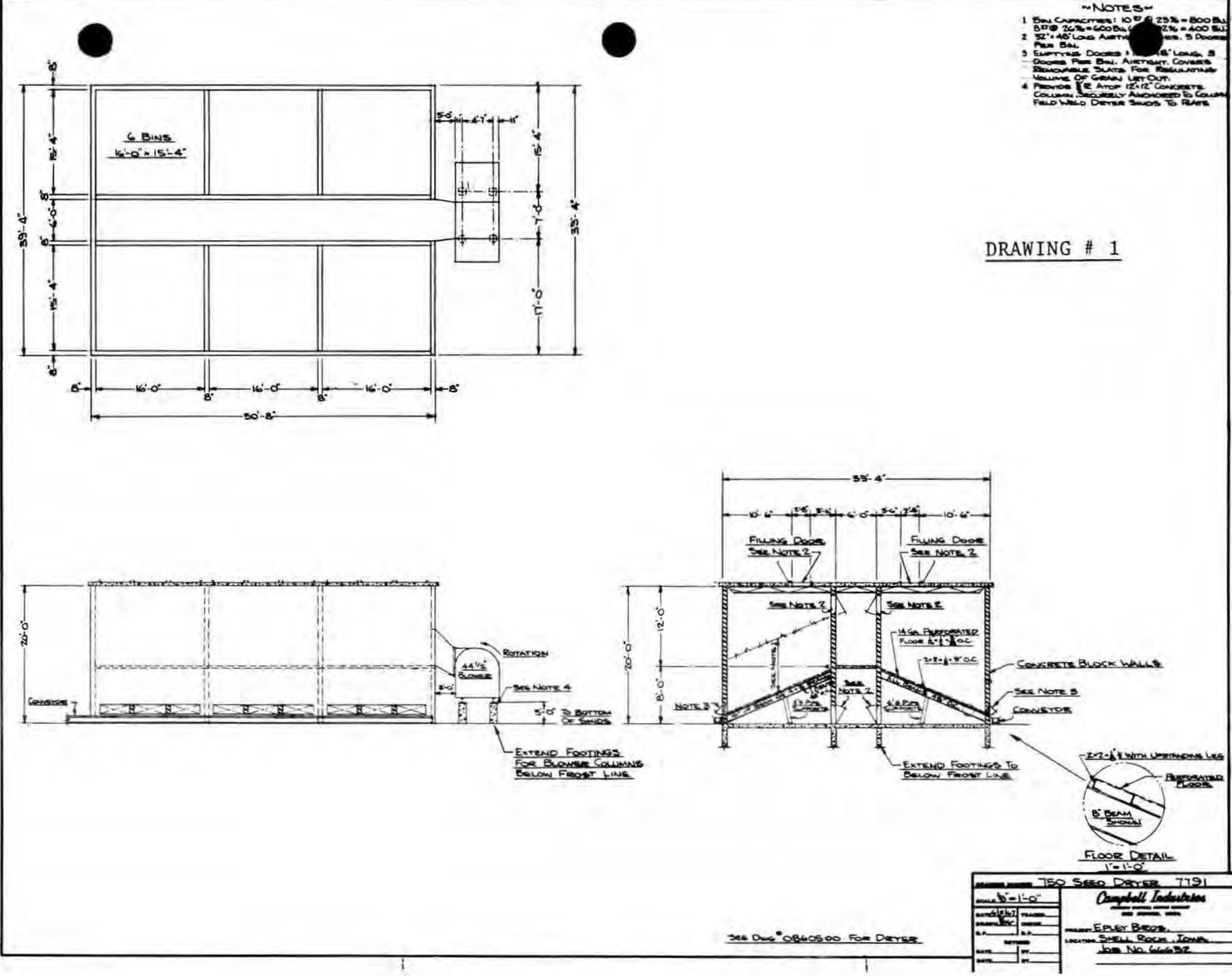
3. An operating high temperature limit control set a few degrees higher than the normal operating temperature. It will shut the burner down. The burner in all cases should shut down and remain off till manually relighted.

