To the Graduate Council:

I am submitting herewith a thesis written by Deron Scott Jaggers entitled "Construction and Evaluation of a Bale Weighing Gantry." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Engineering Technology.

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Construction and Evaluation of a Bale Weighing Gantry

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Deron Scott Jaggers

May 1997

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To:

My parents,

Corlett and Wandalene Jaggers,

and

my wife,

Kris Ann Jaggers,

for their unconditional love and support.

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Abstract

Development of a more precise method of determining drying rate parameters was the main objective of this experiment. Therefore, a bale weighing gantry was designed to meet this need. The gantry was designed to suspend four large, round, hay bales so that their weights could be continuously monitored while the bales were drying. The bale weighing gantry was constructed and assembled using research facilities of the Agricultural Engineering Department at The University of Tennessee, Knoxville. After the gantry had been successfully constructed and assembled, it was shipped to the Middle Tennessee Experiment Station for testing in the solar-heated forced-air dryer located there. The gantry was tested using large, round bales that had 6-inch and 12-inch hollow cores. Bales dried on the solar dryer floor consisted of solid, 6-inch hollow core, and 12-inch hollow core bales. Drying rate parameters were determined by taking core samples of bales on the dryer floor and monitoring weight of bales suspended by the gantry.

The gantry did provide a more precise method of determining drying rate parameters. The gantry method had a significantly lower standard error associated with the predicted drying rate parameter than did the core sampling method ($P<.001$). No statistically significant differences were found in the drying rate parameters of the solid, 6-inch hollow core, and 12-inch hollow core bales ($P>.11$). The 12-inch hollow core bales suspended by the gantry tended to have higher drying rate parameters than did the 6-inch hollow core bales but is not supported statistically ($P>.13$). Two types of fans were used in the drying process. Inline centrifugal fans produced significantly faster drying rates

compared to the vane-axial fans ($P<.05$). Results showed that there was no significant loss of bale dry matter during the drying process of the experiment ($P<.001$).

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Chapter 1

Introduction and Objectives

The production of high quality hay is a goal of most forage producers. The quality of a standing forage crop is susceptible to degradation from both environmental and mechanical factors during harvest. Environmental conditions such as rain, dew, sun, and wind can reduce quality during field drying of the cut herbage. These detriments, along with mechanical damage from cutting, conditioning, raking, and baling, can greatly alter the quality of hay.

One method of maintaining the initial quality of herbage is to dry the hay artificially. This practice reduces the amount of time a hay crop must lie afield, thus decreasing the chances of losses due to environmental conditions. Artificially drying hay can also reduce the effects of mechanical losses, especially those occurring during baling, because baling at higher moisture contents reduces losses due to leaf shattering.

A solar-heated, forced air dryer was constructed at the Middle Tennessee Experiment Station near Spring Hill, Tennessee, in 1981 (see Figure 1). The facility provides a means of drying hay and grains artificially and also serves as an equipment storage area during winter months. The facility has been very successful in artificially drying hay using solar-heated air. However, a recent study showed that the facility would not be economically feasible over its expected life (Hobby,1995). The economic infeasibility was attributed to the initial cost of the facility, calculated to be $40,532. A reduction in this initial cost of the drying facility is desirable. Design of a lower-cost

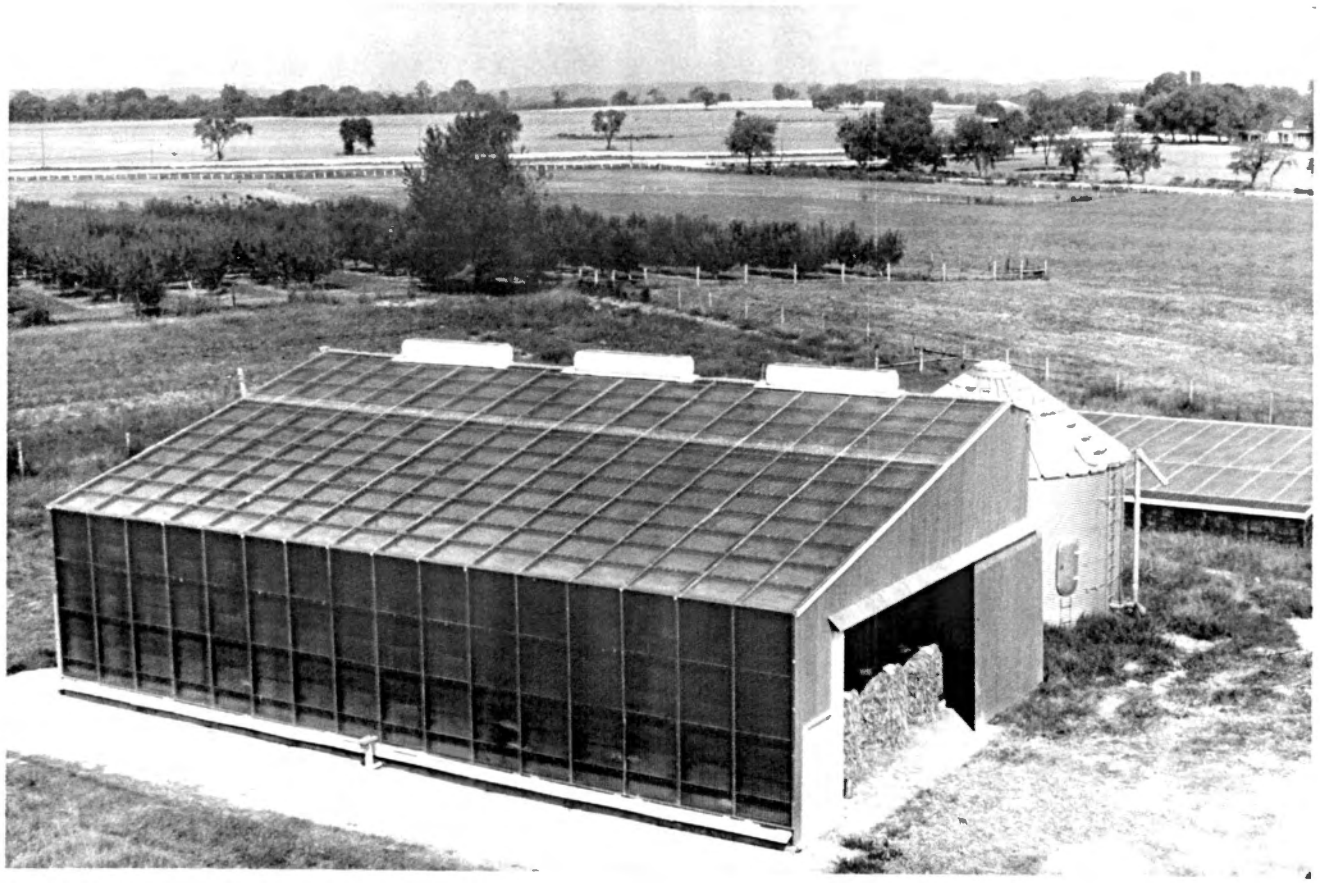


Figure 1. Solar-heated, forced-air dryer located at the Middle Tennessee Experiment Station.

facility would be expedited by bales with greater drying rates. Mathematically, the bale drying rate is defined as the parameter *k* in the simplified, declining rate drying equation characterizing hay:

$$M = M_o e^{-kt} \quad (1)$$

Where,

M_o	=	initial moisture content, decimal dry basis
M	=	moisture content at time t, decimal dry basis
k	=	drying parameter, h^{-1}
t	=	time from start of drying, hours (h)

Taking logarithms of both sides of Equation (1) linearizes it to:

$$\ln (M/M_o) = -(kt) \quad (2)$$

Then,

$$k = -(\ln (M/M_o))/t. \quad (3)$$

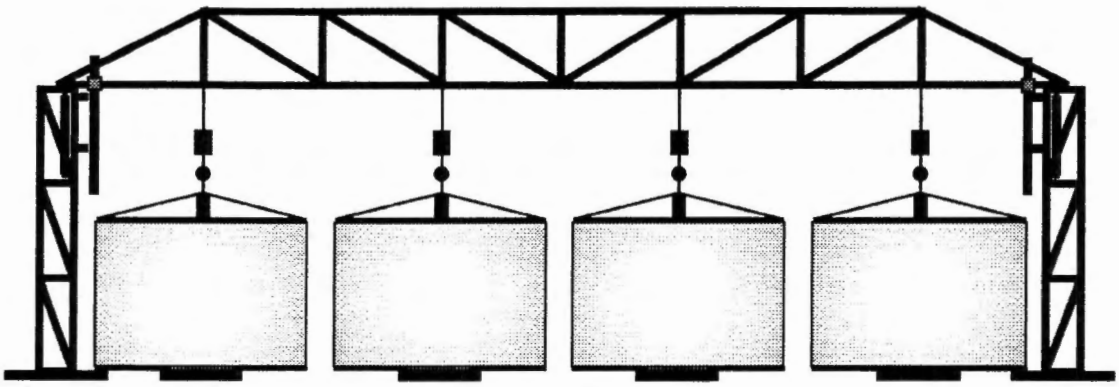
Knowing the drying rate parameter makes it possible to estimate the amount of time required to dry a given hay bale. If this drying rate parameter for a particular crop and bale configuration can be accurately determined for specific drying conditions, then the effects of changes in dryer design and operating conditions can be accurately evaluated.

Problems in accurately determining drying rate parameters in the past have caused inaccurate determination of bale drying times. Core samples physically withdrawn from the bale have been the usual way of determining moisture content. The core sampling process requires large amounts of physical work and time. With a crew size of three persons, sampling frequency is limited to every four hours at best in a large scale

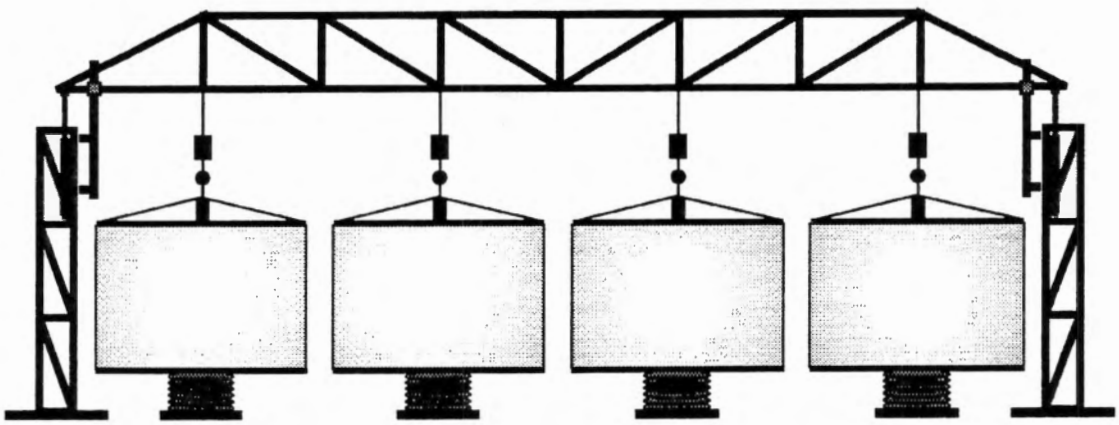
experiment. Although the cylindrical openings left by core extractions are plugged with loose hay, air flow patterns through the bale are altered somewhat, which leads to unbalanced drying and inaccurate experimental results. To overcome these problems, the idea of a bale weighing gantry evolved.

A bale weighing gantry provides a means of constantly monitoring bale weight throughout the drying process. The bales are lifted, suspended from the gantry, and weighed continuously using load cells (see Figure 2). With the initial moisture content of the bale accurately determined, knowing the bale weight change with time makes it possible to mathematically determine the moisture content of a bale at any given time. Then, a regression analysis of moisture-time data over the drying period can be used to determine the drying rate parameter. Use of the gantry to determine the drying rate parameter eliminates channels from core sampling except for those created by obtaining initial moisture content samples.

The objectives of this experiment were to: (1) design, fabricate, assemble, and evaluate a hay bale weighing gantry, (2) determine if use of the gantry provides for a more precise method of evaluating drying parameters of large, round, hay bales compared to coring at specific intervals of time, (3) relate variation in drying rate to atmospheric conditions and solar conversion of the drying system, and (4) compare drying rate parameters of large, round, solid bales to those of large, round, hollow core bales.



a. Bales as initially placed on gantry.



b. Bales suspended for continuous weight measurement.

Figure 2. Concept drawing of bale weighing gantry.

Chapter 2

Literature Review

1. Importance of Artificially Drying Hay

One method to improve hay quality preservation is to artificially dry the hay using solar-heated air. To be acceptable to farmers, this method of hay preservation must improve the economic and nutritional value of hay and reduce dry matter loss.

Economic Value

Alfalfa is probably the world's leading hay crop. It is grown on approximately 49.42 million acres worldwide with Argentina and the United States leading in production (Martin *et al.*, 1976). Since 1984, between 24.71 and 27.18 million acres of alfalfa have been grown annually in the United States (Barnes and Sheaffer, 1995). D.R. Buckmaster and A.J. Heinrichs (1993) reported that the annual U.S. hay production is worth nearly $10 billion. Dry matter, mechanical, and nutritional losses from harvest, storage, and feeding of alfalfa hay are valued at $23.08/ton of dry matter available for animal use. Buckmaster and Heinrichs state that reducing these losses is imperative for improving the efficiency and profitability of forage-based agriculture.

According to Tennessee Agriculture (1995), hay production in the state during 1994 yielded 3.8 million tons on 1.7 million acres. Alfalfa hay production was 165,000

tons grown on 50,000 acres. The dollar value for all hay was calculated to be $193.8 million with $16 million of that from alfalfa hay. Price per ton was $51 for all hay and $97 for alfalfa hay.

The production of alfalfa plays a vital role in the economy both in the state of Tennessee and worldwide. It is important to reduce forage losses and maintain high nutritional quality by using good preservation practices so that farm profitability may be improved.

Nutritional Value

Bohstedt (1944) reported that the original feed value in a hay crop can be most effectively conserved by the retention of all leaves and by a rate of drying that quickly stops respiration, enzyme action, and fermentation. Leaves contain most of the feed value in hay. The leaves of alfalfa contribute about 50% of crop weight, but more importantly, contain about 70% of the protein and 90% of the carotene (provitamin A) of the entire plant. Considering that leaves are 40% more digestible than stems, the loss of protein, carotene, and other nutrients through leaf loss becomes even more alarming.

According to Barnes and Sheaffer (1995), the leaves of both grasses and legumes have a much higher concentration of digestible nutrients than do stems. In alfalfa, the leaves contain more digestible nutrients as well as proteins and vitamins than do stems. Alfalfa is often referred to as the "Queen of the Forages," and is one of the most important forage plants grown in the United States. Of all the commonly grown hay crops, alfalfa has the highest feed value per unit mass for farm animals. It produces more protein per

hectare than oil seed or grain crops. Alfalfa has a high concentration of minerals. It contains at least 10 different vitamins and is a valuable source of vitamin A. It is important to realize that loss of alfalfa leaves increases during harvesting operations as hay moisture concentration decreases.

Martin *et al.* (1976) stated that factors affecting the quality of alfalfa hay consist of color, leafiness, fineness of stems, and freedom from foreign material. Protein content is closely correlated with retention of leaves during the harvesting process. The leaves contain 70% of the total protein in the plant and are easily lost by shattering when the hay is handled improperly. The concentration of vitamin A or carotene is closely associated with green color. The green color is controlled by the factors involved in the curing process. The natural green color is retained to a greater extent in artificially dried hay. The nutrients in artificially dried hay are similar in content to that of fresh cut herbage, except for the unavoidable loss of some carotene.

Dry Matter Losses

According to a study by B. F. Parker *et al.* (1988) , there is a deficit of high quality hay in the humid Eastern United States. Leaf shattering during baling when hay is field dried, as well as weather conditions in the Eastern United States, make it difficult to consistently obtain high quality alfalfa hay by field drying. Adverse weather conditions such as rain can cause loss of an entire cutting of hay. Dry matter losses for field cured hay range from 4 to 15% from plant respiration, 3 to 35% from leaf shattering of legume hays, and 5 to 14% from leaching by rain. Nutrient losses during field curing are usually

higher than dry matter losses.

P. Savoie *et al.* (1982) reported that successful harvesting of high quality alfalfa hay is heavily dependent upon weather conditions. Respiration and mechanical losses of dry matter are 15 to 22% during the field drying of alfalfa under typical field conditions. Dry matter loss from leaching is greatly increased through adverse weather conditions. To maintain forage quality, harvesting systems must be developed that reduce field drying time for the crop and consequently reduce respiration and weathering losses. If weather exposure is reduced and leaf loss is minimized, a high quality alfalfa product results.

C.A. Rotz *et al.* (1988) stated that losses of dry matter and quality during the harvest and storage of alfalfa hay can be very large. He reports that typical dry matter losses for the full process are 15 to 25% under good drying conditions. Under more adverse conditions such as rain, the dry matter losses for the full process range anywhere from 35 to 100%. The dry matter that is most susceptible to loss is that with the highest nutritive value to animals. Hay losses are normally categorized into field losses and storage losses. Hay storage losses are related to respiration and microorganism activity in the hay. These losses were reported in the range of 2 to 5% for dry hay stored inside a structure. Field losses, whether from respiration, rain, or machine losses, occur while processing the standing crop through baling.

Rain causes losses by shattering leaves and washing or leaching soluble material from the plant, according to Rotz *et al.* (1988). Separation of respiration and leaching losses from rain losses is difficult except when rain is absent during the field curing process. Rain was reported to cause leaf loss as high as 20%. This loss combined with

respiration loss was as high as 40%.

Machinery operations cause loss by shattering leaves and disassociating some small stem particles from the crop. Typical machinery losses were reported by Rotz *et al.* (1988) to be: 1 to 3% for mowing, 1 to 2% for tedding, 3 to 6% for raking, and 2 to 10% for baling. The amount of losses is related to the speed of operation and the moisture content of the crop at the time of the operation.

Respiration loss is described by Rotz *et al.* (1988) as being the dry matter loss which occurs during field curing due to respiration of plant cells or microorganisms on the plant. Crop temperature and moisture content are factors which control the rate of respiration. Rotz *et al.* (1988) stated that when the plant dries to 40% moisture, which occurs about midway through the field curing period, respiration ceases. Respiration can account for 5 to 10% of the loss of crop dry matter, primarily consisting of nonstructural carbohydrate losses.

Some controversy exists among researchers as to what the specific moisture content is when respiration is inhibited. Most would agree that respiration is inhibited at moisture contents between 20% and 40% (C.A. Rotz *et al.*, 1988; Bohstedt, 1944; Martin *et al.*, 1976; Buckmaster *et al.*, 1990). D.R. Buckmaster and A.J. Heinrichs (1993) stated hay respiration is inhibited when the moisture of the hay falls below 25% moisture content. If this is true, then baling of hay at moisture levels of 25 to 30% moisture content should have no effect on respiration losses. A slight reduction in baling loss is expected when baling at higher moisture contents due to reduced leaf shatter. Also, baling at higher moisture contents reduces field curing time. This reduced curing time results in less time

for hay to be exposed to possible rain that greatly increases losses; thus reduced field curing time greatly reduces the probability of severe field losses.

Artificially drying large, round, hay bales with solar-heated air is a fairly new method that is not widely practiced. However, it appears that artificially drying hay can improve the economic and nutritional value of hay by decreasing dry matter losses. In a study by B.L. Bledsoe and J. Walter Hitch (1986), hay was dried from 35% initial moisture content (wet basis) to 15% moisture content (wet basis) with a solar-heated, forced air dryer. Peak nutrient value of the hay was retained by reducing leaf loss from shattering of dry hay and possible protein loss from the bleaching action of extended swath drying before baling. Since the field drying time was reduced, risk of rain damage was less.

2. Drying Rate and Variables Affecting It

High quality alfalfa hay can be produced if weather exposure is reduced and leaf shatter is minimized, according to P. Savoie *et al.* (1982). They also state that weather exposure can be reduced by increasing the drying rate, by storing at a higher moisture content, or by a combination of both. Experiments were conducted to assess the ability of machinery systems to reduce the exposure time and field losses of alfalfa between mowing and baling by increasing the drying rate. The cutterbar mower with a roller conditioner and the cutterbar mower followed by a crimper had the best performances. The drying rate was slightly slower for the rotary mower with a flail type conditioner. The rotary

mower without a conditioning unit had the slowest drying rate, because hay was left in a flat, dense, slow drying windrow. A crimper reduced final moisture content significantly and produced the best results when used after a cutterbar mower. Drying rate was increased slightly by the tedder. The tedder is probably more useful when spreading wet hay after a rainfall. No differences in drying rate between the side-delivery rake and the rotary rake were apparent.

K.J. Shinners *et al.* (1991) performed experiments to determine leaf loss and drying rate of alfalfa for seven mower-conditioner machines. Four different conditioning roll types were involved. The drying rates were determined from samples taken approximately every 3 hours from a swath laying on a plastic sheet in the field. The sample was placed in a bag and weighed, then transported to a dryer to determine moisture content. The drying rate was described by determining an average drying parameter for each treatment. The drying data were analyzed using the drying rate equation $M = M_o e^{-kt}$ where

M = Sample dry basis moisture content at the end of time interval

M_o = Sample dry basis moisture content at beginning of time interval

k = Drying parameter, h^{-1}

t = Length of time interval, hours (h).

A drying parameter was determined for each time interval between consecutive moisture measurements. Drying parameters for time intervals between initial and either the final or 20% wet basis moisture were determined. Then, a time weighted drying parameter for each treatment was calculated. A larger valued drying parameter indicates a faster drying

rate. No significant differences were found in drying rate for roll type or machine type.

S.L. Brandemuehl *et al.* (1988) performed experiments extending over a two year period to determine the feasibility of radially drying high moisture, large, round, hay bales. Bales to be radially dried were formed around an 8-inch diameter PVC tube. The tube was later removed to form a passage or void along the central axis of the bale. Radially dried bales were compared to axially dried bales. The weights of the bales and their moisture contents allowed calculation of the amount of water and dry matter in each. For hay handling purposes, heavier bales with high amounts of dry matter are usually preferred over lighter bales. However, for study purposes, it was preferred to have lighter bales with low density to aid in reducing airflow resistances.

Faster drying was common during the initial stage of drying as more available moisture from the plant was quickly dried. Drying slowed in later stages as moisture within the plant material was removed. The equation $M\text{-}M_e = (M_o\text{-}M_e)\, e^{-kt}$ was first considered to relate moisture contents and drying times through a drying rate parameter. However, based on experiments performed by Rotz and Chen (1985), M_e, equilibrium moisture content, can be set to zero without significant error, and doing so simplified the equation to $M = M_o * e^{-kt}$. By logarithmic conversion, the equation is linearized resulting in the simplified declining drying rate equation $\ln(M/M_o) = -kt$, where M, M_o, k, and t are defined as previously described in reference to the work by K.J. Shinners *et al.* (1991). Higher k-values indicate faster drying rates (shorter drying times) for bales. Results showed that radially dried bales had a higher mean k-value of 0.01172 compared to the 0.00774 value for the axially dried bales. Using the experimentally determined drying rate

parameters, drying times to 17% moisture content were projected for comparison. The calculated difference in projected drying time was typically 20 hours shorter for radially dried bales than axially dried bales. Radially dried bales also dried more uniformly than axially dried bales. An economic analysis showed that radial drying could provide an economic return due to the higher quality material it provides.

A similar experiment was performed by Bledsoe *et al.* (1995). Low-density hollow-core bales were formed by placing 6, 8, 10, and 12-inch diameter pieces of PVC tubing in a Gehl Model 1470 baler. Four different sizes of hollow core bales were created by extracting the PVC tubes from the bales. Hollow core bales and solid bales were then dried using a solar-heated, forced air dryer. Using the drying rate parameter k from the simplified declining drying rate equation as an indicator of drying rate, results showed that k values of hollow core bales were 1.56 times that of k values for solid bales. This meant hollow core bales dried 56% faster than did solid bales.

Bledsoe *et al.* (1985) reported that dry matter density affects the drying rate in two ways. Dry matter density affects the airflow rate through the bale, and for a given bale size and moisture content, dry matter density determines the amount of hay to be dried and therefore the amount of water to be removed. Controlling dry matter density is critical to artificially drying hay. Uniform density bales compared to low density core bales of equal bale size contain more dry matter. However, the increased drying rate of the low density core bales make them more suitable for drying. Another factor that affects drying rate is inlet and outlet geometry. Inlet and outlet geometry can affect the drying rate of large round bales by changing total airflow rate through the bale including the

slowest drying streamtube.

A drying rate equation developed through consideration of simultaneous heat and mass transfer was used in an experiment drying large, round hay bales with solar-heated air by Bledsoe *et al.* (1985). However, agreement with experimentally observed drying times was poor. The equation used significantly underpredicted the time for the drying front to reach the outermost portions of the bale. It is believed that the lack of agreement was due to values for parameters used in the drying rate equation. Future research was recommended for accurate determination of parameters to be used in the equation.

There are many variables which affect the drying rate. These include harvesting and conditioning methods, density of the bale, and drying methods. If the variables are properly considered and drying rate parameters accurately determined, it may be possible to improve the methods of drying hay, resulting in improved economic value, greater preservation of nutritional value, and decreased dry matter loss of the crop.

3. Gantry Usage in Agricultural Applications

The use of a gantry can increase accuracy of determining the drying rate parameter. Taylor (1991) defined a gantry as a framework supported at each end so that it spans a distance. Gantries have provided means of performing various agricultural tasks in the past.

Tillett *et al.* (1988) used an experimental gantry for leaf vegetable production. The gantry was manually controlled and driven on tracks. It could be hauled from one

location to another by lowering wheels to the ground and pulling it by a tractor. The gantry demonstrated that it could perform all operations associated with leaf vegetable production with the exception of primary cultivation.

Holt and Tillett (1989) experimented with a gantry for production and harvest of vegetable and salad crops. The gantry in this experiment was similar to the gantry used by Tillett *et al.* (1988). However, this gantry was capable of cultivation, chemical spraying, and automatic steering during slow processes so that the operator could assist in other tasks. The project led to construction of a highly successful gantry for commercial use. Tillet and Nybrant (1990) worked on improving the automatic steering capabilities. This was accomplished by replacing the analogue circuitry with a digital controller. This also provided opportunities to control other production functions automatically.

Hsieh and Coates (1993) designed and evaluated a gantry for field operations. Gantries capable of performing field operations such as traveling, turning, tilling, chemical application, harvesting, etc. are subject to many different forces acting on them. Therefore, the Hsieh and Coates gantry assembly was constructed primarily from rectangular or square structural steel tubing and steel plate. Tests showed the assembly met or exceeded the desired factor of safety.

Many and various tasks have been performed using gantries in the past two decades according to Chamen *et al.* (1994). In the former USSR, gantries have been used for both field and glasshouse operations, irrigation processes, and chemical application. Japan has used gantries for robotic transplanting, soil tillage, and for puddling and harvesting. In the United States, gantries have been used in the production of cotton,

soybeans, sweet corn, wheat, and sorghum. Australia farmers have used gantries specifically constructed to harvest tomatoes and rockmelons. The reason for gantry use worldwide is that its benefits include automation, boom stability, accurate position location, reduction of crop damage, minimization of land lost to wheelways, and improved soil management. Also, it can be used as an aid to research projects.

Chapter 3

Materials and Methods

1. Gantry Design

The initial gantry design was developed in 1993 by a senior design class at The University of Tennessee. It was a project assigned to the Agricultural Engineering 413 class and whose final report was titled "Final Design Analysis of Support System for Round Bale Hay Drying Experiment" by Maynard *et al.* (1993). Objectives of the class project were to design a mobile, rigid, sturdy, yet compact structure capable of lifting a row of four large round bales and continuously weighing them for the duration of a drying cycle. The structure was to be stable in all modes of operation and safe to move and operate. In addition, the structure was to be designed to handle variable loads applied only when the gantry was in a stationary position. A factor of safety of 2 or more was required for the gantry. The design also was to include a means to clamp a round bale making it air tight at the top and bottom. The bottom was to be connected to an air tight duct that would attach to a pre-existing air duct in the floor of the Middle Tennessee Experiment Station (MTES) solar-heated, forced air dryer.

Converting initial engineering drawings of proposed new equipment into hardware almost always necessitates changes or improvements in the design, and such was the case for the gantry. A few revisions were necessary to accommodate ease of construction,

allowable cost, and adequate performance.

Description of the gantry design will be in four parts, one for each major sub assembly of the device. These include the space frame assembly, column assembly, bale clamp/suspension assembly, and the hydraulic system. Although each major sub assembly of the gantry will be discussed, a full set of plans for the design will not be included in this thesis.

Space Frame Assembly

The primary loading on the space frame assembly comes from vertical loads imposed by weights of the suspended bales. Side and torsional loads are possible during the lifting and suspending of the bales. A space frame design (see Figure 3) was chosen over a single truss design because of its ability to better handle side and torsional loads and its inherent greater stability.

The space frame component parts were constructed primarily from 1.50-inch square structural steel tubing having a wall thickness of 0.13 inches. The space frame is designed as a two piece unit that bolts together at the center plane of the frame (see Figure 4). The two part design allows easy transport of the space frame from one location to another. When bolted together, it has a span of 30 feet (see Figure 5). This length was determined by the space available to suspend four bales at once over a lateral, four-outlet, main air duct in the solar dryer floor. The four air outlets are spaced 7 feet apart on center. The solar dryer inside width is 31 feet-6.50 inches. The space frame has four bale suspension cross members spaced 7 feet on center to accommodate connection to

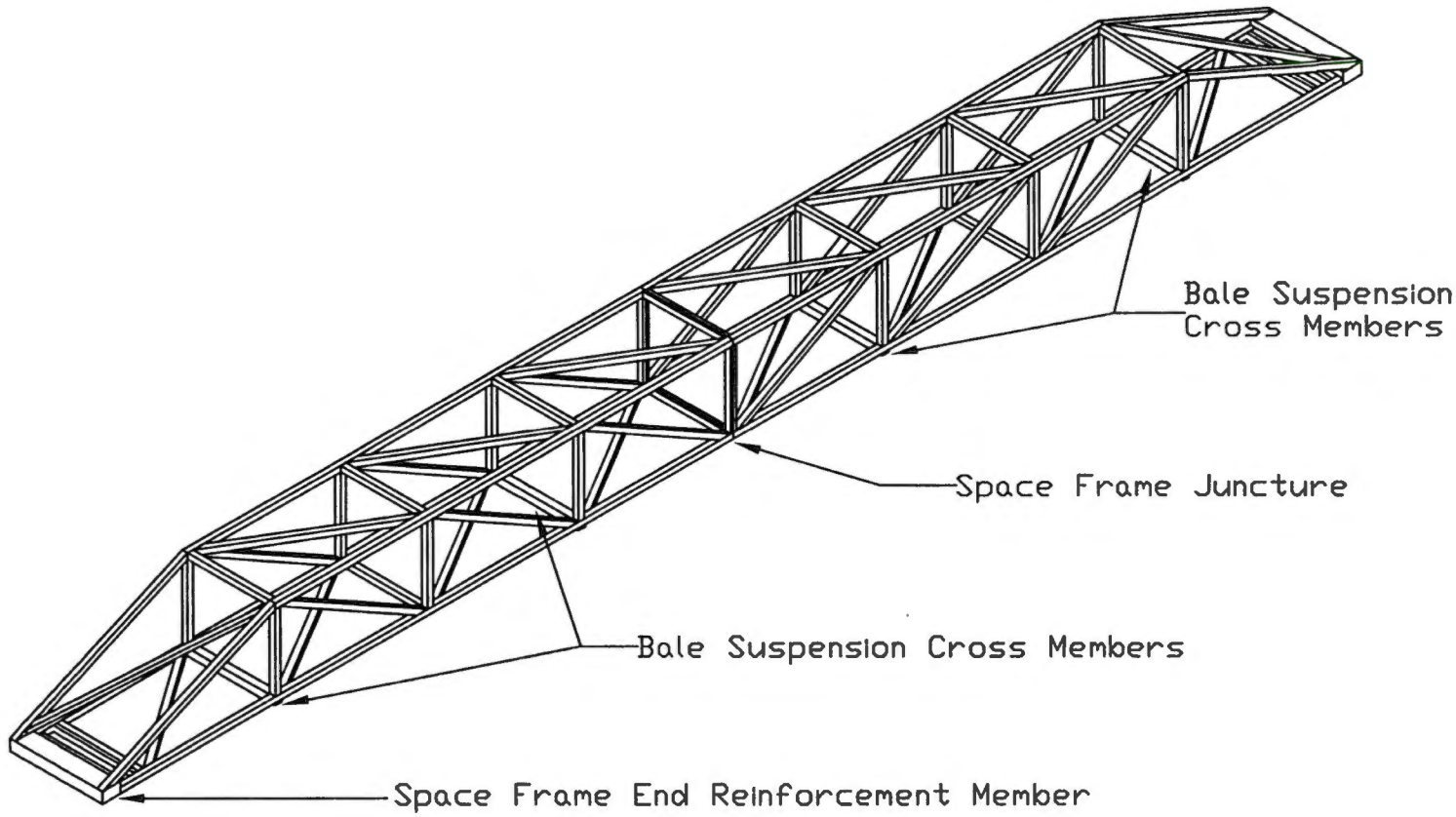


Figure 3. Space frame assembly.

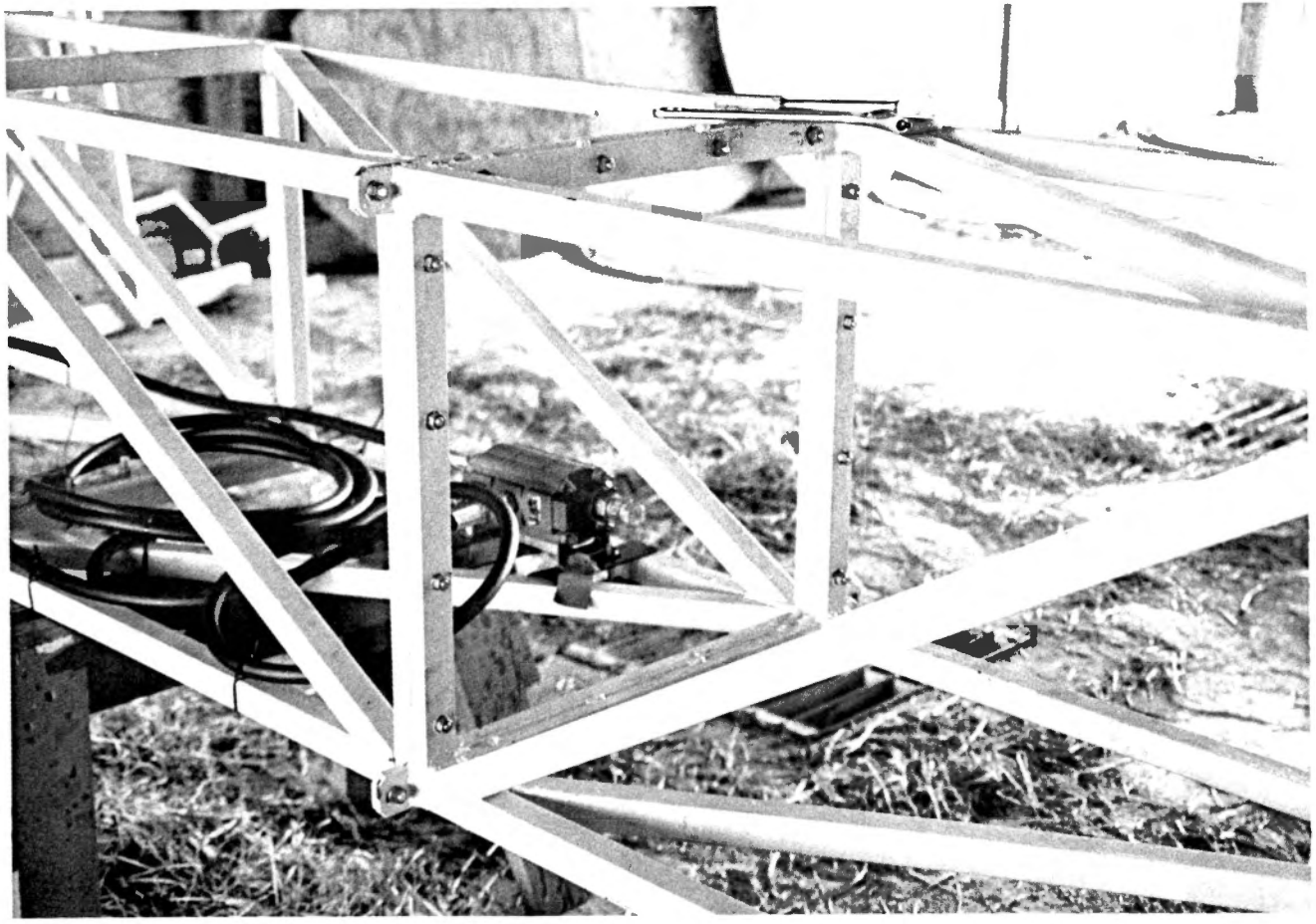


Figure 4. Space frame juncture.

