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WHAT'S IN A NAME?

M.G. (Ron) Britton

President, 1987–1988

When was the last time you explained what Agricultural Engineering is? Existing, as we do, on the interface of two poorly understood professions, we spend a measurable amount of our lives explaining who, and what we are. Is this reasonable?

The quality of the professionals within our ranks is not open to question. Agricultural Engineers occupy positions of influence in government, industry, academia and professional organizations in far greater proportion than our numbers would justify. New Agricultural Engineering graduates, when given the opportunity to compete with more traditional engineering specialties, can and do demonstrate the breadth and depth of their technical education. The very existence, and recognized quality, of this publication speaks volumes for the abilities and dedication of Agricultural Engineers. We are looked upon, by those who know us, as leaders in both engineering and agriculture. Why then, must we continue to justify our existence to the public at large? Why are we not seeing increasing numbers of young people accepting the challenge of our "brand" of engineering.

Agricultural Engineering skills are not obsolete. The food and fiber production and processing industries have increased in complexity and diversity. Traditional processes are being replaced. Restrictions on how, where and even if, production and processing can proceed are now a regular part of the design environment. Certainly the focus of opportunities is shifting from that which existed when many of us made the decision to become Agricultural Engineers, but the opportunities still exist. If anything, the need for engineers who understand the constraints of biological systems is increasing. Engineered systems now have more impact on the food machine than at any time in history.

But the reality persists. CSAE is a small society when viewed from either the engineering or the agriculture perspective. Most undergraduate programs in Canada and elsewhere suffer from relatively small, and traditionally varying, student numbers. Many potential employers still advertize for persons with training in traditional engineering disciplines and a "farm background". Ability and need notwithstanding, we are still a largely misunderstood element in both engineering and agriculture. Like Rodney Dangerfield, we "don't get no respect".

If Agricultural Engineers can, and do, contribute to the solution to problems in the world, why are we not known? Are we sending the wrong message? Are the discussions about new names for Agricultural Engineering Departments more than simple academic posturing? Is there a more understandable, more acceptable title for our profession?

Shakespeare said that a rose, by any other name, would smell as sweet. Maybe it is time to consider the wisdom of his advice.

Canadian Agricultural Engineering publishes papers covering the general field of Agricultural Engineering that fit into one of the following classifications: (1) a scientific paper based on original research; (2) a technical paper based on design, development, testing, or analysis of machines, equipment, structures, processes, or practice; (3) a general paper on education relative to curricula and philosophy or trends in science, on a survey or investigation of some phase of research or research methods, or on extension or extension methods. The Editorial Board may also publish abstracts published elsewhere and interesting news items from members of Agricultural Engineering.

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ABSTRACTS OF PAPERS TO BE PRESENTED AT THE CANADIAN SOCIETY OF AGRICULTURAL ENGINEERING CONFERENCE, 21-24 AUGUST 1988, CALGARY, ALBERTA

88–110. MICROWAVES AS A HEAT SOURCE FOR ANIMALS

L. Otten, School of Engineering, **D. Morrison,** Dept. of Animal and Poultry Science, University of Guelph, Guelph, Ont., and **D. Pei,** Department of Chemical Engineering, University of Waterloo, Waterloo, Ont.

During the past 2 yr low-intensity microwaves have been used to provide heat for chicks and piglets. It has been demonstrated that the response of chicks and pigs subjected to microwaves is similar to that of animals exposed to infrared or other conventional heat sources.

Experiments have been performed to determine the growth and feed efficiency response of male broiler chicks to microwaves heating and to determine the effect of such procedures on body composition and mortality. There was no significant difference in the performance characteristics and health of these birds and those exposed to intermittent and continuous infrared heating.

The work with newly-weaned pigs has shown that microwaves, as a heat source, were a suitable reward for operant conditioning. It was found that an increase in the duration of microwave and infrared delivery resulted in a decrease in the frequency of heat demand by the piglets. Thus, for each minute difference in duration of the reward, the piglets voluntarily altered the number of rewarded activations by about 0.32 and 0.19 activations per hour for the infrared and microwave conditions, respectively. There were no significant differences in total weight gain and feed:gain ratio between piglets kept under continuous infrared, operant infrared and operant microwave conditions.

This paper will describe the microwave equipment designed for the project and present the results of the experiments.

88–111. AIR QUALITY IN TURKEY FACILITIES

Z. J. Licsko and J. J. R. Feddes, University of Alberta, Edmonton, Alta.

Animal heat and moisture production data, together with data for production of airborne contaminants, are fundamental to the design of environmented control systems in animal confinement facilities. This project involves a study of air quality and heat and moisture production in commercial-scale turkey rearing facilities. The objectives are as follows:

(a) to quantify the rates of production of aerial contaminants,
(b) to determine the histo-pathology of turkey deaths and quantify turkey health as it relates to air quality,
(c) to evaluate the use of foggers on the concentration of dust particles and this distribution,
(d) to measure moisture and heat loads in such units.

Monitoring will consist of measuring temperatures, exhaust fan flow rates, heat fluxes, carbon dioxide, ammonia, dust concentrations, supplemental heating events such as lights operation, feeder operation. Data will be collected continuously over a 24-h period once a week over the entire turkey cycle. Monitoring will begin in January of 1988.

The results from this project will provide basic data for the design of environmental control systems that will minimize supplemented heating requirements and maintain good air quality while providing an optimal thermal environment in turkey housing.

88–112. GAS CONCENTRATIONS IN DAIRY-CATTLE CONFINEMENT BUILDINGS AND SLURRY STORAGE TANKS

N. K. Patni, Animal Research, Agriculture Canada, Ottawa, Ont.

The proposed paper will present the results of a study of hazardous manure gases inside dairy-cattle confinement buildings with slotted floors and gutter-scraper systems, and on the outside and inside of outdoor, covered, concrete slurry storage tanks, $12.3 \times 7.2 \times 3.0$ m deep (i.e., gas concentrations were measured above and below the concrete covers of storage tanks). Slurry was in storage for up to 6 wk inside the barns and for about 3-6 mo in the storage tanks. Concentrations of H_2S, NH_3, CO_2 and CH_4 were measured both when the slurry was undisturbed and when it was being agitated for mixing. A unique microprocessor system was used to continuously monitor H_2S concentrations. Long-term and immediate-use Drager gas detector tubes were used for NH_3, CO_2 and CH_4 measurements. Under normal ventilation, concentrations of all gases were low to not-detectable and were below the time-weighted average threshold limit values (TWA-TLV). However, when the slurry was agitated and mixed, concentrations of H_2S and CO_2 increased whereas NH_3 concentration variation was relatively small and methane was not detectable (detection limit $\doteq$ 1000 ppm). H_2S concentrations exhibited periodic short-term excursions beyond the TWA-TLV value (10 ppm) which were associated primarily with the degree of slurry agitation. These concentration excursions were not detectable with long-term indicator tubes. Dangerous concentrations of H_2S and very high concentrations of CO_2 were observed when slurry in the outdoor tanks was mixed, and surprisingly, methane was not detectable. Factors affecting gas release and procedures that would reduce manure gas hazards will be discussed in the paper.

88–113. WIND DIRECTION EFFECTS ON AIRFLOW PATTERNS IN NATURALLY VENTILATED SWINE BUILDINGS UNDER ISOTHERMAL CONDITIONS

Y. Choinière and O. Ménard, Collège d'Alfred, Alfred, Ont.

A wind tunnel and smoke were used to visualize three dimensional airflow patterns inside a scale model of a naturally ventilated barn with gable roof and sloped ceilings.

Design parameters studied were:

1. equal versus nonequal opening of sidewall doors;
2. four different continuous ridge opening widths;
3. center versus side alley layout;
4. solid versus partially open wall at the building midlength and;
5. building end wall with and without windows.

Each building configuration was tested with the building oriented 0°, 30°, 60 and 90° to wind direction. Airflow patterns were visualized and recorded on video tapes.

The optimum ventilation patterns were obtained for winds perpendicular to the building length. For winds parallel, the addition of windows in the end wall reduced stagnant zones.

88–114. AIR MOVEMENT AT ANIMAL LEVEL

J. A. Dewloo, D. Darby, J. J. R. Feddes, and **J. J. Leonard,** University of Alberta, Edmonton, Alta.

Recirculation ducts are becoming popular in livestock buildings as a means of achieving good air circulation at low ventilation rates. Air velocity in the vicinity of the animals is particularly critical to animals in the first few weeks of life. Fresh air must be uniformly distributed to all areas of the building and should be warmed to near room temperature before reaching the animals. Air in the immediate vicinity of the animals should have sufficient movement to carry away respiratory gases and pollutants, but not excessive as to significantly increase the thermal demand of the animal.

Current design methods for recirculation ducts are based on a number of "rules of thumb". These rules of thumb do not directly address the effects that various parameters have on air velocities at animal level. This paper will present some empirically derived relationships between duct parameters and the air velocity at animal level for small livestock rooms. The parameters studied were recirculation rate, outlet hole diameter, outlet air velocity, duct size, room size, and method of fresh air introduction. Air circulation patterns were also noted.