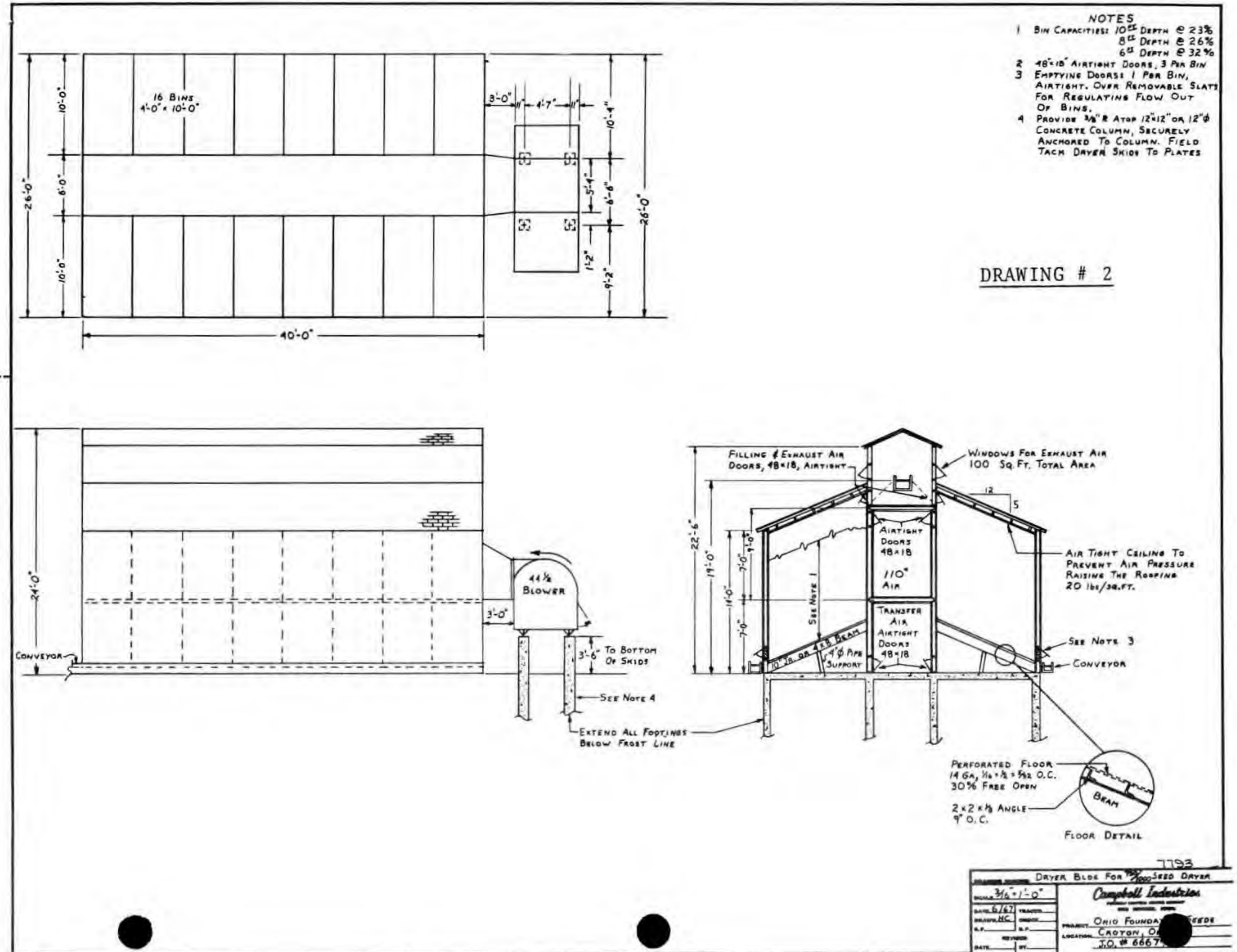
4. The automatic temperature regulation should modulate the burner with a good steady size to maintain the drying temperature without the fluctuations, hunting, and surging that is sometimes observed with what is expected to be a modulating temperature control.

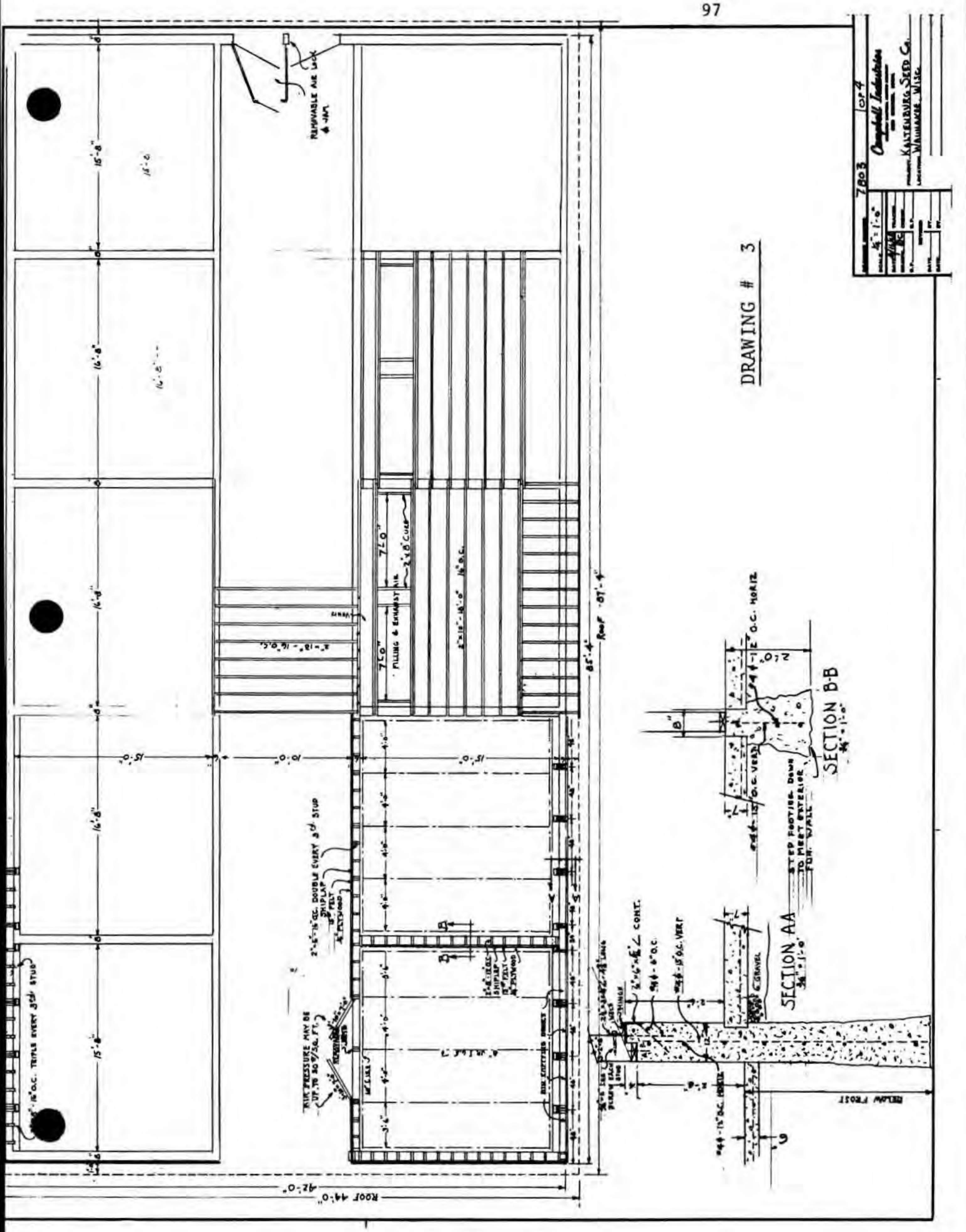
5. A flame sensing device that will shut down the burner in case of flame failures does not need to be quick acting, complicated or expensive electronic control that is so essential on burners in boilers and confined combustion spaces. A shut down of the burner in a matter of 20 or 30 seconds even after the flame has gone out presents no hazard.