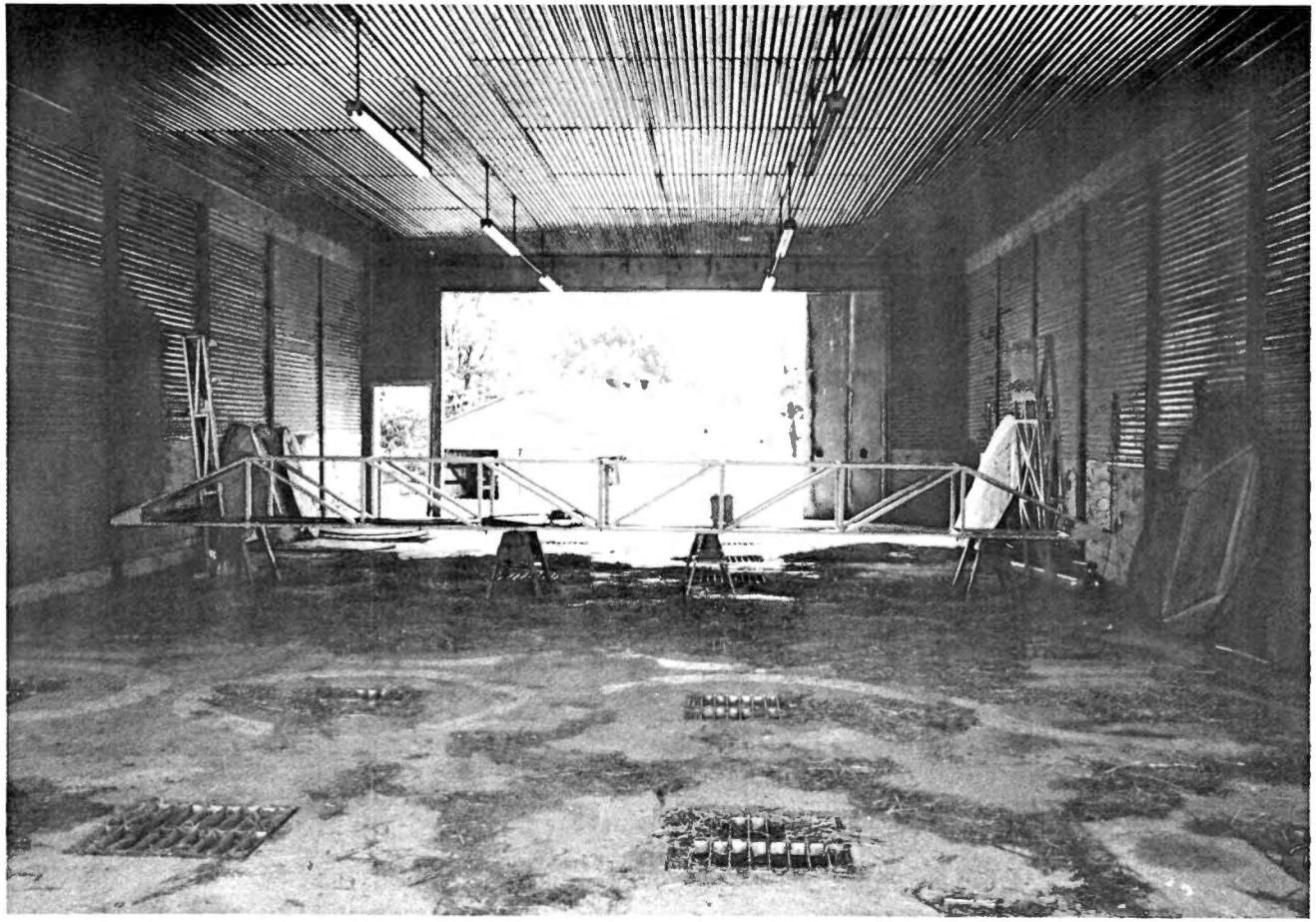


Figure 5. Space frame bolted together.

individual bales. These cross members are made from rigid 2-inch square structural steel tubing having a wall thickness of 0.25 inches.

The space frame design provides for attachment of a slider assembly at each end (see Figure 6). The slider assembly is made from 2.50-inch outside diameter (O.D.) welded, mandrel drawn steel tubing with 0.25-inch wall thickness. The tube was machined to accept pressed in bronze, oil-impregnated sleeve bearings. The slider assembly moves along a 2-inch O.D. by 0.25-inch wall stainless steel guide rod which is affixed to the column assembly. There are two slider assemblies at each end of the space frame. These slider assemblies allow the space frame to move vertically relative to the end column support assemblies when activated by two hydraulic cylinders. This action lifts and suspends the four large round hay bales from load cells to provide continuous weighing during the drying cycle.

Column Assembly

The column assembly has three functions: 1) provides a means of support for the space frame assembly; 2) houses the hydraulic cylinders used for raising and lowering the space frame; 3) supports the wheel assembly provided to move the gantry from one place to another.

The column assembly component members were constructed mainly from 1.50-inch square structural steel tubing having a wall thickness of 0.13 inches (see Figures 7 and 8). At the base of each column assembly is a 4-inch by 6-inch rectangular steel tube having a wall thickness of 0.31 inches. On each end of the 4-inch by 6-inch rectangular

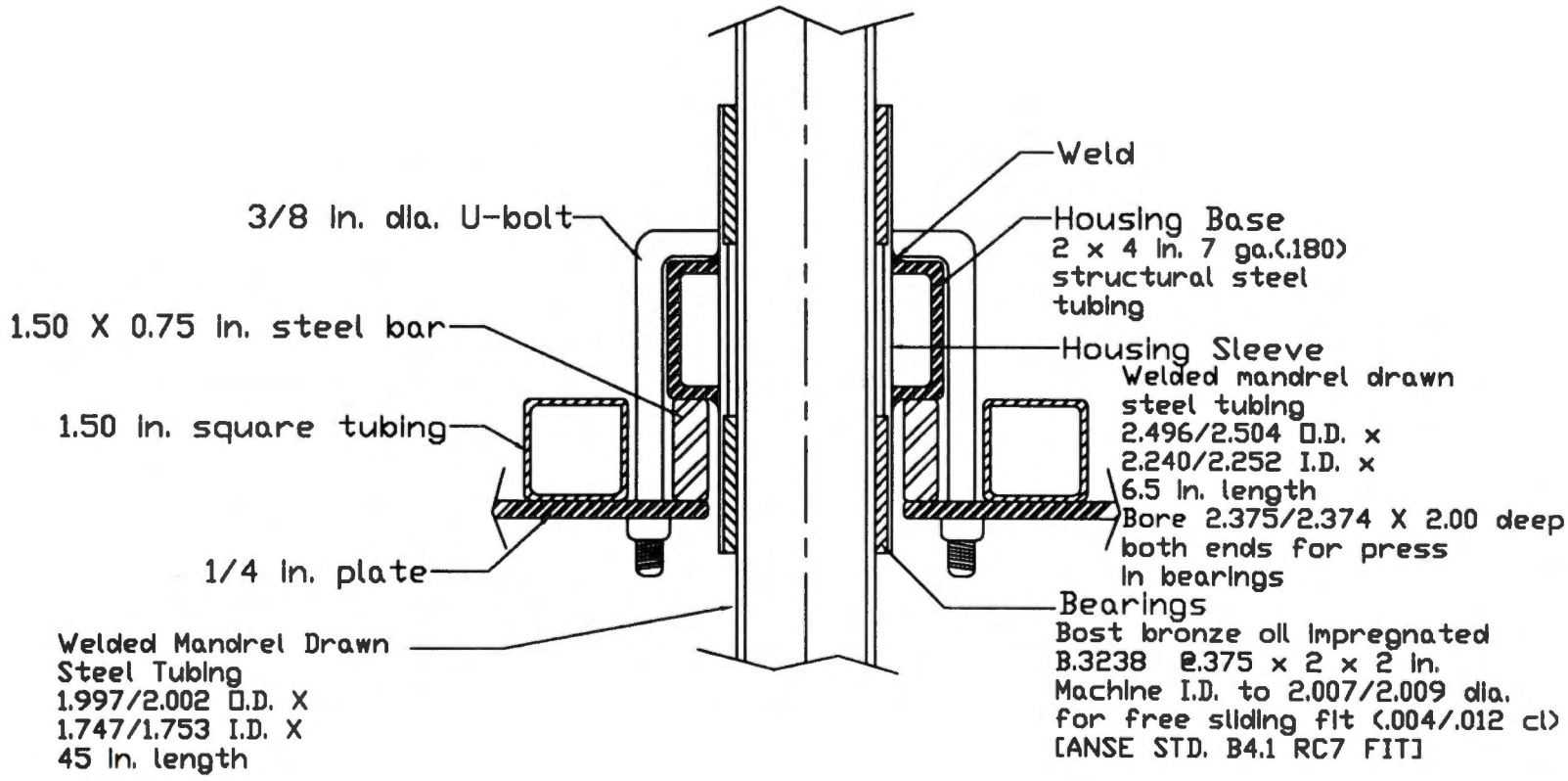


Figure 6. Slider assembly cross-section.

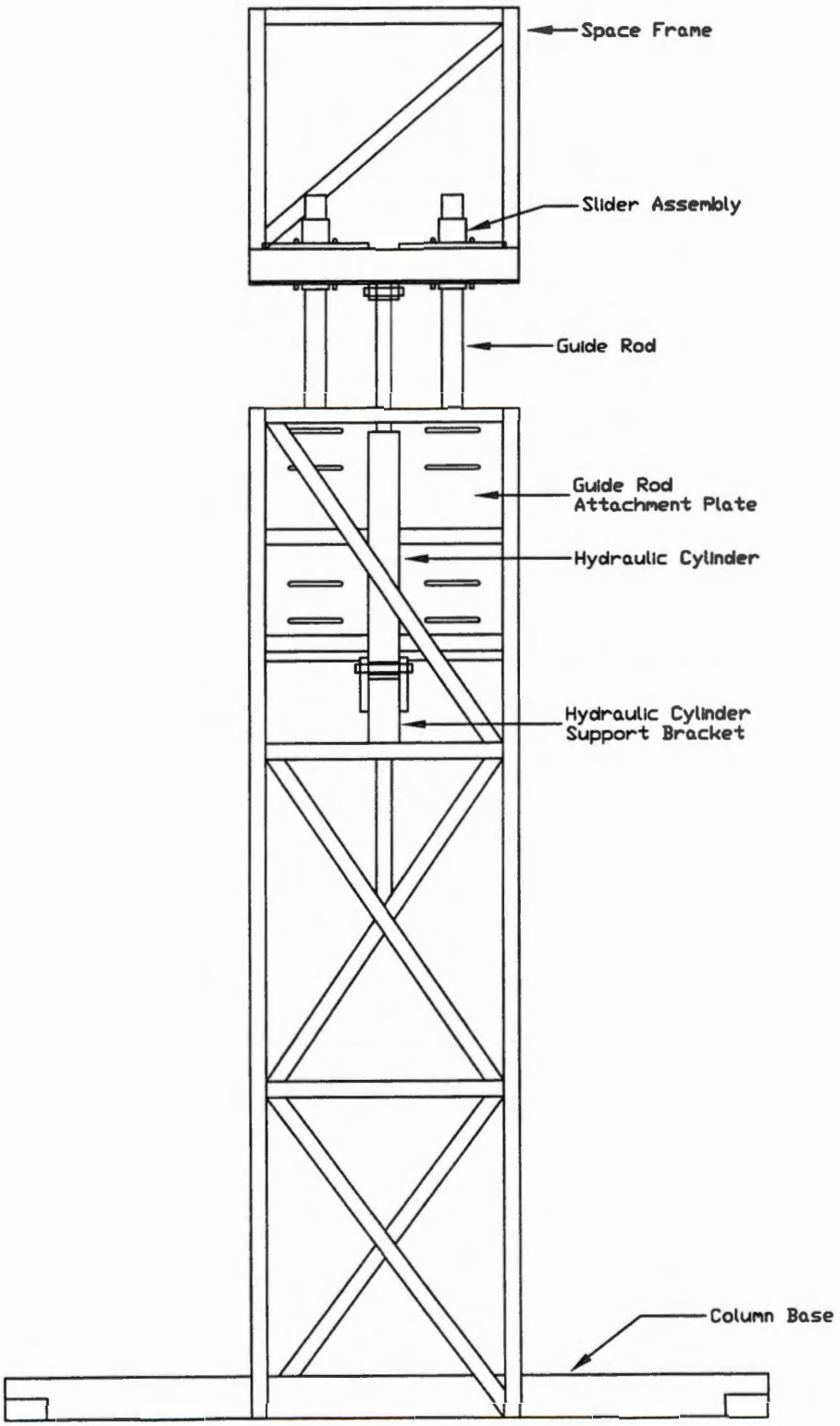


Figure 7. Column assembly end view.

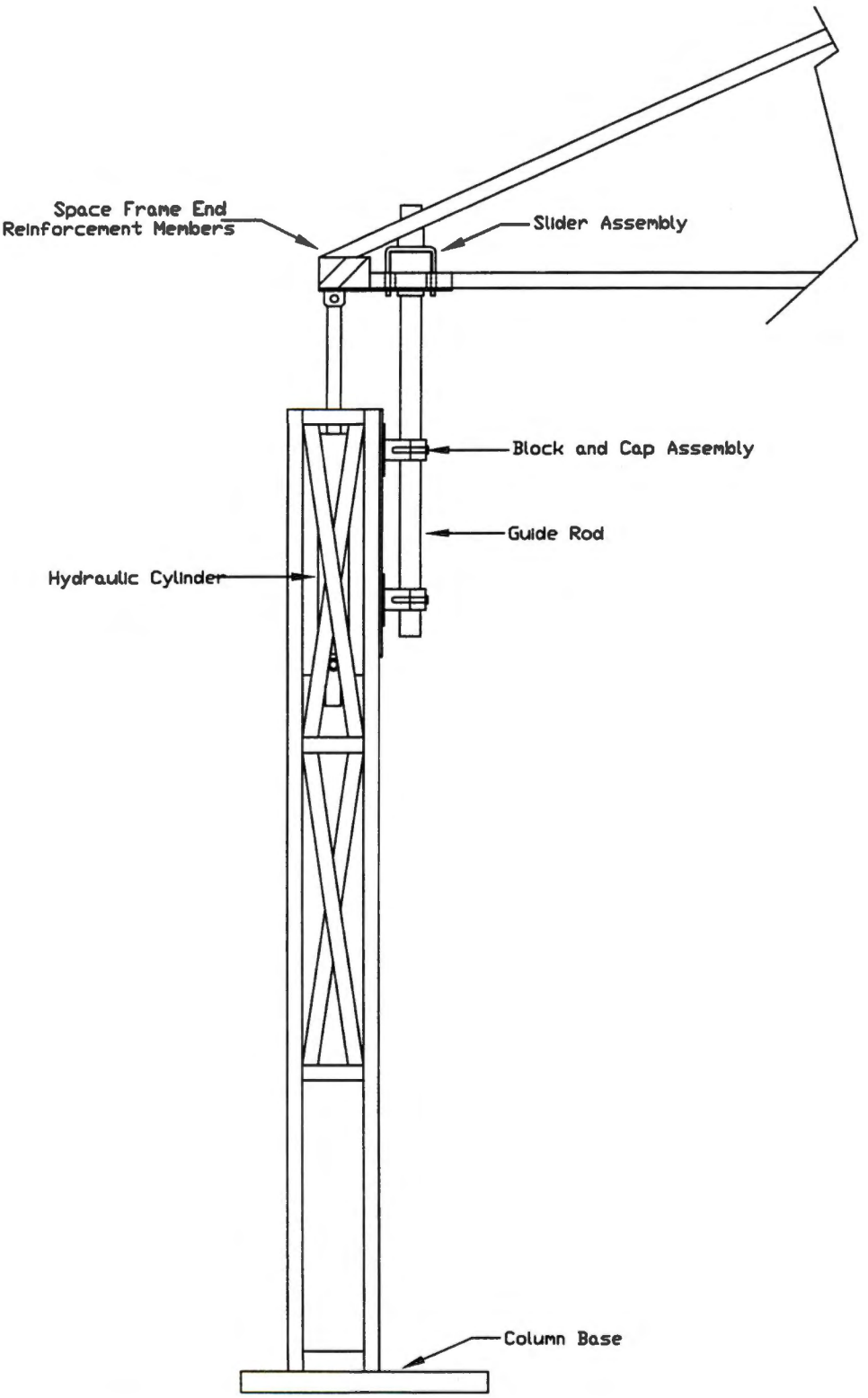


Figure 8. Column assembly side view.

steel tube is a 2-inch by 4-inch rectangular steel tube with wall thickness of 0.25 inches. These 2-inch by 4-inch tubes are welded perpendicular to the 4-inch by 6-inch tube to provide stability for the gantry. The original design for the column assembly called for a triangular cross-section space frame. The design was changed to a rectangular cross-section space frame to accommodate easy construction, with only a minimal increase in cost. Total height of the column assembly is 7 feet-11.25 inches. The height dimension was determined by: 1) the space needed to set a bale on end and attach to a bale clamp/suspension mechanism; 2) the height of the ceiling lights in the solar-heated, forced air dryer.

The guide rods and slider assemblies, as previously mentioned, are used to remove transverse shear loads from the hydraulic cylinders. The guide rods are designed to be removable to ease assembly of the gantry. This is accomplished by welding a 0.25-inch steel attachment plate to the top and front of the column assembly. Four block and cap assemblies bolt to the attachment plate which is slotted to make it possible to correctly align the guide rods through movement of the block and cap assemblies clamping the guide rods (see Figure 9). The block and cap assemblies are 2-inch by 4-inch solid steel blocks welded to 5-inch by 5-inch by 0.25-inch steel plates. The blocks have 2-inch diameter holes bored through them to hold the 2-inch O.D. guide rods. The blocks are divided into two pieces at the center of the 2-inch diameter holes. The two pieces are drilled and tapped so that the guide rod can be secured by bolting the two block and cap pieces together.

The hydraulic cylinders support the vertical load of the space frame assembly when

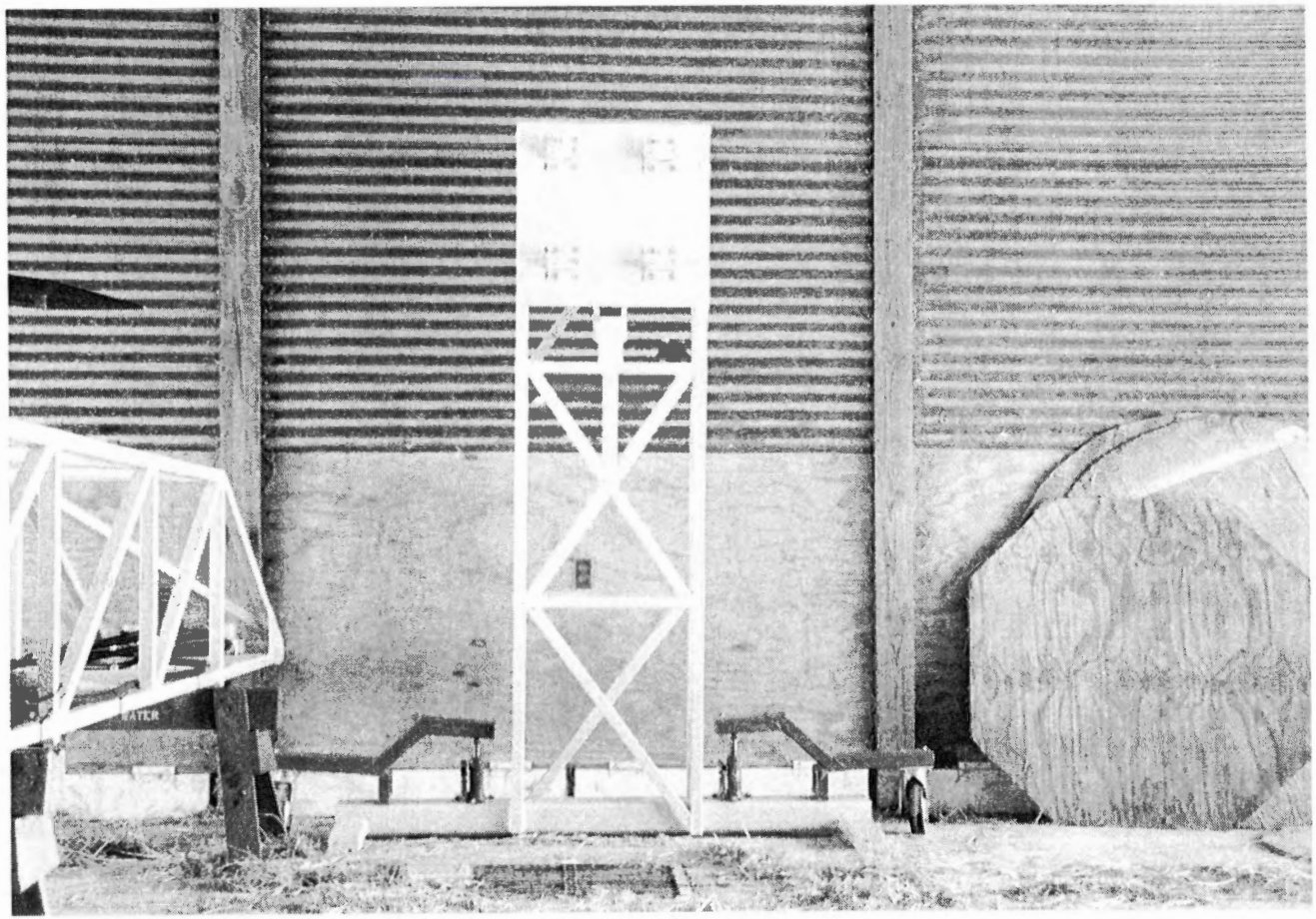


Figure 9. End column assembly with guide rod attachment plate, block and cap assemblies, and wheel assemblies.

it is raised off the top of the column assembly. Therefore, each cylinder was placed in the center of its supporting column so that the weight would be distributed evenly among column structural components (see Figure 10). The cylinder ends are pinned to 3-inch by 6-inch pieces of rectangular steel tubing that are welded to the column frame. The cylinder rods are pinned to tabs welded on the bottom of the space frame assembly.

The wheel assembly of the original gantry design included a linkage actuated by a hydraulic cylinder. To reduce the complexity of the mechanism, this assembly was redesigned. A manually operated hydraulic jack was placed at each end of the column assembly base and secured by steel clips fixed to the column base. A lever system then is employed, which when activated by the hydraulic jack piston, moves the two 8-inch diameter caster wheels mounted to the lever system against the floor and raises the column assembly off of the floor (see Figure 11). The main lever arm is made of 2-inch by 4-inch rectangular steel tubing having a wall thickness of 0.18 inches. This lever arm pivots on a 0.75-inch diameter pin that is supported by a pivot bracket mounted on each end of the column base. The brackets are made from 1.50-inch by 0.75-inch rectangular steel bar stock formed into U-shaped brackets. With the wheels in the down position, the gantry is mobile and can be pushed to the desired location. The wheel assembly was not designed to support the gantry loaded with bales. Therefore, the gantry should never be moved when loaded.

Bale Clamp/Suspension Assembly

The purpose of the bale clamp/suspension assembly is to provide an airtight seal at

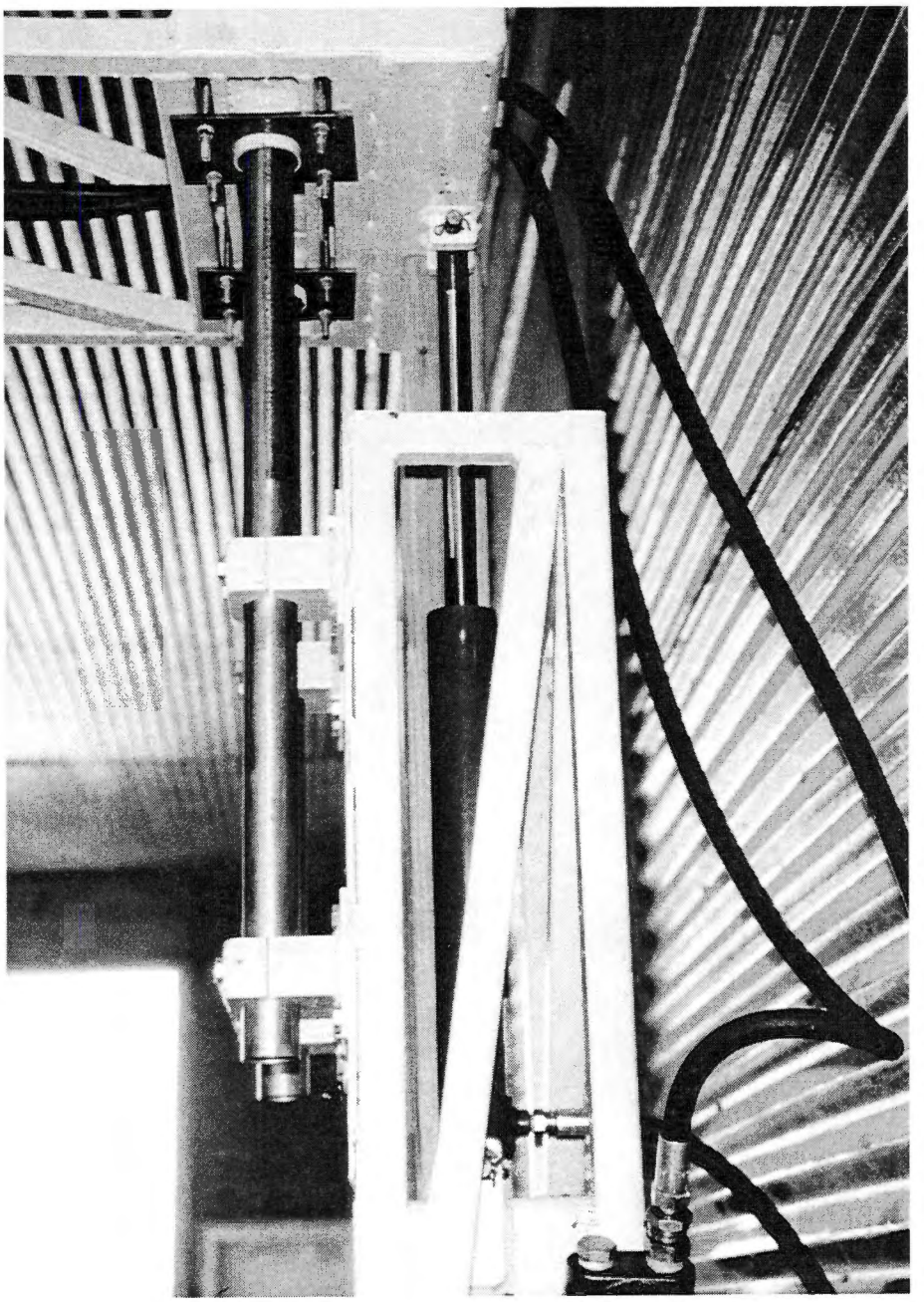


Figure 10. Placement of hydraulic cylinder in column assembly.

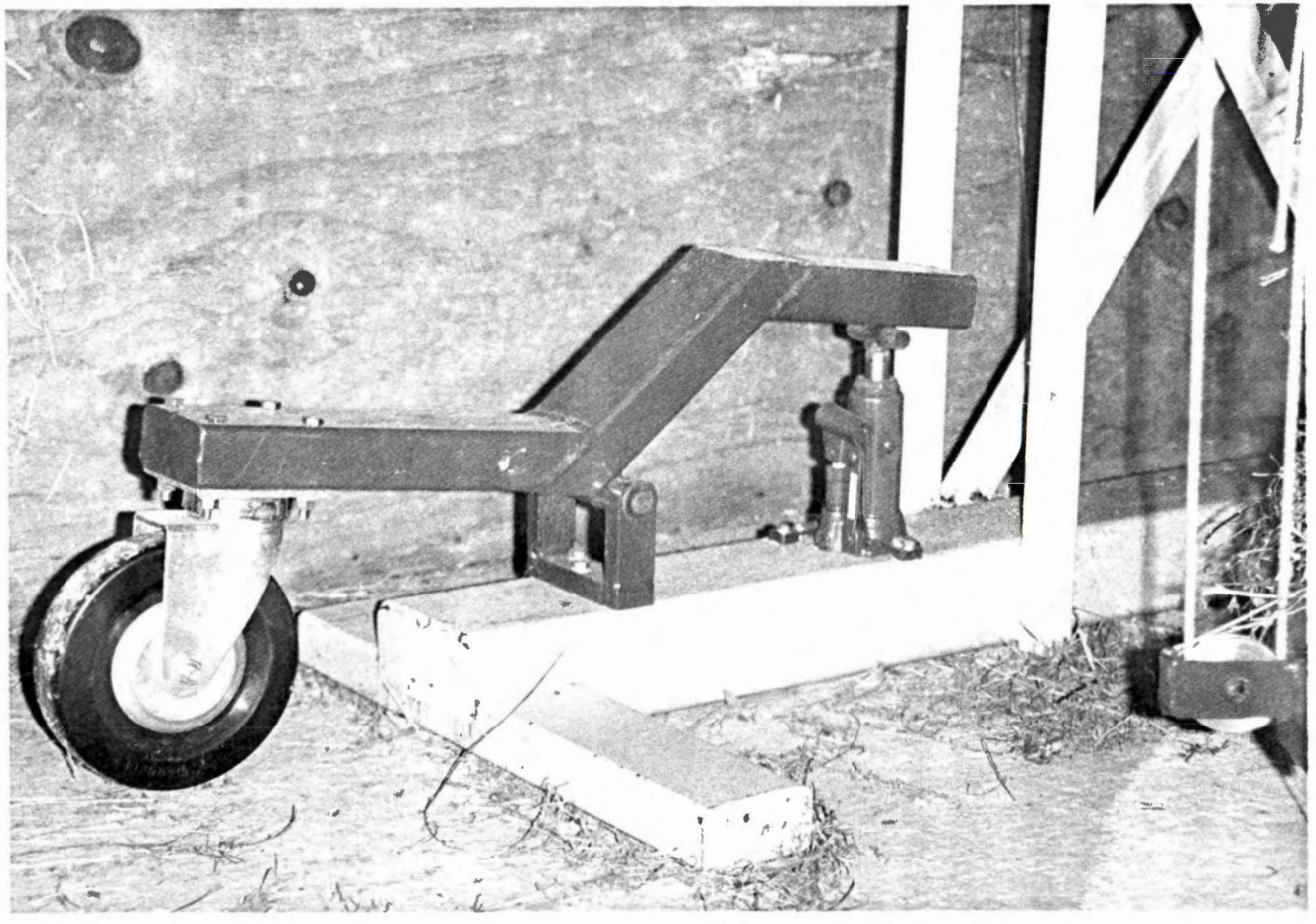


Figure 11. Wheel assembly mounted to column base.

both the top and bottom of the bale and to freely suspend it from a load cell to weigh it continuously during drying. The means of free suspension also must allow air to flow up through the bottom of the bale. Clamping bale plates to bale top and bottom surfaces to create an air tight seal was accomplished by harnessing the weight of the bale as the clamping force.

Bale clamp/suspension assemblies (see Figure 12) are connected to the space frame at the equally spaced bale connection cross members of the frame. A 0.50-inch diameter hole is in the center of each bale connection cross member so that a 0.50-inch shoulder type eyebolt can be bolted to the member. A double clevis link connects between the eyebolt and a rod end bearing. The rod end bearing is screwed into the top end of an Interface Inc., Sealed Super-Mini load cell used for determining bale weight. Another rod end bearing is screwed into the bottom of the load cell and connects to the bale suspension plate. The bale suspension plate is a piece of 0.31-inch steel plate cut and formed into three equally spaced arms reinforced for strength. The equally spaced arms and rod end bearing connections allow free suspension of the bale such that its center of gravity aligns with the vertical axis of the load cell. The load cells in this setup measure only vertical loads (bale weight).

A slot in each arm of the suspension plate accepts and anchors a 0.25-inch clevis slip hook attached to a 0.19-inch diameter steel cable that connects top and bottom bale plates restraining the bale through a pulley system. The cable runs from the suspension plate around the outside surface of the top bale plate pulley sheave, continues down and around the bottom bale plate pulley sheave, then back up to the top bale plate where it is

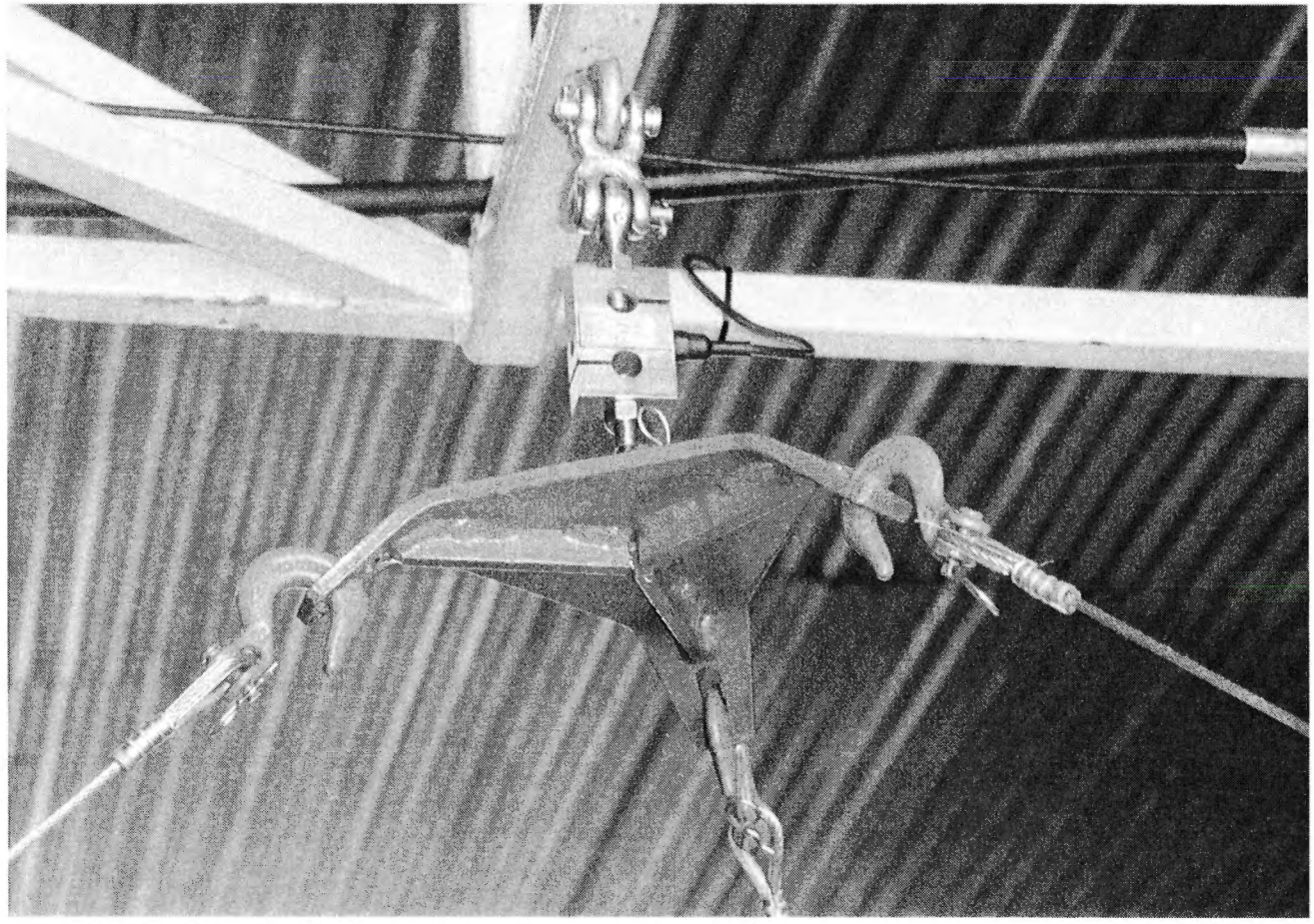


Figure 12. Bale clamp/suspension assembly connection to space frame.

hooked on a slip clevis hook attached to the bale plate assembly (see Figure 13). This arrangement applies the weight of the bale to pull the top and bottom bale plates toward one another to create seals at the top and bottom surfaces of the bale.

The bale plates are plywood disks, 5 feet in diameter, and 0.75 inches thick, bolted to supporting steel frames. Circular openings, 2 feet in diameter, are cut in the bottom bale plates to provide air entrances (see Figure 14). Circular attachment flanges are fastened to the disks and are also fastened to pre-existing floor duct opening grids of the MTES solar dryer. The circular attachment flanges are made of 28 gauge sheet metal cut, rolled and welded to shape. The disk supporting metal frames are welded, triangular-shaped assemblies, consisting of three identical pieces of 1-inch by 3-inch rectangular cross-section steel tubing having a wall thickness of 0.13 inches. A 0.25-inch thick gusset plate is welded to the juncture points of each triangle for strength and as a place to mount pulley brackets. The gussets for the top bale plates have an added tab with a hole for a clevis slip hook to be mounted. The pulley brackets are made of 0.25-inch by 1.50-inch flat steel stock. The brackets are welded to the gusset plates on the bale plate frames. A 0.50-inch diameter steel axle is pushed through a 0.50-inch diameter hole in the pulley bracket to mount the pulley sheaves.

A flexible duct was used to connect between the pre-existing floor duct and the bale bottom plate (see Figure 15). The duct, manufactured by Flex King Inc., was neoprene coated, double-ply cotton fabric with a wire coil sewn into it. The flexible duct is connected between the attachment flange on the bottom bale plate and the attachment flange on the pre-existing floor duct grid using adjustable steel bands (see Figure 16). The

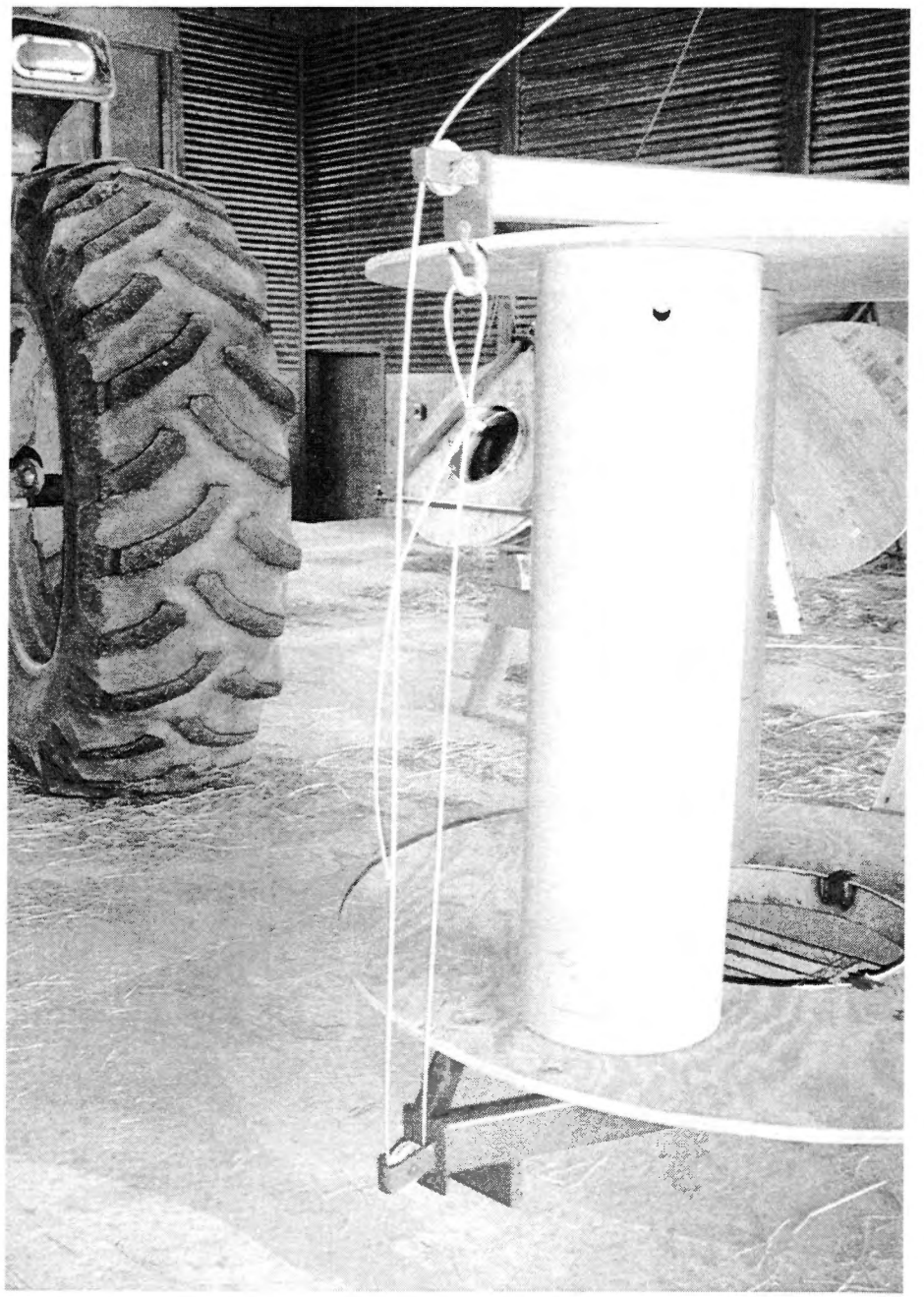


Figure 13. Bale clamp/suspension assembly connection to bale plates.