88–115. RIDGE OPENING WIDTH OF AN ACNV SWINE BARN FOR MODERATE TO COLD CLIMATE

Y. Choinière and **O. Ménard,** Collège d'Alfred, Alfred, Ont.

Conventional ACNV barns have continuous ridge opening widths ranging from 150 to 600 mm.

A smaller ridge opening can help reduce environmental control problems as well as the initial construction cost.

Minimum ridge opening widths ranging from 5 to 10 mm, which represented an area of 0.09–0.18 m² (0.04–0.07% of floor area) and conventional widths ranging from 20 to 40 mm, respectively 0.36–0.72 m² (0.15–0.30% of floor area) were studied for moderate and cold weather.

Ridge performance was evaluated by assessing airflow patterns, temperature profiles and fluctuations, and CO_2 concentrations within the barn.

Recommendations for minimum ridge opening design are discussed.

88–116. CALORIMETRY IN LIVESTOCK HOUSING

K. McDermott and **J. J. R. Feddes,** University of Alberta, Edmonton, Alta.

An experiment for comparing indirect and direct calorimetry methods of measuring heat production from a simulated broiler chicken house was undertaken. Combusted propane gas was used to simulate energy production from broilers, in an environmentally controlled chamber.

Indirect calorimetry involves measuring oxygen consumption and carbon dioxide production from combustion of propane, using gas analyzers. Direct calorimetric measurements were obtained by measuring energy of the air entering and leaving the chamber. By measuring the quantity of combusted propane over a given time the actual heat output was known. This experiment involved comparing the direct and indirect methods with the actual heat output. Experiments were carried out for different ventilation and combustion rates. The two methods agreed within five per cent of each other and within seven per cent of the actual value.

88–117. EVALUATION OF FOUR ENVIRONMENTAL CONTROL SYSTEMS IN HOT NURSERIES

R. D. MacDonald, O.M.A.F. Engineering Services, Ministry of Agriculture and Food, 279 Weber Street North, Waterloo, Ont.; and **F. A. Kains,** Guelph Agriculture Centre, P.O. Box 1030, Guelph, Ont.

Four control systems were installed in identical hot nurseries for newly weaned pigs. Each system was designed to provide optimal control and modified if required to improve performance.

The four control systems installed were:

(1) MULTI-FAN 5 speed controller,
(2) ALPHA BC01-T sequential controller,
(3) Honeywell T731 variable speed controller,
(4) ALPHA MC01-T variable speed controller.

A Campbell Scientific CR-7 data logger was installed to monitor temperature control capabilities of each system. T-type thermocouples measure temperatures at each location every 30 s for 3 min. After 3 min the six readings are averaged and stored onto audio tape.

Energy consumption for heating is also recorded using hour meters for each room plus the preheat hallway.

Preliminary results indicate that systems one and four experience temperature fluctuations of up to 3°C in 6 min. Energy consumption was almost double that for numbers one and four compared to two and three.

System modifications have improved on the above results, but at the time of this writing, no analysis has been made.

The final report for Calgary will summarize 1½ yr of operation and include information on wiring, operation and modifications, as well as environmental control performance.

88–118. HORIZONTAL SILO WALL LOADS

Jan Jofriet, School of Engineering, University of Guelph, Guelph, Ont.; **Dennis Darby,** Alberta Agriculture and **Hank Bellman,** Ontario Ministry of Agriculture and Food.

The Current Canadian Farm Building Code (CFBC 1983) specifies a uniformly distributed load of 6.7 kN/m² for the design of walls of horizontal silos, regardless of the height of the wall. In addition to the uniformly distributed load a pointload of 5 kN provides for load concentrations due to the packing operation.

Severe structural cracking has been observed in several A-frame supports for 6-m-high precast tilt-up walls. Excessive cracking is also evident in the rear surface, the tension side, of many wall panels. The silos in question were built to Canada Plan Service plan 7435. The presentation will review some of the failures and try to explain them with detailed analyses of the structures. Both the 1983 CFBC design load and a loading estimated from theories on soil pressures will be considered.

An ad hoc subcommittee of the NRC standing committee on farm buildings has considered the problem and has made recommendations for changes to be incorporated in the 1990 CFBC. The presentation will review these changes and their implications. Also included will be preliminary results from an experimental project which includes the measurement of wall pressures on the wall of a 5-m high horizontal silo in Walkerton, Ontario.

88–119. PLATE BEAM DESIGN FOR FARM STRUCTURE

Dennis E. Darby, Alberta Agriculture, Lethbridge, Alta.; **J. A. Munroe** and **Harold Jackson,** Engineering and Statistical Research Institute, Agriculture Canada, Ottawa, Ont.

Plate beams are an integral structural component of pole frame buildings, and as headers across door openings in the side of other frame structures.

Plate beams are usually fabricated from built-up sawn lumber. Design information previously available did not account for a number of factors critical to the design, such as continuity of beams, point loading from trusses, and shear strength of wood.

This paper presents a comprehensive design procedure for all practical combinations of beams, taking into account the design factors previously mentioned. Beams are analyzed as (1) simple beams, (2) two-span beams, and (3) continuous beams. Shear and bending factors are tabulated for a variety of loading conditions for each beam type. A computer program generates load tables based on building width, beam span and type which are easy for builders or engineers in the field to use.

88–120. POLYURETHANE INSULATION IN HIGH-HUMIDITY ENVIRONMENTS

Harold House, Ontario Ministry of Agriculture and Food, Toronto, Ont., and **Jan Jofriet** and **Lambert Otten,** School of Engineering, University of Guelph, Guelph, Ont.

The use of sprayed-on polyurethane foam is popular for insulating agricultural buildings. It can be applied easily over irregular surfaces and is therefore ideal for retrofitting existing livestock housings and storage buildings, as well as for new construction.

Many agricultural structures experience a high relative humidity inside throughout the year. This is particularly so in storage structures for potatoes and some vegetables. Recently, problems have been noticed in these buildings if polyurethane insulation had been sprayed from the inside directly on the metal siding, covering some of the structural members in the process. The insulation encased members became very wet, rotted and, in some cases, caused a collapse of the building. The insulation itself was found to be saturated near the metal siding. It is obvious that this must have some detrimental effect on the thermal resistance of the insulation.

In the proposed presentation the problem will be presented in some detail. A mathematical model describing the heat and vapor transport through the insulation will be presented. As well, a testing program intended to verify the model and to demonstrate the reduction in thermal resistance will be discussed.

88–121. THE USE OF GEOTEXTILES FOR THE SEALING OF EARTHEN MANURE STORAGE FACILITIES

R. Raimondo, S. F. Barrington, and **S. O. Prasher,** Department of Agricultural Engineering, McGill University, Macdonald College, Ste. Anne de Bellevue, Que.

The mechanisms by which manures seal soils indicate the need for an interface of fine porosity between the waste's liquids and the porous medium. Thus, fine porosity geotextile liners should create a sealing layer for sandy and gravelly soils in contact with manure. The purpose of this experiment was therefore the testing of the extent of the sealing of geotextiles while exposed to swine slurries.

This research was conducted in the laboratory using 150-mm experimental columns. For all tests, infiltration rates were measured for 1500 h by collecting the seepage liquids and all experimental combination was carried out in triplicates.

The experiment tested five geotextiles of different porosity (20, 30, 40, 50 and 70 micrometer) by exposure to 0.9, 1.8 and 2.7 m of swine slurries. In order to determine the effects of total solids, the 20 micrometer geotextile was then tested under 1, 2, 3, 4, 6 and 8% total solids hog manure. Finally, physical and biological sealing mechanisms were individually investigated by measuring infiltration rates of sterilized and natural swine slurries.

88–122. MICRO COMPUTER NETWORK MODEL FOR THE SELECTION OF DAIRY WASTE MANAGEMENT SYSTEMS

S. Hengnirun, K. C. Watts, and **J. R. Burney,** Department of Agricultural Engineering, Technical University of Nova Scotia, Halifax, N.S.

Based on the Dairy Waste Management Program developed by J. R. Burney, K. V. Lo and W. M. Carson, a microcomputer version has been structured for use with IBM Compatibles using M. S. Fortran Version 3.0. Two operation modes were structured — an interactive mode and a batch processing mode. The batch processing mode outputs the optimum ranked solution but does not plot the results. The interactive mode is more useful for individual farmers with some existing equipment, and has been made very user friendly.

Two further refinements have been incorporated into both models — the negative cost of methane generation and of composting, although further work to refine these routines is required. The program has been structured for ease of upgrading if incorporation of further options is desired.

88–123. COMPOSTING OF MANURE SLURRIES WITH PEAT WITHOUT MECHANICAL AERATION

S. P. Mathur, Land Resource Research Centre, **N. K. Patni,** Animal Research Centre, and **M. P. Lévesque,** Land Resource Research Centre, Agriculture Canada Research Branch, Ottawa, Ont.