6. An alarm system using multiple 165°F. thermostats to detect over heating from any cause and especially from external source of fires. This control should not only shut down the burner but shut off the blower and sound an alarm. It is intended to detect fires from sources other than the burner. It should shut off the blower to keep from fanning the fire to greater intensity. These alarm thermostats are relatively inexpensive and can be located at many points throughout the drying plant.

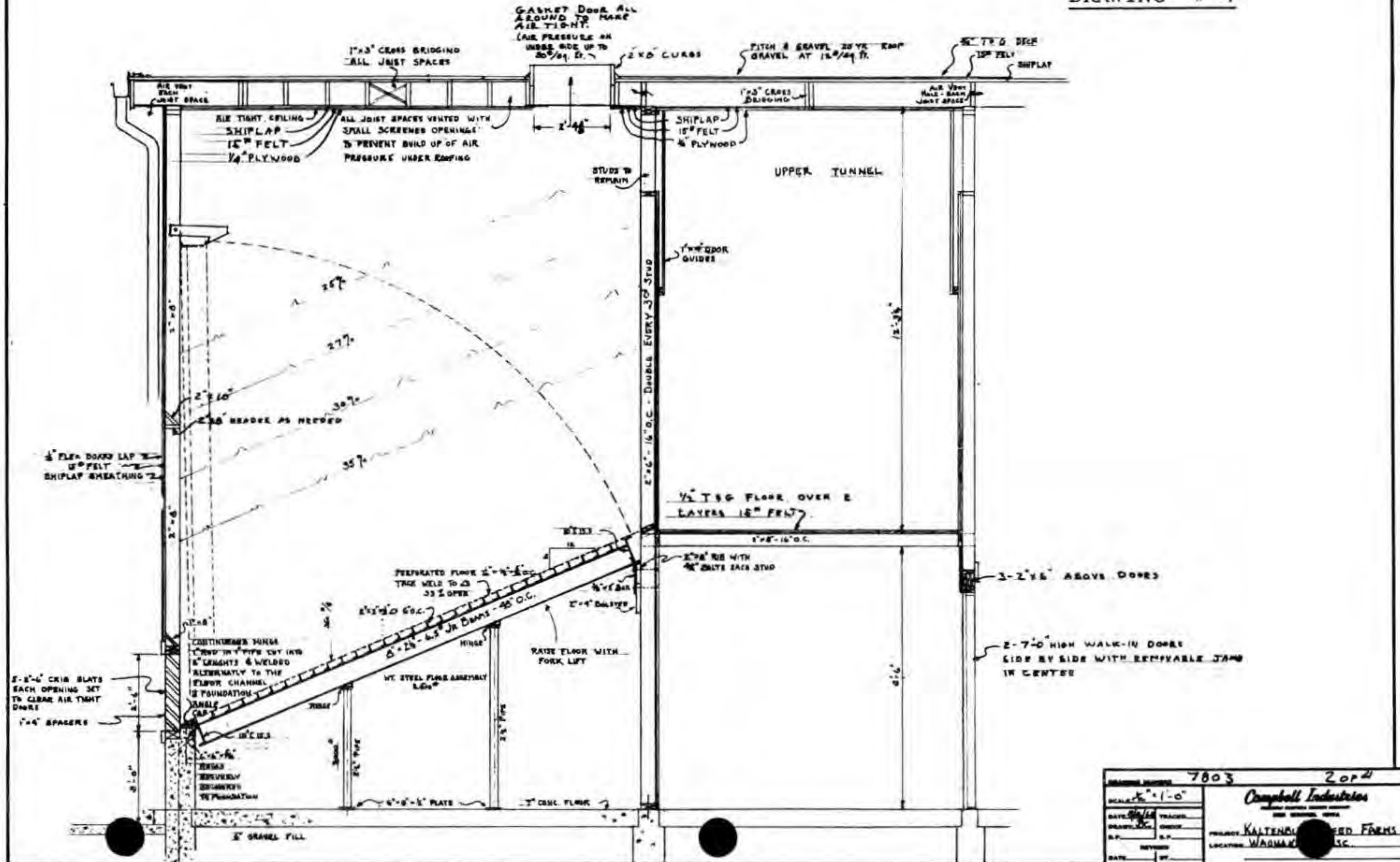
DRAWING INDEX


~NOTES~
DRAWING # 1
6 BINS
16'-0" x 15'-4"
39'-4"
33'-4"
50'-8"
16'-0"
15'-4"
17'-0"
7'-0"
20'-0"
12'-0"
8'-0"
ROTATION
44 1/2" BLOWER
SEE NOTE 4
5'-0" TO BOTTOM OF SKIDS
EXTEND FOOTINGS FOR BLOWER COLUMNS BELOW FROST LINE
CONVEYOR
FILLING DOOR SEE NOTE 2
SEE NOTE 2
14 GA. PERFORATED FLOOR
CONCRETE BLOCK WALLS
SEE NOTE 3
NOTE 3
EXTEND FOOTINGS TO BELOW FROST LINE
PERFORATED FLOOR
8" BEAM SHOWN
FLOOR DETAIL
1" = 1'-0"
SEE DWG. #0860500 FOR DRYER
750 SEED DRYER 7191
Campbell Industries
EPLEY BROS.
SHELL ROCK, IOWA
JOB NO. 66632