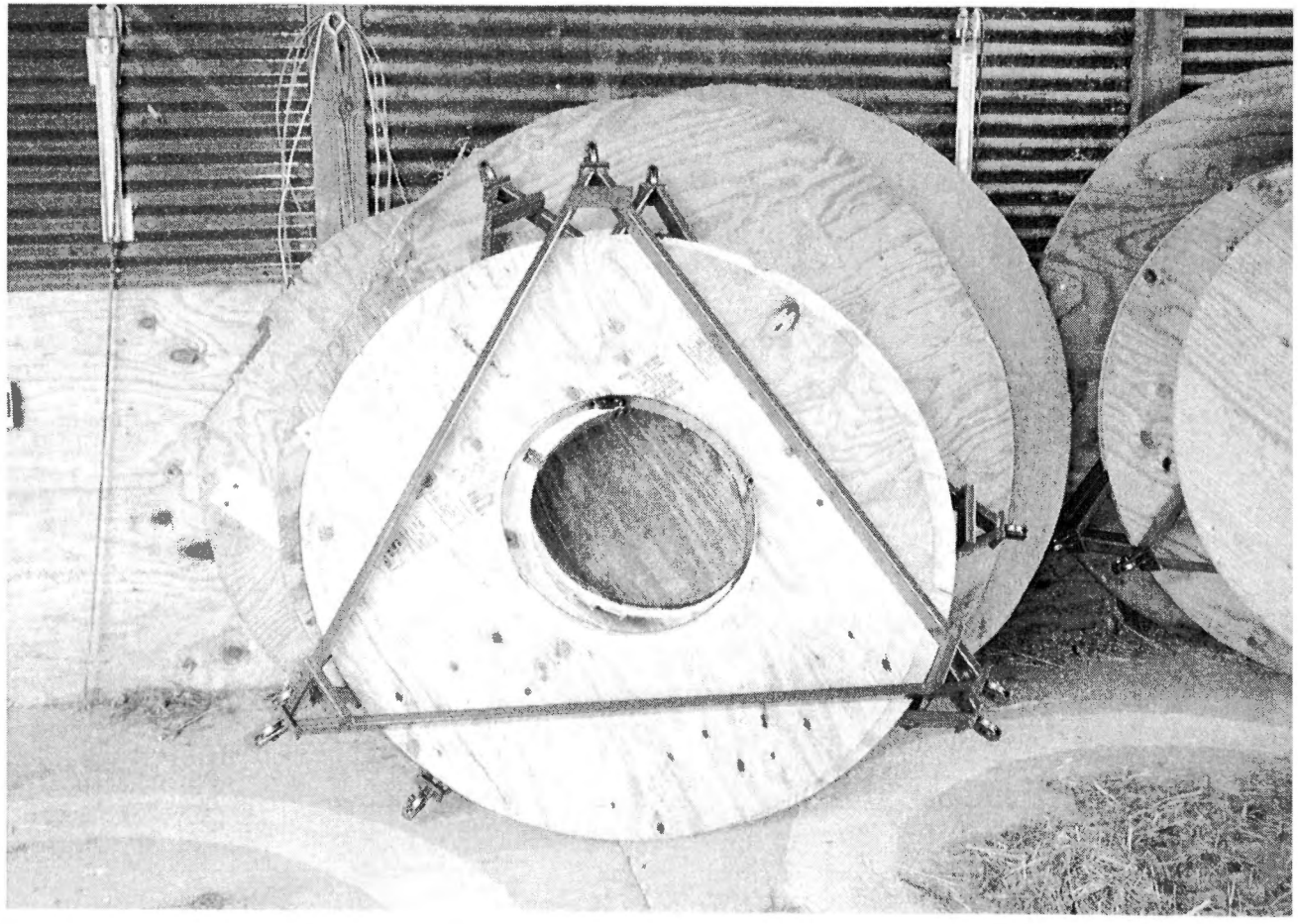


Figure 14. Bottom bale plate with circular attachment flange.

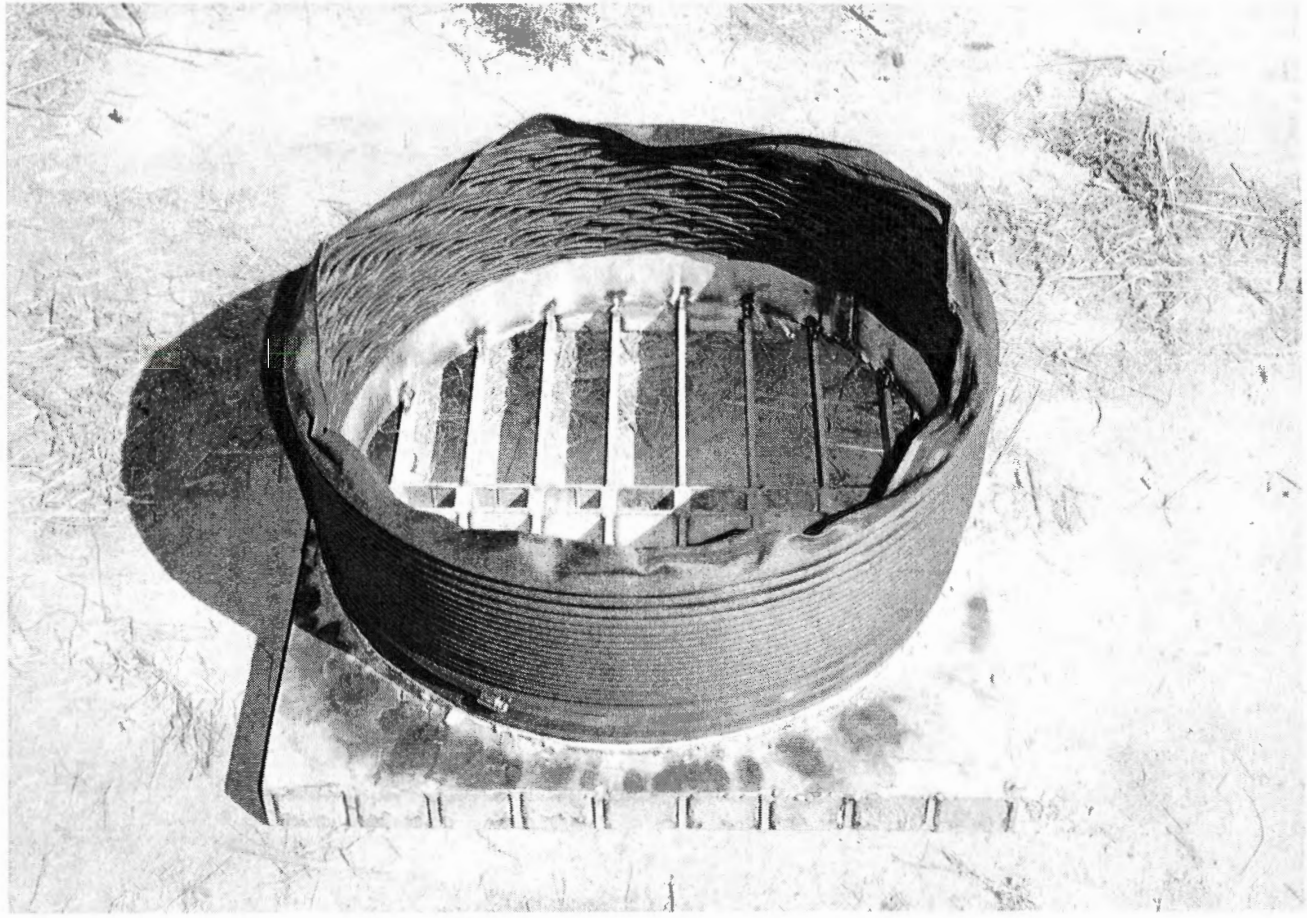


Figure 15. Flexible duct connected to pre-existing floor duct opening grid.



Figure 16. Connection between floor duct opening grid and bottom bale plate using flexible duct and adjustable steel bands.

floor grid can be removed from the floor and turned upside down for storage purposes. This prevents the attachment flange from protruding upwards when not in use.

Hydraulic System

The hydraulic system of the gantry (Figure 17) is powered from a remote hydraulic port of a farm tractor (see Figure 18). An International Standards Organization type universal quick coupler connects the 0.75-inch inside diameter (I.D.) hydraulic system hose to the tractor hydraulic port. This hose connects through another quick coupler to an on/off valve (two position, two way selector valve) mounted on a gantry column. This arrangement allows the hydraulic system to be controlled from the tractor or at the gantry using the on/off valve (see Figure 19). Another 0.75-inch I.D. hydraulic hose connects the on/off valve to a Delta HPR21-1 gear-type flow divider/combiner located near the space frame center (see Figure 20). The flow divider/combiner separates flow equally to the two hydraulic cylinders used to raise and lower the space frame. Specifications of the Delta HPR21-1 gear-type flow divider/combiner indicate that it can divide or combine flow equally within plus or minus 1%. Hydraulic lines run from the two output ports on the flow divider/combiner to the two hydraulic cylinders, one located in each gantry column assembly. The double acting hydraulic cylinders have 1.38-inch rod diameters, 2.50-inch bore diameters, and 16-inch strokes. A breather (muffler) plug installed in the top port of each hydraulic cylinder allows filtered air movement through the port during expansion/retraction strokes of the cylinder piston and rod. Gravity lowers the space frame; hydraulic power raises it. Hence the double acting cylinders are converted to single

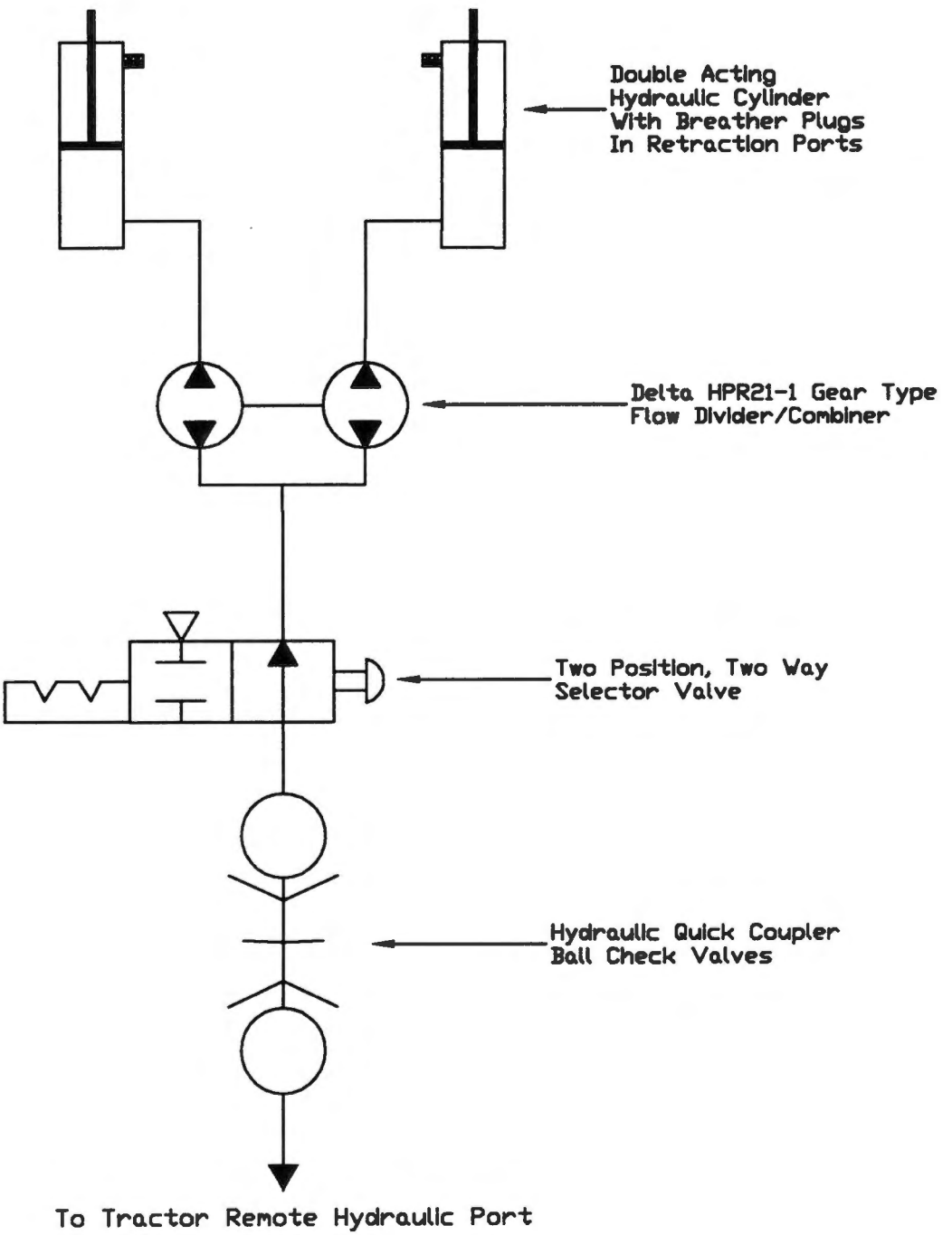


Figure 17. Schematic diagram of hydraulic system.

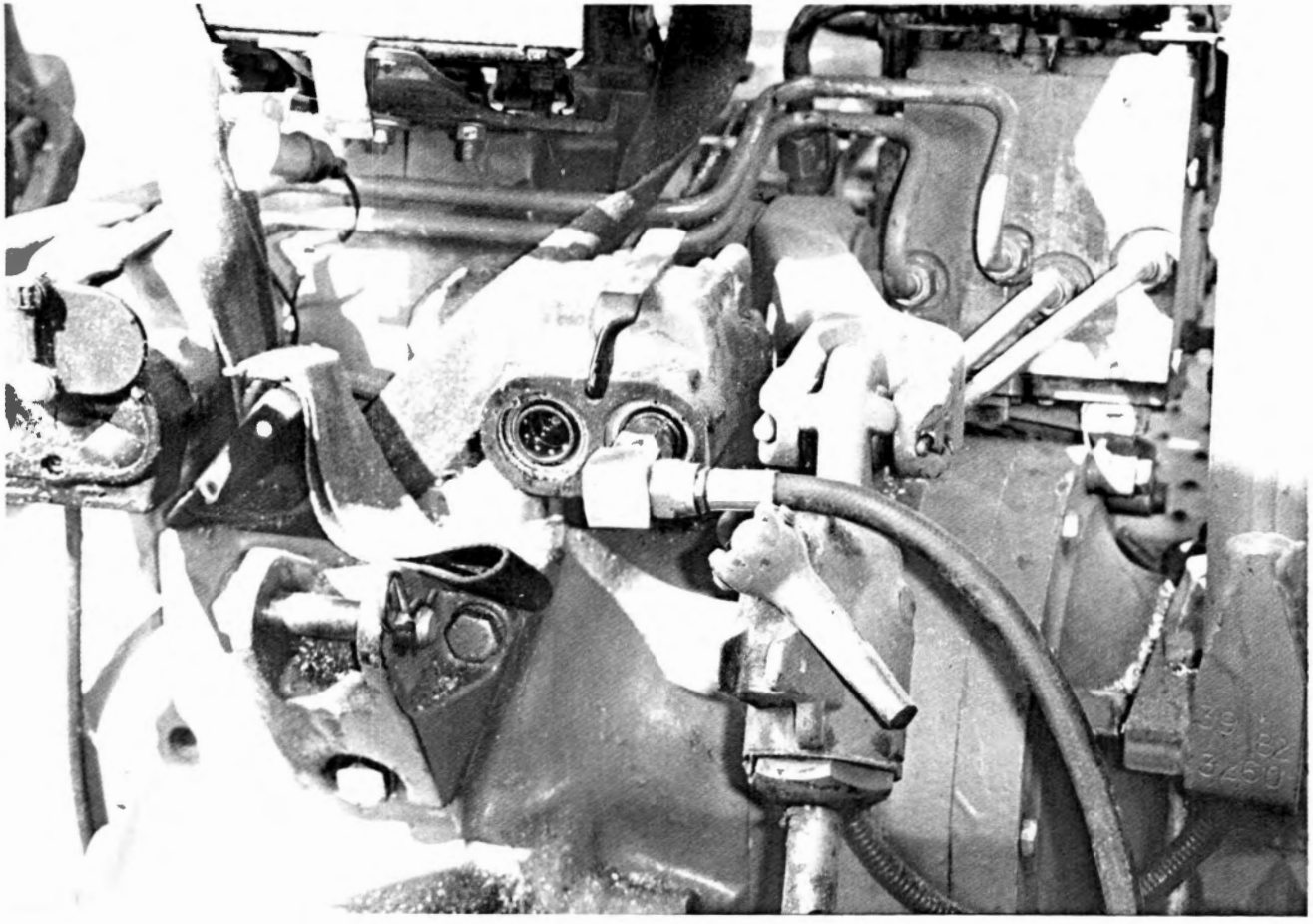


Figure 18. Connection of hydraulic system to tractor hydraulic port.

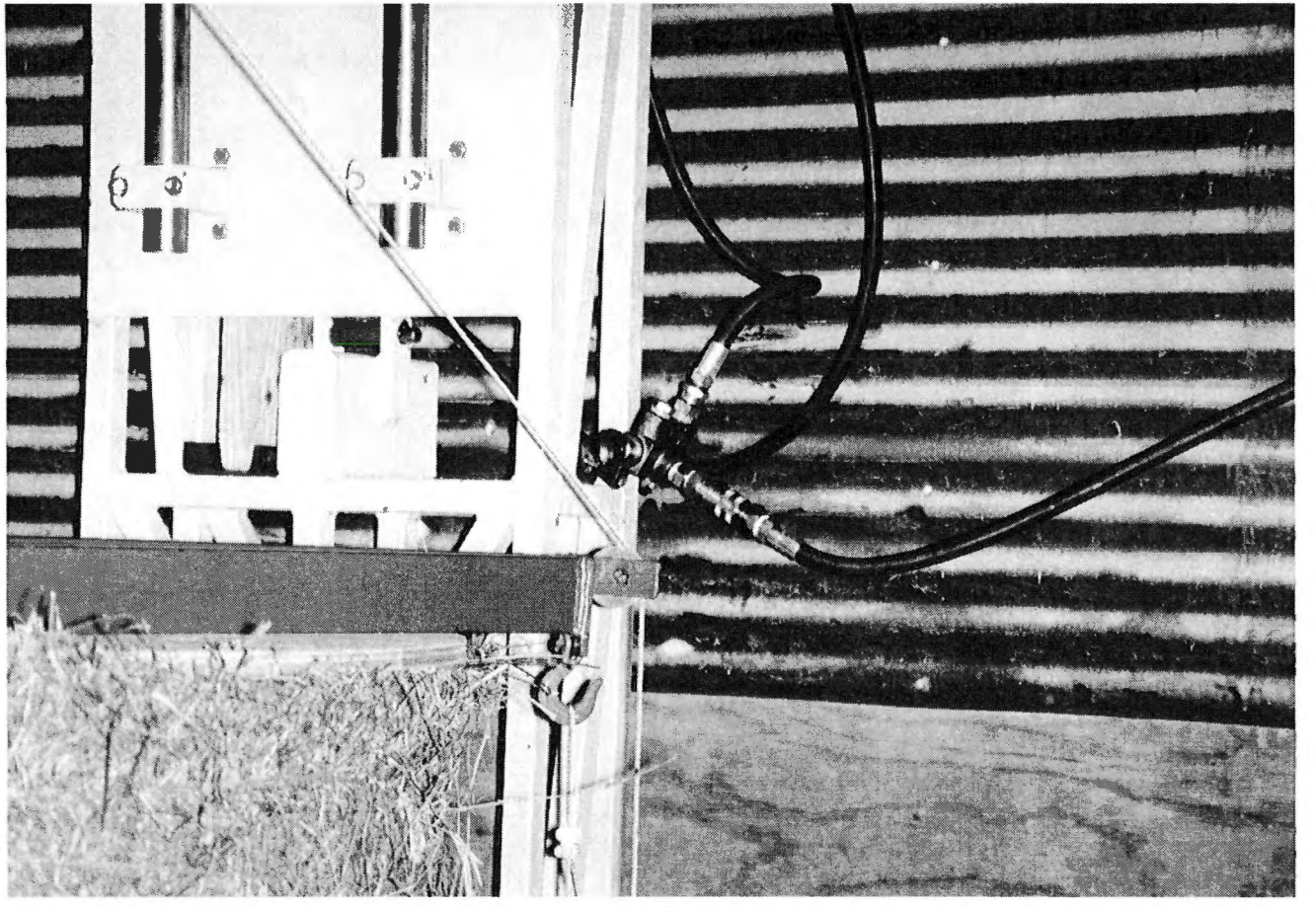


Figure 19. On/off valve mounted on the column assembly.

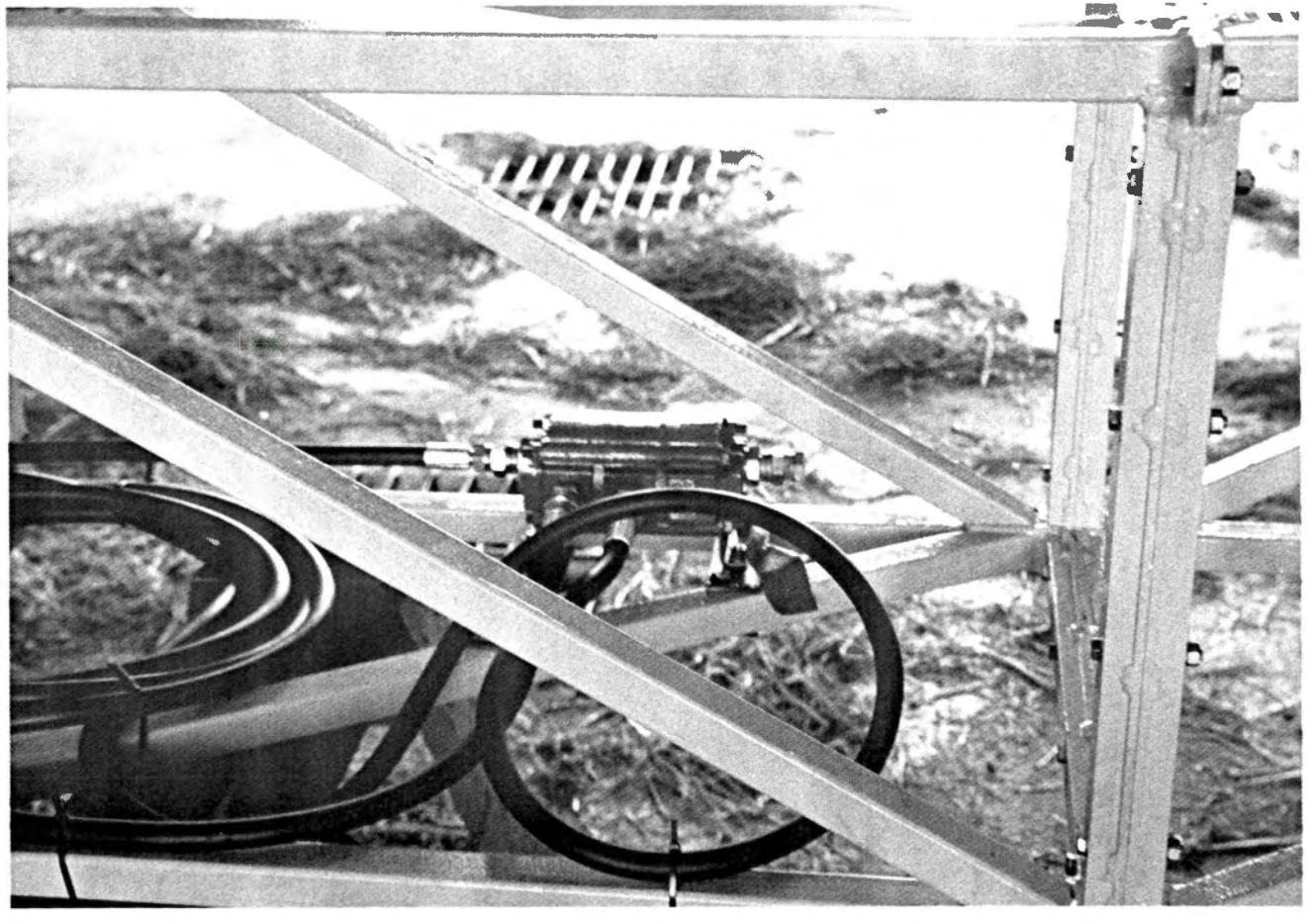


Figure 20. Delta HPR21-1 gear-type flow divider/combiner.

acting cylinders by the addition of breather plugs in the top ports.

2. Fabrication and Assembly of Gantry

Fabrication

Fabrication of the gantry began in September of 1995 and was completed in September of 1996. The work was done in Agricultural Engineering Research Shop facilities. The space frame assembly was the first portion of the gantry fabricated.

Materials were ordered based on gantry design plan bill of materials. The metals were ordered in full length pieces and cut to desired lengths and angles on shop bandsaws. After a piece was cut, it was marked with an identifying part number for later welding into the space frame assembly. The space frame was fabricated in two halves for ease of transport as previously mentioned. Components were welded into place beginning at the frame center juncture and continued to the column attachment end. Using clamps and a square, the component pieces were clamped together and welded. A Metal Inert Gas (MIG) welder was used for making the welds. Voltage and wire speed were determined by testing the welder on a scrap piece of metal until the desired settings were reached. Bolt holes in the center junction cross members were made using a variable speed drill press. Mounting holes in the bale suspension cross members were made using a drill motor after the space frame had been welded together. The space frame was then painted with an oil-based primer to inhibit rust.

The end columns were the next components fabricated. The procedure was similar

to that for the space frame assembly. Materials were ordered, cut, and labeled into component parts. Component parts were then welded to form the completed assemblies. Clamps and a square were again used to properly align and hold column members while welding. The steel guide rod attachment plate slots were made with a milling machine. Attachment plates were then welded to the top front of each column assembly for attaching guide rods to control space frame vertical movement relative to the end columns. When the vertical portion of the column assembly was completed, it was then welded to the support base unit. This procedure allowed adjustments in the squareness of the column to base assembly if needed. During the time period required for welding the column members into an assembly, machinists of the research shop fabricated slider joint components.

The slider assembly required the use of milling machines and lathes. The 2.50-inch diameter mandrel-drawn steel tubing was cut to length and bored at each end so that bronze bearings could be pressed into the tubing length. This bearing tube was then centered and welded into the pre-bored hole of a 2-inch by 4-inch piece of rectangular steel tubing.

The block and cap assemblies also required the use of milling machines and lathes. A 2-inch diameter hole was bored through 2-inch by 4-inch pieces of solid steel block using a lathe. Two holes were then drilled in the face of the cap blocks and threaded using a tap and die set before the cap blocks were cut in half. The block assemblies were then welded to pieces of 5-inch by 5-inch by 0.25-inch steel plate having pre-drilled bolt holes for mounting to the attachment plates of the column assemblies.

Column wheel assemblies were fabricated next. Wheel lever components were cut to specified lengths and angles then welded to form the lever assembly including the pivot tube made of 1.25-inch diameter by 0.25-inch wall steel tubing. Pivot brackets used to support the pivot shafts were then cut and welded into U-shaped brackets. Holes for the pivot shafts were drilled 0.75 inches in diameter in the top of the brackets using a drill press. Wheel bracket mounting holes were then drilled through the brackets and the base of each column assembly. Holes in the base were threaded using a tap and die set. The pivot brackets were then bolted to the column bases. Hydraulic jack "hold-down" clips were made from steel plate. The clips were clamped to the column bases while holes were drilled through them and the column base. Holes in the base were threaded so that the clips could be bolted to the bases to hold the hydraulic jacks in place.

The bale end sealing plates were fabricated next. Design drawings called for plywood plates with a diameter of 5 feet. This posed a problem since plywood comes in only 4-foot by 8-foot sheets. However, by cutting the 4-foot by 8-foot sheet into 5-foot lengths and the remaining piece into three 1-foot by 4-foot pieces; a piece of plywood big enough to make 5-foot diameter circles could be made by glueing the 5-foot by 4-foot piece to a 1-foot by 4-foot piece using keyed edge joints. The wood keys added strength to the glued joint. To cut the sheet into a 5-foot diameter disk, a nail was driven into the center of the sheet and a piece of string was tied to it. Using a pencil at the end of a 2.5-foot string held taut, a 5-foot diameter circle was drawn on the plywood. A jig saw following the scribed circle was then used to cut out the disk. Bottom plates were cut with an additional 2-foot diameter center hole for air entry ports. The plate supporting

frames were cut and welded together. Mounting holes were drilled in the top gusset plates for the slip clevis hooks and then the gusset plates were welded to the plate supporting frames. The pulley bracket materials were cut and welded into U-shaped brackets. A drill press was used to drill a 0.50-inch diameter hole in the brackets. Pulley brackets were welded onto the gusset plates. Plywood disk attaching holes then were drilled through the plywood disks and into the steel frames while the disks were clamped to the frames. Self-tapping steel screws were used to secure the plywood disks to the frames, one disk per frame.

Flexible duct attachment flanges were made using a plasma cutter. Floor duct opening grids from the solar drying building were brought to the shop. These grids had a 2-foot O.D. metal flange made of 28 gauge steel welded to them. The flanges were 10 inches in height. The flange height for flexible duct attachment needed to be only 3 inches. Therefore, the plasma cutter was used to remove the excess height from the floor grid flange. The excess flange piece was then cut to correct height for an attachment flange for the bale bottom plate. The flange was attached to the plywood disk by welding tabs to it for bolting to the plywood. Cracks between the plywood and the attachment flange were filled with silicone caulk to create an airtight seal.

The bale suspension plate was the only part not fabricated in the Agricultural Engineering Research Shop. A local machine shop equipped with laser cutting devices and precision forming equipment fabricated the suspension plates. Reinforcement members were cut and welded to the suspension plates in the Agricultural Engineering Research Shop.

The completed gantry assemblies were painted with an oil based primer. Several finish coats of enamel were then applied to protect the structure from corrosion. All excess openings of the structure were closed using a spray foam to fill the voids. This was done to protect the interior parts from corrosion and to prevent insects from building nests in the voids.

Assembly

The gantry was assembled for testing at the Agricultural Engineering Department before it was shipped to the Middle Tennessee Experiment Station (MTES) for use in the solar-heated, forced-air hay drying facility there. The two halves of the gantry space frame were moved outside the Agricultural Engineering Research Shop using a fork lift. They were placed on saw horses on fairly level pavement. The two halves were bolted together and the slider assemblies attached to the space frame. The assembled space frame unit then was lifted using the fork lift so that the column assemblies could be rolled into position under each end of the space frame. The guide rods were slid up through the block and cap assemblies on the end columns and through the slider assemblies of the space frame one at a time. After each guide rod was in place, the bolts connecting the caps to the blocks were tightened to secure the guide rods in place (see Figure 21). The block and cap assemblies were loosely bolted to the slotted attachment plates on the end columns to avoid binding when the space frame was lowered onto the column assembly. Also, the hydraulic cylinders were not attached at this stage to avoid another possible source of binding. With these precautions, the space frame was lowered along the guide

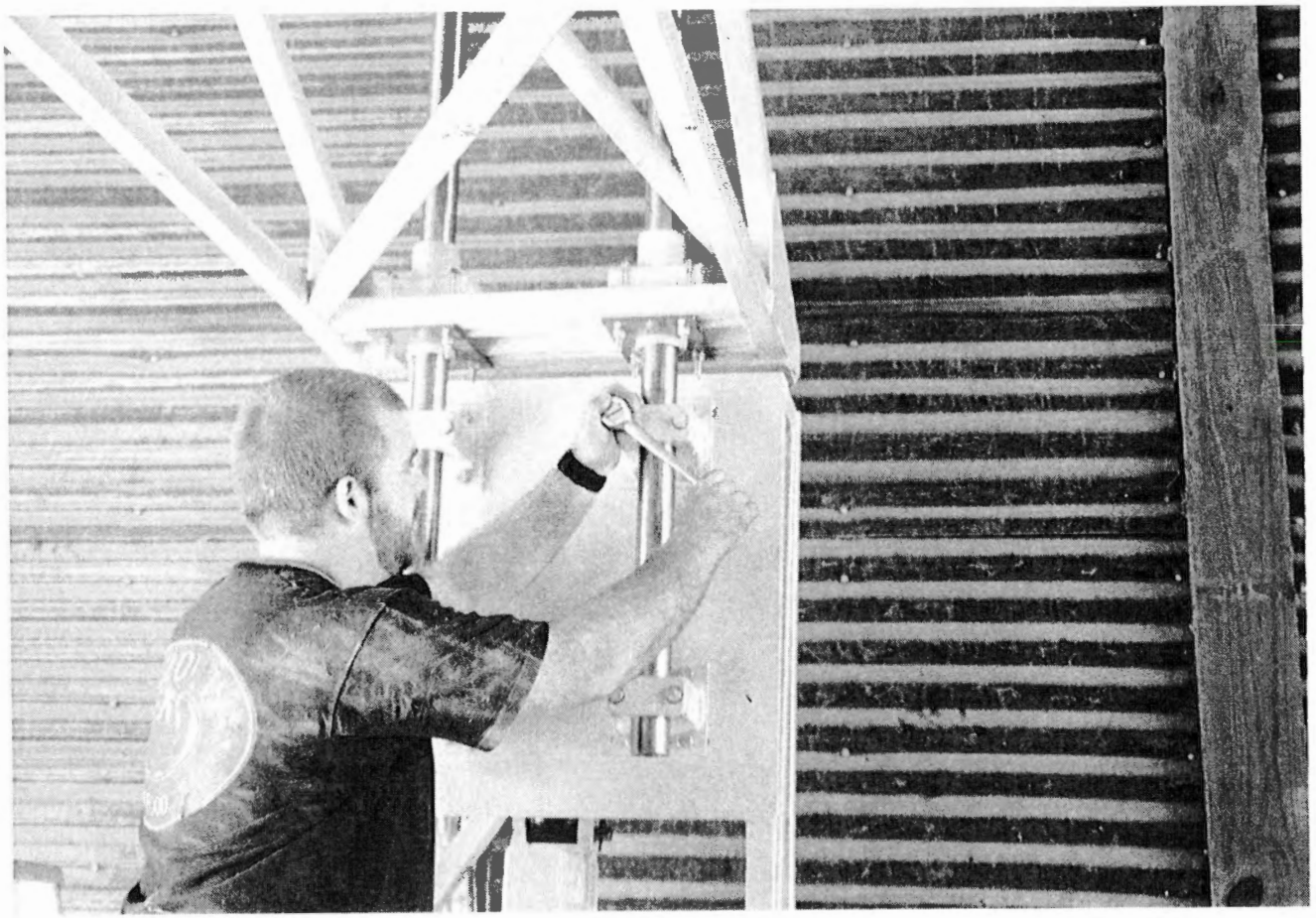


Figure 21. Tightening caps to blocks to secure the guide rods in place.

rods until it rested on the column assembly. The wheel assembly then was used to roll the gantry into the Farm Machinery Laboratory, where a level floor existed. Here the gantry space frame was squared, the guide rods plumbed, then bolted securely to the end columns. The gantry was leveled by squaring the corners of the column assemblies to the end plates of the space frame. Finally, the hydraulic cylinders were attached to make certain the columns were properly centered. Position of the guide rods were checked by measuring the top and bottom center distances and adjusting the guide rod plate mounting positions until the distances were identical. Column assembly register with the space frame (lateral position relative to common reference on space frame) was made identical at both ends.

The hydraulic system was assembled on the gantry and tested to ensure it functioned properly and that there were no leaks in the system. The gantry was then disassembled and shipped to the MTES to be reassembled for the experiment. After the gantry was reassembled, cable length for the bale clamp/suspension assemblies was determined by using pieces of PVC pipe (used for forming hollow core bales) as braces between the bale plates (see Figure 22). Cables with adjustable loops were then routed as described in the Bale Clamp/Suspension portion of the thesis. The cables were adjusted until they were taut. The cables were then removed and measured to determine cable length. The remaining cables were adjusted to the measured cable length.