The proposed paper will present the results of a study on the feasibility of composting manure slurries with peat. Acidic, hydrophilic sphagnum peat of low bulk density and high ion buffering capacity was mixed with manure slurries from poultry, sheep, and dairy cows in 1:7 to 9 proportions. The mixtures were laid down as windrows over perforated horizontal pipes open to the atmosphere at the ends. A similar system is being used commercially for composting fish wastes with peat. In the manure composts, the acid peat retained the NH_3 and its fibrosity supported aerobic decomposition in which neither malodourous S compounds nor amines are normally formed. No detectable H_2S or NH_3 emanated from the compost piles. Thermophilic range temperatures that "pasteurize" the composts were attained in 1-3 d and maintained for 2-5 wk without further mixing of the composts. No mechanical aeration was provided. After 7 wk when the composts were remixed and relaid, no reheating occurred suggesting that the composts were biostable.

The finished composts had water-holding capacities nearly equal to that of the unamended peat. The data thus suggested that peat can be used to deodorize and retain ammonia in manure slurries during storage (peat floats on manure lagoons), and then used more than once for absorbing the water and providing a medium in which aerobic, hygienic, thermophilic activity can produce high quality composts in a relatively short period.

88–124. GREENHOUSE PRODUCTION OF HORTICULTURAL CROPS

D. St. George and **J. J. R. Feddes,** University of Alberta, Edmonton, Alta.

This paper will discuss the economic and technical aspects of producing horticultural crops in Northern Canada. It will also focus on associated problems and the potential of developing food production systems for this region.

During 1988, the Department of Agricultural Engineering at the University of Alberta will evaluate the production of horticultural crops in Northern Canada with computer models. The computer models will simulate the production of horticultural crops under a variety of controlled environment and management options which are adaptable to the physical and economicl characteristics of Northern Canada. The objective will be to identify the alternatives for supplementing or replacing imports of horticultural products from Southern Canada and the United States.

The paper will discuss (1) the characteristics of northern climates, (2) the economics of horticultural production in Northern Canada, (3) the procedures used to evaluate the production of horticultural crops under various options, and (4) the controlled environment and management options being considered for producing horticultural crops in Northern Canada.

88–125. ENVIRONMENTAL QUALITY IN AN INFRARED HEATED GREENHOUSE IN A COLD CLIMATE

P. Caouette and **A. Marquis,** Dépt. de Génie rural, Université Laval, Quebec.

Infrared radiant heating systems have been used in the past for greenhouse heating, either under glass or polyethylene covering. The authors reported relativley uniform heating and substantial energy savings (from 6 to 65%). Most studies were made under relatively moderate climate.

Our paper presents the results of an experiment conducted at the "Centre de Spécialisation des Cultures Abritées" of Laval University. Low intensity infrared heating increases the temperature of every surface which receives thermal radiation. Therefore, the leaf temperature is increased while the temperature of the surrounding air is unaffected. A direct consequence is that the air temperature setting can be lowered for greater energy savings compared with a forced-air heating system. But, for a cold region such as Quebec City, leaves placed near or directly under radiant pipes may receive too much radiation when the heating system works continuously. The temperature rise can create a high transpiration rate which may result in plant wilting.

Air temperature distribution patterns, leaf temperatures and radiation patterns have been monitored; they are analyzed to determine the ability of a radiant heating system for greenhouse heating in a cold region.

88–126. USING AN EARTH-TUBE FOR HEATING OR COOLING AIR

D. O. Baxter, Dept. Agricultural Engineering, University of Tennessee, Knoxville, Tenn.

An earth-tube heat exchanger has been studied for both winter and summer seasons to determine its operational characteristics and also to evaluate its feasibility as an energy conservation system for plant and animal structures. The research arrangement consisted of 200 feet of 6-inch diameter corrugated metal pipe buried 6 feet deep in clay soil. The earth-tube was instrumented with thermocouples for obtaining air and soil temperatures at the inlet, at 50-foot intervals and at the outlet. Vertical soil temperature profiles were also determined for 1-foot increments from 1 foot through 7 feet. High-pressure direct-drive blowers were used for air movement through the pipe.

The first series of tests was conducted on an 8-h daily basis but later tests were conducted on a 24-h or continuous run basis. Each seasonal performance had a characteristic seasonal pattern which was influenced by ambient temperature and other climatic variables. Tests on magnitudes of cooling capacities during summer and heating capacities during winter were conducted. Results for each mode of operation were encouraging and indicate that an earth-tube heat exchanger may have potential as an energy conservation system for both heating and cooling. Selected topics related to heating and cooling performance will be presented in this paper.

88–201. ANALYSIS OF SOIL FORCES ON CERAMIC COATED AND REGULAR CULTIVATOR SHOVEL

T. M. Borstmayer, and **R. L. Kushwaha,** Agricultural Engineering Department, University of Saskatchewan, Saskatoon, Sask.

Tillage and planting operations manipulate soil by mechanical action of the soil engaging tools. A major portion of energy loss can be attributed to movement of tool in soil and resulting soil-metal friction.

In order to reduce soil-metal friction, teflon coatings and lubrication of tillage tools with water, air or liquid polymer have been experimented with but did not prove successful on farm level. Substitution of cutting edges with ceramic pieces has also been studied in limited soil types due to brittleness of ceramic materials. However, ceramic coated tillage tools retain their normal strength. This project compares ceramic coated and regular cultivator shovel to determine relative energy savings.

88–202. ROD WEEDER SOIL REACTIONS FOR DIFFERING ROD SHAPES AND SPEEDS

Xueyuan Bai and **H. Page Harrison,** Department of Agricultural Engineering, University of Alberta, Edmonton, Alta.

A rod weeder experiment was conducted in a laboratory soil for the purpose of improving the implement's penetration without adversely affecting its draft. A spilt-plot experimental design was used with differing rod shapes in the main plots and differing rotational and translational speeds in the sub-plots. In addition to an analysis of variance, the load spectrums were subjected to a frequency analysis to identify the resonant frequencies of the rods at differing rod speeds.

88–203. TRACTION PERFORMANCE OF A MODEL 4-WD TRACTOR

R. L. Kushwaha, L. E. Zyla and **J. D. Close,** Agricultural Engineering Department, University of Saskatchewan, Saskatoon, Sask.

A model tractor based upon approximately 1/4 scale of the John Deere 8640, four-wheel drive tractor was designed and fabricated for traction studies in the soil bin. The tractor is powered with 2.25-kW electric motor and is capable of either two wheel or four wheel drive modes. Various components have been instrumented to measure individual wheel load, torque and speed, power input and drawbar load. Data were collected with a HP 2240A data logger connected to a HP 1000 main frame computer.

Tests have been conducted in front wheel drive, rear wheel drive and four wheel drive modes to determine dynamic weight transfer and traction characteristics.

88–204. EXPERIENCE WITH A STAR PENETROMETER

G. Wang and **G. C. Zoerb,** Agricultural Engineering Department, University of Saskatchewan, Saskatoon, Sask.

Soil cone index plays a very important role in pneumatic tire analysis. Soil cone index is measured by using a cone penetrometer. The optimization of farm tractor operation requires the information of soil strength. Many researchers have been searching for a convenient and rapid way of measuring soil cone index. This paper presents some experience with a wheeled-type penetrometer, or a star penetrometer. The star penetrometer was made of steel. It has a diameter of 35 cm with 16 teeth. The star penetrometer measured the penetration depth rather than penetration resistance. The penetration depth was measured by using a potentiometer and a pneumatic tire was used behind the star penetrometer as a reference wheel. The relative penetration depth was defined as the star penetrometer index. Laboratory tests were carried out. The correlation between the star penetrometer index and soil cone index was found. The advantages of applying the star penetrometer index to pneumatic tire traction analysis are described. Field tests were conducted to compare results with laboratory tests.

88–205. FINITE ELEMENT ANALYSIS OF SOIL FORCE IN TILLAGE

L. Chi and **R. L. Kushwaha,** Agricultural Engineering Department, University of Saskatchewan, Saskatoon, Sask.

The finite element models were developed to simulate the soil cutting problem in tillage. The paper described how to use the finite element method to predict the reaction force, soil failure pattern, and the soil movement during the soil cutting. The Duncan's hyperbolic stress-strain model was used in the analysis. The incremental procedure was applied to approximate the nonlinearity of the soil. The analysis was performed for both 2-D soil failure under a wide blade and 3-D soil failure under a narrow blade. The results showed the effects of rake angle, external friction, and operating depth on the reaction force and soil movement.

88–206. EVALUATION OF THREE ZERO-TILL DRILLS

D. May, Prairie Agricultural Machinery Institute, Portage la Prairie, Man.

In 1984 the Prairie Agricultural Machinery Institute (PAMI) initiated a 3 yr study of three types of zero-till drills in conjunction with the Plant Science Department of the University of Manitoba. The three drills had distinctly different opener designs: Amazone NT375 hoe drill, Lilliston 9680 triple disk drill and the Swift Current prototype offset double disk drill. They were tested on the basis of functionability, durability and agronomic performance.

The hoe drill had better penetration and worked better in wet or trashy conditions. However, the disk drills had less soil disturbance and stubble knockdown, both of which are important to the zero-till farming method. The Swift Current drill generally had the lowest power requirements in most soil types. Both of the commercial drills were easy to operate and adjust. The metering accuracy while seeding wheat and rapeseed was very good on both drills.