NOTES
1 Bin Capacities: 10' Depth @ 23%
8' Depth @ 26%
6' Depth @ 32%
2 48"x18" Airtight Doors, 3 Per Bin
3 Emptying Doors: 1 Per Bin, Airtight. Over Removable Slats For Regulating Flow Out Of Bins.
4 Provide 3/8" R Atop 12"x12" or 12"φ Concrete Column, Securely Anchored To Column. Field Tack Dryer Skids To Plates
DRAWING # 2
16 Bins 4'-0" x 10'-0"
10'-0"
6'-0"
26'-0"
40'-0"
3'-0"
4'-7"
11"
10'-4"
5'-4"
6'-6"
1'-2"
9'-2"
24'-0"
Conveyor
44 1/2 Blower
3'-0"
3'-6" To Bottom Of Skids
See Note 4
Extend All Footings Below Frost Line
Filling & Exhaust Air Doors, 48x18, Airtight
Windows For Exhaust Air 100 Sq. Ft. Total Area
Airtight Doors 48x18
110" Air
Transfer Air Airtight Doors 48x18
See Note 1
4"φ Pipe Support
Air Tight Ceiling To Prevent Air Pressure Raising The Roofing 20 lbs/sq.ft.
See Note 3
Conveyor
22'-6"
19'-0"
14'-0"
7'-0"
9'-0"
12
5
Perforated Floor 14 Ga, 1/16 x 1/2 x 5/32 O.C. 30% Free Open
2x2x1/8 Angle 9" O.C.
Beam
Floor Detail
7793
Dryer Bldg For Seed Dryer
Campbell Industries
3/16"=1'-0"
6/67
HC
Ohio Foundation Seeds
Croton, O.
J.O. # 6667

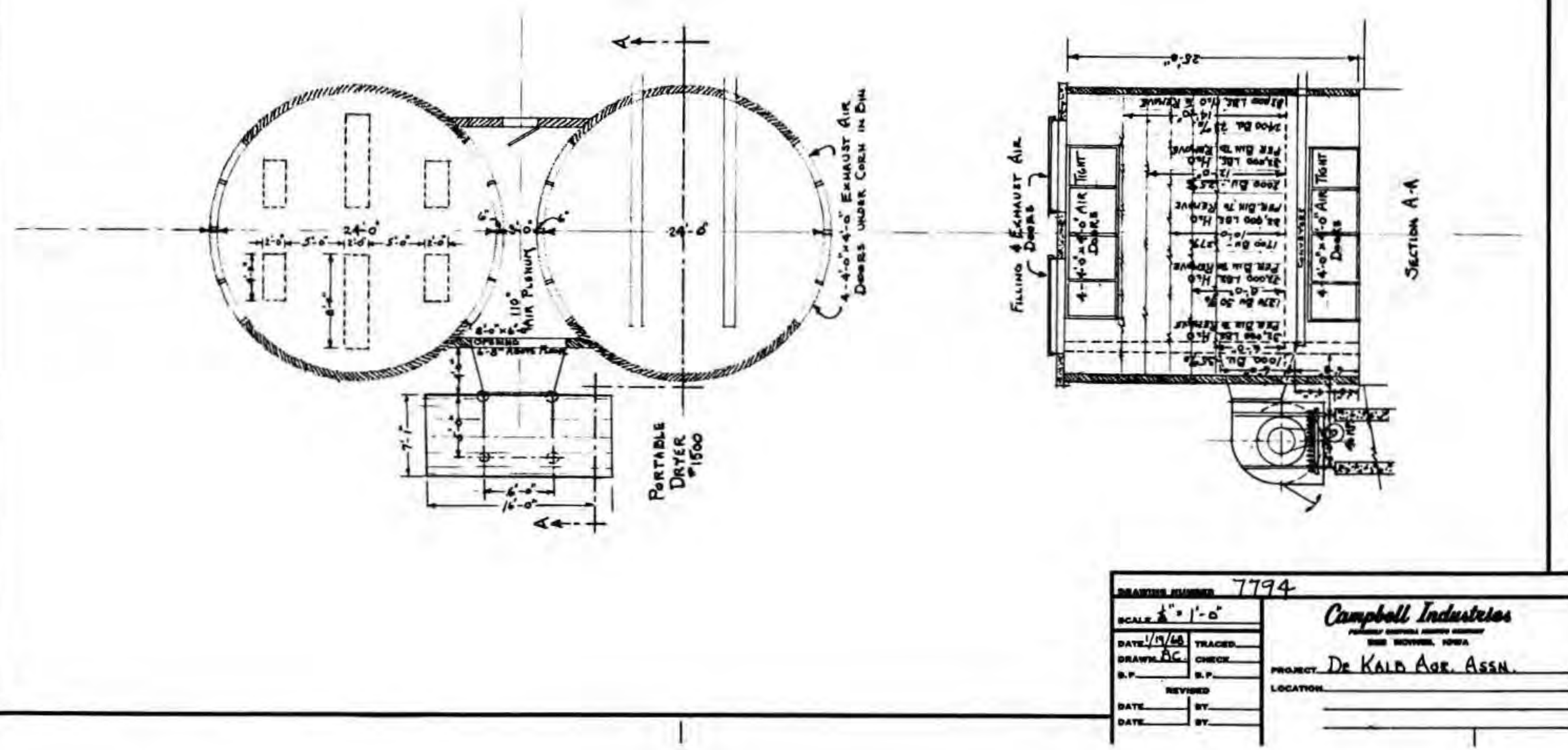

DRAWING # 3
SECTION AA
SECTION B-B
KALTENBURG SEED CO.
WAUNAKEE, WISC.
7803
ROOF 44'-0"
42'-0"
85'-4"
ROOF 87'-4"
REMOVABLE AIR LOCK & JAM
FILLING & EXHAUST AIR
STEP FOOTING DOWN TO MEET EXTERIOR FDN. WALL
AIR PRESSURE MAY BE UP TO 30#/SQ. FT.
BELOW FROST