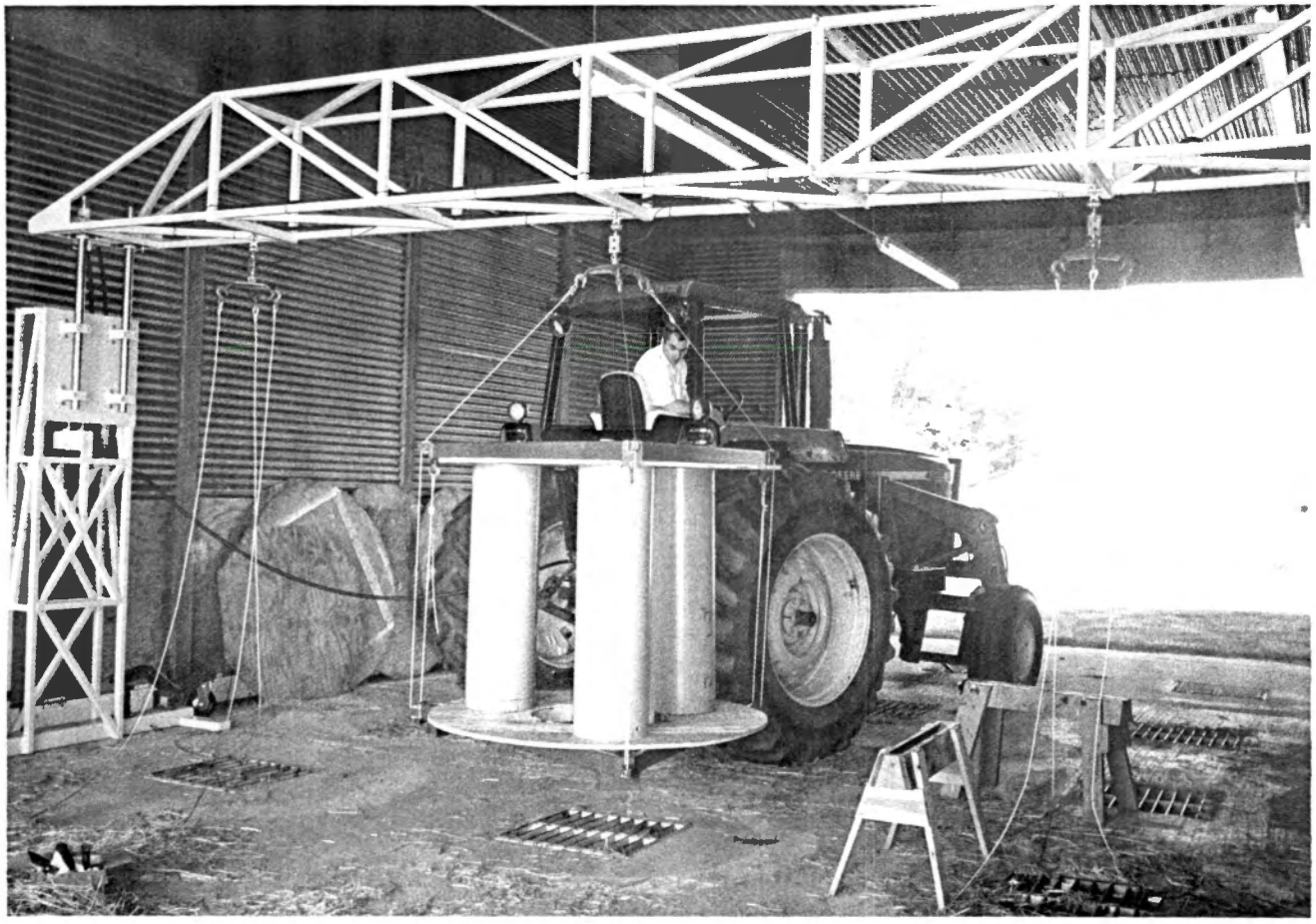


Figure 22. Using PVC pipe to determine appropriate cable length.

3. Instrumentation Used on Gantry and Solar Collector

Instantaneous weights of bales suspended on the gantry were the main response variables of interest in this experiment. Other variables of interest were the temperature and percent relative humidity of ambient air and dryer fan discharge air, and the intensity of solar radiation, because these were needed to relate drying rate to atmospheric conditions. Two Campbell Scientific Inc. 21X Microloggers were used to collect data. One 21X Micrologger was used for collecting bale weight data. The other was used for collecting temperature, relative humidity, and solar radiation data.

Weights of the bales suspended by the gantry during the experiment were determined by using four Interface Model SSM-EV-3000 Sealed Super-Mini load cells. The rated capacity of each load cell is 3000 lbs. Bale clamp/suspension assemblies were tared by suspending the assemblies and monitoring their weights for a day (see Figure 23). The weights were averaged and then subtracted in the 21X program. Bale weight readings were taken every minute using the 21X Micrologger. Weights from a 15 minute interval were then averaged and recorded by the 21X. The program for determining bale weight using the 21X can be found in Appendix A1.

Temperature and relative humidity readings were made each minute and averaged over 15 minute intervals the same as bale weight. Readings were recorded for the ambient and dryer fan discharge air. Ambient air data were determined by placing two Campbell Scientific Inc. Model 207 Temperature and Relative Humidity Probes at two different positions in the air inlet of the solar collector. Dryer fan discharge air data were

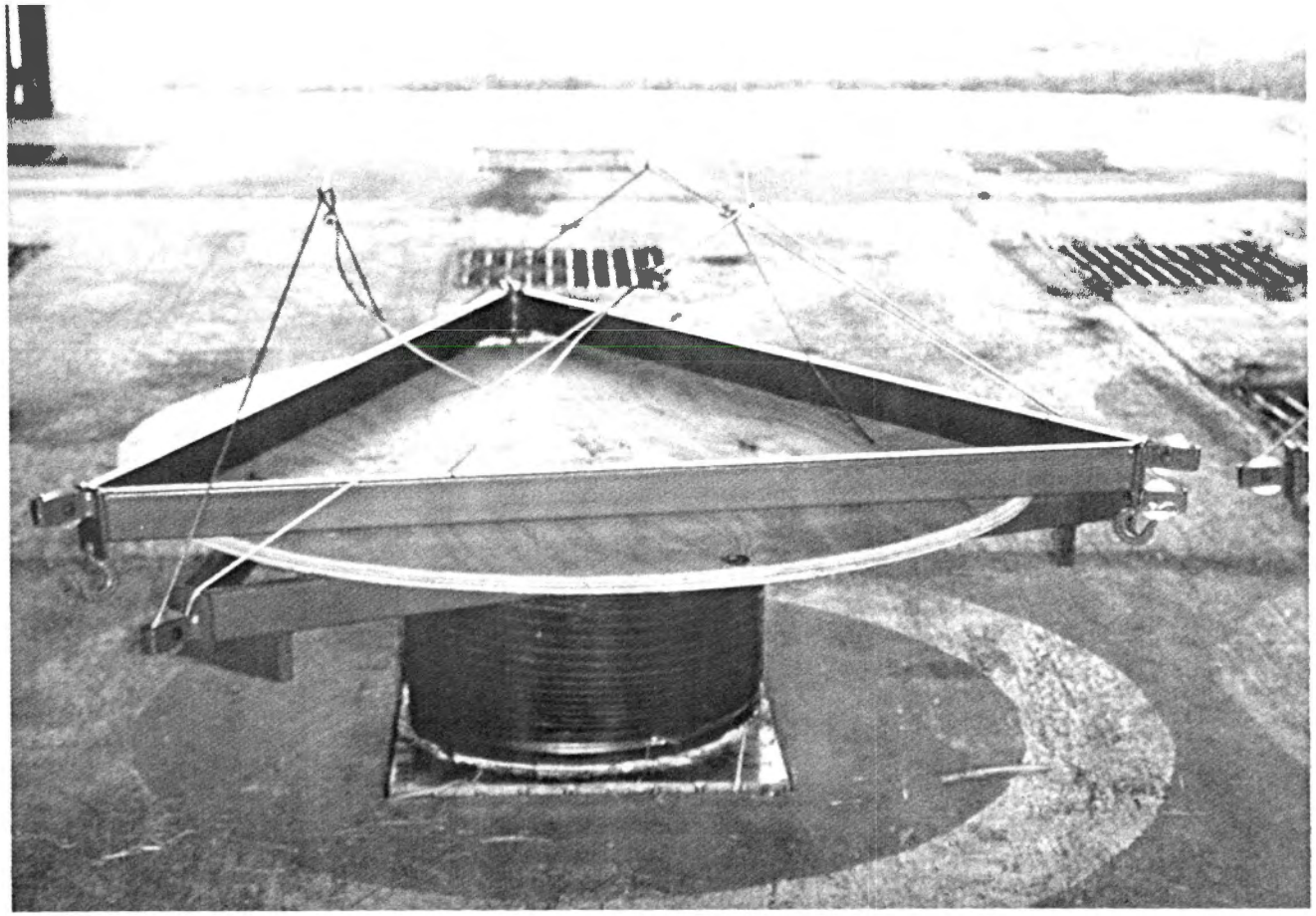


Figure 23. Weighing the bale clamp/suspension assembly.

determined by placing a Model 207 probe in the air discharge side of two dryer fan ducts: one serving four bales on the dryer floor; another serving the four bales suspended by the gantry. Specified accuracy of the probes was plus or minus 0.4°C in the temperature range from minus 33°C to plus 48°C, and plus or minus 5% over the 12 to 100% relative humidity range according to Campbell Scientific (1988). A Campbell Scientific Inc., Model AM32 Multiplexer was used to link the probes to the micrologger.

Solar radiation was measured using two Eppley Model 8-48 pyranometers. One pyranometer was mounted vertically on the south wall of the collector. The other was mounted at the top of the south wall at the same angle as the roof of the collector. The multiplexer was used to link the pyranometers with the micrologger. The same 21X Micrologger was used for temperature, relative humidity, and radiation data. The 21X Micrologger was programmed to take readings once a minute. The data were averaged over a 15 minute period and then recorded as previously stated. The 21X program for taking temperature, relative humidity and solar radiation data can be found in Appendix A2.

4. Forming Solid and Hollow Core Bales

One objective of this experiment was to artificially dry solid and hollow core bales with solar-heated, forced-air and compare drying rate parameters for the two types of bales. Hollow core bales were made as previously reported by Bledsoe *et al.* (1995). They state that the process consists of "...opening (raising) the baler gate and positioning

the PVC tube in front of the lower main roll of the bale chamber (see Figures 24 and 25). Once the tube is positioned, the rear gate is closed and the normal baling process resumes. Completed bales are transported on trailers to the dryer. Loading and unloading is performed with a spear-type bale loader attachment on a tractor-mounted, front end loader. Once unloaded, the PVC tubes are removed by tieing a rope through a hole drilled in one end of the tube and pulling the tube out of the bale with a tractor."

Bales with hollow core diameters of 6 and 12 inches were of interest for this experiment. The PVC stock pipe (6-inch and 12-inch diameter) were cut to the length of the minimum inside width of the round bale forming baler. This dimension was measured to be 44.63 inches for the Gehl Model 1470 baler used in the experiment (see Figure 26). The 6-inch and 12-inch diameter PVC pipe were cut using either the shop bandsaw or a handsaw. A 0.75-inch diameter hole was drilled in each end of the PVC pipe so it could be removed as described previously.

To keep hay moisture content and field conditions similar among comparative bale types, bales were formed in the following sequence: solid core, 6-inch hollow core, 12-inch hollow core. The sequence was repeated over and over until the appropriate number of bales had been formed.

5. The Experiment

The 20 acre alfalfa field used for the experimental hay bales was cut at 9:30 a.m. Central Standard Time on 9/19/96. The hay dried to acceptable baling moisture around

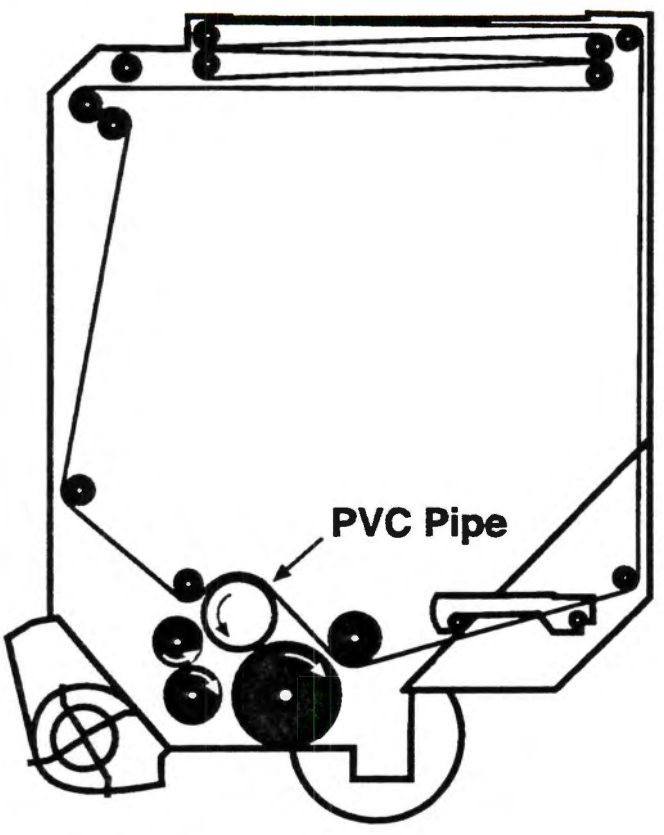


Figure 24. Position of PVC pipe in bale chamber to produce a hollow core bale.

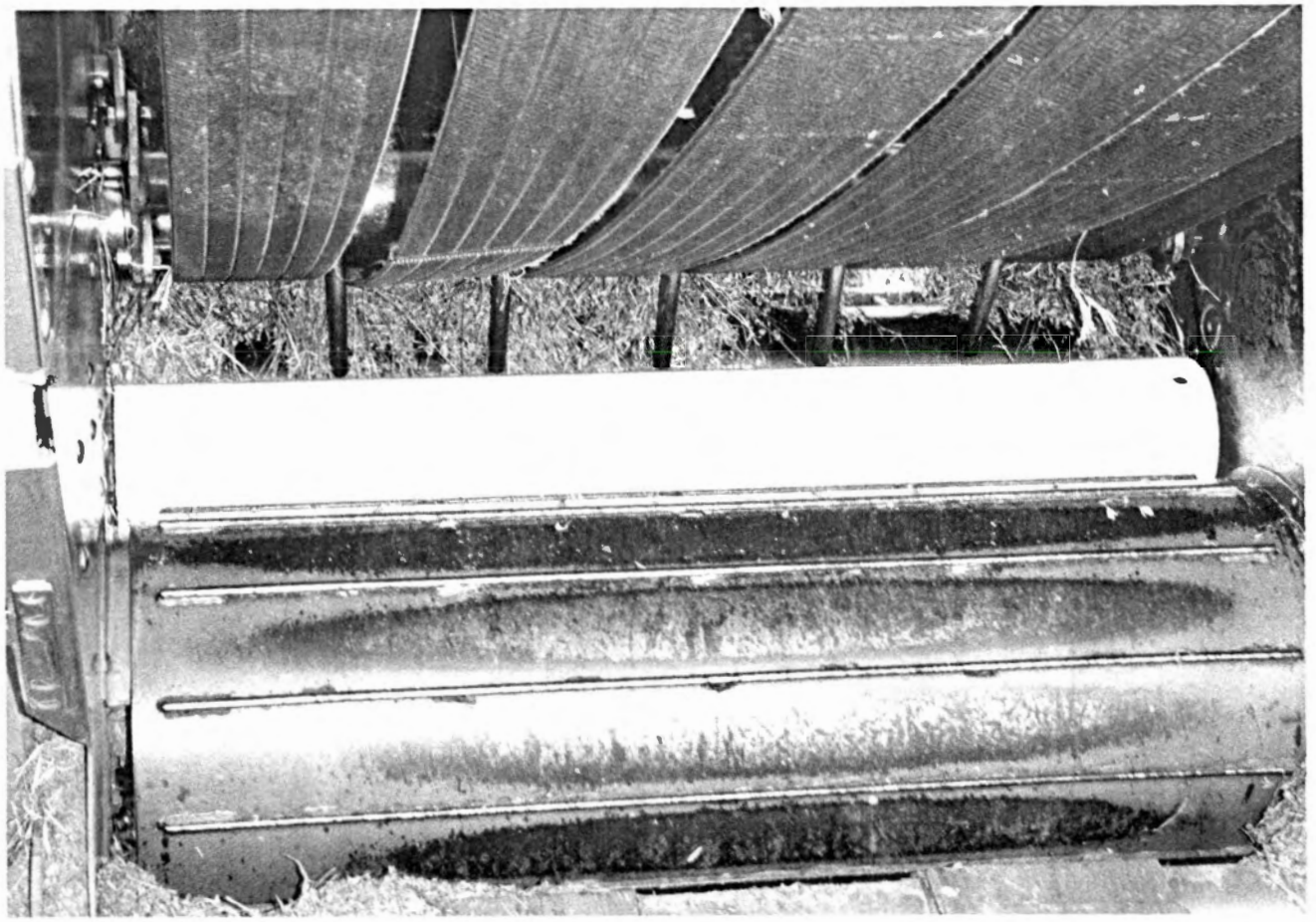


Figure 25. PVC pipe placed in the Gehl Model 1470 baler.



Figure 26. Gehl Model 1470 baler used in the experiment.

3:30 p.m. that day. The hay was not baled, however, because it was late in the day. Therefore, a decision was made to wait until the following morning so that the hay could be baled "in case" meaning sufficiently moist to avoid leaf shattering. The hay was raked the following morning (9/20/96) at 9:30 a.m.. Baling began at 12:30 p.m. when the field moisture content of the hay was about 35% wet basis. The baling process was performed as described in the Forming Solid and Hollow Core Bales section of this thesis. Baling was completed at 2:15 p.m.. Each bale was tagged for identification purposes and then loaded on a trailer and hauled to the solar drying barn (see Figure 27). There bales were unloaded from the trailer and the PVC pipes were extracted. Each bale was then weighed using a support platform on a pair of electronic weigh bars connected to a readout device. The weights were recorded manually. Bales were core sampled using a drill motor and a Pennsylvania coring tool (Figure 28) and plugged with sorghum-sudangrass hay (see Figure 29). Bales were then positioned on the dryer according to a predetermined randomization scheme.

The statistical design chosen for the hay drying experiment was a completely randomized design. The solar barn has 8 rows of dryer fan ducts with 4 outlets in each row. Centrifugal and van-axial fans are used to force air through the air ducts. The fans alternate each row. Therefore, all bale types were tested using both fan types. Figure 30 illustrates the location and placement of the bales. The eighth row used a centrifugal fan and had four solid bales placed on it. The seventh row used a vane-axial fan and had four solid bales on it also. The sixth row had a centrifugal fan with two 6-inch and two 12-inch hollow core bales. The fifth row consisted of a vane-axial fan with two 6-inch and two



Figure 27. Solid, 6-inch hollow core, and 12-inch hollow core bales loaded on a trailer.



Figure 28. Bale being core sampled using a drill motor and Pennsylvania coring tool.

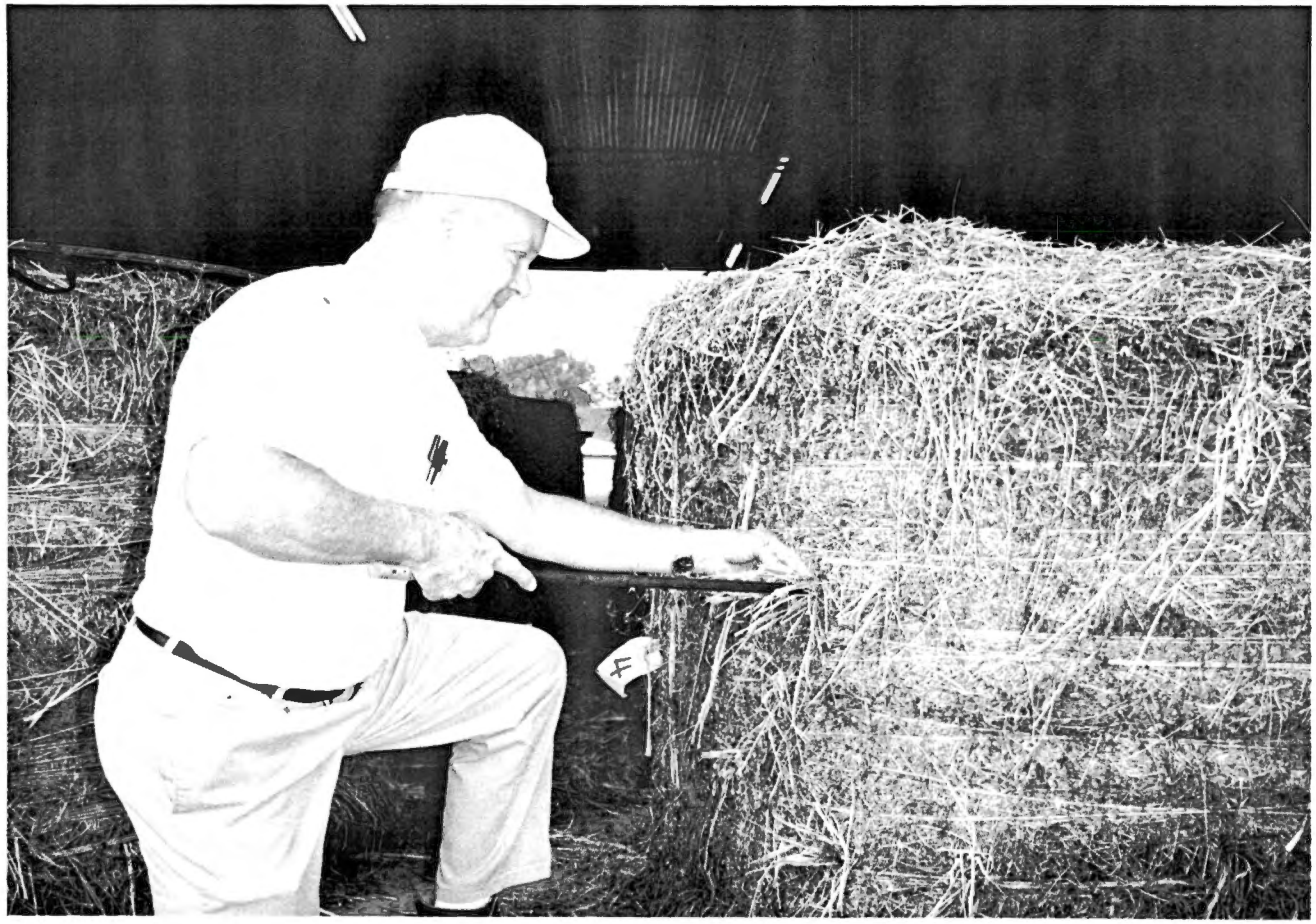


Figure 29. Plugging air channel with sorghum-sudangrass hay.

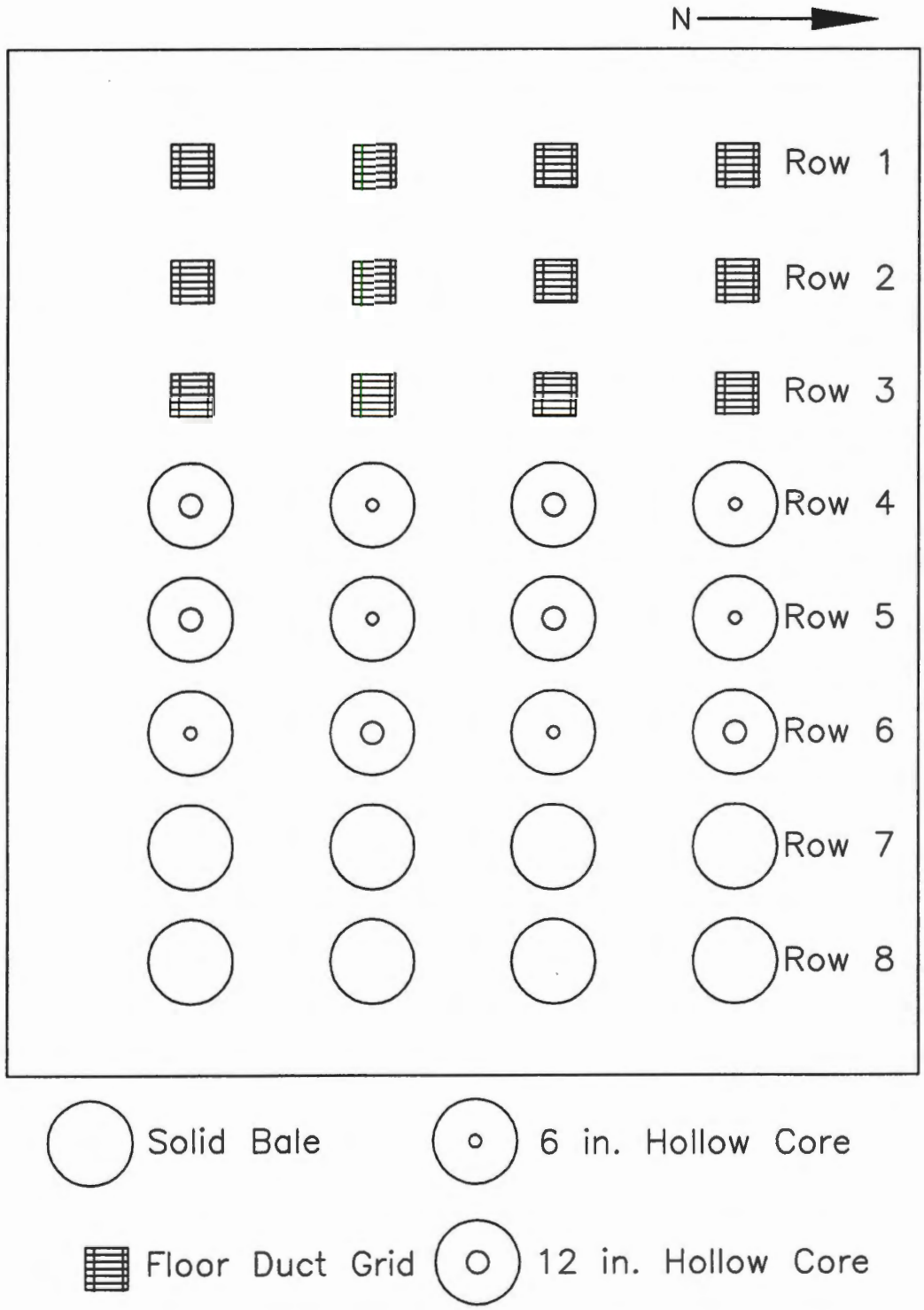


Figure 30. Diagram of bale placement in solar dryer facility.

12-inch hollow core bales. The fourth row used a centrifugal fan with two 6-inch and two 12-inch hollow core bales. The bales on the fourth row were the bales suspended by the gantry (see Figure 31). The heaviest two 6-inch and the heaviest two 12-inch hollow core bales were chosen to be used on the gantry thus altering the complete randomization scheme. The experiment consisted of a total of eight solid bales, six hollow core bales with 6-inch core diameters, and six hollow core bales with 12-inch core diameters (see Figure 32). The barn had enough room to dry a total of thirty-two bales. This experiment consisted of a total of twenty bales. The reason more bales were not used in this experiment was due to an insufficient amount of alfalfa hay. The MTES began using a new diet for its dairy herd which consisted of alfalfa silage instead of alfalfa hay. Therefore, the MTES had already used a majority of the alfalfa hay crop for silage leaving a small amount for experimental use.

Fans were turned on at 11:00 p.m. on 9/20/96 and ran until 1:00 a.m. on 9/21/96. The fans were turned on to cool the bales of heat generated by microbial respiration. During this period, it was discovered that the 21X program for the load cells was not correct for monitoring bale weight. The input voltage used to excite the load cells was incorrect causing them to be unable to read bale weights. This problem was resolved and bale weights for the gantry bales were recorded. The 21X program for the load cells, shown in Appendix A1, is the correct version after resolving this problem.

On 9/21/96, it rained until about 10:30 a.m.. Exhaust fans were turned on at 10:35 a.m. to remove moisture from the solar heater air conveying ducts and ran until 12:05 p.m.. The dryer fans were turned on at 12:12 p.m. to cool the bales even though the

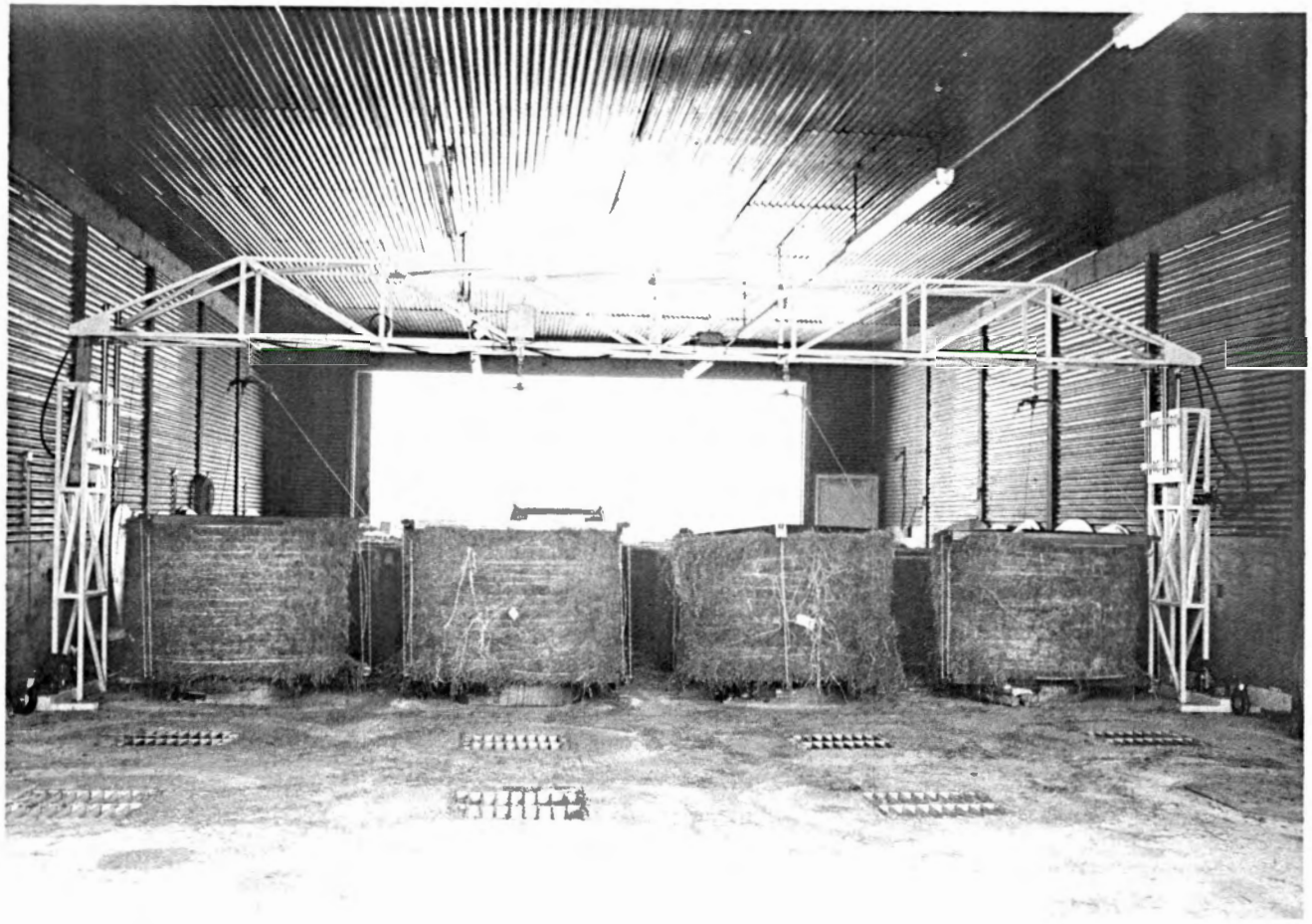


Figure 31. Weighing experimental bales suspended by the gantry.

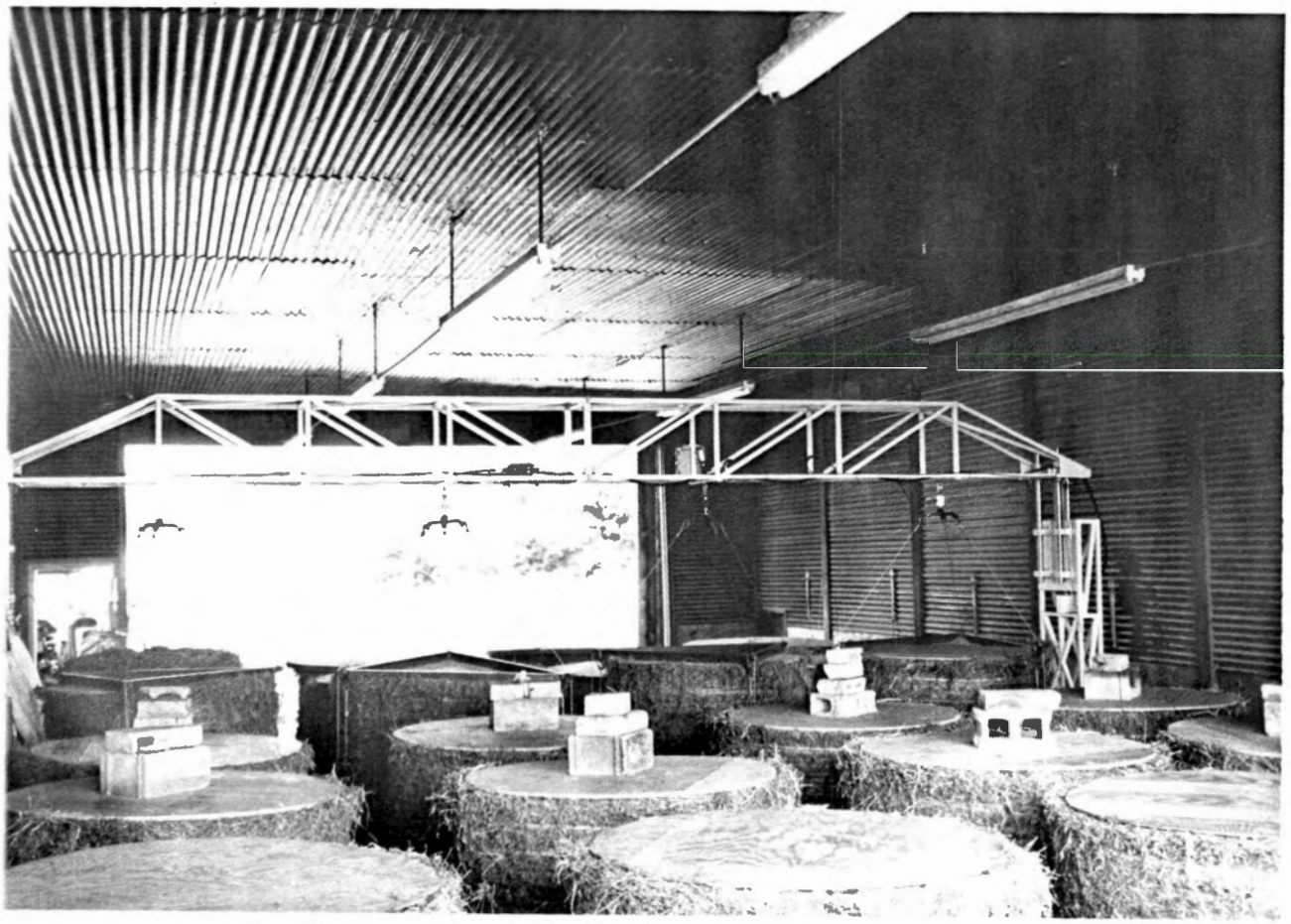


Figure 32. Experimental bales being dried in the solar-heated, forced-air facility.

relative humidity was above 60%. The dryer fans remained on until 7:30 p.m.. Sufficient solar radiation, despite partly cloudy skies, allowed the dryer solar collector to provide heat to reduce the relative humidity of the drying air to below 60% until that time. Core samples were taken from the bales when the drying fans were turned off. It was discovered at this time that bale weights changed significantly when the fans were turned off. The impact force of the air blowing through the bales caused the weight readings to be 100 to 125 lbs lighter than they actually were. It was decided at this time to take weight readings with the fans turned off periodically during the drying process for the remainder of the experiment.

The next day provided ideal conditions for drying. Exhaust fans were turned on at 8:15 a.m. on 9/22/96. At 8:45 a.m., the exhaust fans were turned off and the drying fans were turned on. It was a bright, clear sunny day and drying air relative humidity was already below 60% at this time. Fans were left on until 9:00 p.m. that evening. Bales were core sampled at 2:15 p.m. and again at 9:00 p.m..

On 9/23/96 the exhaust fans were turned on at 8:20 a.m. and the dryer fans at 8:45 a.m.. The fans ran until 7:30 p.m. that evening. Due to the large amount of time it takes to dry a set of test samples using ASE Standard S358.2, core samples were taken only once that day around 5:30 p.m..

The fourth day (9/24/96) of the drying experiment was a cloudy day with higher relative humidity. Exhaust fans were turned on at 9:15 a.m.. Dryer fans were turned on at 9:48 a.m. and turned off at 6:45 p.m.. Fans were turned off earlier than previous days because bale weights from the gantry indicated that moisture was being added to the bales.

Core samples taken at 5:30 p.m. indicated that a good portion of the bales were at or below the safe storage moisture content of 15% wet basis. However, there were a few bales that were above the safe storage level. A decision was made to dry the bales a few more hours the following morning to ensure safe storage conditions and to remove the moisture that had been added back to the bales that evening.

Exhaust fans were turned on at 7:15 a.m. the next morning (9/25/96). Dryer fans were not turned on until 9:30 a.m. to make sure that all the moisture was removed from the air conveying ducts. Bales were dried until the bale weights on the gantry were equal to or lower than the lowest weight readings from the evening before. The fans were turned off at 12:20 p.m.. Bales were then weighed on the electronic bar scales and the weights manually recorded. Bales from the gantry were core sampled again to compare final moisture contents from the core sampling process to the gantry weighing process. The bales were then moved to a storage facility for later use by the MTES.

Chapter 4

Results and Discussion

1. Gantry Evaluation

The first objective of this experiment was to design, fabricate, assemble, and evaluate a hay bale weighing gantry. Accomplishment of this objective was assessed based upon the completion of the gantry and whether or not it could suspend bales in a safe manner. The gantry was completed and then tested using large, round hay bales. The gantry safely suspended the bales in all modes of operation during a five day experiment.

The second objective of this experiment was to determine if use of the gantry provided a more precise method of determining drying rate parameters of large, round, hay bales compared to coring at specific intervals of time. Standard errors from the gantry method and core sampling method of determining drying rate parameters were compared statistically. Dry matter density has been known to significantly affect drying rate parameters in past experiments. Therefore, standard error was tested with and without dry matter density as a covariate. Results showed that dry matter density did not significantly affect the comparison standard errors ($P>.10$). An analysis of variance (SAS, 1996) comparing standard errors without dry matter density as a covariate was used to determine which method was better. The gantry method yielded a significantly lower

standard error than did the core sampling method (P<.001). Table 1 lists the standard error mean values for the ten treatments in this experiment. Notice the effect that the gantry method had on reducing the standard error means. The standard error means were reduced by almost ten fold in treatments in which the gantry method was used instead of the core sampling method.

The reason for the difference in standard error may best be explained by looking at Figures 33 and 34. Figure 33 shows moisture content data points taken using the core sampling method. Only a total of six data points were taken over the 5 day experiment because of the large amount of time required for core sampling. If an error were made in

Table 1. Standard error least square means for each treatment type.