The durability portion of the study demonstrated design and manufacture problems on all three of the drills.

For any one trial year, differences in winter wheat yields as affected by drill performance and seeding depth were not significant. On average, winter wheat yields were highest in plots seeded with the Amazone drill followed by the Lilliston and Swift Current drills.

In both spring wheat and canola drill trials overall yields in zero tillage were highest in plots seeded with the Amazone followed closely by the Lilliston and Swift Current drills. Yield differences in all three crops were usually considered insignificant under any given set of conditions for the three drills.

88–207. DEVELOPMENT OF A DUAL-FUEL CONTROL SYSTEM FOR DIESEL ENGINES

J. G. Davies, and **W. B. Reed,** Department of Agricultural Engineering, University of Saskatchewan, Saskatoon, Sask.

A control system to dual-fuel a diesel engine with propane or compressed natural gas has been developed.

(1) Exhaust temperature dual-fuel control system,
(2) Diesel flow dual-fuel control system,
(3) Feedback dual-fuel control system.

The exhaust temperature dual-fuel control system design was developed using propane. The use of engine exhaust gas temperature as an indication of engine power output was found not to be dependable, particularly with turbocharged engines.

The diesel flow dual-fuel control system design using propane was then developed. An agricultural tractor was converted and field tested. A highway tractor was also converted and highway tested. Both were dual-fuelled with propane.

The diesel flow dual-fuel control system was then modified for use with compressed natural gas. The initial testing and development was done on a stationary engine. The highway tractor was then converted to CNG dual-fuel operation and highway tested.

The diesel flow dual-fuel control system design provided dependable dual-fuel control. A major drawback of the system was that it had to switch the engine back to diesel fuel only operation at full engine load in order to avoid overfuelling the engine because the dual-fuel control system had no direct control over the diesel fuel delivery rate. Another problem with this control system design was that the maximum level of gaseous fuel substitution was often limited by the stability of the stock mechanical governor.

Finally, the feedback dual-fuel control system was designed and developed on the stationary diesel engine. CNG was the gaseous fuel used. This dual-fuel control system design provided acceptable dual-fuel control under steady-state conditions. The control system is ready for field testing. However, more development is required for both the software, and the control system actuators before the system would be ready for commercial use.

88–208. DEVELOPMENT OF AN INEXPENSIVE INSTRUMENT MEANS TO DETERMINE SPRAYER DROPLET SIZE

A. B. Kinnie and **K. C. Watts,** Department of Agricultural Engineering, Technical University of Nova Scotia, Halifax, N.S.

In order to deposit agricultural chemicals efficiently on plants, it is necessary to have a sprayer with a controlled droplet size. However, determination of the size of droplets, a prerequisite in the development and evaluation of a controlled droplet sprayer, cannot be accomplished accurately and inexpensively at present. This paper presents the progress on the development of an inexpensive device, with its attendant computer, to determine the size of agricultural sprayer droplets.

The electro-optical device used to convert video to electrical signals is a 128 element linear charged coupled device (CCD) which can be operated up to 10 MH_z photodiode element sweep frequency. The output of the CCD can be processed in one of several methods to obtain the size of water droplets passing by it. The method chosen uses a threshold detector in which an on or off signal is output in a digital string which in turn is output to a high speed buffer and later sent to a Tandy Model 100 Computer for analysis. The speed of operation needs to be as high as possible in order to capture as many shots as possible of a single droplet as it passes in front of the element. This allows both the maximum dimension of the droplets as well as their velocity to be determined.

The output of this device should give an absolute value. However, in order to check the functioning of the system, a device that produces droplets of a known size was constructed. To generate a droplet of a given size, a tube having a specific internal diameter and through which a certain flow rate of water is passing is vibrated piezoelectrically at a specified frequency.

88–209. INVESTIGATION OF TRANSPLANTING METHODS FOR PROCESSING TOMATOES IN ONTARIO

G. B. Hergert, Agriculture Canada, Ottawa, Ont.; **M. Feldman,** Agriculture Canada, Ottawa, Ont.; **S. Burgoyne,** Dept. Agricultural Engineering, McGill University, Macdonald College, Ste Anne de Bellevue, Que.; and **E. J. Tomecek,** Ont. Min. of Agric. & Food, Ridgetown, Ont.

A new trend in the processing tomato industry is the use of locally-grown media-block seedlings (tray plants) in place of bare-root seedlings imported from Georgia. The purpose of the investigation described here was to compare the cost of labor and other inputs for transplanting bare-root and tray-grown plants using systems presently available. The information was gathered in Southern Ontario during the 1987 season.

Data were collected and analyzed concerning planting rate, field efficiency, plant stand, labor costs and plant costs. Information was gathered on automated transplanters from other countries, and some trials conducted with types of planters not yet introduced to Southern Ontario.

88–210. METERING AND PLACEMENT OF UREA SUPER GRANULES

W. Wasylciw, J. J. Mayko, and **K. W. Domier,** Department of Agricultural Engineering, University of Alberta, Edmonton, Alta.

Nitrogen fertilizer, primarily urea, is the dominant fertilizer in Western Canada. The use of large Super Granules of urea (1-, 2- and 3-g sizes) manufactured by Norsk Hydro has been shown by soil scientists at Agriculture Canada, Lacombe, Alberta and the University of Alberta to substantially reduce the losses associated with fall broadcasting and incorporation of granular urea. The soil scientists placed their Super Granules by hand. A logical extension of their work was a study of the engineering aspects of metering and placement of these large granules.

A number of physical and engineering properties have been determined. These included mean weights and diameters, shear strength, compressive strength, hardness and angle of repose. Several exisitng systems (used or modified) have been evaluated for metering and transport from the hopper to the furrow opener. Each system was evaluated for accuracy of metering individual granules, the degree of disintegration or cracking, and the extent of bridging.

88–211. CHEMICAL CONDITIONING OF MIXED LEGUME-GRASS HAY

S. Beauregard, P. Savoie, and **D. Désilets,** Dépt de Génie rural, Université Laval, Québec, PQ

Chemical conditioning of hay is achieved by spraying an aqueous solution of potassium carbonate at mowing. Previous studies have shown that chemical conditioning increased the drying rate of alfalfa and other legume hays but had little impact on grasses. Most forages grown in Eastern Canada are mixed legume and grass. The purpose of this study was to measure the effect of chemical conditioning in a mixed hay.

Field trials were conducted in Deschambault (Québec) during the first and second forage growth cycles in 1986. A spray boom was installed on a disk mower with rubber conditioning rolls to apply the chemical solution just before the forage is cut. Chemical conditioning was compared to a control in three fields: a relatively pure (over 80%) alfalfa stand, a mixed grass-alfalfa stand (about 50/50) and a predominantly grass (timothy) field. Dry matter yields were about 3.5 and 2.2 t per hectare at each cutting.

During the first growth cycle, hay was treated with potassium carbonate at a rate of 12 kg/ha diluted in 400 L of water. The treatment increased the drying rate of pure alfalfa by 14% and mixed alfalfa-grass by 9% during the first day. Drying rate increases were slightly lower during the second field curing day. No effect was measured on the predominantly grass stand.

During the second cut climatic conditions were less favorable for drying than during the first cut. No drying rate increase was measured for all three stands. It was concluded that chemical conditioning might be useful by saving a few hours of drying only under good weather conditions and for a relatively pure alfalfa stand.

88–212. A SELF-UNLOADING POWER BALE SAMPLER

En-Zen Jan, Agriculture Canada Research Station, Melfort, Sask., and **Tony Yeager,** Sweeprite Manufacturing, Regina, Sask.

A power bale sampler which completes coring, unloading hay or silage bale samples in a single operating cycle was developed. A 1-m-long, 32-mm-diameter core mounted on a chain-driven carriage cores sample on the forward stroke and unloads at the end of the retrieval by pushing against a stationary rod extending into the tube.

A sample of about 50 g dry matter can be taken in 1 min as compared to 30 g in 4 min using "Penn State Sampler". The operation is controlled with two switches, one for linear movement and one for rotational. The sampler cores and unloads dry hay, silage and frozen silage bales without difficulty. It makes bale sampling safe and requires no physical effort.

The design utilizes wood hole saw as the coring head which can be repeatedly sharpened as needed. Most components used in this machine are available from the agriculture service center, the repair and maintenance can easily be performed by a mechanically inclined person.

88–213. DEVELOPMENT OF EQUIPMENT FOR TYING THE LEAVES OF GROWING CAULIFLOWER PLANTS

G. B. Hergert and **M.-A. Pelletier,** Agriculture Canada, Research Branch, Ottawa, Ont.

Hand tying the leaves to protect the young curd from discoloration by sunlight represents 23% of the total labor required for producing cauliflower. A prototype machine for tying the leaves was evaluated and modified to improve tying performance. Speed of tying averaged 45 plants/min. The concept of once-over mechanical tying was tested in comparison to selective hand tying showing that potential yields were lower but labour requirements were reduced substantially.