DRAWING # 4

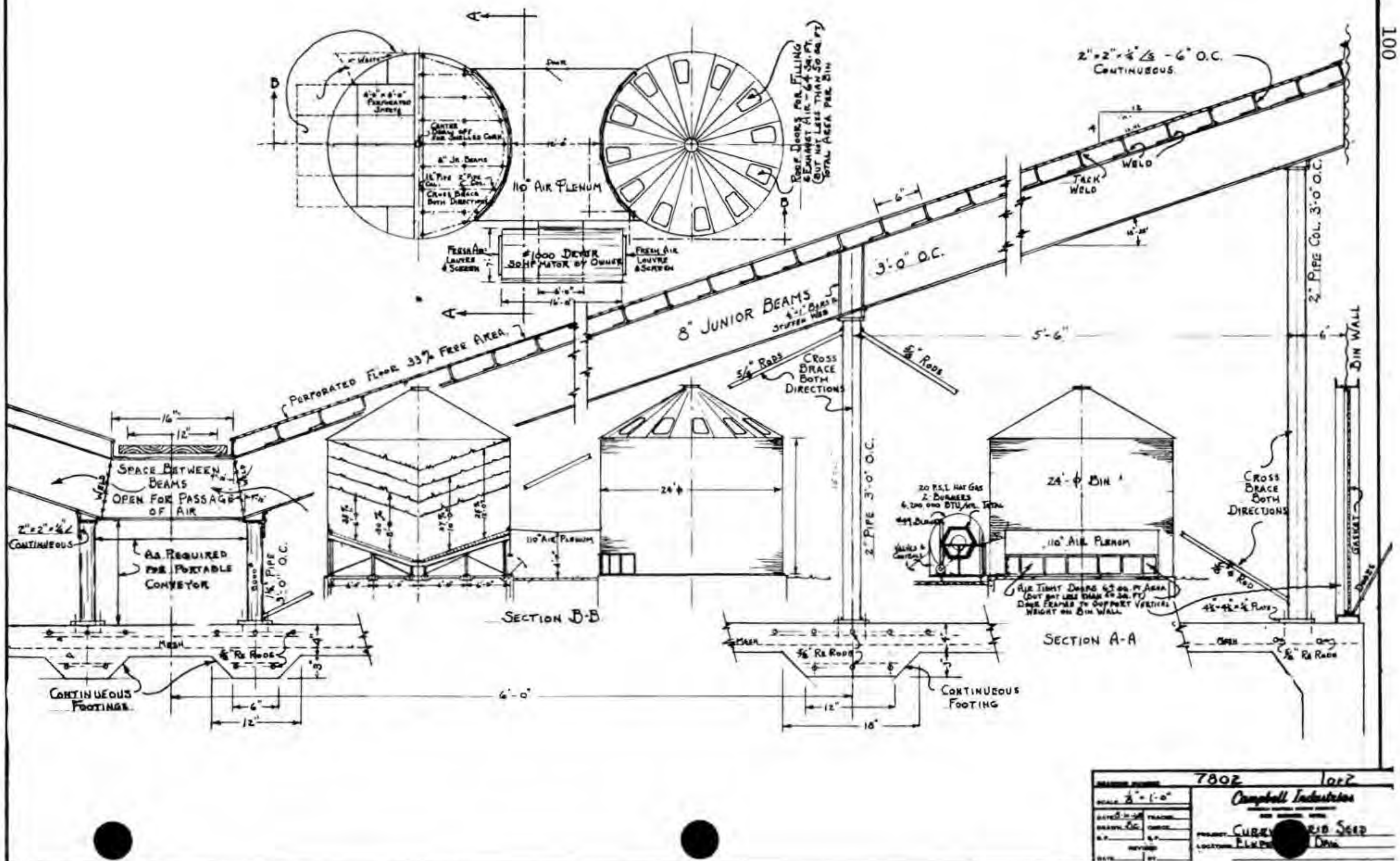


GASKET DOOR ALL AROUND TO MAKE AIR TIGHT.
1"x3" CROSS BRIDGING ALL JOIST SPACES
2"x6" CURBS
PITCH & GRAVEL 20 YR. ROOF
SHIPLAP
AIR TIGHT CEILING
SHIPLAP
15# FELT
1/4" PLYWOOD
ALL JOIST SPACES VENTED WITH SMALL SCREENED OPENINGS TO PREVENT BUILD UP OF AIR PRESSURE UNDER ROOFING
SHIPLAP
15# FELT
UPPER TUNNEL
STUDS TO REMAIN
DOOR GUIDES
2"x6" HEADER AS NEEDED
SHIPLAP SHEATHING
1/2" T&G FLOOR OVER 2 LAYERS 15# FELT
3-2"x6" ABOVE DOORS
2-7'-0" HIGH WALK-IN DOORS SIDE BY SIDE WITH REMOVABLE JAMB IN CENTER
RAISE FLOOR WITH FORK LIFT
HINGE
1"x4" SPACERS
GRAVEL FILL
7803
2 OF 4
Campbell Industries