TREATMENT	STANDARD ERROR LSMEAN
Core sampled, centrifugal, solid, fan on	0.00136653
Core sampled, centrifugal, 6 in., fan on	0.00215678
Core sampled, centrifugal, 12 in., fan on	0.00158015
Core sampled, vane-axial, solid, fan on	0.00181572
Core sampled, vane-axial, 6 in., fan on	0.00159055
Core sampled, vane-axial, 12 in., fan on	0.00151713
Gantry, centrifugal, 6 in., fan off	0.00038748
Gantry, centrifugal, 6 in., fan on	0.00015392
Gantry, centrifugal, 12 in., fan off	0.00053110
Gantry, centrifugal, 12 in., fan on	0.00024599

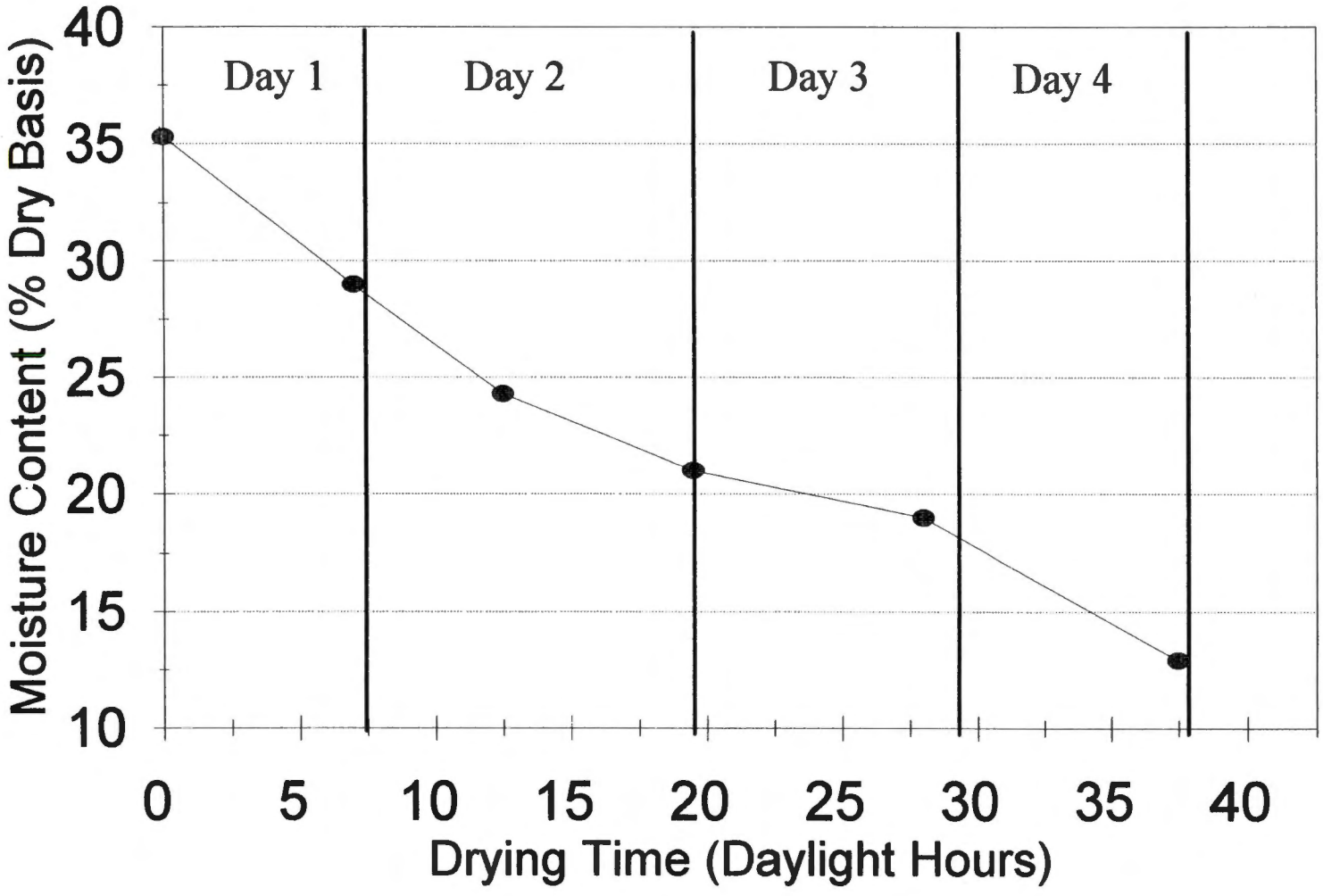


Figure 33. Moisture content of a 6-inch hollow core bale based on core sampling.

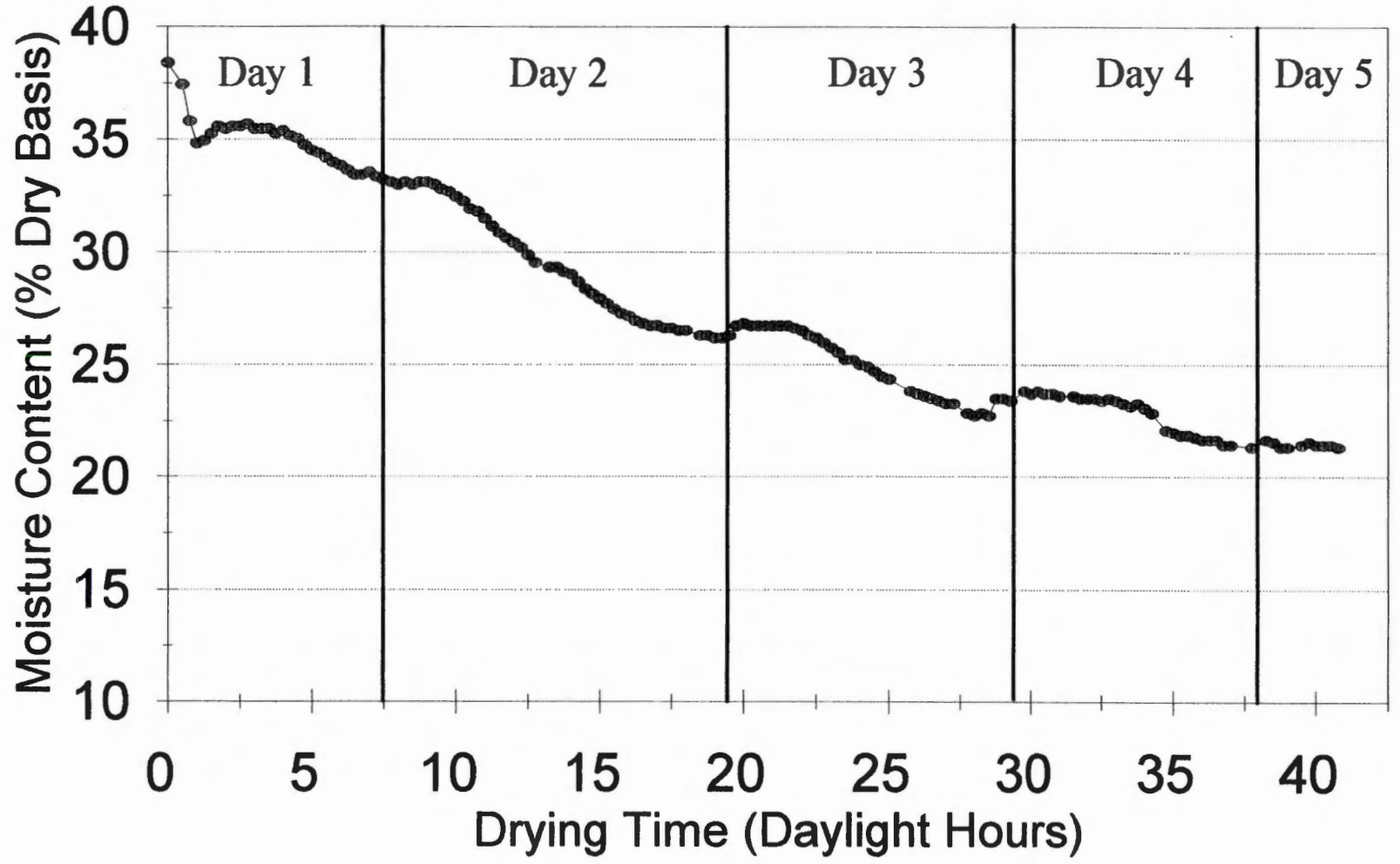


Figure 34. Moisture content of a 6-inch hollow core bale based on continuous weighing on the gantry.

the core sampling process, such as sampling from wet pockets in a bale, accidental drying by ambient air before the sample is oven dried, or making a mistake in the oven drying process, then the drying curve would be greatly affected. Figure 34 shows moisture content data points taken using the gantry method. Numerous data points are obtained from weighing the bales using the gantry. If one or two of these data points were to be in error, they would be considered outliers and the drying curve would hardly be affected. Results from this experiment indicate that the gantry provides a more precise method of determining drying rate parameters of large, round bales than core sampling does.

The gantry provides another advantage in that by monitoring bale weight, it allows the operator of the solar dryer to shut down the drying fans when moisture is being added back to bales. This quick evaluation of bale weight enables the solar dryer to be operated more efficiently. In the past, the dryer was shut down when relative humidity of the drying air rose above 60%. This set point criteria meant that the solar dryer was shut down when under certain conditions, it was possible to continue drying bales. Under certain conditions, it also was possible that bales were already gaining moisture back before that set point was reached. The gantry helps to eliminate both of these possibilities.

Using the gantry, an important discovery was made concerning the drying process of large, round bales in the drying facility. Bales on the dryer floor in the experiment had wooden plates placed on them. The wooden plates were weighted in place using concrete blocks. This weighted sealing plate was used in the attempt to reduce the loss of air through the tops of the bales and increase radial drying. However, weight data collected from bales suspended by the gantry indicated that the weight used to hold down the

wooden plates was insufficient. When the drying fans were turned on, the force of the air going through the bales and turning 90 degrees from action of the top sealing plate caused the weight readings of the bales to drop by as much as 100 to 125 lbs. Figures 35 thru 38 show the weight differences in the four bales suspended by the gantry with the fan turned on and off. The weight difference between bales with the fan on and off varied slightly throughout the experiment. It is difficult to say what caused this variation without performing other experiments. Therefore, an assumption was made that the force of the air flowing through the bale remained constant for the duration of drying process. The weight data with the fans on and off may be found in Table 3 of Appendix B.

2. Atmospheric Conditions

The third objective of the experiment was to relate the variation in drying rate to atmospheric conditions and solar conversion of the drying system. The conditions that were monitored include the temperature of ambient and drying air, relative humidity of ambient and drying air, and the amount of solar radiation absorbed by the collectors. Figure 39 illustrates the sensor data graphically. Problems with the instrumentation system caused loss of some data. The graph in Figure 39 shows the conditions of the first four drying days. Conditions from the fifth day were not recorded because of loss of power to the 21X micrologger. Figure 40 shows the drying curves of bales suspended by the gantry based on their moisture contents (percent dry basis).

The drying process began on 9/21/96 which both graphs represent as hour 0. On

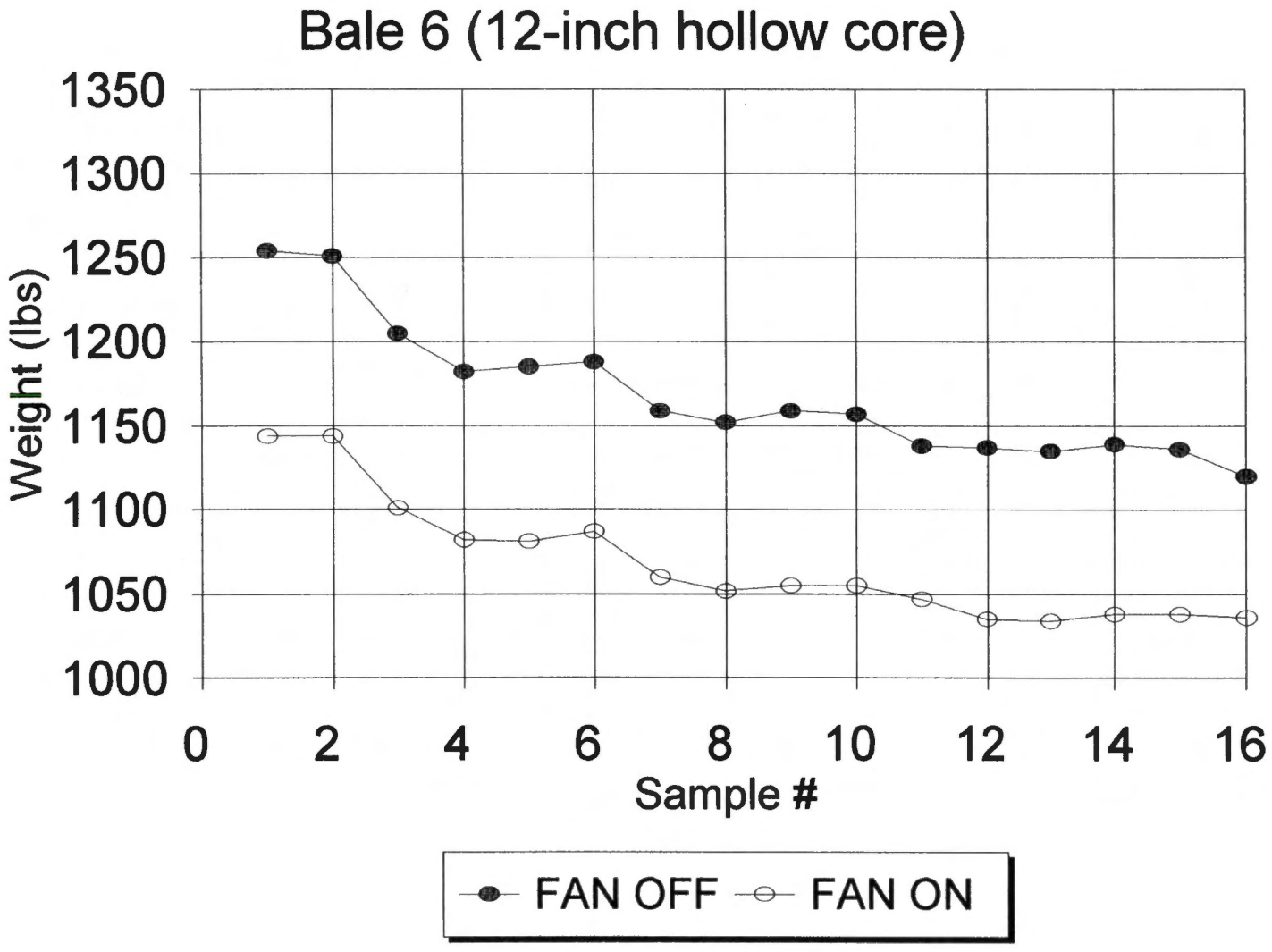


Figure 35. Bale 6 weights manually recorded while suspended on the gantry with the fan on and off.

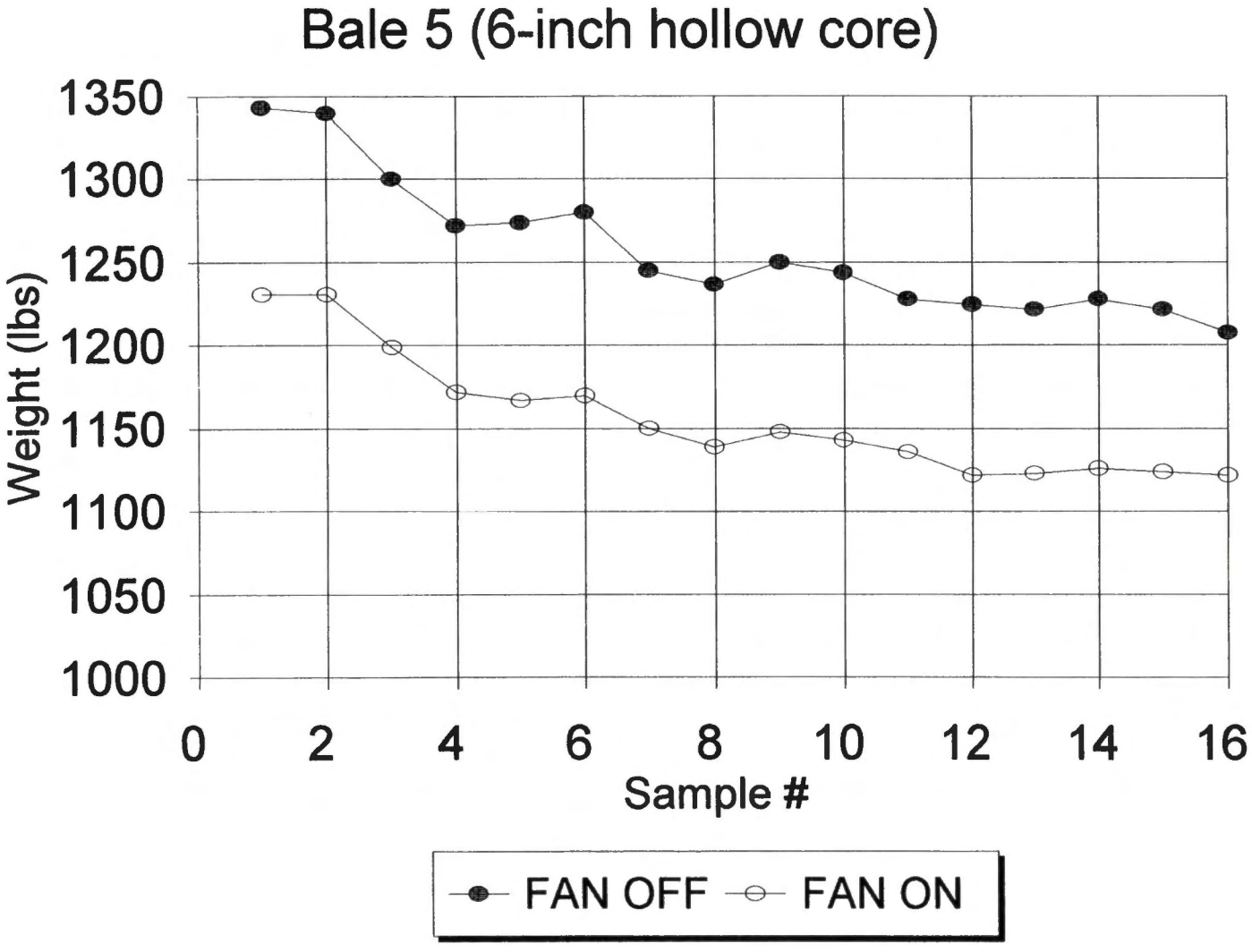


Figure 36. Bale 5 weights manually recorded while suspended on the gantry with the fan on and off.

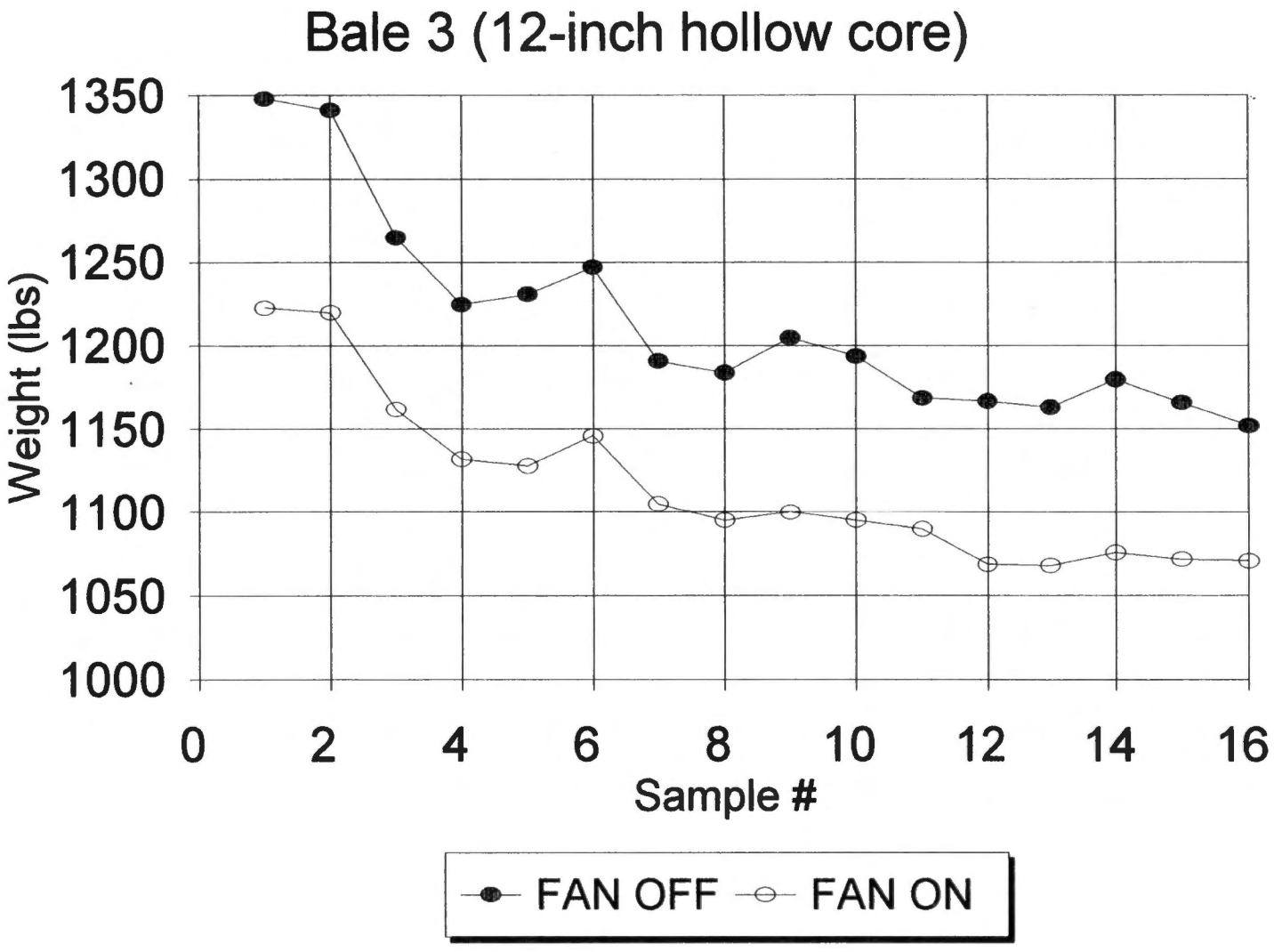


Figure 37. Bale 3 weights manually recorded while suspended on the gantry with the fan on and off.

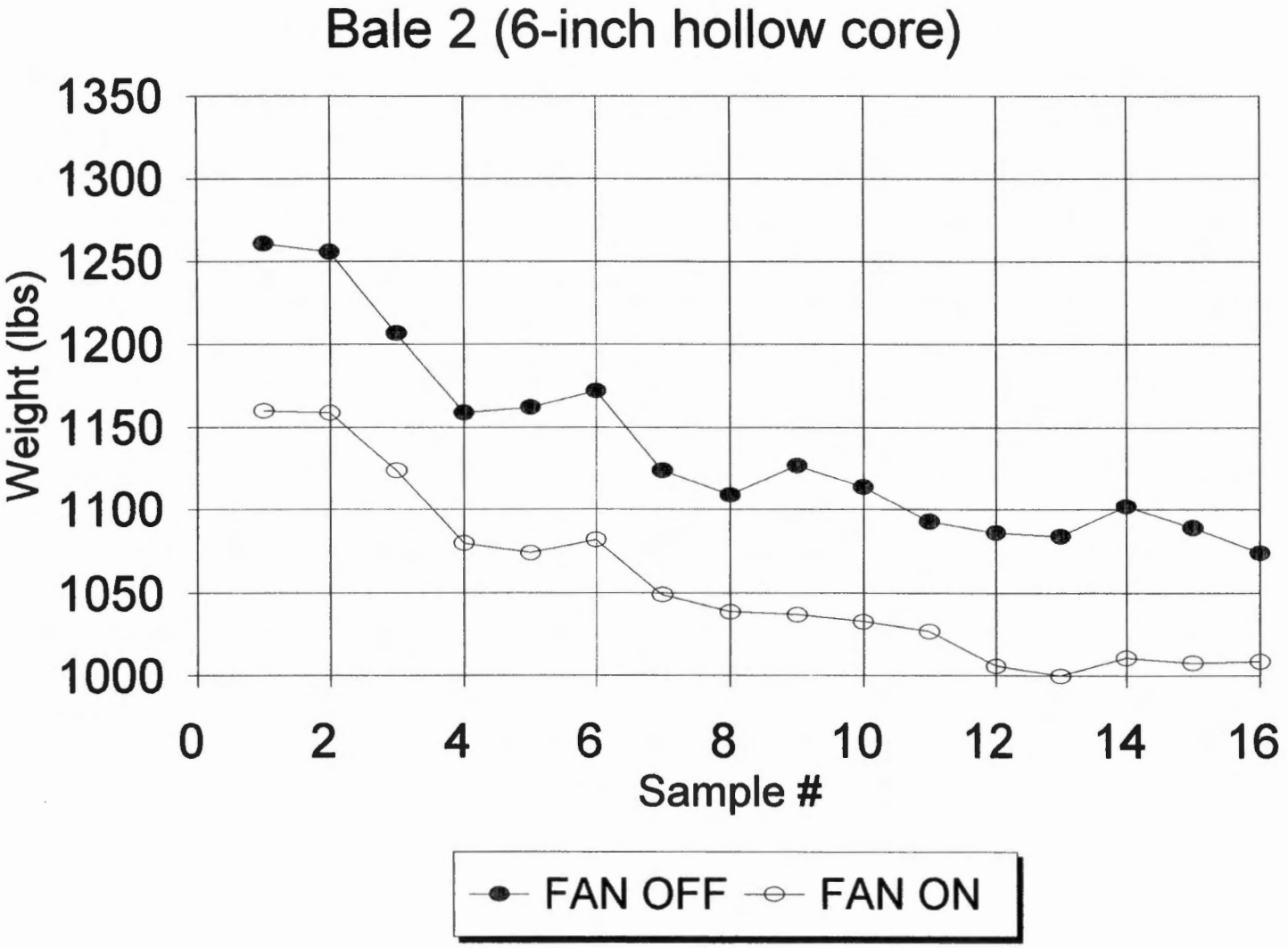


Figure 38. Bale 2 weights manually recorded while suspended on the gantry with the fan on and off.

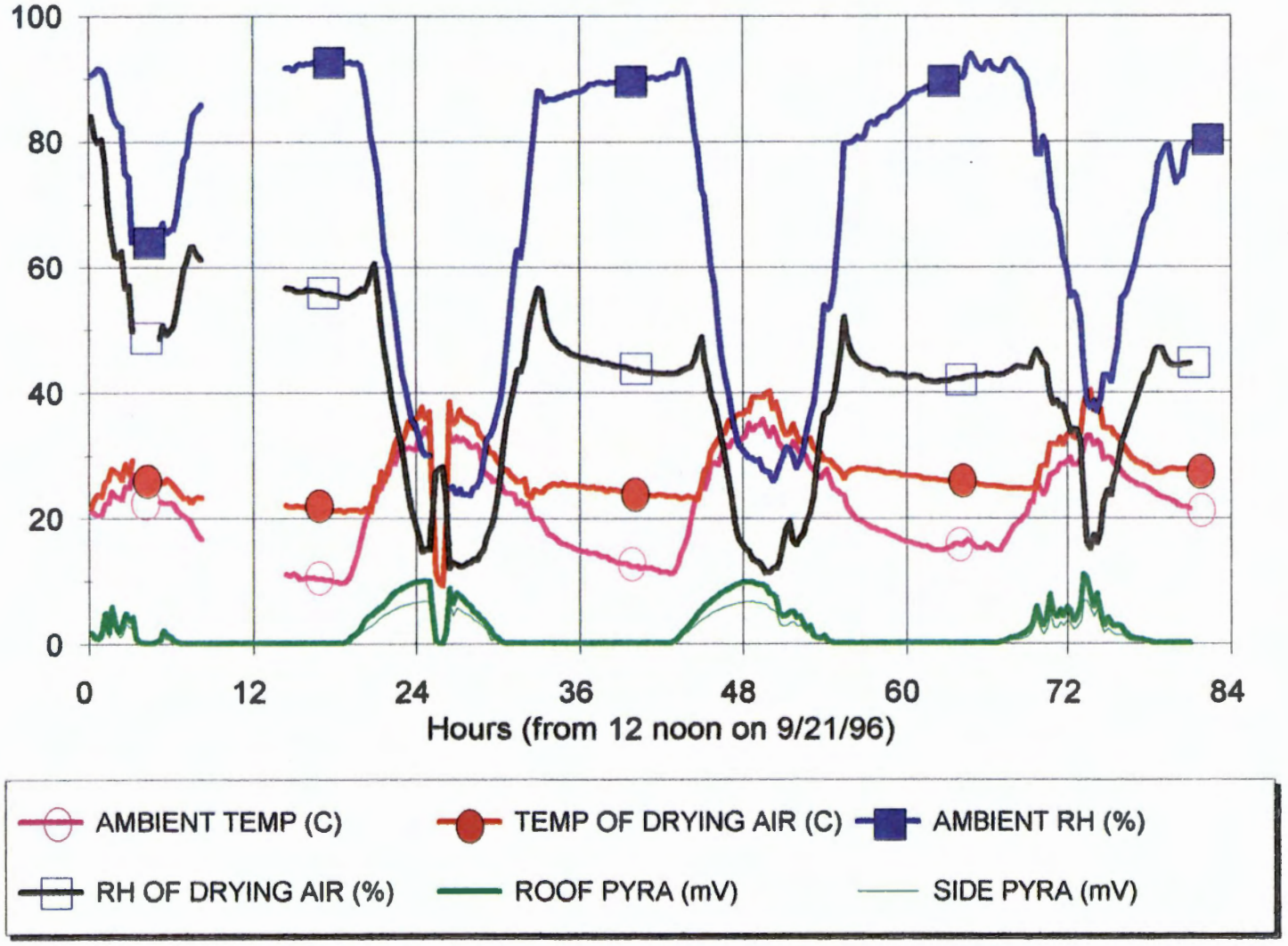


Figure 39. Variation of atmospheric conditions during drying cycle.

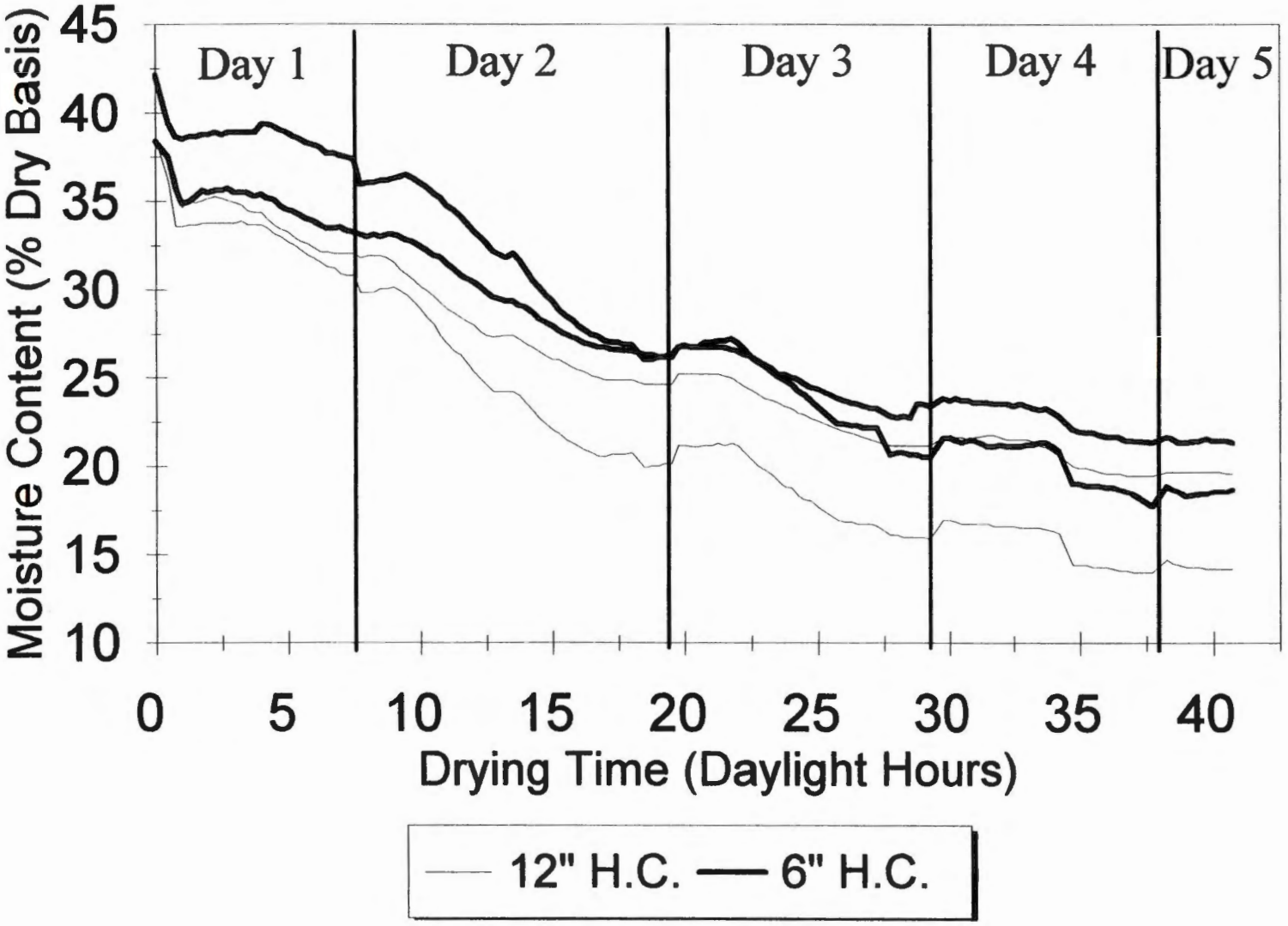


Figure 40. Drying curves for 6-inch and 12-inch hollow core bales on the gantry.

the first day (Day 1), drying curves in Figure 40 indicate that the bales quickly lost moisture and then regained a little moisture before they began to dry. One possible explanation could be that microbial action had generated heat in the bales and when the drying fans were turned on, the warm moist air was removed from the bales. After the warm air was removed, cooler drying air with high humidity added some moisture back to the bales. When the drying air warmed and the relative humidity decreased, the bales began to dry again. Although part of the data is missing, Figure 39 illustrates that it was a cloudy day with high humidity and as the sun began to emerge from the clouds, the collector began to heat the drying air and lower relative humidity. The reason for the missing data is believed to be loose wires.

The second and third days (Days 2 and 3) provided ideal drying conditions with bright, clear, sunny skies and low relative humidity. Figure 40 indicates that these two days provided the bulk of the drying in the experiment. Data for Day 2 in Figure 39 indicates another problem occurred with the monitoring system. The data indicates that the solar radiation absorbed dropped to zero, relative humidity increased quickly, and drying temperature dropped below ambient temperature. This was not possible, however, since there was not a cloud in the sky. A loose ground wire may have been the cause for the error.

The fourth day was a cloudy day with higher relative humidity than the previous two days. The drying curves in Figure 40 indicate a sharp drop in the moisture content on Day 4 at about 34 hours into the drying process. Figure 39 shows that there was a large increase in the solar radiation and temperature, and a sharp decrease in relative humidity.

This indicates that the sun appeared from behind the clouds for a period of time causing the solar dryer to dry the bales faster. Bales were dried one more day to ensure safe storage moisture content. Sensor readings are not available for that day due to conditions previously stated. Therefore, a comparison analysis of the fifth day cannot be performed. Data for atmospheric conditions can be found in Table 4 of Appendix B.

3. Drying Rate Parameters

The final objective of this experiment was to compare drying rate parameters of large, round, solid bales to those of large, round, hollow core bales. An analysis of variance (SAS, 1996) was used to compare the drying rate parameters (k). Dry matter density was used as a covariate in this analysis because of its significance on the drying rate parameter ($P<.05$). No significant differences were found in the drying rate parameters of solid bales and hollow core bales ($P>.11$). Also, no significant difference was found between the drying rate parameters of 6-inch hollow core and 12-inch hollow core bales ($P>.51$). The 12-inch hollow core bales suspended by the gantry tended to have higher drying rate parameters than did the 6-inch hollow core bales suspended by the gantry. This tendency was not significant ($P>.13$). Table 2 shows the mean drying rate parameter for each treatment.

Power for the statistical analysis on drying rate parameters was considered to be low. A low power factor indicates that the results from the analysis could be incorrect. The low power factor in this experiment was due to an insufficient number of each type of

test bale.

Table 2. Mean drying rate parameter for each treatment type.

TREATMENT	DRYING RATE PARAMETER (K) LSMEAN
Core sampled, centrifugal, solid, fan on	0.02407019
Core sampled, centrifugal, 6 in., fan on	0.02063952
Core sampled, centrifugal, 12 in., fan on	0.01865728
Core sampled, vane-axial, solid, fan on	0.01443081
Core sampled, vane-axial, 6 in., fan on	0.01698971
Core sampled, vane-axial, 12 in., fan on	0.01465814
Gantry, centrifugal, 6 in., fan off	0.02468989
Gantry, centrifugal, 6 in., fan on	0.02682872
Gantry, centrifugal, 12 in., fan off	0.02912027
Gantry, centrifugal, 12 in., fan on	0.03327842

By observation, it appears that the drying rate parameters of bales suspended by the gantry had faster drying rates. This supports the theory that air leakage from bales on the floor was excessive, especially since the bales on the gantry were four of the most dense bales in the experiment. Bales suspended by the gantry appeared to have no air leakage through the entire experiment. Air leakage was observed from the top bale plates of bales on the dryer floor.

Inline centrifugal fans and vane-axial fans were compared to determine which fan type produced the best drying rate parameters. The analysis of variance showed that the

centrifugal fans produced better drying rate parameters than did vane-axial fans ($P<.05$). Dry matter loss was also tested in the experiment. Univariate procedure (SAS, 1996) results showed that dry matter loss was not significantly different from zero in this experiment ($P<.001$).

Chapter 5

Summary and Recommendations

1. Summary

The design of an efficient, low cost, drying facility is a major objective to make artificially drying hay more profitable for forage producers. This effort begins with obtaining valid drying rate parameters for certain bale types under specific conditions. A more precise method of determining the drying rate parameters of large, round, hay bales was the major goal of this experiment. A bale weighing gantry was designed for this purpose. The gantry was designed with the capability of suspending four large, round, hay bales so that bale weights could be continuously sensed and recorded during a drying process. The weight data then allowed calculation of drying rate parameters without physically taking time consuming core samples from the bales.

The gantry was constructed and assembled using research facilities of the Agricultural Engineering Department at The University of Tennessee, Knoxville. The construction and assembly of the gantry took approximately one year. The gantry was then shipped to the Middle Tennessee Experiment Station located near Spring Hill, Tennessee. There the gantry was tested and evaluated in a solar-heated, forced-air, drying facility. A total of twenty bales were dried during the experiment which included six of

the 6-inch hollow core bales, six of the 12-inch hollow core bales, and eight solid bales. Two of the 6-inch and two of the 12-inch hollow core bales were successfully suspended by the gantry. The bale weights were recorded and calculations were made to determine drying rate parameters.