88–214. COMPARISON OF PREDICTED AND MEASURED FUEL CONSUMPTION OF A DIESEL TRACTOR OPERATING UNDER VARYING LOADS

Z. Wang, and **K. W. Domier,** Department of Agricultural Engineering, University of Alberta, Edmonton, Alta.; **J. Chang,** Engineering Services Branch, Alberta Agriculture, Edmonton, Alta.; and **F. M. Green,** Engineering Services Branch, Alberta Agriculture, Airdrie, Alta.

A Case-IH model 2394 tractor with various sensors and an on-board computer was used by Alberta Agriculture and Olds College for on-farm demonstrations of tractor fuel efficiency. Instantaneous fuel consumption was measured along with drawbar pull, engine speed, field speed, wheel slip, tillage depth and engine exhaust temperature. The actual fuel consumption is compared to a predicted value obtained from a computer model that takes engine load and speed into account.

88–215. PHYSICAL PROPERTIES OF THE SOIL-SEED ENVIRONMENT

S. Tessier, K. E. Saxton, R. I. Papendick, and **G. M. Hyde.** Agriculture Canada Research Station, Swift Current, Sask.

88–301. SNOW RETENTION IN GRAIN STUBBLE

H. Steppuhn and **B. G. McConkey,** Agriculture Canada Research Station, Swift Current, Sask.

88–302. THE EFFECT OF FALL TILLAGE PRACTICES UPON SNOWMELT INFILTRATION

C. P. Maule and **D. S. Chanasyk,** Department of Soil Science, University of Alberta, Edmonton, Alta.

The amount of water infiltrating into frozen and unfrozen soils is influenced by the physical state of the soil surface. In agricultural fields postharvest practices may have an important effect on snowmelt infiltration. This paper presents the results of a continuing field study which utilized four fall tillage treatments (summerfallow, standing barley stubble, disced barley stubble, and chiselled barley stubble). The plots were established in a randomized block design at the Ellerslie Research Station, Alta. Soil moisture measurements were taken with a neutron probe

The results of two springmelts (1986 and 1987) are summarized below:

In ascending order of snow water equivalent before snowmelt:

fallow < disced < stubble ≈ chiselled

In ascending order of greatest increase in spring soil moisture from fall soil moisture:

fallow < stubble ≈ disced < chiselled

In ascending order of greatest soil moisture content for the top 1.0 m:

disced ≈ stubble < chiselled < fallow

The increase in spring soil moisture was greater for the dry year (1985-1986). Approximately 30–60% of the increase was in the top 30 cm, with the chiselled and stubble plots having greater increases in this near-surface zone than the fallow and disced plots.

88–303. SUBSOILING TO ENHANCE SNOWMELT INFILTRATION

B. McConkey, D. Ulrich, W. Nicholaichuk and **H. Steppuhn,** Agriculture Canada Research Station, Swift Current, Sask., and National Hydrology Research Institute.

88–304. ERODIBILITY MEASUREMENTS ON SMALL PLOTS USING SIMULATED RAINFALL

R. T. MacLean and **C. L. Armstrong,** University of Saskatchewan, Saskatoon, Sask.

The Universal Soil Loss Equation (USLE) has been used with limited success on the Canadian prairies. A major problem has been in the determination of soil erodibility values, which have shown to be inconsistent with values derived by the USLE soil erodibility nomograph. Erosion runoff plots were set up on three soils in Saskatoon, Saskatchewan, to determine and compare calculated soil erodibility values with those determined from the nomograph. Each plot was 1 square metre in area and had a 9 percent slope. Rain was applied using a rainfall simulator with intensities of 120 mm/h. Runoff and sediment samples were collected in each of three plots for each soil type, determining the amount of soil lost. Both a dry and wet (24 hours later) run were performed on each plot. Results are tabulated and graphed, with yearly soil erodibility values calculated.

88–305. EFFECT OF RAINFALL, SLOPE AND SOIL TYPE ON RILLING AND SEDIMENTATION

W. Staltie, R. P. Rudra, and **W. B. Dickinson,** University of Guelph, Guelph, Ont.

88–306. FIELD INVESTIGATIONS AND RECOMMENDATIONS FOR IMPROVED PRACTICES FOR INSTALLING DRAIN PIPES

R. S. Broughton, J. Mayo, R. Bonnell and **S. Ami,** Dept. Agricultural Engineering, McGill University, Macdonald College, Ste. Anne de Bellevue, Que.

88–307. CHARACTERISTICS OF A DOUBLE WALL POLYETHYLENE PIPE, A FINE NEW PRODUCT FOR IRRIGATION, DRAINAGE, VENTILATION AND CONDUIT APPLICATIONS

R. S. Broughton, J. Mayo, R. Bonnell and **S. Barrington,** Dept. Agricultural Engineering, McGill University, Macdonald College, Ste. Anne de Bellevue, Que.

88–308. INTERCEPTOR DRAINS FOR CANAL SEEPAGE CONTROL

R. Galatiuk, D. Millette, G. Buckland, and **B. Paterson,** Hill Engineering, Calgary, Alberta Agriculture.

88–309. CANAL LININGS FOR SEEPAGE CONTROL

T. G. Sommerfeldt, C. Chang, J. R. Allan, and **L. Spiess,** Agriculture Canada, Lethbridge, Alberta Agriculture.

88–310. RECLAMATION OF SALINE/WATERLOGGED SOILS

R. Bennett, Alberta Agriculture.

88–311. RECLAMATION OF A SALINE-SODIC SOIL

G. D. Buckland and **M. J. Henry,** Alberta Agriculture.

88–314. POTENTIAL CAPILLARY RISE FROM GROUNDWATER

G. J. Beke, Agriculture Canada, Lethbridge, Alta.

88–315. EVAPOTRANSPIRATION IN SOUTHERN ALBERTA

N. Foroud and **C. Chang,** Agriculture Canada, Lethbridge, Alta.

88–312. ARTIFICIAL RECHARGE OF GROUNDWATER

C. Adams and **J. A. Gillies,** Department of Agricultural Engineering, University of Saskatchewan, Saskatoon, Sask.

A system to pump, treat, and inject surface water into selected aquifers through existing wells has been developed. The factors considered in the design of a system for recharging groundwater and a procedure for evaluating potential groundwater recharge sites, are discussed. A pumping, treatment and injection system has been successfully field tested. In addition, laboratory studies to investigate the mixing process in aquifers, when lower density water is injected into higher density (saline) water, have shown that the low density water does not mix with the higher density water. The technology developed in this research can be applied to improve the quality and the reliability of a groundwater supply.

88–313. IRRIGATION WITH GROUNDWATER

M. Sloan and **J. A. Gillies,** Department of Agricultural Engineering, University of Saskatchewan, Saskatoon, Sask.

In Saskatchewan a detailed hydrogeological study of any proposed groundwater irrigation project, the cost of which must be borne by the proponent, is mandatory. A water right authorizing the development of the project will be issued only if the study provides conclusive evidence that pumping groundwater for irrigation will not significantly affect the long-term supplies of other higher priority users.

Generally, the only aquifers capable of supplying irrigation pumping rates are the buried preglacial and glacial valley systems. However, the quality of water from such aquifers is generally not suitable for irrigation.

A study has been undertaken to obtain information which may assist groundwater irrigation proponents when evaluating the potential for long-term success, prior to making a major financial commitment.

Preliminary results of this long-term study suggest that unless the soils being irrigated are light and surface profiles are deep, harmful levels of soluble salts will accumulate wihtin root zone. Significant impact on the quality of shallow groundwater and on the physical characteristics of the source aquifer have not been observed.

88–314. POTENTIAL CAPILLARY RISE FROM GROUNDWATER

G. J. Beke, Agriculture Canada, Lethbridge, Alta.

88–315. EVAPOTRANSPIRATION IN SOUTHERN ALBERTA

N. Faroud and **C. Chang,** Agriculture Canada, Lethbridge, Alta.

88–401. A BEEHIVE MONITOR SYSTEM

C. Liu, J. J. Leonard and **J. J. Feddes,** Department of Agricultural Engineering, University of Alberta, Edmonton, Alta.

In this paper the authors describe a system designed for scientists and beekeepers who are interested in studying the behaviour of bees. Essentially, the device is a microprocessor-based counter which can be installed at the entrance of a hive to monitor flying activity or within the hive to monitor in-hive movement.

The system was based on the Intel 8088 processor with appropriate peripheral chips. This processor was far more powerful than required for this application but was chosen for reasons of convenience and familiarity with the assembly language.

The sensors were constructed by locating infra-red diodes and opto-transistors on either side of paths machined in an acrylic plastic sheet. This allowed for non-contact sensing and, by using two sensor pairs on each path, the direction of bee travel also could be determined. Software was developed to keep statistics on the number of bees leaving and returning to the hive and the times at which these events occurred.

Future applications of the system in the study of bee behaviour, particularly in over-wintering facilities, are discussed.

88–402. REVIEW OF SENSORS AND TECHNOLOGY FOR HUMIDITY MEASUREMENT IN AGRICULTURAL ENVIRONMENTS

I. Erdebil and **J. Leonard,** Dept. of Agricultural Engineering, University of Alberta, Edmonton, Alta.

Current and potential applications of humidity measurement in agriculture are outlined and the environments in which measurements must be made are described. These environments differ form industrial, business or residential environments because of heavy contaminant loads (e.g., dust, ammonia, etc.) and the wide range of humidities that we encountered. Consequently, sensors that may be applied successfully elsewhere may not be appropriate in agricultural applications.