DRAWING # 5

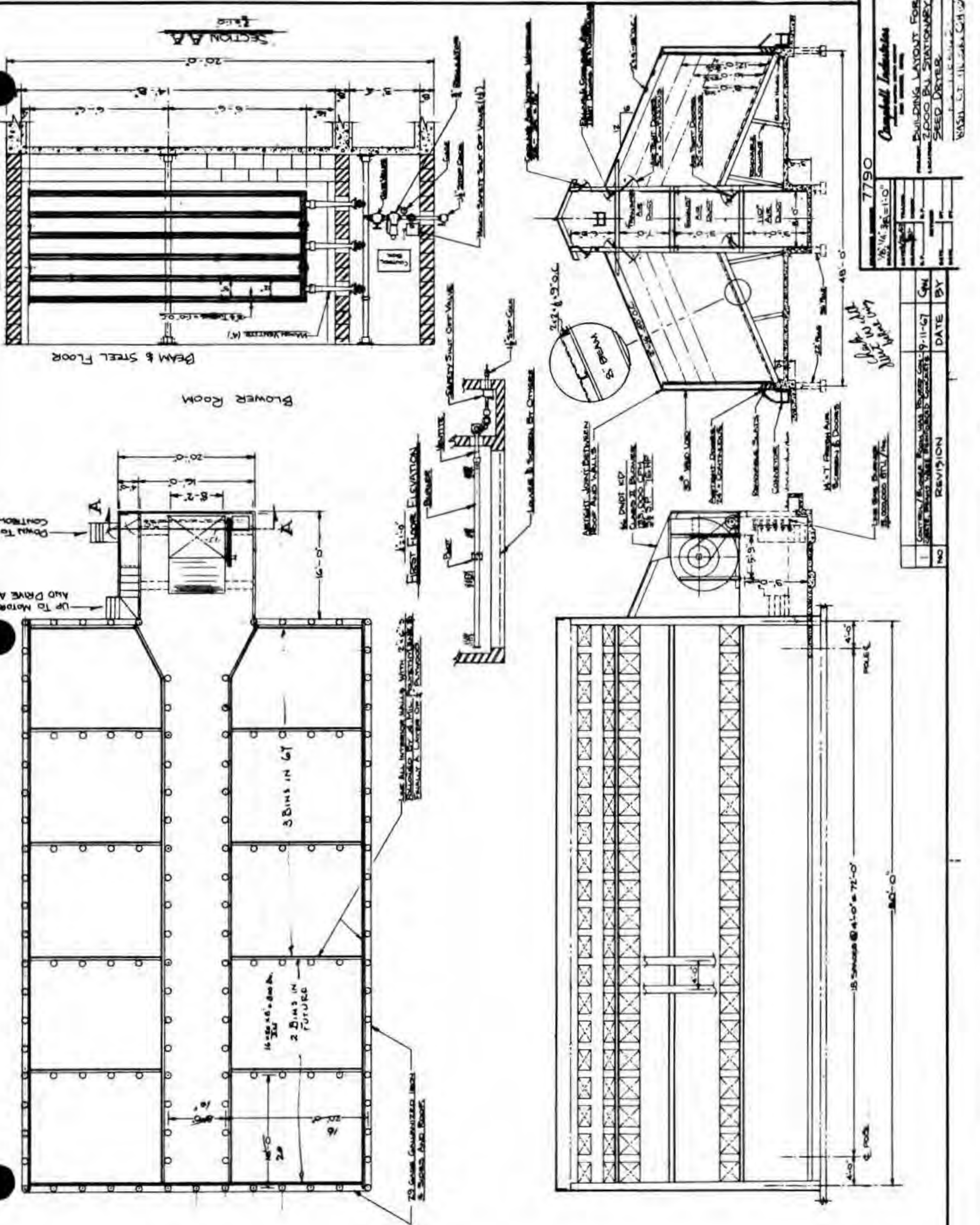

24'-0"
24'-0"
110° AIR PLENUM
8'-0" x 6'-0" OPENING
7'-1"
6'-0"
16'-0"
A
A
PORTABLE DRYER #1500
4-4'-0" x 4'-0" EXHAUST AIR DOORS UNDER CORN IN BIN
FILLING & EXHAUST AIR DOORS
4-4'-0" x 4'-0" AIR TIGHT DOORS
25'-0"
SECTION A-A
DRAWING NUMBER 7794
SCALE 1/8" = 1'-0"
DATE 1/19/68
DRAWN BC
TRACED
CHECK
REVISED
DATE
BY
Campbell Industries
DES MOINES, IOWA
PROJECT De Kalb Agr. Assn.
LOCATION