The gantry method of determining drying rate parameters proved to be more precise than the core sampling method. The standard error of determining drying rate parameters was significantly lower using the gantry method ($P<.001$). The gantry method also provided a much more detailed drying curve than did the core sampling method. Having a detailed drying curve made it much easier to relate atmospheric conditions to the drying process. It was easy to see that second and third days provided the bulk of the drying in this experiment. This correlates well with the data taken on atmospheric conditions and solar conversion which indicate bright, clear, sunny days with low relative humidity. A significant finding, although not one of the original objectives, was the amount of weight needed to create an airtight seal between the bales and the bale top plates. The weight needed to overcome the force of the air being blown through the bales and turned 90 degrees was determined to be between 100 and 125 lbs.

Drying rate parameters among solid and hollow core bales did not significantly differ in this experiment ($P>.11$). Also, the data did not support the theory that 12-inch hollow core bales dry faster than 6-inch hollow core bales ($P>.51$). However, 12-inch hollow core bales suspended by the gantry tended to have higher drying rate parameters than did the 6-inch hollow core bales suspended by the gantry but is not supported statistically ($P>.13$). Lack of statistical power may be a reason why no statistically

significant differences were found in drying rate parameters among bale types. Inline centrifugal fans produced significantly faster drying rates than did the vane-axial fans ($P<.05$). The drying process did not cause any significant loss in the dry matter of bales in this experiment ($P<.001$).

2. Recommendations

The gantry worked successfully in this experiment, but a few problems need to be resolved. The hydraulic system on the gantry has a leakage problem. The leakage is occurring around the flow divider ports. This problem was present when the gantry was set up for a test run at the Agricultural Engineering Department. Cause of the leakage was investigated there and the problem was thought to be resolved after tightening the fittings. When the gantry was reassembled for testing in the experiment, leakage occurred again. The leakage was small and had no effect on the experiment. If overlooked, though, it could pose problems in future experiments. The leakage was caused by the wrong type of threads on the male fittings that screw into the flow divider ports. The male fittings are standard tapered thread. It was discovered that the male fittings should have number 12 SAE (1-1/16 inch) standard straight threads for the outlet ports and number 12 SAE (1-5/16 inch) standard straight threads for the inlet ports.

Connecting the flexible duct between the floor duct and the bottom bale plate was a rather difficult and somewhat dangerous task. Crawling under the bales while suspended could lead to serious injury if something were to go wrong (even with the use of

jackstands to support the bales as in this experiment). A possible alternative to this solve problem would be to use a connection material similar to the plastic ventilation tubing used for greenhouses. Unlike the semi-rigid flexible duct used in this experiment, the plastic material would be capable of collapsing when the bale plate rests on the floor. The attachment flanges would need to be shortened to keep the plastic from pinching between them. The plastic would also be less likely to alter any weight readings during the experiment than the more rigid flexible ducting currently being used. Disadvantages of the plastic ducting might be that it is less durable than is the flexible ducting used and would have a lower insulation value. The author believes that the heat loss through either material would be minimal considering the high velocity and flow rate of air being forced through the bale.

Another possible solution would be to attach brackets to the bottom bale plate frames that would raise them higher above the floor. This would allow the flexible duct to remained attached throughout the experiment. This could create a problem with loading the bale onto the bale plate. Careful thought should be given before trying this method. If no change is made in the bale clamp/suspension assembly, shortening the cable lengths would provide more room to attach the flexible duct making the process easier. The cable length should be shortened by at least 2 to 4 inches.

The discovery of major air leakage problems in this experiment must be resolved before future experiments. According to the data, the force exerted on top sealing plates by the drying air could be as high as 125 lbs. Therefore, it is recommended that bales with hollow cores have top bale plates secured with 125 lbs of weight. Lead bricks owned by

the Agricultural Engineering Department would work well for weighting the bale tops. Solid bales probably do not need this much weight placed on them since air velocity is reduced by resistance of the bale. Another air leakage problem occurred between the floor duct and the floor duct grid. This problem can probably be corrected by using weather stripping where the two surfaces contact.

Results of this experiment show that the drying rate parameters were significantly affected by bale density. Differences in future experiments might be more conclusive if bale densities were similar. Adjustments in baler tension during baling may provide uniform density among bales.

Finally, the statistical power of this experiment was low for determining the effect of bale types on the drying rate parameter. It is recommended that only two types of bales be compared in an experiment. The power would be greatly increased by comparing sixteen solid bales to sixteen 12-inch hollow core bales. Then a follow up study could be performed to compare sixteen 6-inch hollow core bales to sixteen 12-inch hollow core bales. These two experiments would provide more valid statistical results due to the higher power factors.

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Appendices

Appendix A

21X Micrologger Programs

```
Program: bale96.doc
Flag Usage:
Input Channel Usage:
Excitation Channel Usage:
Continuous Analog Output Usage:
Control Port Usage:
Pulse Input Channel Usage:
Output Array Definitions:


*    1      Table 1 Programs
  01: 60     Sec. Execution Interval

01:  P10     Battery Voltage
  01: 19     Loc : BATVOLT

02:  P17     Panel Temperature
  01: 20     Loc : PANLTEMP

03:  P20     Set Port
  01: 1      Set high
  02: 1      Port Number

04:  P87     Beginning of Loop
  01: 0      Delay
  02: 8      Loop Count

05:  P22     Excitation with Delay
  01: 1      EX Chan
  02: 1      Delay w/EX (units=.01sec)
  03: 0000   Delay after EX (units=.01sec)
  04: 5000   mV Excitation

06:  P11     Temp 107 Probe
  01: 1      Rep
  02: 1      IN Chan
  03: 3      Excite all reps w/EXchan 3
  04: 1--    Loc : TMP#1
  05: 1      Mult
  06: 0.0000 Offset
```

A1. Program for determining bale weight.

07: P12 RH 207 Probe
01: 1 Rep
02: 2 IN Chan
03: 3 Excite all reps w/EXchan 3
04: 1-- Temperature Loc TMP#1
05: 9-- Loc : RH#1
06: 1 Mult
07: 0.0000 Offset

08: P95 End

09: P87 Beginning of Loop
01: 0000 Delay
02: 2 Loop Count

Page 2 Table 1

10: P22 Excitation with Delay
01: 1 EX Chan
02: 0001 Delay w/EX (units=.01sec)
03: 0000 Delay after EX (units=.01sec)
04: 5000 mV Excitation

11: P2 Volt (DIFF)
01: 1 Rep
02: 2 15 mV slow Range
03: 1 IN Chan
04: 17-- Loc : PY#1
05: 1 Mult
06: 0.0000 Offset

12: P95 End

13: P87 Beginning of Loop
01: 0000 Delay
02: 4 Loop Count

A1. (continued)

```
14:  P14     Thermocouple Temp (DIFF)
 01: 1       Rep
 02: 5       5000 mV slow Range
 03: 1       IN Chan
 04: 1       Type T (Copper-Constantan)
 05: 20      Ref Temp Loc
 06: 21--    Loc : TC#1
 07: 1       Mult
 08: 0.0000  Offset

15:  P95     End

16:  P20     Set Port
 01: 0       Set low
 02: 1       Port Number

17:  P92     If time is
 01: 0       minutes into a
 02: 15      minute interval
 03: 10      Set high Flag 0 (output)

18:  P77     Real Time
 01: 0110    Day,Hour-Minute

19:  P71     Average
 01: 20      Reps
 02: 1--     Loc TMP#1

20:  P       End Table 1


*    2       Table 2 Programs
 01: 0.0000  Sec. Execution Interval

01:  P       End Table 2


*    3       Table 3 Subroutines
```

A1. (continued)

Page 3 Table 3

01: P End Table 3

* 4 Mode 4 Output Options
01: 00 (Tape OFF) (Printer OFF)
02: 00 Printer 300 Baud

* A Mode 10 Memory Allocation
01: 28 Input Locations
02: 64 Intermediate Locations

* C Mode 12 Security (OSX-0)
01: 00 Security Disabled
02: 0000 Security Code

Page 4 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

T: E: L:
1: 6: 1: Loc : TMP#1
1: 7: 9: Loc : RH#1
1: 11: 17: Loc : PY#1
1: 1: 19: Loc : BATVOLT
1: 2: 20: Loc : PANLTEMP
1: 14: 21: Loc : TC#1

A1. (continued)

```
Program: gantry96.doc
Flag Usage:
Input Channel Usage:
Excitation Channel Usage:
Continuous Analog Output Usage:
Control Port Usage:
Pulse Input Channel Usage:
Output Array Definitions:

*   1      Table 1 Programs
  01: 60     Sec. Execution Interval

01:  P6      Full Bridge
  01: 1      Rep
  02: 2      15 mV slow Range
  03: 1      IN Chan
  04: 1      Excite all reps w/EXchan 1
  05: 5000   mV Excitation
  06: 1      Loc :
  07: 949.7  Mult
  08: -219.35 Offset

02:  P6      Full Bridge
  01: 1      Rep
  02: 2      15 mV slow Range
  03: 2      IN Chan
  04: 2      Excite all reps w/EXchan 2
  05: 5000   mV Excitation
  06: 2      Loc :
  07: 943.4  Mult
  08: -217.06 Offset

03:  P6      Full Bridge
  01: 1      Rep
  02: 2      15 mV slow Range
  03: 3      IN Chan
  04: 3      Excite all reps w/EXchan 3
  05: 5000   mV Excitation
  06: 3      Loc :
  07: 940.1  Mult
  08: -219.63 Offset
```

A2. Program for temperature, relative humidity, and solar radiation data.

```
04:  P6      Full Bridge
  01: 1      Rep
  02: 2      15 mV slow Range
  03: 4      IN Chan
  04: 4      Excite all reps w/EXchan 4
  05: 5000   mV Excitation
  06: 4      Loc :
  07: 946.1  Mult
  08: -222.44 Offset

05:  P33     Z=X+Y
  01: 1      X Loc
  02: 5      Y Loc
  03: 5      Z Loc :
```

Page 2 Table 1

```
06:  P33     Z=X+Y
  01: 2      X Loc
  02: 6      Y Loc
  03: 6      Z Loc :

07:  P33     Z=X+Y
  01: 3      X Loc
  02: 7      Y Loc
  03: 7      Z Loc :

08:  P33     Z=X+Y
  01: 4      X Loc
  02: 8      Y Loc
  03: 8      Z Loc :

09:  P32     Z=Z+1
  01: 9      Z Loc :

10:  P89     If X<=>F
  01: 9      X Loc
  02: 1      =
  03: 15     F
  04: 1      Call Subroutine 1
```

A2. (continued)

```
11: P       End Table 1


*   2       Table 2 Programs
 01: 0.0000  Sec. Execution Interval

01: P       End Table 2

*   3       Table 3 Subroutines

01: P85     Beginning of Subroutine
 01: 1      Subroutine Number

02: P38     Z=X/Y
 01: 5      X Loc
 02: 9      Y Loc
 03: 10     Z Loc :

03: P38     Z=X/Y
 01: 6      X Loc
 02: 9      Y Loc
 03: 11     Z Loc :

04: P38     Z=X/Y
 01: 7      X Loc
 02: 9      Y Loc
 03: 12     Z Loc :

05: P38     Z=X/Y
 01: 8      X Loc
 02: 9      Y Loc
 03: 13     Z Loc :

Page 3  Table 3

06: P86     Do
 01: 10     Set high Flag 0 (output)

07: P70     Sample
 01: 4      Reps
 02: 10     Loc
```

A2. (continued)

```
08:  P30     Z=F
 01: 0.0000  F
 02: 5       Z Loc :

09:  P30     Z=F
 01: 0.0000  F
 02: 6       Z Loc :

10:  P30     Z=F
 01: 0.0000  F
 02: 7       Z Loc :

11:  P30     Z=F
 01: 0.0000  F
 02: 8       Z Loc :

12:  P30     Z=F
 01: 0.0000  F
 02: 9       Z Loc :

13:  P95     End

14:  P       End Table 3


*    4      Mode 4 Output Options
 01: 00      Tape/Printer Option
 02: 00      Printer Baud Option


*    A      Mode 10 Memory Allocation
 01: 28      Input Locations
 02: 64      Intermediate Locations


*    C      Mode 12 Security (OSX-0)
 01: 00      Security Option
 02: 0000    Security Code
```

A2. (continued)

Page 4 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

T: E: L:
1: 1: 1: Loc :
1: 2: 2: Loc :
1: 3: 3: Loc :
1: 4: 4: Loc :
1: 5: 5: Z Loc :
3: 8: 5: Z Loc :
1: 6: 6: Z Loc :
3: 9: 6: Z Loc :
1: 7: 7: Z Loc :
3: 10: 7: Z Loc :
1: 8: 8: Z Loc :
3: 11: 8: Z Loc :
1: 9: 9: Z Loc :
3: 12: 9: Z Loc :
3: 2: 10: Z Loc :
3: 3: 11: Z Loc :
3: 4: 12: Z Loc :
3: 5: 13: Z Loc :

A2. (continued)

Appendix B

Experimental Data

Table 3. Manually recorded weight data for bales suspended on the gantry with the fan on and off.

SAMPLE	WEIGHT (lbs) WITH FAN OFF				WEIGHT (lbs) WITH FAN ON			
#	BALE 6	BALE 5	BALE 3	BALE 2	BALE 6	BALE 5	BALE 3	BALE 2
1	1254	1343	1348	1261	1144	1231	1223	1160
2	1251	1340	1341	1256	1144	1231	1220	1159
3	1205	1300	1265	1207	1101	1199	1162	1124
4	1182	1272	1225	1159	1082	1172	1132	1080
5	1185	1274	1231	1162	1081	1167	1128	1074
6	1188	1280	1247	1172	1087	1170	1146	1082
7	1159	1245	1191	1124	1060	1150	1105	1049
8	1152	1237	1184	1109	1052	1139	1095	1039
9	1159	1250	1205	1127	1055	1148	1100	1037
10	1157	1244	1194	1114	1055	1143	1095	1033
11	1138	1228	1169	1093	1047	1136	1090	1027
12	1137	1225	1167	1086	1035	1122	1069	1006
13	1135	1222	1163	1084	1034	1123	1068	1000
14	1139	1228	1180	1102	1038	1126	1076	1011
15	1136	1222	1166	1089	1038	1124	1072	1008
16	1120	1208	1152	1074	1036	1122	1071	1009

Table 4. Atmospheric conditions recorded during experiment.

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
0	15	21.15	21.37	21.79	22	90.5	90.9	84.1	83	156.29	77.32	1.666	0.859
0	30	20.7	20.26	23.31	24.07	90.8	91.5	80.8	80	106.10	49.32	1.131	0.548
0	45	20.33	19.81	23.81	23.84	91.5	91.5	79.7	79.9	84.05	39.60	0.896	0.44
0	100	20.58	20.68	23.44	23.87	91.3	91.7	80.3	80.2	165.10	78.85	1.76	0.876
0	115	22.25	22.03	25.65	26.24	90.5	90.9	76.5	75.1	446.72	229.70	4.762	2.552
0	130	22.4	22.35	26.25	26.71	88.4	89.3	68.96	67.18	166.32	91.27	1.773	1.014
0	145	24.18	24.67	27.87	28.14	85.1	86.5	65.39	63	547.94	332.31	5.841	3.692
0	200	23.39	23.38	27.4	27.61	83.2	85	61.76	60.49	258.63	152.84	2.757	1.698
0	215	23.23	22.98	27	27.57	82.3	84.5	61.5	59.95	179.08	95.41	1.909	1.06
0	230	22.96	22.91	26.11	26.45	82.2	84.6	62.62	61.48	277.39	128.89	2.957	1.432
0	245	25.02	25.45	28.68	29.15	74.8	78.9	56.6	54.19	442.40	284.61	4.716	3.162
0	300	24.77	25.13	27.06	27.94	74.2	78.5	57.02	55.19	338.27	222.50	3.606	2.472
0	315	26.93	26.82	29.24	30.43	63.85	70	49.83	46.94	393.90	265.98	4.199	2.955
0	330	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	74.48	47.16	0.794	0.524
0	345	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	16.42	8.46	0.175	0.094
0	400	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	7.22	3.33	0.077	0.037
0	415	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2.16	1.17	0.023	0.013
0	430	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0	0
0	445	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0	0
0	500	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	41.93	29.43	0.447	0.327
0	515	22.57	22.59	26.05	26.15	65.64	70.4	48.57	48.96	62.95	45.81	0.671	0.509
0	530	22.44	22.29	25.58	26.04	66.92	72.5	50.8	51.48	191.37	69.76	2.04	0.775
0	545	22.32	22.93	26.16	25.93	65.27	70.7	49.27	49.93	135.18	64.99	1.441	0.722
0	600	22.42	22.07	25.66	25.84	65.88	71.7	50.06	50.99	98.69	32.67	1.052	0.363
0	615	22.09	21.77	25.09	24.91	65.88	71.8	50.58	52.25	39.02	23.49	0.416	0.261
0	630	21.25	21.21	24.5	23.91	68.15	73.7	53.1	55.35	17.73	11.97	0.189	0.133
0	645	20.65	20.45	23.67	23.12	72.2	77.4	56.42	59.32	6.00	3.78	0.064	0.042
0	700	20.28	20.13	23.11	22.69	76.9	80.9	59.73	63.06	0.00	0.00	0	0
0	715	19.91	20.34	23.27	22.78	77.8	81.1	61.08	64.71	0.00	0.00	0	0
0	730	19.3	19.21	22.52	21.48	82.4	84.6	63.22	67.72	0.00	0.00	0	0
0	745	18.24	18.25	23.01	22.15	84.4	86	63.25	67.58	0.00	0.00	0	0

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
0	800	17.17	16.81	23.34	22.36	85.1	86.5	61.88	65.19	0.00	0.00	0	0
0	815	16.6	16.46	23.31	23.38	85.8	87	61.25	63.62	0.00	0.00	0	0
0	830	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.19	0.27	0.002	0.003
0	845	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.84	0.90	0.009	0.01
0	900	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.09	0.09	0.001	0.001
0	915	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0	0
0	930	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0	0
0	945	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0	0
0	1000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.09	0.09	0.001	0.001
0	1015	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.28	0.27	0.003	0.003
0	1030	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.38	0.36	0.004	0.004
0	1045	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.66	0.63	0.007	0.007
0	1100	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.47	0.45	0.005	0.005
0	1115	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.28	0.27	0.003	0.003
0	1130	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.13	1.08	0.012	0.012
0	1145	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.94	0.90	0.01	0.01
0	1200	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.75	0.72	0.008	0.008
0	1215	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.94	0.90	0.01	0.01
0	1230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.75	0.81	0.008	0.009
0	1245	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.66	0.63	0.007	0.007
0	1300	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.03	1.08	0.011	0.012
0	1315	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.22	1.17	0.013	0.013
0	1330	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1.03	0.99	0.011	0.011
0	1345	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.75	0.72	0.008	0.008
0	1400	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.56	0.63	0.006	0.007
0	1415	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.28	0.36	0.003	0.004
0	1430	11.02	10.75	22.08	22.53	91.6	92.3	56.74	61.82	0.09	0.36	0.001	0.004
0	1445	10.79	10.39	21.82	22.57	91.7	92.5	56.67	61.75	0.47	0.63	0.005	0.007
0	1500	11.09	10.46	21.85	22.36	91.2	92.4	56.4	61.82	0.56	0.90	0.006	0.01
0	1515	10.76	10.12	21.95	22.25	91.9	92.9	56.13	61.9	0.66	0.90	0.007	0.01
0	1530	10.19	10.23	21.81	22.32	92.2	92.8	56.07	61.82	0.47	0.63	0.005	0.007

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
0	1545	10.33	10.53	21.83	22.3	92.1	92.9	56.13	61.82	0.19	0.36	0.002	0.004
0	1600	10.45	10.2	21.49	22.15	92.3	93.3	56.38	61.89	0.00	0.27	0	0.003
0	1615	10.42	10.35	21.65	22.2	92.2	93.2	56.26	61.87	0.00	0.18	0	0.002
0	1630	10.48	10.22	21.65	22.15	92.5	93.3	56.27	61.91	0.00	0.27	0	0.003
0	1645	10.13	10.19	21.4	22.01	92.5	93.1	56.27	61.89	0.00	0.27	0	0.003
0	1700	10.29	10.15	21.57	22.12	92.3	93.2	56.02	61.87	0.19	0.45	0.002	0.005
0	1715	10.1	10.14	21.58	22.29	92.2	92.9	55.75	61.72	0.09	0.63	0.001	0.007
0	1730	10	9.9	21.28	22.01	92.4	93.1	55.75	61.75	0.00	0.36	0	0.004
0	1745	9.97	9.73	21.15	21.98	92.4	93	55.68	61.71	0.00	0.27	0	0.003
0	1800	9.8	9.9	21.13	22.27	92.2	92.7	55.5	61.49	0.00	0.27	0	0.003
0	1815	9.77	9.52	21.24	21.91	92.3	93.1	55.38	61.71	0.00	0.27	0	0.003
0	1830	9.53	9.63	21.18	22.09	92.4	93.1	55.22	61.57	1.03	0.99	0.011	0.011
0	1845	9.62	9.57	20.96	21.97	92.4	93.2	55.14	61.61	9.66	7.11	0.103	0.079
0	1900	10.2	10.29	21.24	22.11	92.4	93.1	55.09	61.63	43.71	34.20	0.466	0.38
0	1915	11.11	11.25	21.28	21.78	92.6	93	55.27	61.99	94.00	68.50	1.002	0.761
0	1930	12.76	12.81	21.22	21.72	92.2	92.5	55.54	62.13	136.30	101.80	1.453	1.131
0	1945	14.36	14.94	21.22	22.18	92.4	92.1	56.05	62.01	170.36	132.85	1.816	1.476
0	2000	16.72	16.97	20.99	22.17	91.9	91.3	56.47	61.81	239.02	165.26	2.548	1.836
0	2015	19.07	19.28	21.53	22.13	89.6	89.1	56.14	61.13	349.34	197.57	3.724	2.195
0	2030	20.71	20.55	21.55	22.48	86	86.5	57.43	61.42	399.62	228.17	4.26	2.535
0	2045	22.54	22.46	20.98	22.07	81	83	58.76	62.13	422.89	258.96	4.508	2.877
0	2100	22.67	23.44	24.95	23.97	78	80.1	60.53	61.66	478.99	304.05	5.106	3.378
0	2115	25.19	23.26	24.37	27.58	74.5	78.8	55.93	55.3	521.67	357.70	5.561	3.974
0	2130	24.68	24.89	27.38	27.21	69.3	73.8	50.83	50.57	547.47	387.13	5.836	4.301
0	2145	26.44	28.2	25.93	27.74	62.64	68.2	46.63	44.58	600.38	417.64	6.4	4.64
0	2200	27.26	28.53	28.17	29.68	60.29	65.63	42.85	40.9	662.29	447.43	7.06	4.971
0	2215	29.3	29.03	29.46	32.4	55.91	62.31	39.15	37.09	724.20	473.54	7.72	5.261
0	2230	28.55	29.42	31.87	32.43	52.72	59.31	36.49	35.13	764.54	498.11	8.15	5.534
0	2245	30.5	29.86	32.98	34.91	47.84	55.82	33.76	31.58	797.37	520.61	8.5	5.784
0	2300	31.76	31.93	32.06	35.13	43.06	51.34	31.08	27.63	827.39	539.24	8.82	5.991
0	2315	30.92	33.02	33.41	34.91	40.85	47.79	27.93	24.81	853.66	555.45	9.1	6.171

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
0	2330	31.16	32.24	35.36	36.45	37.89	43.69	23.59	20.79	879.92	570.21	9.38	6.335
0	2345	31.01	34.79	34.37	35.43	35.78	39.77	21.25	17.78	897.75	581.82	9.57	6.464
1	0	30.79	33.41	35.88	35.77	34.81	38.91	18.99	16.44	913.70	591.09	9.74	6.567
1	15	32.78	33.92	36.16	38.43	32.44	37.32	16.97	14.14	925.89	598.20	9.87	6.646
1	30	33.4	33.14	37.61	39.98	30.66	36.27	14.64	12.72	930.58	602.16	9.92	6.69
1	45	34.28	34.81	35.88	40.12	29.91	35.53	15.06	11.9	934.33	603.33	9.96	6.703
1	100	32.88	37.06	36.91	38.11	30.03	34.49	15.01	12.33	927.77	600.81	9.89	6.675
1	115	n/a	n/a	24.74	23.02	n/a	n/a	20.68	20.32	451.13	282.81	4.809	3.142
1	130	n/a	n/a	11.38	7.48	n/a	n/a	27.44	28.34	26.92	16.29	0.287	0.181
1	145	n/a	n/a	9.77	6.751	n/a	n/a	27.98	28.28	6.19	3.60	0.066	0.04
1	200	n/a	n/a	9.16	6.64	n/a	n/a	28.24	28.12	0.94	0.18	0.01	0.002
1	215	n/a	n/a	17.27	14.89	n/a	n/a	23.53	23.99	159.76	103.60	1.703	1.151
1	230	33.41	32.54	38.47	39.43	24.68	32.5	11.97	10.82	826.45	553.74	8.81	6.152
1	245	32.11	32.68	34.9	37.75	24.93	32.68	12.95	10.7	592.40	399.55	6.315	4.439
1	300	32.92	32.74	35.53	38.16	23.9	31.99	12.63	10.59	755.16	508.01	8.05	5.644
1	315	32.23	32.48	37.22	37.06	24.54	32.43	12.28	11.34	712.01	480.29	7.59	5.336
1	330	32.68	32.74	36.22	37.75	23.73	31.95	12.37	11.06	662.29	447.43	7.06	4.971
1	345	32.24	33.76	35.84	36.9	23.8	31.53	12.71	11.21	609.01	416.29	6.492	4.625
1	400	31.35	33.1	35.41	35.93	23.54	31.34	12.91	11.71	554.22	381.64	5.908	4.24
1	415	31.23	32.08	35.08	35.57	24.84	32.77	13.43	12.47	480.21	336.00	5.119	3.733
1	430	31.57	30.69	34.77	35.71	24.96	33.26	13.32	12.77	440.81	312.42	4.699	3.471
1	445	30.64	30.51	33.13	35.36	26.06	33.69	14.33	13.22	386.30	271.47	4.118	3.016
1	500	27.31	29.87	32.58	33.57	29.39	34.11	15.11	14.21	330.96	227.63	3.528	2.529
1	515	26.93	28.66	31.78	32.12	32.74	36.71	17.09	16.16	272.89	160.58	2.909	1.784
1	530	26.54	27.43	30.38	31.25	33.22	38.21	18.19	17.44	216.79	44.82	2.311	0.498
1	545	25.82	26.76	30.3	29.91	34.35	39.41	19.51	19.78	115.10	55.36	1.227	0.615
1	600	26.02	26.37	29.29	29.66	36.87	42.03	22.86	23.9	86.59	26.82	0.923	0.298
1	615	25.7	25.72	28.48	28.8	39	45.09	26.75	28.53	32.18	20.97	0.343	0.233
1	630	24.2	26.05	27.63	26.7	42.48	48.65	31.69	33.83	12.66	8.73	0.135	0.097
1	645	23.88	25	27.63	26.1	47.78	55.56	35.77	38.33	3.85	2.34	0.041	0.026
1	700	23.91	24.43	26.86	26.23	54.3	61.47	38.73	41.61	0.00	0.00	0	0

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
1	715	23.67	23.2	26.38	26.19	59.6	66.76	41.15	45.18	0.00	0.00	0	0
1	730	22.24	23.22	25.8	24.83	62.64	68.92	43.56	48.44	0.00	0.00	0	0
1	745	22.67	22.97	25.87	25.4	61.36	67.48	43.33	48.29	0.00	0.00	0	0
1	800	21.93	23.53	26.25	24.11	66.13	71.1	45.68	51.86	0.00	0.00	0	0
1	815	22.36	22.72	23.78	24.78	70.8	76	49.44	54.41	0.00	0.00	0	0
1	830	20.81	20.85	23.21	23.26	77	81.3	52.65	57.71	0.00	0.00	0	0
1	845	19.75	20.84	24.49	22.18	81.1	83.7	54.22	60.41	0.00	0.00	0	0
1	900	19.9	19.33	24.16	23.5	88	88.8	56.55	63.34	0.00	0.00	0	0
1	915	19.35	19.06	24.04	23.08	87.8	88.5	56.21	62.78	0.00	0.00	0	0
1	930	18.27	18.2	24.83	25	86.3	86.8	52.24	57.76	0.00	0.00	0	0
1	945	17.48	17.44	25.02	25.41	86.7	87.4	50.07	54.96	0.00	0.00	0	0
1	1000	17.1	17.13	25.4	25.75	86.6	87.4	48.83	53.14	0.00	0.00	0	0
1	1015	16.65	16.59	25.39	25.72	86.7	87.5	47.99	52.03	0.00	0.00	0	0
1	1030	16.22	16.2	25.29	25.66	86.9	87.8	47.47	51.17	0.00	0.00	0	0
1	1045	15.87	15.92	25.61	25.71	87.1	87.9	47.08	50.45	0.00	0.00	0	0
1	1100	15.7	15.47	25.33	25.77	87.5	88.5	46.87	49.89	0.00	0.00	0	0
1	1115	15.45	15.4	25.3	25.6	87.3	88.3	46.45	49.54	0.00	0.00	0	0
1	1130	15.2	15.01	25.2	25.75	87.7	88.7	46.12	49.05	0.00	0.00	0	0
1	1145	14.94	15.16	25.29	25.74	87.8	88.6	45.93	48.7	0.00	0.00	0	0
1	1200	14.74	14.65	24.95	25.34	87.8	88.8	45.72	48.57	0.00	0.00	0	0
1	1215	14.56	14.45	25.06	25.63	88.1	89.1	45.47	48.17	0.00	0.00	0	0
1	1230	14.6	14.42	24.91	25.35	88.5	89.5	45.52	48.09	0.00	0.09	0	0.001
1	1245	14.34	14.19	24.82	25.39	88.9	89.7	45.28	47.82	0.00	0.36	0	0.004
1	1300	14.25	14.2	24.95	25.37	89	90	45.03	47.55	0.00	0.09	0	0.001
1	1315	14.26	14.1	24.71	25.3	89.2	90.3	45.15	47.47	0.00	0.00	0	0
1	1330	13.94	13.72	24.62	25.22	89.3	90.3	44.92	47.3	0.00	0.18	0	0.002
1	1345	13.72	13.32	24.73	25.68	89.2	90.4	44.64	46.93	0.00	0.09	0	0.001
1	1400	13.7	13.36	24.22	25.4	89.1	90.5	44.75	46.82	0.00	0.00	0	0
1	1415	13.22	13.24	24.59	25.09	89.3	90.3	44.5	46.9	0.00	0.00	0	0
1	1430	13.11	13.02	24.39	25.11	89.2	90.4	44.34	46.68	0.00	0.27	0	0.003
1	1445	12.87	12.88	24.39	24.86	89.3	90.5	44.24	46.62	0.00	0.00	0	0

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
1	1500	12.72	12.31	24.21	25.13	89.5	90.7	44.16	46.43	0.00	0.00	0	0
1	1515	12.62	12.7	24.35	24.57	89.4	90.5	44.06	46.54	0.00	0.00	0	0
1	1530	12.65	12.27	24.04	24.79	89.6	90.8	43.96	46.39	0.00	0.00	0	0
1	1545	12.22	12.33	23.97	24.62	89.6	90.6	43.79	46.29	0.00	0.18	0	0.002
1	1600	12.09	11.9	24.2	24.91	89.8	90.7	43.51	46.08	0.00	0.00	0	0
1	1615	12.21	12.13	23.78	24.52	89.7	91	43.63	46.11	0.00	0.00	0	0
1	1630	11.85	12.13	24.31	24.46	89.9	90.8	43.39	46.06	0.00	0.00	0	0
1	1645	12.05	11.9	23.78	24.52	89.9	90.8	43.28	45.93	0.00	0.27	0	0.003
1	1700	11.92	11.75	23.63	24.56	90	90.8	43.16	45.74	0.00	0.18	0	0.002
1	1715	12.03	11.67	23.58	24.52	90.1	90.8	43.15	45.57	0.00	0.00	0	0
1	1730	11.67	11.49	23.49	24.5	90.1	91	43.16	45.45	0.00	0.00	0	0
1	1745	11.62	11.53	23.65	24.25	89.8	90.9	43.02	45.49	0.00	0.00	0	0
1	1800	11.28	11.58	23.75	24.23	90.1	91.1	42.97	45.41	0.00	0.00	0	0
1	0	11.3	11.54	23.6	24.22	90.1	91.3	42.97	45.32	0.00	0.00	0	0
1	0.25	11.34	11.33	23.44	24.24	90.5	91.7	43.04	45.22	0.19	0.18	0.002	0.002
1	0.5	11.03	11.2	23.42	24.13	90.7	91.6	43.01	45.21	7.79	5.85	0.083	0.065
1	0.75	11.49	11.71	23.54	23.99	90.6	91.4	43.04	45.25	41.93	34.20	0.447	0.38
1	1	12.65	12.56	23.38	24.22	90.9	91.2	43.14	45.3	90.34	68.50	0.963	0.761
1	1.25	14.35	14.14	23.08	24.05	92.8	91.1	43.5	45.67	150.19	102.61	1.601	1.14
1	1.5	15.46	16.23	23.25	24.01	92.8	91.2	43.74	45.95	191.65	138.70	2.043	1.541
1	1.75	17.4	18.03	23.5	24.07	91.1	89.5	44.01	46.05	252.35	178.04	2.69	1.978
1	2	19.83	20.62	23.18	23.72	86.6	86.2	44.18	46.11	313.13	215.39	3.338	2.393
1	2.25	22.52	22.06	23.21	24.05	81.4	83.1	45.3	46.48	380.86	261.03	4.06	2.9
1	2.5	23.61	23.11	22.96	24.97	78.8	80.4	47.03	46.21	458.16	304.14	4.884	3.379
1	2.75	24.95	22.8	25.44	27.25	72.3	75.5	48.9	48.28	517.82	339.96	5.52	3.777
1	3	24.58	23.5	27.74	27.99	71.1	74.4	44.95	45.42	564.63	371.02	6.019	4.122
1	3.25	26.08	26.38	28.14	29.1	65.35	69.57	42.65	42.37	598.22	406.57	6.377	4.517
1	3.5	28.48	26.05	30.58	31.48	60.07	66.16	39.51	39.09	636.96	439.60	6.79	4.884
1	3.75	28.81	28.48	31.77	32.12	56.53	62.39	37.84	37	678.24	465.26	7.23	5.169
1	4	28.41	29.54	32.55	32.51	50.35	57.01	35.32	34.08	722.33	485.96	7.7	5.399
1	4.25	29.61	31.21	33.29	33.57	45.94	53.39	32.83	30.83	757.97	504.95	8.08	5.61

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
1	4.5	31.74	31.15	33.47	35.85	42.72	50.79	30.31	27.06	788.93	523.76	8.41	5.819
1	4.75	31.17	31.63	35.43	36.2	39.84	46.69	26.4	23.36	818.95	541.58	8.73	6.017
1	5	32.36	31.82	34.55	37.45	36.32	42.25	22.95	18.97	844.28	556.17	9	6.179
1	5.25	32.23	31.77	36.24	38.48	33.98	39.21	19.31	16.26	868.67	569.22	9.26	6.324
1	5.5	32.06	32.53	36.43	38.31	31.56	36.85	16.74	13.84	889.31	581.37	9.48	6.459
2	5.75	32.79	33.29	36.47	38.98	30.88	36.26	15.8	12.69	907.13	591.36	9.67	6.57
2	6	33.03	34	37.07	39.41	30.22	35.58	15.02	11.86	917.45	598.11	9.78	6.645
2	6.25	35.01	34.6	36.94	40.91	29.58	35.58	14.69	10.91	913.70	597.30	9.74	6.636
2	6.5	33.95	35.03	39.17	40.84	29.48	35.08	13.45	10.89	919.32	604.41	9.8	6.715
2	6.75	34.64	35.57	39.16	40.84	29.05	34.86	13.11	10.47	891.18	580.29	9.5	6.447
2	7	34.8	35.68	39.25	41.29	29.33	35.13	12.9	10.31	877.11	581.82	9.35	6.464
2	7.25	35.62	34.96	39.22	42.41	27.78	34.58	12.05	9.73	863.98	572.46	9.21	6.36
2	7.5	34.4	34.46	39.82	41.64	27.4	34.48	11.28	10.03	843.34	557.88	8.99	6.198
2	7.75	32.96	34.54	40.19	39.69	27.21	33.89	11.36	10.6	745.78	491.54	7.95	5.461
2	8	34.4	34.01	37.39	40.65	25.9	33.81	12	9.77	733.58	469.76	7.82	5.219
2	8.25	33.47	33.85	38.35	39.63	26.71	33.99	12	10.42	687.62	438.07	7.33	4.867
2	8.5	31.78	32	36.73	38.25	28.25	35.24	13.02	11.6	446.34	273.99	4.758	3.044
2	8.75	30.91	31.64	34.04	36.46	29.97	36.2	16.16	12.7	405.63	244.10	4.324	2.712
2	9	31.05	31.48	33.23	36.02	31.23	37.05	18.39	13.74	424.86	259.86	4.529	2.887
2	9.25	30.73	31.01	33.44	36.44	30.86	36.94	19.45	14.04	471.48	293.16	5.026	3.257
2	9.5	32.11	31.15	34.94	37.01	29.79	36.53	16.3	13.47	477.77	308.01	5.093	3.422
2	9.75	31.32	30.76	33.39	36.15	27.97	35.36	15.72	13.32	382.74	246.35	4.08	2.737
2	10	30.51	30.63	32.07	34.98	29.11	36.04	16.91	14.2	402.72	258.69	4.293	2.874
2	10.25	30.21	30.41	32.63	34.7	30.75	37.16	17.49	15.24	301.13	197.30	3.21	2.192
2	10.5	29.77	29.76	32.82	33.36	33.5	39.42	19.29	18.08	221.39	149.05	2.36	1.656
2	10.75	28.18	29.78	32.73	32.56	36.41	40.96	21	21.07	252.63	170.93	2.693	1.899
2	11	27.76	28.06	31.28	31.68	38.18	43.35	23.42	24.05	105.72	69.22	1.127	0.769
2	11.25	26.94	27.3	30.7	30.95	41.85	47.46	27.75	29.16	90.06	49.32	0.96	0.548
2	11.5	26.32	27.51	30.39	28.91	46.43	54.43	32.55	34.67	84.24	42.93	0.898	0.477
2	11.75	27.25	27.71	29.22	29.89	53.79	59.94	36.59	37.22	108.44	43.47	1.156	0.483
2	12	27.76	27.36	29.29	29.95	53.09	60.03	36.92	37.87	47.94	27.63	0.511	0.307