Various sensor technologies are described and their appropriateness for agricultural applications are discussed. Although older technologies (such as mechanical hygrometers) are mentioned, the emphasis is on electrical and electronic devices and recent or emerging technologies (such as solid state and thin-film polymer sensors) are discussed. Consideration of useful ranges, expected accuracies, susceptibility to contamination, cost and ease of field calibration lead to the identification of sensor technologies that show the greatest promise for agricultural applications.

88–403. MICROPROCESSOR-BASED GRAIN LOSS SENSING — FIELD TESTS

R. G. Larson and **J. J. Leonard,** Department of Agricultural Engineering, University of Alberta, Edmonton, Alta.

Four commercially-available grain-loss sensor pads were interfaced with an 8-bit microprocessor development board, and installed at intervals along the straw walkers of a pull-type combine. Tests were carried out in a barley crop near Boyle, Alberta, to ascertain whether actual grain loss over the straw walker could be predicted from grain impact counts recorded from the sensors by the microprocessor system.

Impact count data were obtained in real time and subsequently processed to reconstruct grain separation curves. The curves were integrated beyond the end of the walkers to obtain predicted values for grain loss. Actual grain loss values were obtained by collecting straw walker and sieve effluent, separately, on plastic sheets that were unrolled behind the combine.

Because of time constraints, the total number of tests carried out was limited. However, the agreement obtained between actual and predicted values of grain loss was considered to be sufficiently good to justify further development of this loss measurement technique. On the basis of the data collected during the tests, some general comments are made on desirable sensor configurations and locations.

88–404. GRAIN AERATION WITH PERFORATED FLOOR AND DUCT INLETS

H. Page Harrison, Department of Agricultural Engineering, University of Alberta, Edmonton, Alta.

The air flow in a bin of wheat was determined using a tracer gas technique for a number of stations located in two horizons. Five different aeration inlet systems with two ventilation rates were used. Three dimensional contours of the air flow were drawn for each aeration inlet system, ventilation rate and horizon. They indicated that the air distribution was adversely affected by some of the inlet systems and by uneven distribution of the intergranular voids but was largely unaffected by the ventilation rate.

88–405. STORAGE OF GRAIN CORN

L. Otten and **Qinghua Zhang,** School of Engineering, University of Guelph, Guelph, Ont.

The short- and long-term storage of grain have been an area of interest following our work with the United Cooperatives of Ontario. In those studies criteria were developed for the temporary storage of wet grain corn before drying and long-term storage of corn with storage corn with moisture contents less than 17%. Aside from equipment specifications, a management strategy was developed.

This work has now been expanded to the conceptual development of a microcomputer-based storage control system. It would include the use of real time moisture content, temperature and carbon dioxide concentration data to determine past and current storage conditions. Comparison of the measured conditions with safe storage criteria will determine the appropriate control action. The control system will also include a predictive component which will determine the probability of future storage problems based on weather patterns in the geographic area of the facility. This component will allow management decisions before problems occur and will make the control system superior to exisiting grain storage control systems.

The models and simulations have been completed. Experiments to verify the model predictions were performed. The experimental apparatus consists of a 1-m-diam × 2-m-high storage bin which was instrumented with CO_2 sampling ports and temperature sensors. It has been shown that the environment within the grain bulk was strongly affected by the conditions at the boundaries. There is also some evidence that gravity may be more significant in describing the movement of CO_2 than is suggested in the literature. The paper will describe the conceptual design of the control system and present the experimental results.

88–406. ECONOMIC POTENTIAL OF STRAW BASED DECENTRALIZED POWER GENERATION

A. S. Bining, Department of Agricultural Engineering, Technical University of Nova Scotia, Halifax, N.S.

Cereal straw, the most abundantly available agricultural residue, has a large potential as a fuel in combustion and gasification systems. However, most of the annually produced straw is burnt in open fields creating serious environmental pollution problems and health hazards in many parts of the World and full economic potential of its utilization as fuel for decentralized power generation has not been realized.

This paper deals with the complete economic analysis of decentralized power generation using straw as substitute for coal in a given straw production catchment area. The analysis has been conducted for three different sizes of power generation plants (2 MW, 5 MW, and 10 MW) and three different power generation systems (Combustion and steam power generation, Gasification and steam power generation, and Integrated gasification combined cycle). The transportation costs which ultimately affect the straw fuel cost at the plant site, and on-site fuel storage costs as affected by plant size have been investigated. The results indicate favourable prospects of economic utilization of straw as fuel in a 5 MW Integrated gasification combined cycle power generation system.

88–407. MOISTURE SORPTION CHARACTERISTICS OF SOLID CLAY-SUPPORTED $CaCl_2$

T. N. Thoruwa and **N. Ben Abdallah,** Department of Agricultural Engineering, Technical University of Nova Scotia, Halifax, N.S.

Experiments were conducted to determine water vapor sorption characteristics of fabricated spherical solid clay-supported $CaCl_2$ dried/cured between 450-700°C. Moisture sorption characteristics were generated using constant humidity atmosphere maintained in sealed bottles for 24 and 48 h. Effects of curing/drying temperature on the fabricated solid sorbents were also determined. Regeneration cycle characteristics of the sorbents were established, with the sorbent reactivated at 50°C. It was concluded that the fabricated dessicants are solar regenerative and could be used in solar crop drying systems as an energy storage material to provide supplemental drying energy. The fabricated sorbents exhibited average moisture sorption of 20% (DWB) after 48 h exposure to humid atmosphere.

88–408. NATURAL AIR DRYING WITH VARIOUS AIRFLOW RATES AND CONTROL STRATEGIES

B. Kennedy Alberta Agriculture, Vermillion, Alta.; **M. Eliason,** Alberta Agriculture, Edmonton, Alta.; **B. Brad** and **M. Fabel,** Lakeland College, Vermillion, Alta.

Various airflow rates have been successfully used to natural air dry stored grain. To establish a data base for the performance of natural air drying systems under east central Alberta climatic conditions, a series of natural air drying trials began in 1986. In a cooperative project between Lakeland College and Alberta Agriculture, wheat was placed in three bins equipped with fully perforated floors. Airflow rates of 7.8, 11.7 and 15.6 l/s/m³ were used to dry wheat from a 19% initial moisture content. Airflow, static pressures, moisture contents and temperatures were recorded at various intervals and locations. Power consumption and ambient weather conditions were recorded throughout the drying process. During the fall only the bin receiving the 15.6l/s/m³ airflow rate dried completely. The electrical energy of cost associated with this drying was 2.68 $/t ($.058/bu).

During the fall of 1987 tough barley and wheat were placed in four bins. Fans were operated at air flow rates ranging from 14 to 15l/s/m³. One fan/bin combination was operated continuously while the others were operated under thermostat and humidistat control. The drying process was observed throughout the fall.

88–409. CHAFF COLLECTION AND PROCESSING OPTIONS

M. Stumborg and **W. Craig,** Saskatchewan Research Council.

Cereal chaff resources were analyzed, based on PAMI historical data, to determine their potential availability in Saskatchewan. Several chaff collection systems were analyzed to determine the cost/benefit of each on the basis of collection cost, potential agronomic benefit, feed replacement benefit, and use of chaff as an ethanol fermentation substrate. The results of the cost benefit analysis showed that, regardless of the type of collection system utilized, the benefits outweighed the cost of collection. Savings of between $1.80 and $4.10 per dollar spent were calculated provided the chaff was not transported long distances. Fermentation pretreatment trials revealed that cereal chaff had quality equal to that of aspen wood but did not require the expensive size reduction wood required. Further research to define the ethanol potential and agronomic benefits are ongoing.

88–501. TESTING OF FREEZING TIME MODELS

D. I. LeBlanc, R. Kok, Dept. of Agricultural Engineering, McGill University, Macdonald College, Ste. Anne de Bellevue, Que., and **G. E. Timbers,** Engineering and Statistical Research Centre, Agriculture Canada Research Branch, Ottawa, Ont.

Simple solutions to the phase change heat transfer problem were tested to determine the freezing time of French fried potatoes. These calculated results were compared to French fry freezing times obtained experimentally under controlled conditions. The models tested were those which assumed conditions similar to those encountered during the freezing experiments, namely a finite surface heat transfer coefficient, heat transfer along two orthogonal axes, an initial product temperature above the freezing point, and a final product center temperature of −18°C.

All simple models tests overestimated the freezing time of French fries except for Plank's (1941) model and the International Institute of Refrigeration's (IIR, 1986) model which both underestimated the freezing time. Hayakawa et al.'s (1983) equation estimated the freezing time of French fries with the most precision.

88–502. THIN-LAYER MICROWAVE DRYING OF PEANUTS

C. St. John and **L. Otten,** School of Engineering, University of Guelph, Guelph, Ont.

The present peanut drying or 'curing' process is a two-stage one in which peanuts are field dried to about 25% moisture content (WB) before combining. Further drying is done with a conventional batch-type dryer. However, the rate of moisture removal during the conventional drying process is limited by the need to prevent surface hardening of kernels of milling damage in the form of skin slippage and splits.