DRAWING #6

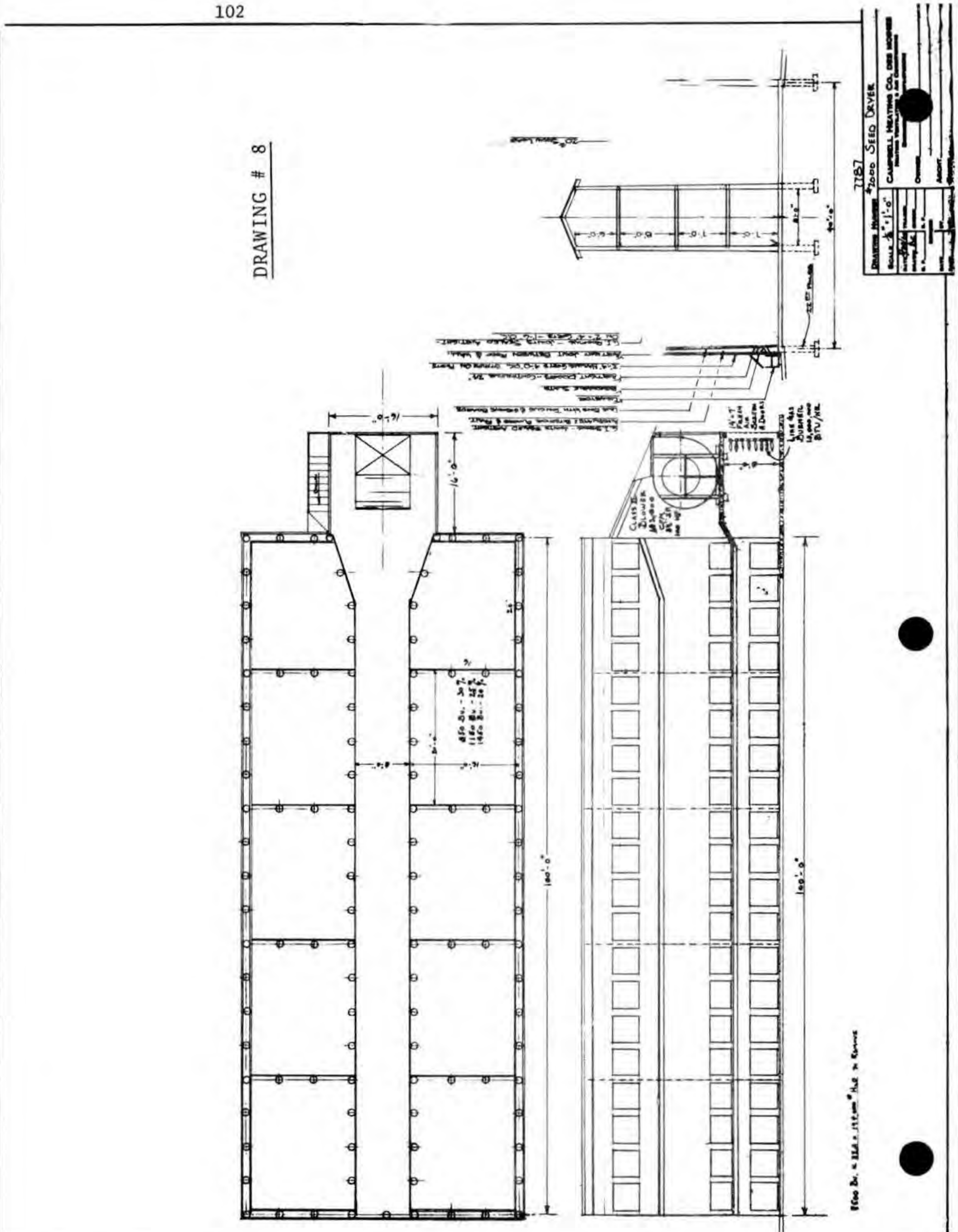


2" x 2" x ¼" ∠s - 6" O.C. CONTINUOUS
WELD
JACK WELD
2" PIPE COL. 3'-0" O.C.
BIN WALL
GASKET
5'-6"
6"
3'-0" O.C.
8" JUNIOR BEAMS
PERFORATED FLOOR 33% FREE AREA
ROOF DOORS FOR FILLING & EXHAUST AIR - 64 SQ. FT. (BUT NOT LESS THAN 50 SQ. FT.) TOTAL AREA PER BIN
110" AIR PLENUM
FRESH AIR LOUVRE & SCREEN
#1000 DRYER 30HP MOTOR BY OWNER
CROSS BRACE BOTH DIRECTIONS
5/8" RODS
2" PIPE 3'-0" O.C.
24'-ϕ BIN
110" AIR PLENUM
20 P.S.I. NAT GAS 2 BURNERS
SPACE BETWEEN BEAMS OPEN FOR PASSAGE OF AIR
AS REQUIRED FOR PORTABLE CONVEYOR
2" x 2" x ¼" ∠ CONTINUOUS
1½" PIPE 3'-0" O.C.
16"
12"
24'ϕ
SECTION B-B
SECTION A-A
MESH
5/8" RE RODS
CONTINUOUS FOOTINGS
CONTINUOUS FOOTING
6'-0"
6"
12"
18"
7802
OF 2
Campbell Industries
SCALE ⅛" = 1'-0"

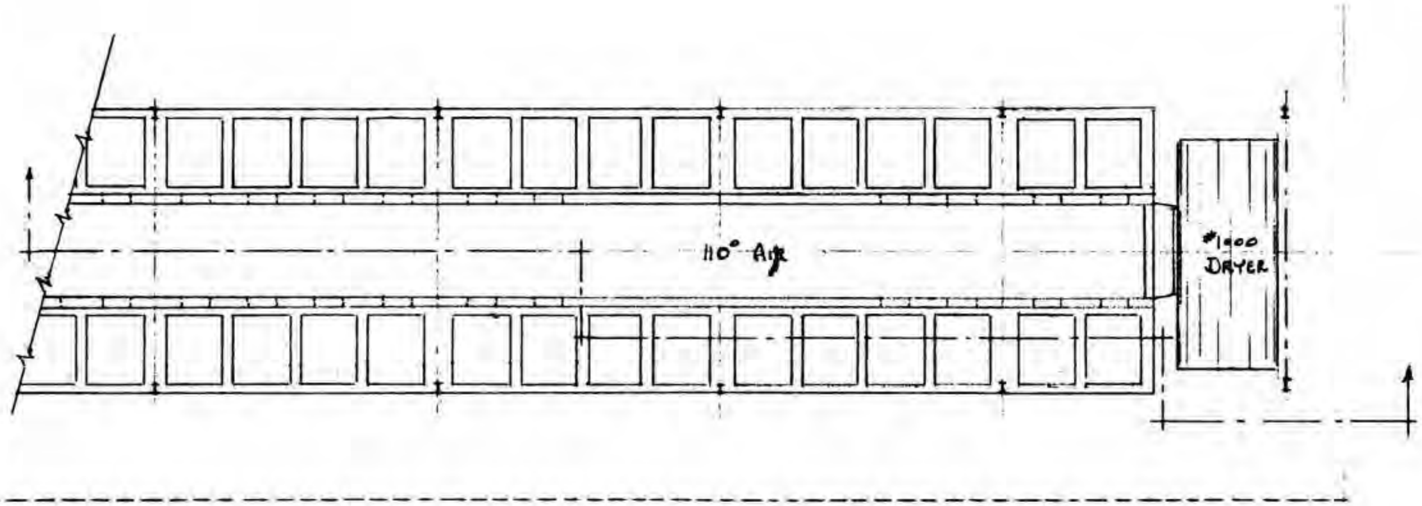
DRAWING # 7


SECTION A-A
BEAM & STEEL FLOOR
BLOWER ROOM
3 BINS IN 67
2 BINS IN FUTURE
FIRST FLOOR ELEVATION
REVISION
DATE
BY
7790
BUILDING LAYOUT FOR
2000 BU STATIONARY
SEED DRYER