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
2	12.25	26	26.44	29.08	28.61	53.71	60.23	37.6	39.29	19.79	11.97	0.211	0.133
2	12.5	24.58	25.8	28.41	27.18	56.81	63.03	39.41	41.94	2.44	1.62	0.026	0.018
2	12.75	24.31	24.28	27.98	26.86	62.73	68.77	42.75	46.69	0.00	0.00	0	0
2	13	23.79	23.77	27.4	26.27	69.36	74.3	46.62	51.69	0.00	0.00	0	0
2	13.25	23.54	22.87	26.34	26.22	79.5	83.1	52.02	56.68	0.00	0.00	0	0
2	13.5	21.82	21.81	27.22	26.62	79.6	82.8	48.8	54.47	0.00	0.00	0	0
2	13.75	20.84	20.91	27.7	27.57	79.7	82.2	46.5	49.76	0.00	0.00	0	0
2	14	20.08	20.08	27.82	28.16	80.2	82.8	45.62	47.22	0.00	0.00	0	0
2	14.25	19.61	19.7	27.94	28.28	80.6	82.7	45.03	45.82	0.00	0.00	0	0
2	14.5	19.44	19.4	27.9	28.31	80.2	82.8	44.51	44.96	0.00	0.00	0	0
2	14.75	19.06	18.97	27.85	28.26	81	83.7	44.35	44.37	0.00	0.00	0	0
2	15	18.68	18.66	27.76	28.3	82.6	84.9	44.03	43.95	0.00	0.00	0	0
2	15.25	18.33	18.34	27.68	28.29	83	84.8	43.85	43.64	0.00	0.00	0	0
2	15.5	18.31	18.23	27.59	28.18	82.5	84.4	43.66	43.41	0.00	0.00	0	0
2	15.75	17.93	17.94	27.58	28.14	83.4	85.4	43.64	43.25	0.00	0.00	0	0
2	16	17.8	17.76	27.43	28.12	83.8	85.9	43.67	43.15	0.00	0.00	0	0
2	16.25	17.7	17.54	27.23	28	83.8	86.3	43.32	43.05	0.00	0.00	0	0
2	16.5	17.36	17.16	27.14	27.91	84.2	86.6	42.85	42.83	0.19	0.36	0.002	0.004
2	16.75	17.07	16.96	27.1	27.9	84.9	87	42.81	42.67	0.47	0.54	0.005	0.006
2	17	16.91	16.9	27.08	27.73	85.2	87.2	42.93	42.62	0.28	0.36	0.003	0.004
2	17.25	16.6	16.51	27	27.83	85.5	87.4	42.86	42.46	0.28	0.36	0.003	0.004
2	17.5	16.39	16.29	26.84	27.63	86	87.9	42.85	42.47	0.38	0.72	0.004	0.008
2	17.75	16.04	16.05	26.83	27.64	86.7	88.3	42.4	42.34	0.94	0.99	0.01	0.011
2	18	16.08	16.01	26.72	27.5	87.3	88.8	42.43	42.34	0.66	0.72	0.007	0.008
2	18.25	15.91	15.88	26.75	27.43	87.6	89.1	42.6	42.4	0.66	0.63	0.007	0.007
2	18.5	15.7	15.66	26.65	27.28	87.7	89.3	42.67	42.6	0.56	0.63	0.006	0.007
2	18.75	15.52	15.48	26.57	27.32	87.9	89.3	42.49	42.43	0.94	1.08	0.01	0.012
2	19	15.39	15.44	26.38	27.25	88.1	89.2	41.95	42.42	1.31	1.44	0.014	0.016
2	19.25	15.43	15.75	26.22	27.22	88.5	92.7	41.8	42.5	1.13	1.35	0.012	0.015
2	19.5	15.16	15.38	26.26	27.22	88.4	92.7	41.8	42.5	0.56	0.90	0.006	0.01
2	19.75	14.87	14.87	26.11	26.97	88	91.2	41.68	42.48	0.47	0.81	0.005	0.009

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
2	20	14.73	14.77	26.12	26.93	88.6	91	41.69	42.38	0.66	0.63	0.007	0.007
2	20.25	14.75	14.48	25.94	27.03	89.1	91.2	41.81	42.07	0.56	0.63	0.006	0.007
2	20.5	14.82	14.89	25.96	26.8	89.5	91.4	41.84	41.95	0.75	0.81	0.008	0.009
2	20.75	15.04	15.04	25.86	26.79	90	91.6	41.84	41.74	0.66	0.72	0.007	0.008
2	21	15.33	15.34	25.81	26.81	90	91.7	41.97	41.76	0.66	0.72	0.007	0.008
2	21.25	15.66	15.84	25.65	26.66	90.1	92.9	42.21	41.74	0.66	0.72	0.007	0.008
2	21.5	15.82	16.03	25.65	26.59	90.1	94.1	42.2	41.81	0.56	0.72	0.006	0.008
2	21.75	15.5	15.62	25.69	26.56	90	93	42.17	41.86	0.75	0.90	0.008	0.01
2	22	15.98	15.53	25.33	26.64	90.5	92.3	42.41	41.76	0.66	0.72	0.007	0.008
2	22.25	16.42	15.67	25.41	26.59	93.1	91.7	42.55	41.71	0.66	0.72	0.007	0.008
2	22.5	16.09	15.55	25.54	26.55	93.8	91	42.64	41.82	0.47	0.63	0.005	0.007
2	22.75	15.55	15.28	25.36	26.47	93	91.1	42.73	41.87	0.56	0.72	0.006	0.008
2	23	15.07	15.03	25.5	26.39	91.9	91.1	42.66	41.92	0.66	0.81	0.007	0.009
2	23.25	15.1	14.95	25.22	26.4	91.5	91.3	42.7	41.85	0.84	0.90	0.009	0.01
2	23.5	15.08	15.02	25.28	26.36	91.2	91.3	42.75	41.74	0.75	0.81	0.008	0.009
2	23.75	15.7	15.25	25.05	26.21	92.4	91.6	43	41.77	0.66	0.63	0.007	0.007
2	24	15.46	15.21	25.04	26.14	92.6	91.2	42.9	41.85	0.56	0.81	0.006	0.009
2	24.25	14.9	14.82	25.03	26.09	91.7	91	42.82	41.82	1.59	1.71	0.017	0.019
2	24.5	14.78	14.72	25.03	26.15	91.3	91.2	42.77	41.72	5.16	3.60	0.055	0.04
2	24.75	14.85	14.91	24.96	26.05	91.1	91.1	42.83	41.62	17.26	10.80	0.184	0.12
2	25	15.67	15.52	24.9	25.99	91.5	91.1	42.94	41.59	35.93	22.05	0.383	0.245
2	25.25	16.59	16.42	24.8	26.04	92.7	92.9	43.12	41.78	54.78	32.67	0.584	0.363
2	25.5	17.6	17.43	24.75	25.87	92.9	93.3	43.42	42.06	75.80	43.11	0.808	0.479
2	25.75	18.53	18.25	24.7	25.99	92.6	92.9	43.84	42.29	91.74	51.85	0.978	0.576
2	26	19.07	19.01	24.75	25.81	91.7	92.1	44.15	42.49	94.09	50.59	1.003	0.562
2	26.25	19.54	19.35	24.62	25.9	91.2	91.7	44.03	42.5	120.36	59.77	1.283	0.664
2	26.5	20.08	19.89	24.74	25.88	90.6	91	43.96	42.59	140.53	71.83	1.498	0.798
2	26.75	20.71	20.73	24.57	25.77	89.6	90.2	43.94	42.67	181.52	96.49	1.935	1.072
2	27	22.53	22.58	24.64	25.71	86.5	87.8	43.97	42.71	236.68	144.64	2.523	1.607
2	27.25	22.42	22.63	24.8	25.44	84.9	86.4	45.51	42.7	320.92	219.53	3.421	2.439
2	27.5	26.06	25.71	24.69	26.07	77.8	80.6	46.85	41.95	540.53	332.76	5.762	3.697

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
2	27.75	24.57	24.88	28.1	27.74	77.7	80.9	45.63	44.75	348.78	189.56	3.718	2.106
2	28	23.65	23.29	28.34	28	80.5	83.6	44.77	45.93	264.54	130.15	2.82	1.446
2	28.25	24.61	23.99	28.36	28.56	79.4	82.7	44.24	45.13	377.30	208.64	4.022	2.318
2	28.5	26.82	26.78	31.81	31.54	74.5	78.3	39.94	40.64	725.14	408.55	7.73	4.539
2	28.75	27.08	26.83	31.62	31.53	69.32	74	38.19	39	438.93	233.03	4.679	2.589
2	29	27.45	26.74	31.61	31.78	68.53	74	38.78	39.77	391.28	218.72	4.171	2.43
2	29.25	28.51	27.77	32.82	32.87	65.93	71.7	37.84	38.65	497.65	296.04	5.305	3.289
2	29.5	28.48	28.1	31.69	32.73	61.82	68.28	38	37.26	405.07	244.19	4.318	2.713
3	29.75	29.06	29.13	33.19	33.13	59.73	66.07	36.02	36.41	535.46	332.76	5.706	3.697
3	30	29.54	29.65	33.64	33.96	55.17	62.03	33.78	34.4	468.95	263.91	4.999	2.932
3	30.25	28.4	28.58	32.92	32.59	55.77	62.45	34.27	35.31	335.55	194.60	3.577	2.162
3	30.5	28.41	28.61	32.73	32.51	54.94	61.71	34.06	35.04	410.04	228.17	4.371	2.535
3	30.75	29.34	29.21	33.56	33.99	51.98	59.69	32.4	33.2	557.04	314.76	5.938	3.497
3	31	31.28	31.62	37.51	37.09	44.44	53.19	24.92	25.41	1021.58	613.59	10.89	6.817
3	31.25	32.98	33.13	40.17	40.21	38.61	46.77	16.13	16.26	968.11	599.73	10.32	6.663
3	31.5	33.05	33.91	40.32	39.4	37.47	44.97	15.04	15.59	755.16	484.79	8.05	5.386
3	31.75	31.54	31.7	37.13	37.35	38.65	46.67	17.33	18.09	545.22	375.16	5.812	4.168
3	32	32.2	32.77	38.61	38.02	36.94	44.19	16.02	16.76	738.27	490.19	7.87	5.446
3	32.25	31.72	31.75	37.28	37.39	38.93	47.01	17.82	18.51	448.97	265.98	4.786	2.955
3	32.5	29.36	29.67	34.38	34.18	42.68	51.17	22.44	23.95	264.54	150.32	2.82	1.67
3	32.75	29.57	29.81	34.18	34.29	42.67	51.56	24.4	25.66	376.74	210.71	4.016	2.341
3	33	29.4	29.51	34.16	33.98	41.68	50.19	23.76	25.07	290.99	155.72	3.102	1.73
3	33.25	28.73	29.12	33.42	32.9	44.33	52.94	26.43	28.16	250.66	125.29	2.672	1.392
3	33.5	28.25	28.5	32.97	32.58	47.21	55.77	27.9	29.82	269.14	119.17	2.869	1.324
3	33.75	27.36	27.58	32.03	31.68	54.87	62.53	31.96	34.12	242.96	115.57	2.59	1.284
3	34	26.78	26.9	31.31	30.86	55.36	63.04	33.13	35.34	169.61	85.78	1.808	0.953
3	34.25	26.35	26.58	30.39	30.06	56.35	63.74	34.84	36.88	115.76	55.09	1.234	0.612
3	34.5	25.88	25.99	29.7	29.32	58.24	65.47	36.63	38.73	84.15	37.89	0.897	0.421
3	34.75	25.57	25.67	29.13	28.84	60.38	67.31	38.28	40.56	62.57	27.90	0.667	0.31
3	35	25.27	25.43	28.76	28.4	62.47	69.3	39.76	42.45	63.79	27.54	0.68	0.306
3	35.25	25.13	25.13	28.61	28.21	65.23	72.2	41.35	44.65	53.56	24.21	0.571	0.269

Table 4. (continued)

DAY	MINUTES INTO DAY	AMBIENT AIR TEMP (C)	AMBIENT AIR TEMP (C)	DRYING AIR TEMP (C)	DRYING AIR TEMP (C)	AMBIENT AIR RH (%)	AMBIENT AIR RH (%)	DRYING AIR RH (%)	DRYING AIR RH (%)	ROOF PYRA. (W/m^2)	SOUTH PYRA. (W/m^2)	ROOF PYRA. (millivolts)	SOUTH PYRA. (millivolts)
3	35.5	24.99	24.95	28.3	27.97	67.32	73.9	42.89	46.77	41.56	19.08	0.443	0.212
3	35.75	24.65	24.72	28.12	27.61	68.5	74.8	43.39	48.05	25.61	12.42	0.273	0.138
3	36	24.37	24.46	27.49	27.18	69.3	75.4	44.99	49.41	13.13	5.85	0.14	0.065
3	36.25	23.88	23.84	27.12	26.71	72.7	78.2	46.9	51.72	4.13	1.89	0.044	0.021
3	36.5	23.5	23.53	27.14	26.4	76.3	80.7	47.03	53.72	0.00	0.00	0	0
3	36.75	23.26	23.21	27.19	26.74	77.9	81.7	46.98	52.43	0.00	0.00	0	0
3	37	23.06	23	27.58	27.43	79	82.3	45.43	50.14	0.00	0.00	0	0
3	37.25	22.96	22.85	27.8	27.74	79.2	82.9	44.72	48.85	0.00	0.00	0	0
3	37.5	22.73	22.66	27.85	27.86	76.2	81.5	44.4	48.05	0.00	0.00	0	0
3	37.75	22.33	22.27	27.8	27.88	73.2	80.8	44.29	47.52	0.00	0.00	0	0
3	38	21.9	21.77	27.75	27.88	74.1	81.4	44.31	47.17	0.00	0.00	0	0
3	38.25	21.64	21.48	27.7	27.84	74.5	83.2	44.42	46.84	0.00	0.00	0	0
3	38.5	21.64	21.4	27.64	27.82	78.5	88.2	44.5	46.74	0.00	0.00	0	0
3	38.75	21.4	21.25	27.55	27.77	79.4	88.2	44.57	46.65	0.00	0.00	0	0

Table 5. Gantry bale weights recorded by the 21X micrologger.

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/21/96	12:02 P.M.	1297	1378	1396	1297	0	fan off
9/21/96	12:17 P.M.	1271	1352	1370	1271	15	bad data*
9/21/96	12:32 P.M.	1192	1272	1277	1186	30	fan on
9/21/96	12:47 P.M.	1183	1257	1254	1180	45	fan on
9/21/96	01:02 P.M.	1168	1248	1254	1179	60	fan on
9/21/96	01:17 P.M.	1171	1249	1255	1180	75	fan on
9/21/96	01:32 P.M.	1170	1252	1255	1180	90	fan on
9/21/96	01:47 P.M.	1171	1255	1256	1181	105	fan on
9/21/96	02:02 P.M.	1172	1254	1256	1181	120	fan on
9/21/96	02:17 P.M.	1173	1255	1256	1182	135	fan on
9/21/96	02:32 P.M.	1172	1255	1256	1181	150	fan on
9/21/96	02:47 P.M.	1171	1256	1256	1182	165	fan on
9/21/96	03:02 P.M.	1170	1254	1256	1182	180	fan on
9/21/96	03:17 P.M.	1169	1254	1257	1182	195	fan on
9/21/96	03:32 P.M.	1166	1254	1255	1182	210	fan on
9/21/96	03:47 P.M.	1165	1252	1255	1182	225	fan on
9/21/96	04:02 P.M.	1165	1253	1255	1186	240	fan on
9/21/96	04:17 P.M.	1162	1251	1253	1186	255	fan on
9/21/96	04:32 P.M.	1159	1250	1250	1185	270	fan on
9/21/96	04:47 P.M.	1157	1247	1249	1183	285	fan on
9/21/96	05:02 P.M.	1156	1245	1246	1182	300	fan on
9/21/96	05:17 P.M.	1153	1244	1244	1180	315	fan on
9/21/96	05:32 P.M.	1151	1242	1242	1179	330	fan on
9/21/96	05:47 P.M.	1150	1240	1239	1177	345	fan on
9/21/96	06:02 P.M.	1148	1239	1237	1176	360	fan on
9/21/96	06:17 P.M.	1146	1237	1235	1175	375	fan on
9/21/96	06:32 P.M.	1146	1235	1233	1172	390	fan on
9/21/96	06:47 P.M.	1145	1235	1232	1172	405	fan on
9/21/96	07:02 P.M.	1145	1236	1229	1171	420	fan on
9/21/96	07:17 P.M.	1145	1234	1228	1170	435	fan on
9/21/96	07:32 P.M.	1145	1233	1228	1169	450	fan off
9/21/96	07:47 P.M.	1252	1339	1344	1259	465	bad data
9/21/96	08:02 P.M.	1253	1340	1344	1260	480	fan off
9/21/96	08:17 P.M.	1254	1341	1345	1260	495	fan off
9/21/96	08:32 P.M.	1255	1343	1349	1262	510	fan off
9/21/96	08:47 P.M.	1225	1313	1315	1234	525	bad data
9/21/96	09:02 P.M.	1231	1319	1320	1240	540	bad data
9/21/96	09:17 P.M.	1253	1342	1346	1261	555	fan off
9/21/96	09:32 P.M.	1253	1342	1346	1261	570	fan off
9/21/96	09:47 P.M.	1253	1342	1348	1261	585	fan off
9/21/96	10:02 P.M.	1253	1342	1346	1260	600	fan off
9/21/96	10:17 P.M.	1253	1342	1346	1261	615	fan off
9/21/96	10:32 P.M.	1253	1342	1346	1261	630	fan off
9/21/96	10:47 P.M.	1253	1342	1346	1261	645	fan off
9/21/96	11:02 P.M.	1253	1342	1346	1260	660	fan off

*bad data - 15 minute period when the fan was both on and off.

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/21/96	11:17 P.M.	1253	1342	1345	1260	675	fan off
9/21/96	11:32 P.M.	1253	1342	1346	1261	690	fan off
9/21/96	11:47 P.M.	1253	1342	1345	1260	705	fan off
9/22/96	12:02 A.M.	1253	1342	1345	1260	720	fan off
9/22/96	12:17 A.M.	1252	1342	1345	1260	735	fan off
9/22/96	12:32 A.M.	1252	1342	1345	1260	750	fan off
9/22/96	12:47 A.M.	1253	1342	1345	1260	765	fan off
9/22/96	01:02 A.M.	1253	1342	1345	1260	780	fan off
9/22/96	01:17 A.M.	1252	1342	1345	1260	795	fan off
9/22/96	01:32 A.M.	1252	1342	1344	1260	810	fan off
9/22/96	01:47 A.M.	1252	1341	1344	1260	825	fan off
9/22/96	02:02 A.M.	1252	1342	1344	1260	840	fan off
9/22/96	02:17 A.M.	1252	1342	1344	1260	855	fan off
9/22/96	02:32 A.M.	1252	1341	1344	1259	870	fan off
9/22/96	02:47 A.M.	1252	1341	1344	1260	885	fan off
9/22/96	03:02 A.M.	1252	1341	1344	1260	900	fan off
9/22/96	03:17 A.M.	1252	1341	1344	1260	915	fan off
9/22/96	03:32 A.M.	1252	1341	1344	1260	930	fan off
9/22/96	03:47 A.M.	1252	1341	1344	1260	945	fan off
9/22/96	04:02 A.M.	1252	1341	1344	1259	960	fan off
9/22/96	04:17 A.M.	1252	1341	1344	1259	975	fan off
9/22/96	04:32 A.M.	1252	1341	1344	1259	990	fan off
9/22/96	04:47 A.M.	1252	1341	1344	1260	1005	fan off
9/22/96	05:02 A.M.	1252	1341	1344	1260	1020	fan off
9/22/96	05:17 A.M.	1252	1341	1344	1260	1035	fan off
9/22/96	05:32 A.M.	1252	1341	1344	1259	1050	fan off
9/22/96	05:47 A.M.	1252	1341	1344	1260	1065	fan off
9/22/96	06:02 A.M.	1252	1341	1344	1260	1080	fan off
9/22/96	06:17 A.M.	1252	1341	1344	1260	1095	fan off
9/22/96	06:32 A.M.	1252	1341	1344	1260	1110	fan off
9/22/96	06:47 A.M.	1252	1341	1344	1260	1125	fan off
9/22/96	07:02 A.M.	1251	1340	1342	1259	1140	fan off
9/22/96	07:17 A.M.	1251	1340	1340	1258	1155	fan off
9/22/96	07:32 A.M.	1251	1340	1340	1258	1170	fan off
9/22/96	07:47 A.M.	1251	1339	1340	1257	1185	fan off
9/22/96	08:02 A.M.	1251	1339	1340	1257	1200	fan off
9/22/96	08:17 A.M.	1251	1339	1340	1257	1215	fan off
9/22/96	08:32 A.M.	1251	1340	1341	1256	1230	fan off
9/22/96	08:47 A.M.	1251	1341	1341	1256	1245	fan off
9/22/96	09:02 A.M.	1151	1238	1227	1164	1260	bad data
9/22/96	09:17 A.M.	1143	1232	1219	1157	1275	fan on
9/22/96	09:32 A.M.	1144	1231	1219	1158	1290	fan on
9/22/96	09:47 A.M.	1144	1232	1219	1158	1305	fan on
9/22/96	10:02 A.M.	1144	1231	1221	1159	1320	fan on
9/22/96	10:17 A.M.	1143	1232	1221	1159	1335	fan on

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/22/96	10:32 A.M.	1141	1232	1222	1160	1350	fan on
9/22/96	10:47 A.M.	1137	1231	1220	1161	1365	fan on
9/22/96	11:02 A.M.	1135	1229	1218	1162	1380	fan on
9/22/96	11:17 A.M.	1132	1228	1214	1160	1395	fan on
9/22/96	11:32 A.M.	1129	1226	1210	1158	1410	fan on
9/22/96	11:47 A.M.	1127	1224	1206	1156	1425	fan on
9/22/96	12:02 P.M.	1124	1221	1202	1153	1440	fan on
9/22/96	12:17 P.M.	1121	1220	1196	1151	1455	fan on
9/22/96	12:32 P.M.	1118	1217	1192	1147	1470	fan on
9/22/96	12:47 P.M.	1116	1214	1188	1145	1485	fan on
9/22/96	01:02 P.M.	1114	1211	1186	1142	1500	fan on
9/22/96	01:17 P.M.	1112	1209	1182	1139	1515	fan on
9/22/96	01:32 P.M.	1110	1207	1177	1135	1530	fan on
9/22/96	01:47 P.M.	1107	1205	1173	1132	1545	fan on
9/22/96	02:02 P.M.	1105	1202	1170	1129	1560	fan on
9/22/96	02:17 P.M.	1104	1199	1166	1125	1575	fan on
9/22/96	02:32 P.M.	1132	1225	1190	1143	1590	bad data
9/22/96	02:47 P.M.	1105	1197	1166	1122	1605	fan on
9/22/96	03:02 P.M.	1105	1197	1166	1124	1620	fan on
9/22/96	03:17 P.M.	1103	1195	1164	1121	1635	fan on
9/22/96	03:32 P.M.	1101	1194	1160	1116	1650	fan on
9/22/96	03:47 P.M.	1099	1191	1156	1111	1665	fan on
9/22/96	04:02 P.M.	1097	1188	1152	1108	1680	fan on
9/22/96	04:17 P.M.	1095	1186	1149	1104	1695	fan on
9/22/96	04:32 P.M.	1093	1184	1146	1101	1710	fan on
9/22/96	04:47 P.M.	1093	1182	1144	1097	1725	fan on
9/22/96	05:02 P.M.	1091	1180	1141	1094	1740	fan on
9/22/96	05:17 P.M.	1089	1178	1139	1092	1755	fan on
9/22/96	05:32 P.M.	1088	1177	1137	1089	1770	fan on
9/22/96	05:47 P.M.	1087	1175	1135	1087	1785	fan on
9/22/96	06:02 P.M.	1085	1174	1134	1085	1800	fan on
9/22/96	06:17 P.M.	1084	1173	1132	1084	1815	fan on
9/22/96	06:32 P.M.	1083	1173	1132	1082	1830	fan on
9/22/96	06:47 P.M.	1083	1172	1133	1081	1845	fan on
9/22/96	07:02 P.M.	1083	1172	1133	1081	1860	fan on
9/22/96	07:17 P.M.	1083	1171	1133	1080	1875	fan on
9/22/96	07:32 P.M.	1083	1171	1134	1080	1890	fan on
9/22/96	07:47 P.M.	1109	1196	1154	1096	1905	bad data
9/22/96	08:02 P.M.	1081	1169	1126	1073	1920	fan on
9/22/96	08:17 P.M.	1081	1169	1127	1073	1935	fan on
9/22/96	08:32 P.M.	1081	1168	1127	1074	1950	fan on
9/22/96	08:47 P.M.	1081	1168	1128	1074	1965	fan on
9/22/96	09:02 P.M.	1081	1169	1128	1074	1980	fan on
9/22/96	09:17 P.M.	1165	1254	1211	1145	1995	bad data
9/22/96	09:32 P.M.	1187	1279	1239	1167	2010	fan off

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/22/96	09:47 P.M.	1187	1279	1241	1170	2025	fan off
9/22/96	10:02 P.M.	1188	1279	1242	1171	2040	fan off
9/22/96	10:17 P.M.	1188	1279	1243	1170	2055	fan off
9/22/96	10:32 P.M.	1188	1279	1243	1171	2070	fan off
9/22/96	10:47 P.M.	1188	1279	1243	1171	2085	fan off
9/22/96	11:02 P.M.	1188	1279	1244	1172	2100	fan off
9/22/96	11:17 P.M.	1188	1280	1244	1172	2115	fan off
9/22/96	11:32 P.M.	1188	1280	1244	1173	2130	fan off
9/22/96	11:47 P.M.	1188	1280	1245	1173	2145	fan off
9/23/96	12:02 A.M.	1188	1280	1245	1173	2160	fan off
9/23/96	12:17 A.M.	1188	1280	1246	1174	2175	fan off
9/23/96	12:32 A.M.	1188	1280	1246	1174	2190	fan off
9/23/96	12:47 A.M.	1188	1280	1246	1174	2205	fan off
9/23/96	01:02 A.M.	1188	1280	1246	1174	2220	fan off
9/23/96	01:17 A.M.	1188	1280	1247	1175	2235	fan off
9/23/96	01:32 A.M.	1188	1280	1247	1175	2250	fan off
9/23/96	01:47 A.M.	1188	1280	1247	1175	2265	fan off
9/23/96	02:02 A.M.	1188	1280	1247	1175	2280	fan off
9/23/96	02:17 A.M.	1189	1281	1248	1176	2295	fan off
9/23/96	02:32 A.M.	1188	1280	1247	1176	2310	fan off
9/23/96	02:47 A.M.	1188	1280	1247	1176	2325	fan off
9/23/96	03:02 A.M.	1188	1280	1247	1175	2340	fan off
9/23/96	03:17 A.M.	1189	1281	1248	1176	2355	fan off
9/23/96	03:32 A.M.	1189	1281	1248	1176	2370	fan off
9/23/96	03:47 A.M.	1189	1281	1248	1176	2385	fan off
9/23/96	04:02 A.M.	1189	1281	1248	1176	2400	fan off
9/23/96	04:17 A.M.	1189	1281	1248	1176	2415	fan off
9/23/96	04:32 A.M.	1189	1281	1248	1177	2430	fan off
9/23/96	04:47 A.M.	1189	1281	1248	1177	2445	fan off
9/23/96	05:02 A.M.	1189	1280	1248	1177	2460	fan off
9/23/96	05:17 A.M.	1189	1280	1248	1177	2475	fan off
9/23/96	05:32 A.M.	1189	1280	1248	1177	2490	fan off
9/23/96	05:47 A.M.	1189	1281	1249	1177	2505	fan off
9/23/96	06:02 A.M.	1189	1281	1249	1178	2520	fan off
9/23/96	06:17 A.M.	1189	1281	1249	1178	2535	fan off
9/23/96	06:32 A.M.	1189	1281	1249	1178	2550	fan off
9/23/96	06:47 A.M.	1189	1281	1249	1178	2565	fan off
9/23/96	07:02 A.M.	1188	1280	1246	1176	2580	fan off
9/23/96	07:17 A.M.	1188	1279	1245	1175	2595	fan off
9/23/96	07:32 A.M.	1188	1280	1247	1176	2610	fan off
9/23/96	07:47 A.M.	1188	1280	1247	1177	2625	fan off
9/23/96	08:02 A.M.	1188	1279	1246	1176	2640	fan off
9/23/96	08:17 A.M.	1188	1279	1245	1173	2655	fan off
9/23/96	08:32 A.M.	1188	1280	1246	1173	2670	fan off
9/23/96	08:47 A.M.	1188	1280	1247	1173	2685	fan off

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/23/96	09:02 A.M.	1092	1178	1146	1084	2700	bad data
9/23/96	09:17 A.M.	1086	1173	1138	1079	2715	fan on
9/23/96	09:32 A.M.	1086	1174	1138	1079	2730	fan on
9/23/96	09:47 A.M.	1086	1173	1137	1079	2745	fan on
9/23/96	10:02 A.M.	1086	1173	1137	1079	2760	fan on
9/23/96	10:17 A.M.	1086	1173	1138	1081	2775	fan on
9/23/96	10:32 A.M.	1086	1173	1138	1081	2790	fan on
9/23/96	10:47 A.M.	1086	1173	1139	1082	2805	fan on
9/23/96	11:02 A.M.	1085	1173	1138	1082	2820	fan on
9/23/96	11:17 A.M.	1084	1172	1139	1083	2835	fan on
9/23/96	11:32 A.M.	1082	1171	1138	1081	2850	fan on
9/23/96	11:47 A.M.	1080	1169	1134	1078	2865	fan on
9/23/96	12:02 P.M.	1078	1168	1130	1074	2880	fan on
9/23/96	12:17 P.M.	1076	1166	1127	1072	2895	fan on
9/23/96	12:32 P.M.	1074	1164	1125	1070	2910	fan on
9/23/96	12:47 P.M.	1073	1162	1122	1067	2925	fan on
9/23/96	01:02 P.M.	1072	1159	1119	1065	2940	fan on
9/23/96	01:17 P.M.	1070	1159	1116	1063	2955	fan on
9/23/96	01:32 P.M.	1069	1157	1115	1061	2970	fan on
9/23/96	01:47 P.M.	1067	1156	1111	1058	2985	fan on
9/23/96	02:02 P.M.	1066	1154	1109	1056	3000	fan on
9/23/96	02:17 P.M.	1064	1152	1108	1053	3015	fan on
9/23/96	02:32 P.M.	1063	1151	1105	1050	3030	fan on
9/23/96	02:47 P.M.	1104	1192	1143	1082	3045	bad data
9/23/96	03:02 P.M.	1160	1247	1196	1128	3060	fan off
9/23/96	03:17 P.M.	1161	1248	1197	1128	3075	fan off
9/23/96	03:32 P.M.	1141	1228	1178	1112	3090	bad data
9/23/96	03:47 P.M.	1059	1146	1098	1042	3105	fan on
9/23/96	04:02 P.M.	1058	1145	1097	1042	3120	fan on
9/23/96	04:17 P.M.	1057	1144	1097	1041	3135	fan on
9/23/96	04:32 P.M.	1056	1143	1096	1041	3150	fan on
9/23/96	04:47 P.M.	1055	1142	1096	1040	3165	fan on
9/23/96	05:02 P.M.	1054	1141	1096	1040	3180	fan on
9/23/96	05:17 P.M.	1053	1141	1095	1040	3195	fan on
9/23/96	05:32 P.M.	1077	1164	1116	1052	3210	bad data
9/23/96	05:47 P.M.	1051	1137	1090	1027	3225	fan on
9/23/96	06:02 P.M.	1051	1136	1090	1028	3240	fan on
9/23/96	06:17 P.M.	1051	1137	1089	1028	3255	fan on
9/23/96	06:32 P.M.	1051	1136	1089	1027	3270	fan on
9/23/96	06:47 P.M.	1051	1143	1089	1027	3285	fan on
9/23/96	07:02 P.M.	1051	1143	1089	1026	3300	fan on
9/23/96	07:17 P.M.	1051	1142	1088	1026	3315	fan on
9/23/96	07:32 P.M.	1078	1170	1113	1048	3330	bad data
9/23/96	07:47 P.M.	1155	1247	1191	1115	3345	fan off
9/23/96	08:02 P.M.	1156	1247	1193	1117	3360	fan off

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/23/96	08:17 P.M.	1156	1247	1194	1118	3375	fan off
9/23/96	08:32 P.M.	1156	1248	1195	1117	3390	fan off
9/23/96	08:47 P.M.	1156	1248	1195	1118	3405	fan off
9/23/96	09:02 P.M.	1156	1248	1196	1119	3420	fan off
9/23/96	09:17 P.M.	1156	1248	1197	1120	3435	fan off
9/23/96	09:32 P.M.	1156	1248	1198	1120	3450	fan off
9/23/96	09:47 P.M.	1156	1249	1198	1121	3465	fan off
9/23/96	10:02 P.M.	1156	1248	1197	1121	3480	fan off
9/23/96	10:17 P.M.	1156	1248	1198	1120	3495	fan off
9/23/96	10:32 P.M.	1157	1249	1199	1121	3510	fan off
9/23/96	10:47 P.M.	1157	1249	1200	1122	3525	fan off
9/23/96	11:02 P.M.	1157	1249	1199	1121	3540	fan off
9/23/96	11:17 P.M.	1157	1249	1200	1122	3555	fan off
9/23/96	11:32 P.M.	1157	1249	1201	1123	3570	fan off
9/23/96	11:47 P.M.	1157	1249	1200	1123	3585	fan off
9/24/96	12:02 A.M.	1157	1249	1200	1123	3600	fan off
9/24/96	12:17 A.M.	1157	1249	1200	1123	3615	fan off
9/24/96	12:32 A.M.	1157	1249	1201	1124	3630	fan off
9/24/96	12:47 A.M.	1157	1249	1201	1123	3645	fan off
9/24/96	01:02 A.M.	1157	1249	1201	1123	3660	fan off
9/24/96	01:17 A.M.	1157	1249	1201	1124	3675	fan off
9/24/96	01:32 A.M.	1157	1249	1200	1123	3690	fan off
9/24/96	01:47 A.M.	1157	1249	1201	1123	3705	fan off
9/24/96	02:02 A.M.	1157	1249	1201	1124	3720	fan off
9/24/96	02:17 A.M.	1157	1249	1201	1124	3735	fan off
9/24/96	02:32 A.M.	1158	1249	1202	1125	3750	fan off
9/24/96	02:47 A.M.	1158	1249	1202	1125	3765	fan off
9/24/96	03:02 A.M.	1158	1249	1202	1125	3780	fan off
9/24/96	03:17 A.M.	1158	1249	1202	1125	3795	fan off
9/24/96	03:32 A.M.	1158	1250	1202	1126	3810	fan off
9/24/96	03:47 A.M.	1158	1250	1203	1126	3825	fan off
9/24/96	04:02 A.M.	1158	1249	1202	1126	3840	fan off
9/24/96	04:17 A.M.	1158	1250	1203	1126	3855	fan off
9/24/96	04:32 A.M.	1158	1250	1203	1126	3870	fan off
9/24/96	04:47 A.M.	1158	1250	1203	1126	3885	fan off
9/24/96	05:02 A.M.	1158	1250	1203	1127	3900	fan off
9/24/96	05:17 A.M.	1158	1250	1204	1127	3915	fan off
9/24/96	05:32 A.M.	1158	1250	1204	1127	3930	fan off
9/24/96	05:47 A.M.	1158	1250	1204	1127	3945	fan off
9/24/96	06:02 A.M.	1158	1250	1204	1127	3960	fan off
9/24/96	06:17 A.M.	1158	1250	1204	1128	3975	fan off
9/24/96	06:32 A.M.	1158	1250	1204	1127	3990	fan off
9/24/96	06:47 A.M.	1158	1250	1204	1128	4005	fan off
9/24/96	07:02 A.M.	1158	1250	1204	1128	4020	fan off
9/24/96	07:17 A.M.	1158	1250	1204	1128	4035	fan off

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/24/96	07:32 A.M.	1158	1250	1204	1128	4050	fan off
9/24/96	07:47 A.M.	1158	1250	1204	1128	4065	fan off
9/24/96	08:02 A.M.	1158	1250	1204	1128	4080	fan off
9/24/96	08:17 A.M.	1158	1250	1205	1127	4095	fan off
9/24/96	08:32 A.M.	1158	1250	1204	1126	4110	fan off
9/24/96	08:47 A.M.	1158	1250	1205	1127	4125	fan off
9/24/96	09:02 A.M.	1158	1250	1204	1127	4140	fan off
9/24/96	09:17 A.M.	1158	1250	1205	1127	4155	fan off
9/24/96	09:32 A.M.	1159	1251	1205	1128	4170	fan off
9/24/96	09:47 A.M.	1159	1251	1205	1127	4185	fan off
9/24/96	10:02 A.M.	1069	1161	1115	1050	4200	bad data
9/24/96	10:17 A.M.	1055	1146	1098	1035	4215	fan on
9/24/96	10:32 A.M.	1056	1145	1098	1035	4230	fan on
9/24/96	10:47 A.M.	1055	1146	1097	1034	4245	fan on
9/24/96	11:02 A.M.	1055	1145	1096	1033	4260	fan on
9/24/96	11:17 A.M.	1054	1145	1096	1034	4275	fan on
9/24/96	11:32 A.M.	1055	1144	1096	1034	4290	fan on
9/24/96	11:47 A.M.	1124	1211	1162	1088	4305	bad data
9/24/96	12:02 P.M.	1056	1144	1096	1031	4320	fan on
9/24/96	12:17 P.M.	1056	1143	1095	1031	4335	fan on
9/24/96	12:32 P.M.	1055	1143	1095	1032	4350	fan on
9/24/96	12:47 P.M.	1054	1143	1095	1031	4365	fan on
9/24/96	01:02 P.M.	1054	1142	1095	1031	4380	fan on
9/24/96	01:17 P.M.	1054	1143	1094	1031	4395	fan on
9/24/96	01:32 P.M.	1054	1142	1094	1032	4410	fan on
9/24/96	01:47 P.M.	1053	1141	1094	1032	4425	fan on
9/24/96	02:02 P.M.	1051	1140	1094	1033	4440	fan on
9/24/96	02:17 P.M.	1050	1141	1093	1033	4455	fan on
9/24/96	02:32 P.M.	1048	1139	1092	1031	4470	fan on
9/24/96	02:47 P.M.	1046	1137	1091	1029	4485	fan on
9/24/96	03:02 P.M.	1074	1163	1109	1042	4500	bad data
9/24/96	03:17 P.M.	1041	1130	1074	1013	4515	fan on
9/24/96	03:32 P.M.	1040	1129	1074	1013	4530	fan on
9/24/96	03:47 P.M.	1040	1128	1074	1012	4545	fan on
9/24/96	04:02 P.M.	1039	1128	1073	1012	4560	fan on
9/24/96	04:17 P.M.	1038	1127	1073	1012	4575	fan on
9/24/96	04:32 P.M.	1037	1126	1073	1011	4590	fan on
9/24/96	04:47 P.M.	1037	1126	1072	1011	4605	fan on
9/24/96	05:02 P.M.	1037	1126	1071	1010	4620	fan on
9/24/96	05:17 P.M.	1036	1124	1071	1009	4635	fan on
9/24/96	05:32 P.M.	1036	1124	1070	1008	4650	fan on
9/24/96	05:47 P.M.	1049	1137	1082	1017	4665	bad data
9/24/96	06:02 P.M.	1070	1158	1103	1031	4680	bad data
9/24/96	06:17 P.M.	1036	1123	1070	1002	4695	fan on
9/24/96	06:32 P.M.	1043	1131	1076	1008	4710	bad data