The use of microwaves to provide energy for moisture removal is being investigated to determine if a more rapid curing process can be developed. Both shelled and unshelled peanuts at initial moisture contents of 50 and 25% were dried in a single layer at energy inputs of 300, 600, 800 and 1100 W in a 430-mm cube stainless steel oven cavity.

Microwave power was supplied to the cavity via a waveguide from a generator consisting of a variable output 2450 MHz magnetron. Peanut sample size and airflow rate through the sample were held constant at 300 g and 8.3 L/s, respectively. The sample was weighed at intervals by measuring the strain in a cantilever beam from which the sample container was suspended.

The resulting drying curves and prediction equations developed for all combinations of initial moisture contents and energy input rates will be presented in this paper.

88–503. PEANUT ROASTING PROCESS

L. Otten, School of Engineering, University of Guelph, Guelph, Ont. and **J. Moss,** Research Centre, Canada Packers Inc., Toronto, Ont.

Before being ground into butter, peanuts are roasted to produce the appropriate color and flavor. Presently, the only quality control check made in the roasting operation is a manual evaluation of color. No moisture content measurements are made and as a result the nuts are frequently roasted to values below 2%. It is believed that this overdrying reduces the yield of the product, adversely affects the flavor due to excessive removal of volatile components, and increases in stack emissions.

A project to develop a control system for the roasting process was run in cooperation with Canada Packers, Inc. Experiments have been conducted using a Proctor and Schwartz pilot plant roaster. In the experiments drying curves were developed for Runners split peanuts at various roasting conditions. Samples have also been analyzed to determine color and an analysis to find a relationship between moisture content and color was performed. Results of the study will be the subject of the paper.

88–504. HEAT TRANSFER IN A HEATED BED OF NATURAL ZEOLITE AND GRAIN

Z. Alikhani and **G. S. V. Raghavan,** Dept. of Agricultural Engineering, McGill University, Macdonald College, Ste. Anne de Bellevue, Que.

The concept of particle-particle heat transfer has been applied in industry for a considerable period of time. While the application of this technique in agriculture is much older, e.g., for roasting grains, its scientific study is rather new. Researchers in the past decade, or so, have studied the applicability of using different solid particulate media for grain drying. A variety of granular materials has been reported: salt, sand, and beads of steel, aluminum, ceramic and glass. Sand is the most commonly used material, and its use has been reported in rotary dryers, as well as in fluidized beds.

It is well-established that the use of a solid particulate medium improves the heat transfer of the process, as compared to using air as the only medium of heat transfer. The extent of improvement depends on the medium type and the operating conditions. Since drying is a process of simultaneous heat and mass transfer, improvement of heat transfer alone will not effect improvement in drying efficiency. And the mass transfer process will be the limiting factor for the rate of drying.

Recently published work showed that synthetic zeolite (molecular sieves) were far better than sand as the particulate medium for grain drying. In this paper, results of our drying studies with natural zeolite will be reported. Drying will be accomplished by mixing the heated zeolite and grain corn in a batch rotary dryer. The heat transfer aspect of the drying process will be discussed in detail.

88–505. THERMAL PARAMETERS OF A PACKED BED OF SOYBEAN AND WHITE NAVY BEAN SEEDS FROM SYSTEM RESPONSE ANALYSIS.

R. B. Brown and **L. Otten,** School of Engineering, University of Guelph, Guelph, Ont.

Thermal properties of agricultural materials, and in particular cereal grains and oilseeds, are not well documented. These materials are usually granular or heterogeneous in nature, so that conventional methods of thermal parameter determination are not completely satisfactory. An additional complication with biological materials like grain kernels is that thermal properties are nonlinear functions of temperature and moisture content. However these parameters are necessary for simulation and control of processes like grain drying and cooling.

A method to find values for several important thermal parameters of grain kernels based upon system response analysis of a grain-air packed bed of kernels is described. The specific parameters of interest for grain drying simulation are particle thermal conductivity, air-to-particle convective heat transfer coefficient, and axial thermal dispersion coefficient of air. The method of determination is relatively rapid so that a number of measurements can be made to derive the functional relationships of the parameters with temperature and moisture content.

The thermal properties are reported for soybean and white Navy bean seeds. Corresponding parameter values for glass beads, which are well known, are also determined experimentally in order to validate the procedure.

FINAL PROGRAM

CSAE Annual Meeting in Calgary
21-25 August 1988

Technical sessions scheduled

Monday, 22 August 1988 1330h to 1700h
Three concurrent sessions:
1. Structure and environment
   Waste management: 9 papers (invited)
2. Power and machinery
   Soil working implements: 7 papers
3. Food engineering
   Thermal processes: 5 papers

Tuesday 23 August 1988 0830h to 1200h
Three concurrent sessions:
1. Structures and environment
   Animal environment: 8 papers
2. Electric power and processing
   General: 9 papers
3. Soil and water
   Soil protection: 7 papers

Tuesday, 23 August 1988
1300h to 1500h General session on food engineering curriculum development
1530h to 1700h CSAE Annual Meeting
1800h to 2100h CSAE Awards Banquet

Wednesday, 24 August 1988 0830h to 1200h
Three concurrent sessions:
1. Structures and environment
   General: 9 papers
2. Power and machinery
   Field equipment: 8 papers
3. Soil and water
   Land and groundwater management: 8 papers

Thursday, 25 August 1988
One or two technical tours to be prepared by the local committee (Richard Smith). Either half a day or a full day.

STRUCTURES AND ENVIRONMENT

Theme: Waste management and utilization
Chairman: N. R. Bulley, University of Manitoba
Schedule: Monday afternoon, 22 August 1988

13:30 Opening remarks

13:35 Canada manure management guide (88–101)
N. R. Bulley, University of Manitoba

13:50 Manure characteristics (88–102)
A. Ghaly, D. Hodgkinson, and N. R. Bulley, Technical University of Nova Scotia; Manitoba Agriculture; University of Manitoba

14:10 The storage of manure (88–103)
S. Barrington and G. Bayne, McGill University; Saskatchewan Agriculture

14:30 Manure handling methods (88–104)
B. West and D. Hodgkinson, Alberta; Manitoba Agriculture

14:50 Guidelines for manure application to land (88–105)
E. Beauchamp and R. Bertrand, University of Guelph; B.C. Agriculture

15:10 Break

15:30 Site selection (88–106)
B. West and P. Johnson, Alberta; B.C. Agriculture

15:50 Manure treatment methods: aerobic (88–107)
P. Johnson and V. Lo, B.C. Agriculture; University of B.C.

16:10 Barn air quality (88–108)
E. Barber and J. Feddes, University of Saskatchewan; University of Alberta

16:30 Odor production, measurement and control (88–109)
A. Ghaly, Technical University of Nova Scotia

16:50 Program wrap-up

17:00 Adjourn

STRUCTURES AND ENVIRONMENT

Theme: Animal environment
Chairman: Robert Borg, Alberta Agriculture
Schedule: Tuesday morning, 23 August 1988

08:30 Microwaves as a heat source for animals (88–110)
L. Otten, D. Morrison and D. Pei, University of Guelph; University of Waterloo

08:50 Air quality in turkey facilities (88–111)
Z. J. Licsko and J. J. R. Feddes, University of Alberta

09:10 Gas concentrations in dairy barns (88–112)
N. K. Patni, Agriculture Canada, Ottawa

09:30 Airflow patterns in swine building (88–113)
Y. Choinière and O. Ménard, Collège d'Alfred, OMAF

09:50 Break

10:10 Air movement at animal level (88–114)
J. A. Deurloo, D. Darby, J. J. R. Feddes and J. J. Leonard, University of Alberta; Alberta Agriculture

10:30 Ridge opening width and swine barn ventilation (88–115)
Y. Choinière and O. Ménard, Collège d'Alfred, OMAF

10:50 Calorimetry in livestock housing (88–116)
K. McDermott and J. J. R. Feddes, University of Alberta

11:10 Environmental control in hot nurseries (88–117)
R. D. MacDonald and F. A. Kains, Ontario Ministry of Agriculture and Food

STRUCTURES AND ENVIRONMENT

Theme: General
Chairman: Brian Kennedy, Alberta Agriculture
Schedule: Wednesday morning, 24 August 1988

08:30 Horizontal silo wall loads (88–118)
J. Jofriet, D. Darby and H. Bellman, University of Guelph; Alberta Agriculture; OMAF

08:50 Plate beam design (88–119)
D. E. Darby, J. A. Munroe and H. Jackson, Alberta Agriculture; Agriculture Canada, Ottawa

09:10 Polyurethane insulation (88–120)
H. House, J. Jofriet and L. Otten, OMAF, University of Guelph

09:30 Geotextiles for earthen manure tanks (88–121)
R. Raimondo, S. F. Barrington and S. O. Prasher, McGill University

09:50 Dairy waste management systems (88–122)
S. Hengnirun, K. C. Watts and J. R. Burney, Technical University of Nova Scotia