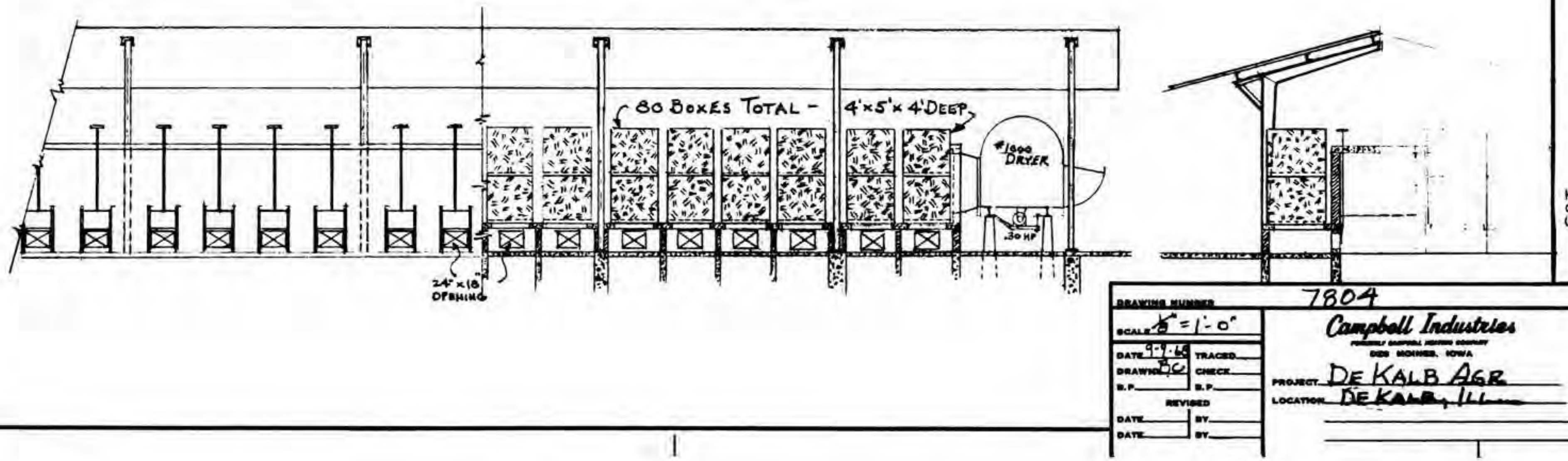
DRAWING # 8



DRAWING # 9



110° AIR
#1000 DRYER



80 BOXES TOTAL - 4'x5'x 4'DEEP
#1000 DRYER
30 HP
24"x18" OPENING
DRAWING NUMBER 7804
SCALE 1/8" = 1'-0"
DATE 9-9-66
DRAWN BC
TRACED
CHECK
B.P.
REVISED
DATE BY
DATE BY
Campbell Industries
DES MOINES, IOWA
PROJECT DE KALB AGR
LOCATION DE KALB, ILL

C I
Since 1880

Campbell Industries, Inc.

FORMERLY CAMPBELL HEATING COMPANY

SEED DRYER DIVISION

AREA 515
PHONE 266-5169

3121 DEAN AVE. DES MOINES, IOWA 50317

REQUEST FOR QUOTATION
SEED CORN DRYING INFORMATION, DRYING EAR CORN IN BINS
ALL DATA TO BE GIVEN IN BUSHELS OF SHELLED SEED CORN AT 12% MOISTURE

1. Bushels per season to be dried. ______ bu.
2. Days of drying plant operation allowing for expected weather delays. ______ days
3. "Use Factor" of the bins taking into account emptying and filling time and other causes when bins are not in the drying cycle. We would suggest a use factor of 75% or 80% ______ %
4. Original kernel moisture ______ | High ______ % | Average ______ % | Low ______ %
5. If you would like to have us recommend drying system sizes fill in the following:
   a. Number of drying bins desired
      4 bins holding one day's production each would be a minimum but smaller bins and greater numbers might help handle various varieties more easily.
   b. Arrangement of bins ______ | All on one side of air duct ______ | On both sides of air duct ______
   c. Drying system ______ | Double pass (Campbell System)(100%) ______ | Single pass reversing system (85%) ______ | Single pass one way (80%) ______
   d. Bin filling system
      Describe ______
   e. Bin emptying system
      Describe ______
   f. Type of drying bin construction ______ | Frame ______ | Building blocks reinforced ______ | Tip up or poured concrete ______
6. If bins are already constructed or planned send us plans or give us data in Par. 5 above and fill in data below. We will then recommend drying equipment size.
   a. Number and size of bins. ______
   b. Maximum depth of ear corn ______
   c. Size of air passages ______
   d. Size of air doors for each bin above the corn. ______
   e. Size of air doors below the corn. ______
   f. Size of exhaust air doors from each bin. ______

Form D888

OVER

7. Fuel for dryer ______ | Nat. Gas less than 5# ______
The higher the natural gas pressure the less the first cost and the better the burner turn down ratio.
| Nat. Gas 5 to 9# ______
| Nat. Gas 10 to 14# ______
| Nat. Gas 20 to 29# ______
| Nat. Gas 30 to 49# ______

LP gas will probably require a vaporizer to be furnished by LP gas supplier ______ LP Gas 30# ______

#2 Fuel Oil ______
Heavy Fuel Oil ______

8. Power available ______ | Single phase ______
| Three phase ______
| 60 cycle ______
| 50 cycle ______
| 220V ______
| 440V ______
| 550V ______
| 380V ______

9. Motor Starter ______ | Across-the-line magnetic ______
| Part winding starter ______
| Y Δ starter ______
| Manual reduced voltage auto trans. starter

10. Type of Motor ______ | Open drip proof ______
| Open drip proof with encapsulated winding ______
| TEFC ______
| Explosion proof ______

11. Type of Dryer ______ | Portable on Skids ______
| Stationary equipment KD ______
| Enclosed steel building for stationary equipment ______
| Steel supports for elevated drying equipment and steel building ______

12. Shipping instructions ______ | Rail on flat car ______
| Truck, common carrier ______
| Truck, contract hauler ______
| Truck, sent by purchaser ______

13. Export Shipping ______ | Crated for export f.o.b. factory ______
| Crated for export F.A.S. port ______
| Chicago ______
| New Orleans ______
| New York ______
Loaded in container FOB Factory ______

14. Delivery date desired ______

Customer Signature ______

Address ______ Town ______

CAMPBELL INDUSTRIES, INC.
3121 DEAN AVENUE
DES MOINES, IOWA 50317

12-20-67
Form D888