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/24/96	06:47 P.M.	1104	1191	1135	1059	4725	bad data
9/24/96	07:02 P.M.	1137	1224	1168	1088	4740	fan off
9/24/96	07:17 P.M.	1137	1225	1170	1089	4755	fan off
9/24/96	07:32 P.M.	1137	1225	1171	1091	4770	fan off
9/24/96	07:47 P.M.	1138	1225	1172	1092	4785	fan off
9/24/96	08:02 P.M.	1138	1226	1173	1093	4800	fan off
9/24/96	08:17 P.M.	1138	1226	1174	1093	4815	fan off
9/24/96	08:32 P.M.	1138	1226	1174	1093	4830	fan off
9/24/96	08:47 P.M.	1138	1228	1172	1092	4845	fan off
9/24/96	09:02 P.M.	1139	1228	1173	1093	4860	fan off
9/24/96	09:17 P.M.	1139	1228	1173	1093	4875	fan off
9/24/96	09:32 P.M.	1139	1228	1173	1093	4890	fan off
9/24/96	09:47 P.M.	1139	1228	1173	1094	4905	fan off
9/24/96	10:02 P.M.	1139	1228	1174	1094	4920	fan off
9/24/96	10:17 P.M.	1139	1228	1174	1095	4935	fan off
9/24/96	10:32 P.M.	1139	1228	1175	1095	4950	fan off
9/24/96	10:47 P.M.	1139	1228	1175	1096	4965	fan off
9/24/96	11:02 P.M.	1139	1228	1175	1096	4980	fan off
9/24/96	11:17 P.M.	1139	1228	1175	1096	4995	fan off
9/24/96	11:32 P.M.	1139	1228	1175	1097	5010	fan off
9/24/96	11:47 P.M.	1139	1228	1176	1097	5025	fan off
9/25/96	12:02 A.M.	1139	1228	1176	1097	5040	fan off
9/25/96	12:17 A.M.	1139	1228	1176	1097	5055	fan off
9/25/96	12:32 A.M.	1139	1228	1176	1098	5070	fan off
9/25/96	12:47 A.M.	1139	1228	1177	1098	5085	fan off
9/25/96	01:02 A.M.	1139	1228	1177	1098	5100	fan off
9/25/96	01:17 A.M.	1139	1229	1177	1099	5115	fan off
9/25/96	01:32 A.M.	1139	1228	1177	1099	5130	fan off
9/25/96	01:47 A.M.	1139	1228	1177	1099	5145	fan off
9/25/96	02:02 A.M.	1139	1228	1177	1099	5160	fan off
9/25/96	02:17 A.M.	1139	1229	1178	1099	5175	fan off
9/25/96	02:32 A.M.	1139	1229	1178	1099	5190	fan off
9/25/96	02:47 A.M.	1139	1229	1178	1099	5205	fan off
9/25/96	03:02 A.M.	1139	1228	1178	1099	5220	fan off
9/25/96	03:17 A.M.	1139	1229	1178	1100	5235	fan off
9/25/96	03:32 A.M.	1139	1228	1178	1100	5250	fan off
9/25/96	03:47 A.M.	1139	1228	1178	1100	5265	fan off
9/25/96	04:02 A.M.	1139	1228	1178	1100	5280	fan off
9/25/96	04:17 A.M.	1139	1228	1178	1100	5295	fan off
9/25/96	04:32 A.M.	1139	1229	1178	1101	5310	fan off
9/25/96	04:47 A.M.	1140	1229	1179	1101	5325	fan off
9/25/96	05:02 A.M.	1140	1229	1179	1101	5340	fan off
9/25/96	05:17 A.M.	1140	1229	1179	1101	5355	fan off
9/25/96	05:32 A.M.	1140	1229	1179	1101	5370	fan off
9/25/96	05:47 A.M.	1140	1229	1179	1101	5385	fan off

Table 5. (continued)

Date	Time	Bale # 6 (lbs)	Bale # 5 (lbs)	Bale # 3 (lbs)	Bale # 2 (lbs)	Minutes	Additional Info
9/25/96	06:02 A.M.	1140	1229	1179	1102	5400	fan off
9/25/96	06:17 A.M.	1140	1229	1179	1102	5415	fan off
9/25/96	06:32 A.M.	1140	1229	1179	1102	5430	fan off
9/25/96	06:47 A.M.	1140	1229	1179	1102	5445	fan off
9/25/96	07:02 A.M.	1140	1229	1179	1102	5460	fan off
9/25/96	07:17 A.M.	1140	1229	1180	1102	5475	fan off
9/25/96	07:32 A.M.	1140	1229	1180	1103	5490	fan off
9/25/96	07:47 A.M.	1140	1229	1181	1103	5505	fan off
9/25/96	08:02 A.M.	1140	1229	1181	1103	5520	fan off
9/25/96	08:17 A.M.	1140	1229	1180	1103	5535	fan off
9/25/96	08:32 A.M.	1140	1229	1180	1103	5550	fan off
9/25/96	08:47 A.M.	1140	1229	1180	1103	5565	fan off
9/25/96	09:02 A.M.	1140	1229	1180	1100	5580	fan off
9/25/96	09:17 A.M.	1140	1229	1180	1100	5595	fan off
9/25/96	09:32 A.M.	1126	1215	1168	1089	5610	bad data
9/25/96	09:47 A.M.	1038	1126	1077	1012	5625	fan on
9/25/96	10:02 A.M.	1038	1125	1075	1010	5640	fan on
9/25/96	10:17 A.M.	1038	1123	1074	1009	5655	fan on
9/25/96	10:32 A.M.	1038	1123	1073	1007	5670	fan on
9/25/96	10:47 A.M.	1052	1137	1086	1019	5685	bad data
9/25/96	11:02 A.M.	1038	1124	1073	1008	5700	fan on
9/25/96	11:17 A.M.	1038	1125	1072	1008	5715	fan on
9/25/96	11:32 A.M.	1038	1124	1072	1009	5730	fan on
9/25/96	11:47 A.M.	1038	1124	1072	1009	5745	fan on
9/25/96	12:02 P.M.	1037	1124	1072	1009	5760	fan on
9/25/96	12:17 P.M.	1037	1123	1072	1010	5775	fan on
9/25/96	12:32 P.M.	1111	1199	1146	1070	5790	bad data
9/25/96	12:47 P.M.	1131	1220	1167	1089	5805	fan off
9/25/96	01:02 P.M.	1131	1220	1168	1090	5820	fan off

Table 6. Moisture contents of bales suspended by the gantry (fan on).

Date	Time	Bale #6		Bale #5		Bale #3		Bale #2		Minutes	Hours
		% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB	Fan On	Fan On
9/21/96	12:02 P.M.	27.8	38.4	27.7	38.4	27.9	38.6	29.6	42.1	0	0.00
9/21/96	12:32 P.M.	27.1	37.5	27.1	37.4	26.0	36.0	27.7	39.3	30	0.50
9/21/96	12:47 P.M.	26.3	36.4	25.9	35.8	24.2	33.6	27.2	38.6	45	0.75
9/21/96	01:02 P.M.	25.1	34.7	25.2	34.9	24.2	33.6	27.1	38.5	60	1.00
9/21/96	01:17 P.M.	25.3	35.0	25.3	35.0	24.3	33.7	27.2	38.6	75	1.25
9/21/96	01:32 P.M.	25.2	34.9	25.5	35.3	24.3	33.7	27.2	38.6	90	1.50
9/21/96	01:47 P.M.	25.3	35.0	25.7	35.6	24.4	33.8	27.3	38.8	105	1.75
9/21/96	02:02 P.M.	25.4	35.2	25.7	35.5	24.4	33.8	27.3	38.8	120	2.00
9/21/96	02:17 P.M.	25.5	35.3	25.7	35.6	24.4	33.8	27.4	38.9	135	2.25
9/21/96	02:32 P.M.	25.4	35.2	25.7	35.6	24.4	33.8	27.3	38.8	150	2.50
9/21/96	02:47 P.M.	25.3	35.0	25.8	35.7	24.4	33.8	27.4	38.9	165	2.75
9/21/96	03:02 P.M.	25.2	34.9	25.7	35.5	24.4	33.8	27.4	38.9	180	3.00
9/21/96	03:17 P.M.	25.1	34.8	25.7	35.5	24.4	33.9	27.4	38.9	195	3.25
9/21/96	03:32 P.M.	24.9	34.5	25.7	35.5	24.3	33.7	27.4	38.9	210	3.50
9/21/96	03:47 P.M.	24.8	34.4	25.5	35.3	24.3	33.7	27.4	38.9	225	3.75
9/21/96	04:02 P.M.	24.8	34.4	25.6	35.4	24.3	33.7	27.7	39.3	240	4.00
9/21/96	04:17 P.M.	24.6	34.0	25.4	35.2	24.1	33.5	27.7	39.3	255	4.25
9/21/96	04:32 P.M.	24.3	33.7	25.4	35.1	23.9	33.2	27.6	39.2	270	4.50
9/21/96	04:47 P.M.	24.1	33.4	25.1	34.7	23.8	33.1	27.4	39.0	285	4.75
9/21/96	05:02 P.M.	24.1	33.3	25.0	34.5	23.6	32.7	27.4	38.9	300	5.00
9/21/96	05:17 P.M.	23.8	33.0	24.9	34.4	23.4	32.5	27.2	38.6	315	5.25
9/21/96	05:32 P.M.	23.6	32.7	24.7	34.2	23.3	32.3	27.1	38.5	330	5.50
9/21/96	05:47 P.M.	23.6	32.6	24.6	34.0	23.1	32.0	27.0	38.3	345	5.75
9/21/96	06:02 P.M.	23.4	32.4	24.5	33.9	22.9	31.8	26.9	38.2	360	6.00
9/21/96	06:17 P.M.	23.2	32.2	24.3	33.7	22.8	31.6	26.8	38.1	375	6.25
9/21/96	06:32 P.M.	23.2	32.2	24.2	33.5	22.6	31.3	26.5	37.7	390	6.50
9/21/96	06:47 P.M.	23.1	32.0	24.2	33.5	22.5	31.2	26.5	37.7	405	6.75
9/21/96	07:02 P.M.	23.1	32.0	24.3	33.6	22.3	30.9	26.5	37.6	420	7.00
9/21/96	07:17 P.M.	23.1	32.0	24.1	33.3	22.2	30.8	26.4	37.5	435	7.25
9/21/96	07:32 P.M.	23.1	32.0	24.0	33.2	22.2	30.8	26.3	37.3	450	7.50
9/22/96	09:17 A.M.	23.0	31.8	24.0	33.1	21.5	29.9	25.3	35.9	465	7.75
9/22/96	09:32 A.M.	23.1	31.9	23.9	33.0	21.5	29.9	25.4	36.1	480	8.00

Table 6. (continued)

Date	Time	Bale #6		Bale #5		Bale #3		Bale #2		Minutes Fan On	Hours Fan On
		% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB		
9/22/96	09:47 A.M.	23.1	31.9	24.0	33.1	21.5	29.9	25.4	36.1	495	8.25
9/22/96	10:02 A.M.	23.1	31.9	23.9	33.0	21.7	30.1	25.5	36.2	510	8.50
9/22/96	10:17 A.M.	23.0	31.8	24.0	33.1	21.7	30.1	25.5	36.2	525	8.75
9/22/96	10:32 A.M.	22.8	31.6	24.0	33.1	21.8	30.2	25.5	36.3	540	9.00
9/22/96	10:47 A.M.	22.5	31.1	23.9	33.0	21.6	30.0	25.6	36.4	555	9.25
9/22/96	11:02 A.M.	22.3	30.9	23.7	32.8	21.4	29.7	25.7	36.5	570	9.50
9/22/96	11:17 A.M.	22.1	30.5	23.6	32.7	21.1	29.3	25.5	36.3	585	9.75
9/22/96	11:32 A.M.	21.8	30.2	23.5	32.5	20.8	28.9	25.4	36.1	600	10.00
9/22/96	11:47 A.M.	21.6	30.0	23.3	32.3	20.5	28.5	25.2	35.8	615	10.25
9/22/96	12:02 P.M.	21.4	29.6	23.1	31.9	20.2	28.0	25.0	35.5	630	10.50
9/22/96	12:17 P.M.	21.1	29.3	23.0	31.8	19.8	27.4	24.8	35.2	645	10.75
9/22/96	12:32 P.M.	20.9	28.9	22.8	31.5	19.5	27.0	24.5	34.8	660	11.00
9/22/96	12:47 P.M.	20.7	28.7	22.5	31.2	19.1	26.6	24.3	34.5	675	11.25
9/22/96	01:02 P.M.	20.6	28.5	22.3	30.9	19.0	26.3	24.1	34.2	690	11.50
9/22/96	01:17 P.M.	20.4	28.2	22.2	30.6	18.7	25.9	23.8	33.8	705	11.75
9/22/96	01:32 P.M.	20.2	28.0	22.0	30.4	18.3	25.4	23.5	33.4	720	12.00
9/22/96	01:47 P.M.	20.0	27.7	21.8	30.2	18.0	25.0	23.2	33.0	735	12.25
9/22/96	02:02 P.M.	19.8	27.4	21.6	29.9	17.8	24.6	23.0	32.6	750	12.50
9/22/96	02:17 P.M.	19.7	27.3	21.4	29.6	17.5	24.2	22.7	32.2	765	12.75
9/22/96	02:47 P.M.	19.8	27.4	21.2	29.3	17.5	24.2	22.4	31.8	795	13.25
9/22/96	03:02 P.M.	19.8	27.4	21.2	29.3	17.5	24.2	22.6	32.1	810	13.50
9/22/96	03:17 P.M.	19.6	27.2	21.1	29.1	17.3	24.0	22.3	31.7	825	13.75
9/22/96	03:32 P.M.	19.5	27.0	21.0	29.0	17.0	23.6	21.9	31.1	840	14.00
9/22/96	03:47 P.M.	19.3	26.7	20.7	28.7	16.7	23.1	21.5	30.5	855	14.25
9/22/96	04:02 P.M.	19.1	26.5	20.5	28.4	16.4	22.7	21.2	30.2	870	14.50
9/22/96	04:17 P.M.	19.0	26.3	20.4	28.2	16.1	22.4	20.9	29.7	885	14.75
9/22/96	04:32 P.M.	18.8	26.0	20.2	27.9	15.9	22.1	20.7	29.4	900	15.00
9/22/96	04:47 P.M.	18.8	26.0	20.0	27.7	15.8	21.9	20.3	28.9	915	15.25
9/22/96	05:02 P.M.	18.6	25.8	19.9	27.5	15.5	21.5	20.1	28.5	930	15.50
9/22/96	05:17 P.M.	18.5	25.6	19.7	27.3	15.4	21.3	19.9	28.3	945	15.75
9/22/96	05:32 P.M.	18.4	25.5	19.7	27.2	15.2	21.1	19.7	27.9	960	16.00
9/22/96	05:47 P.M.	18.3	25.4	19.5	27.0	15.1	20.9	19.5	27.7	975	16.25

Table 6. (continued)

Date	Time	Bale #6		Bale #5		Bale #3		Bale #2		Minutes	Hours
		% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB	Fan On	Fan On
9/22/96	06:02 P.M.	18.1	25.1	19.4	26.9	15.0	20.8	19.3	27.5	990	16.50
9/22/96	06:17 P.M.	18.1	25.0	19.3	26.8	14.8	20.6	19.3	27.4	1005	16.75
9/22/96	06:32 P.M.	18.0	24.9	19.3	26.8	14.8	20.6	19.1	27.1	1020	17.00
9/22/96	06:47 P.M.	18.0	24.9	19.3	26.6	14.9	20.7	19.0	27.0	1035	17.25
9/22/96	07:02 P.M.	18.0	24.9	19.3	26.6	14.9	20.7	19.0	27.0	1050	17.50
9/22/96	07:17 P.M.	18.0	24.9	19.2	26.5	14.9	20.7	18.9	26.9	1065	17.75
9/22/96	07:32 P.M.	18.0	24.9	19.2	26.5	15.0	20.8	18.9	26.9	1080	18.00
9/22/96	08:02 P.M.	17.8	24.7	19.0	26.3	14.4	19.9	18.4	26.1	1110	18.50
9/22/96	08:17 P.M.	17.8	24.7	19.0	26.3	14.5	20.1	18.4	26.1	1125	18.75
9/22/96	08:32 P.M.	17.8	24.7	19.0	26.2	14.5	20.1	18.4	26.2	1140	19.00
9/22/96	08:47 P.M.	17.8	24.7	19.0	26.2	14.5	20.2	18.4	26.2	1155	19.25
9/22/96	09:02 P.M.	17.8	24.7	19.0	26.3	14.5	20.2	18.4	26.2	1170	19.50
9/23/96	09:17 A.M.	18.2	25.2	19.3	26.8	15.3	21.2	18.8	26.8	1185	19.75
9/23/96	09:32 A.M.	18.2	25.2	19.4	26.9	15.3	21.2	18.8	26.8	1200	20.00
9/23/96	09:47 A.M.	18.2	25.2	19.3	26.8	15.2	21.1	18.8	26.8	1215	20.25
9/23/96	10:02 A.M.	18.2	25.2	19.3	26.8	15.2	21.1	18.8	26.8	1230	20.50
9/23/96	10:17 A.M.	18.2	25.2	19.3	26.8	15.3	21.2	19.0	27.0	1245	20.75
9/23/96	10:32 A.M.	18.2	25.2	19.3	26.8	15.3	21.2	19.0	27.0	1260	21.00
9/23/96	10:47 A.M.	18.2	25.2	19.3	26.8	15.4	21.3	19.1	27.1	1275	21.25
9/23/96	11:02 A.M.	18.1	25.1	19.3	26.8	15.3	21.2	19.1	27.1	1290	21.50
9/23/96	11:17 A.M.	18.1	25.0	19.3	26.6	15.4	21.3	19.2	27.2	1305	21.75
9/23/96	11:32 A.M.	17.9	24.8	19.2	26.5	15.3	21.2	19.0	27.0	1320	22.00
9/23/96	11:47 A.M.	17.7	24.5	19.0	26.3	15.0	20.8	18.8	26.7	1335	22.25
9/23/96	12:02 P.M.	17.6	24.3	19.0	26.2	14.7	20.4	18.4	26.2	1350	22.50
9/23/96	12:17 P.M.	17.4	24.1	18.8	26.0	14.5	20.1	18.3	25.9	1365	22.75
9/23/96	12:32 P.M.	17.2	23.9	18.6	25.8	14.3	19.8	18.1	25.7	1380	23.00
9/23/96	12:47 P.M.	17.1	23.7	18.5	25.6	14.1	19.5	17.9	25.4	1395	23.25
9/23/96	01:02 P.M.	17.1	23.6	18.2	25.2	13.8	19.2	17.7	25.1	1410	23.50
9/23/96	01:17 P.M.	16.9	23.4	18.2	25.2	13.6	18.9	17.5	24.9	1425	23.75
9/23/96	01:32 P.M.	16.8	23.3	18.1	25.0	13.5	18.8	17.4	24.7	1440	24.00
9/23/96	01:47 P.M.	16.6	23.1	18.0	24.9	13.2	18.3	17.1	24.3	1455	24.25
9/23/96	02:02 P.M.	16.6	22.9	17.9	24.7	13.1	18.1	16.9	24.1	1470	24.50

Table 6. (continued)

Date	Time	Bale #6		Bale #5		Bale #3		Bale #2		Minutes	Hours
		% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB	Fan On	Fan On
9/23/96	02:17 P.M.	16.4	22.7	17.7	24.5	13.0	18.0	16.7	23.7	1485	24.75
9/23/96	02:32 P.M.	16.3	22.6	17.6	24.4	12.8	17.7	16.4	23.4	1500	25.00
9/23/96	03:47 P.M.	16.0	22.1	17.2	23.8	12.2	17.0	15.8	22.4	1545	25.75
9/23/96	04:02 P.M.	15.9	22.0	17.2	23.7	12.2	16.9	15.8	22.4	1560	26.00
9/23/96	04:17 P.M.	15.8	21.9	17.1	23.6	12.2	16.9	15.7	22.3	1575	26.25
9/23/96	04:32 P.M.	15.7	21.8	17.0	23.5	12.1	16.8	15.7	22.3	1590	26.50
9/23/96	04:47 P.M.	15.6	21.7	16.9	23.4	12.1	16.8	15.6	22.2	1605	26.75
9/23/96	05:02 P.M.	15.6	21.6	16.8	23.3	12.1	16.8	15.6	22.2	1620	27.00
9/23/96	05:17 P.M.	15.5	21.4	16.8	23.3	12.0	16.6	15.6	22.2	1635	27.25
9/23/96	05:47 P.M.	15.3	21.2	16.5	22.9	11.6	16.1	14.5	20.7	1665	27.75
9/23/96	06:02 P.M.	15.3	21.2	16.5	22.8	11.6	16.1	14.6	20.8	1680	28.00
9/23/96	06:17 P.M.	15.3	21.2	16.5	22.9	11.5	16.0	14.6	20.8	1695	28.25
9/23/96	06:32 P.M.	15.3	21.2	16.5	22.8	11.5	16.0	14.5	20.7	1710	28.50
9/23/96	06:47 P.M.	15.3	21.2	17.0	23.5	11.5	16.0	14.5	20.7	1725	28.75
9/23/96	07:02 P.M.	15.3	21.2	17.0	23.5	11.5	16.0	14.5	20.5	1740	29.00
9/23/96	07:17 P.M.	15.3	21.2	16.9	23.4	11.5	15.9	14.5	20.5	1755	29.25
9/24/96	10:17 A.M.	15.6	21.7	17.2	23.8	12.2	17.0	15.2	21.6	1785	29.75
9/24/96	10:32 A.M.	15.7	21.8	17.2	23.7	12.2	17.0	15.2	21.6	1800	30.00
9/24/96	10:47 A.M.	15.6	21.7	17.2	23.8	12.2	16.9	15.1	21.5	1815	30.25
9/24/96	11:02 A.M.	15.6	21.7	17.2	23.7	12.1	16.8	15.0	21.4	1830	30.50
9/24/96	11:17 A.M.	15.6	21.6	17.2	23.7	12.1	16.8	15.1	21.5	1845	30.75
9/24/96	11:32 A.M.	15.6	21.7	17.1	23.6	12.1	16.8	15.1	21.5	1860	31.00
9/24/96	12:02 P.M.	15.7	21.8	17.1	23.6	12.1	16.8	14.9	21.1	1890	31.50
9/24/96	12:17 P.M.	15.7	21.8	17.0	23.5	12.0	16.6	14.9	21.1	1905	31.75
9/24/96	12:32 P.M.	15.6	21.7	17.0	23.5	12.0	16.6	15.0	21.2	1920	32.00
9/24/96	12:47 P.M.	15.6	21.6	17.0	23.5	12.0	16.6	14.9	21.1	1935	32.25
9/24/96	01:02 P.M.	15.6	21.6	16.9	23.4	12.0	16.6	14.9	21.1	1950	32.50
9/24/96	01:17 P.M.	15.6	21.6	17.0	23.5	11.9	16.5	14.9	21.1	1965	32.75
9/24/96	01:32 P.M.	15.6	21.6	16.9	23.4	11.9	16.5	15.0	21.2	1980	33.00
9/24/96	01:47 P.M.	15.5	21.4	16.8	23.3	11.9	16.5	15.0	21.2	1995	33.25
9/24/96	02:02 P.M.	15.3	21.2	16.8	23.2	11.9	16.5	15.0	21.4	2010	33.50
9/24/96	02:17 P.M.	15.2	21.1	16.8	23.3	11.8	16.4	15.0	21.4	2025	33.75

Table 6. (continued)

Date	Time	Bale #6		Bale #5		Bale #3		Bale #2		Minutes	Hours
		% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB	Fan On	Fan On
9/24/96	02:32 P.M.	15.1	20.9	16.7	23.1	11.8	16.3	14.9	21.1	2040	34.00
9/24/96	02:47 P.M.	14.9	20.6	16.5	22.9	11.7	16.2	14.7	20.9	2055	34.25
9/24/96	03:17 P.M.	14.5	20.1	16.0	22.1	10.4	14.4	13.4	19.0	2085	34.75
9/24/96	03:32 P.M.	14.4	19.9	15.9	22.0	10.4	14.4	13.4	19.0	2100	35.00
9/24/96	03:47 P.M.	14.4	19.9	15.8	21.9	10.4	14.4	13.3	18.9	2115	35.25
9/24/96	04:02 P.M.	14.3	19.8	15.8	21.9	10.3	14.3	13.3	18.9	2130	35.50
9/24/96	04:17 P.M.	14.2	19.7	15.7	21.8	10.3	14.3	13.3	18.9	2145	35.75
9/24/96	04:32 P.M.	14.1	19.6	15.7	21.7	10.3	14.3	13.2	18.8	2160	36.00
9/24/96	04:47 P.M.	14.1	19.6	15.7	21.7	10.2	14.2	13.2	18.8	2175	36.25
9/24/96	05:02 P.M.	14.1	19.6	15.7	21.7	10.2	14.1	13.1	18.7	2190	36.50
9/24/96	05:17 P.M.	14.1	19.5	15.5	21.5	10.2	14.1	13.1	18.5	2205	36.75
9/24/96	05:32 P.M.	14.1	19.5	15.5	21.5	10.1	14.0	13.0	18.4	2220	37.00
9/24/96	06:17 P.M.	14.1	19.5	15.4	21.3	10.1	14.0	12.5	17.7	2265	37.75
9/25/96	09:47 A.M.	14.2	19.7	15.7	21.7	10.6	14.7	13.3	18.9	2295	38.25
9/25/96	10:02 A.M.	14.2	19.7	15.6	21.6	10.5	14.5	13.1	18.7	2310	38.50
9/25/96	10:17 A.M.	14.2	19.7	15.4	21.3	10.4	14.4	13.1	18.5	2325	38.75
9/25/96	10:32 A.M.	14.2	19.7	15.4	21.3	10.3	14.3	12.9	18.3	2340	39.00
9/25/96	11:02 A.M.	14.2	19.7	15.5	21.5	10.3	14.3	13.0	18.4	2370	39.50
9/25/96	11:17 A.M.	14.2	19.7	15.6	21.6	10.2	14.2	13.0	18.4	2385	39.75
9/25/96	11:32 A.M.	14.2	19.7	15.5	21.5	10.2	14.2	13.1	18.5	2400	40.00
9/25/96	11:47 A.M.	14.2	19.7	15.5	21.5	10.2	14.2	13.1	18.5	2415	40.25
9/25/96	12:02 P.M.	14.1	19.6	15.5	21.5	10.2	14.2	13.1	18.5	2430	40.50
9/25/96	12:17 P.M.	14.1	19.6	15.4	21.3	10.2	14.2	13.1	18.7	2445	40.75

Table 7. Manually recorded weights and calculated moisture contents of bales suspended by the gantry (fan off).

Date	Time	Bale #6 (lbs)	Bale #5 (lbs)	Bale #3 (lbs)	Bale #2 (lbs)	Bale #6		Bale #5		Bale #3		Bale #2	
						% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB
9/21/96	12:02 P.M.	1297	1378	1396	1297	27.8	38.4	27.7	38.4	27.9	38.6	29.6	42.1
9/21/96	8:30 P.M.	1254	1343	1348	1261	24.5	33.9	25.2	34.8	24.5	33.9	26.8	38.1
9/22/96	8:45 A.M.	1251	1340	1341	1256	24.3	33.6	24.9	34.5	24.0	33.2	26.4	37.6
9/22/96	2:15 P.M.	1205	1300	1265	1207	20.7	28.7	22.0	30.5	18.5	25.7	22.7	32.2
9/22/96	7:30 P.M.	1182	1272	1225	1159	18.9	26.2	20.0	27.7	15.7	21.7	19.0	26.9
9/22/96	9:20 P.M.	1185	1274	1231	1162	19.2	26.5	20.2	27.9	16.1	22.3	19.2	27.3
9/23/96	8:40 A.M.	1188	1280	1247	1172	19.4	26.9	20.6	28.5	17.2	23.9	20.0	28.4
9/23/96	2:40 P.M.	1159	1245	1191	1124	17.2	23.8	18.0	25.0	13.2	18.3	16.3	23.1
9/23/96	5:20 P.M.	1152	1237	1184	1109	16.6	23.0	17.5	24.2	12.7	17.6	15.1	21.5
9/23/96	7:20 P.M.	1154	1244	1186	1110	16.8	23.2	18.0	24.9	12.9	17.8	15.2	21.6
9/24/96	9:45 A.M.	1159	1250	1205	1127	17.2	23.8	18.4	25.5	14.2	19.7	16.5	23.4
9/24/96	11:30 A.M.	1157	1244	1194	1114	17.0	23.6	18.0	24.9	13.4	18.6	15.5	22.0
9/24/96	2:45 P.M.	1138	1228	1169	1093	15.5	21.5	16.8	23.3	11.6	16.1	13.9	19.7
9/24/96	5:45 P.M.	1137	1225	1167	1086	15.5	21.4	16.6	23.0	11.5	15.9	13.3	18.9
9/24/96	6:30 P.M.	1135	1222	1163	1084	15.3	21.2	16.4	22.7	11.2	15.5	13.2	18.7
9/25/96	8:45 A.M.	1139	1228	1180	1102	15.6	21.6	16.8	23.3	12.4	17.2	14.6	20.7
9/25/96	10:30 A.M.	1136	1222	1166	1089	15.4	21.3	16.4	22.7	11.4	15.8	13.6	19.3
9/25/96	12:47 P.M.	1131	1220	1167	1089	15.0	20.8	16.2	22.5	11.5	15.9	13.6	19.3
9/25/96	1:02 P.M.	1131	1220	1168	1090	15.0	20.8	16.2	22.5	11.6	16.0	13.6	19.4

Table 8. Moisture content analysis from core sampling.

BALE ID#	BALE TYPE	0 HRS		7 HRS		12.5 HRS		19.5 HRS		28 HRS		37.5 HRS	
		% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB	% WB	% DB
1	solid	31.2	45.4	26.5	36.1	24.7	32.8	19.7	24.5	16.3	19.5	14.2	16.5
2	6" h.c.	29.6	42.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15.5	18.3
3	12" h.c.	27.9	38.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14.6	17.1
4	solid	26.9	36.7	25.2	33.8	22.2	28.5	20.9	26.4	19.7	24.6	18.1	22.1
5	6" h.c.	27.7	38.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19.5	24.2
6	12" h.c.	27.8	38.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16.4	19.6
7	solid	25.8	34.7	23.2	30.2	19.9	24.8	19.8	24.7	16.2	19.4	9.8	10.9
8	6" h.c.	26.1	35.3	22.5	29.0	19.6	24.3	17.4	21.0	15.9	19.0	11.5	12.9
9	12" h.c.	27.3	37.5	24.8	33.0	21.3	27.0	19.4	24.1	16.4	19.6	10.6	11.9
10	solid	27.3	37.6	24.2	31.8	20.7	26.1	18.9	23.4	14.2	16.6	11.9	13.5
11	6" h.c.	30.4	43.7	24.1	31.7	19.1	23.6	21.1	26.8	12.6	14.5	12.0	13.7
12	12" h.c.	26.0	35.1	24.6	32.6	21.5	27.4	19.6	24.4	19.3	23.9	13.4	15.5
13	solid	25.5	34.3	22.7	29.3	22.3	28.7	20.9	26.5	17.2	20.8	15.7	21.1
14	6" h.c.	26.8	36.7	22.6	29.3	21.6	27.5	20.9	26.5	16.9	20.3	13.3	15.3
15	12" h.c.	23.2	30.3	18.7	23.0	16.4	19.7	14.0	16.3	12.4	14.2	8.2	9.0
16	solid	22.6	29.2	18.3	22.5	18.4	22.5	17.8	21.7	13.7	15.9	14.7	17.3
17	6" h.c.	24.4	32.2	20.2	25.3	19.5	24.2	19.1	23.6	13.2	15.2	12.5	14.3
18	12" h.c.	24.6	32.7	21.0	26.7	21.0	26.5	20.6	25.9	17.6	21.3	15.4	18.2
19	solid	24.3	32.0	20.9	26.5	19.9	24.8	16.8	20.2	12.1	13.8	14.0	16.3
20	solid	25.5	34.2	21.8	27.9	20.2	25.3	19.7	24.5	16.9	20.4	15.8	18.8

Table 9. Dry matter weights and density of experimental bales.

BALE #	INITIAL WEIGHT (lbs)	DRY MAT. WEIGHT INTIAL (lbs)	FINAL WEIGHT (lbs)	DRY MAT. WEIGHT FINAL (lbs)	BALE RADIUS (ft)	BALE LENGTH (ft)	BALE VOLUME (ft^3)	CORE VOLUME (ft^3)	ADJ. BALE VOLUME (ft^3)	DRY MAT. DENSITY (lbs/ft^3)	DRY MAT. DENSITY (kg/m^3)
1	1305	897.84	1102	945.52	2.619	3.6	77.54	N/A	77.54	11.58	185.47
2	1340	943.36	1200	1014	2.552	3.56	72.75	0.7	72.05	13.09	209.71
3	1415	1020.22	1255	1071.77	2.698	3.47	79.4	2.73	76.67	13.31	213.14
4	1470	1074.57	1270	1040.13	2.706	3.64	83.69	N/A	83.69	12.84	205.68
5	1395	1008.59	1250	1006.25	2.635	3.58	78.19	0.7	77.48	13.02	208.5
6	1320	953.04	1154	964.74	2.573	3.58	74.52	2.81	71.71	13.29	212.89
7	1275	946.05	1112	1003.02	2.664	3.57	79.56	N/A	79.56	11.89	190.47
8	1242	917.84	1064	941.64	2.681	3.67	82.82	0.72	82.1	11.18	179.08
9	1188	863.68	1042	931.55	2.642	3.63	79.46	2.85	76.62	11.27	180.57
10	1320	959.64	1110	977.91	2.653	3.67	81.05	N/A	81.05	11.84	189.65
11	1214	844.94	1014	892.32	2.653	3.68	81.36	0.72	80.64	10.48	167.85
12	1190	880.6	1034	895.44	2.638	3.64	79.57	2.86	76.71	11.48	183.88
13	1280	953.6	1140	961.02	2.624	3.69	79.91	N/A	79.91	11.93	191.16
14	1330	973.56	1200	1040.4	2.664	3.68	82.04	0.72	81.31	11.97	191.78
15	1080	829.44	922	846.4	2.628	3.63	78.67	2.85	75.82	10.94	175.23
16	1154	893.2	1036	885.41	2.597	3.63	76.83	N/A	76.83	11.63	186.23
17	1126	851.26	1012	885.5	2.635	3.68	80.28	0.72	79.55	10.7	171.4
18	1130	852.02	1020	862.92	2.646	3.63	79.73	2.85	76.88	11.08	177.51
19	1172	887.2	1024	880.64	2.648	3.64	80.17	N/A	80.17	11.07	177.27
20	1275	949.88	1142	961.56	2.653	3.68	81.36	N/A	81.36	11.68	187.01

Table 10. Drying rate parameters and standard errors for each bale treatment.

Obs.	Bale #	Fan	Fan Type	Core	On Gantry	Treatment	k	s.e.
1	1	on	c	0	no	no-c-00-on	-0.028574	0.000995
2	2	on	c	6	yes	yes-c-06-on	-0.021941	0.0001483
3	2	off	c	6	yes	yes-c-06-off	-0.020286	0.000447
4	3	on	c	12	yes	yes-c-12-on	-0.028233	0.0002739
5	3	off	c	12	yes	yes-c-12-off	-0.023461	0.0006665
6	4	on	c	0	no	no-c-00-on	-0.014548	0.0009024
7	5	on	c	6	yes	yes-c-06-on	-0.016467	0.0001595
8	5	off	c	6	yes	yes-c-06-off	-0.013844	0.000328
9	6	on	c	12	yes	yes-c-12-on	-0.019403	0.0002181
10	6	off	c	12	yes	yes-c-12-off	-0.015859	0.0003958
11	7	on	c	0	no	no-c-00-on	-0.025761	0.0027617
12	8	on	c	6	no	no-c-06-on	-0.025674	0.0011701
13	9	on	va	12	no	no-va-12-on	-0.026959	0.0019154
14	10	on	c	0	no	no-c-00-on	-0.027484	0.0008071
15	11	on	c	6	no	no-c-06-on	-0.033818	0.0031435
16	12	on	c	12	no	no-c-12-on	-0.018775	0.0018084
17	13	on	va	0	no	no-va-00-on	-0.014622	0.0011984
18	14	on	va	6	no	no-va-06-on	-0.021948	0.0013078
19	15	on	c	12	no	no-c-12-on	-0.031035	0.0013519
20	16	on	va	0	no	no-va-00-on	-0.01712	0.002204
21	17	on	va	6	no	no-va-06-on	-0.022616	0.0018733
22	18	on	va	12	no	no-va-12-on	-0.015336	0.0011189
23	19	on	va	0	no	no-va-00-on	-0.022453	0.0026039
24	20	on	va	0	no	no-va-00-on	-0.01751	0.0012566

Vita

Deron Scott Jaggers was born in Bowling Green, Kentucky on July 20, 1972. He moved to Owensville, Indiana in 1976 and then to Hendersonville, Tennessee in 1978. There he attended Beech Senior High School and graduated in May of 1990. He entered Tennessee Technological University in August of 1990 and received a Bachelor of Science Degree in Agricultural Engineering Technology in May of 1994. He entered The University of Tennessee at Knoxville in August of 1994 on a Graduate Research Assistantship where he received a Master of Science in Agricultural Engineering Technology in May of 1997.

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