10:10 Break

10:30 Composting of manure slurries (88–123)
S. P. Mathur, N. K. Patni and M. P. Lévesque, Agriculture Canada, Ottawa

10;50 Greenhouse production of horticultural crops (88–124)
D. St-George and J. J. R. Feddes, University of Alberta

11:10 Greenhouse heated by radiation (88–125)
P. Caouette and A. Marquis, Université Laval

11:30 Earth-tube for heating or cooling air (88–126)
D. O. Baxter, University of Tennessee

POWER AND MACHINERY

Theme: Soil working implements
Chairman: W. B. Reed, University of Saskatchewan
Schedule: Monday afternoon, 22 August 1988

13:30 Soil forces on cultivator shovel (88–201)
T. M. Borstmayer and R. L. Kushwaha, University of Saskatchewan

13:50 Rod weeder soil reactions (88–202)
X. Bai and H. P. Harrison, University of Alberta

14:10 Traction performance of a model tractor (88–203)
R. L. Kushwaha, L. E. Zyla, and J. D. Close, University of Saskatchewan

14:30 Star penetrometer (88–204)
G. Wang and G. C. Zoerb, University of Saskatchewan

14:50 Break

15:10 Finite element analysis of soil forces (88–205)
L. Chi and R. L. Kushwaha, University of Saskatchewan

15:30 Evaluation of three zero-till drills (88–206)
D. May, Prairie Agricultural Machinery Institute

15:50 Physical properties of the soil-seed environment (88–215)
S. Tessier, K. E. Saxton, R. I. Papendick, and G. M. Hyde, Agriculture Canada, Swift Current

POWER AND MACHINERY

Theme: Field equipment
Chairman: H. P. Harrison, University of Alberta
Schedule: Wednesday morning, 24 August 1988

08:30 Dual-fuel diesel engine (88–207)
J. G. Davies and W. B. Reed, University of Saskatchewan

08:50 Sprayer droplet size determination (88–208)
A. B. Kinnie and K. C. Watts, Technical University of Nova Scotia

09:10 Transplanting tomato seedlings (88–209)
G. B. Hergert, M. Feldman, S. Burgoyne, and E. J. Tomecek, Agriculture Canada, Ottawa; McGill University; OMAF

09:30 Placement of urea granules (88–210)
W. Wasylciw, J. J. Mayko, and K. W. Domier, University of Alberta

09:50 Break

10:10 Chemical conditioning of mixed hay (88–211)
S. Beauregard, P. Savoie, and D. Désilets, Université Laval; Agriculture Canada, Lennoxville

10:30 A power bale sampler (88–212)
E. Z. Jan, Agriculture Canada, Melfort

10:50 Equipment for tying cauliflower leaves (88–213)
G. B. Hergert and M. A. Pelletier, Agriculture Canada, Ottawa

11:10 Prediction of a diesel tractor fuel consumption (88–214)
Z. Wang, K. W. Domier, J. Chang, and F. M. Green, University of Alberta; Alberta Agriculture

FOOD ENGINEERING

Theme: Thermal processes
Chairman: K. V. Lo, University of British Columbia
Schedule: Monday afternoon, 22 August 1988

13:30 Freezing time models (88–501)
D. I. LeBlanc, R. Kok, and G. E. Timbers, Agriculture Canada, Ottawa; McGill University

13:50 Thin-layer drying of peanuts (88–502)
C. St. John and L. Otten, University of Guelph

14:10 Peanut roasting process (88–503)
L. Otten and J. Moss, University of Guelph; Canada Packers

14:30 Heat transfer in a grain bed (88–504)
Z. Alikhani and G. S. V. Raghavan, McGill University

14:50 Thermal parameters of bulk bean seeds (88–505)
R. B. Brown and L. Otten, University of Guelph

ELECTRIC POWER AND PROCESSING

Theme: General
Chairman: R. Ford, University of Saskatchewan
Schedule: Tuesday morning, 23 August 1988

08:30 Beehive monitor system (88–401)
C. Liu, J. J. Leonard, and J. J. Feddes, University of Alberta

08:50 Review of humidity sensors (88–402)
I. Erdebil and J. J. Leonard, University of Alberta

09:10 Grain loss sensing (88–403)
R. G. Larson and J. J. Leonard, University of Alberta

09:30 Grain aeration (88–404)
H. P. Harrison, University of Alberta

09:50 Grain corn storage management (88–405)
L. Otten and Q. Zhang, University of Guelph

10:10 Break

10:30 Straw based power generation (88–406)
A. S. Bining, Technical University of Nova Scotia

10:50 Moisture sorption of $CaCl_2$ (88–407)
T. N. Thoruwa and N. Ben Abdallah, Technical University of Nova Scotia

11:10 Natural air grain drying (88–408)
B. Kennedy, M. Eliason, B. Brad, and M. Fabel, Alberta Agriculture; Lakeland College

11:30 Chaff collection and processing options (88–409)
M. Stumborg and W. Craig, Agriculture Canada, Swift Current; Sask. Research Council

SOIL AND WATER

Theme: Soil protection
Chairman: E. Rapp, University of Alberta
Schedule: Tuesday morning, 23 August 1988

08:30 Snow retention in grain stubble (88–301)
H. Steppuhn and B. G. McConkey, Agriculture Canada, Swift Current

08:50 Fall tillage and snowmelt infiltration (88–302)
C. P. Maule and D. S. Chanasyk, University of Alberta

09:10 Subsoiling to enhance snowmelt infiltration (88–303)
B. McConkey, D. Ulrich, W. Nicholaichuk, and H. Steppuhn, Agriculture Canada, Swift Current; National Hydrology Research Institute

09:30 Erodability measurements on small plots (88–304)
R. T. Maclean and C. L. Armstrong, University of Saskatchewan

09:50 Break

10:10 Soil rilling and sedimentation (88–305)
W. Stoltie, R. P. Rudra, and W. B. Dickinson, University of Guelph; University of Saskatchewan

10:30 Improved practices for installing drain pipes (88–306)
R. S. Broughton, J. Mayo, R. Bonnell, and S. Ami, McGill University

10:50 Double wall polyethylene pipes (88–307)
R. S. Broughton, J. Mayo, R. Bonnell, and S. Barrington, McGill University

NOTES TO CONTRIBUTORS

The Editorial Board will assess suitability and essential detail of papers submitted for publication in *Canadian Agricultural Engineering*. One or more reviewers will be used. Their comments and suggestions will be compiled and submitted to the author. The review will ensure that:

1. A *research paper* presents a piece of research carried to a well-defined stage of advancement and the conclusions are adequately supported by the experimental results.
2. A *technical paper* presents a clear, concise, and factual outline and interpretation of the development, design, test, or analysis under consideration and that it is a contribution in the field of agricultural engineering.
3. A *general paper* on education, research, or extension is pertinent to major changes in curriculum, research, or extension or to forward-looking developments in these areas.
4. A *technical note*, of one journal page or less, on equipment development, technique of measurement, or method of analysis will have an application for other workers in the field of agricultural engineering.

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The manuscript should be typed double-spaced on paper 8½ × 11 inches (21.6 × 27.9 cm) with margins not less than 1¼ inches (3.3 cm). The first page should contain only the title, authors' names, addresses (including postal codes), and contribution number where applicable. Tables and captions for illustrations should be on separate pages, placed after the text. Manuscript paper with numbered lines is preferred. The original and two copies are required.

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This paper should be organized to conform with present Journal practice. *Research* and *Technical* papers must include a short abstract section of about 200 words.

Major headings — Center on the page with all words in capital letters.

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Technical and detailed information should be included only in the form of description, table, graph, chart or photograph. In general, follow the *Council of Biological Editors Style Manual*, 5th ed., published by the Council of Biology Editors, Inc., Bethesda, MD 20814.

References

List references alphabetically by authors at the end. Include year of publication, title in lower case except first letter of first word, and source, with volume and page numbers where applicable. Names of periodicals should be abbreviated in the form given in *BIOSIS List of Serials with Title Abbreviations* (Bioscience Information for Service of Biological Abstracts, 211 Arch Street, Philadelphia, PA, 19102). Material in press, with the name of the journal, may be used as a reference. Private communications and unpublished reports should be referred to in parentheses in the text. Avoid the use of footnotes. Use the author-date system in the manuscript when referring to articles in the Reference section.

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Designate tables at the top by table number (Roman numerals) and title, in upper and lower case letters. All headings and other information in tables are to be in lower case except first letter of first word. Keep the table compact and place it across the page wherever possible. Do not use vertical lines.

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Use the metric system (SI) in the text. Tables, charts and graphs should be given only in metric units.

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Equations and formulas must be set up clearly. Use capitals for symbols as much as possible and lower case for superscripts and subscripts. Greek and other characters should be identified clearly. Equations should be numbered on the right-hand margin in large numbers and in line with the center of the equation.

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Either original drawings or clean, glossy photographs are acceptable for illustrations. An illustration or group of them should be planned to fit, after reduction, into a space 90 mm wide (one column) or 183 mm wide (two columns). The original should be not more than three times the size of final figure. For identification, the figure number and author's name should be written on the lower left corner with soft pencil.

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