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Proceedings: 1970 Short Course for Seedsmen (Full Document)

Proceedings
1970 SHORT COURSE for SEEDSMEN

April 20 – April 23, 1970

SEED TECHNOLOGY LABORATORY

STATE COLLEGE MISSISSIPPI

Sponsored By The Mississippi Seedmen's Association

PROCEEDINGS
1970 Short Course for Seedsmen

April 20-23, 1970

Seed Technology Laboratory
Mississippi State University

State College, Mississippi

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THE 1970 SHORT COURSE
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--Conveying

--Treating


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STAFF

SEED TECHNOLOGY LABORATORY

STATE COLLEGE, MISSISSIPPI

1. Dr. James C. Delouche . In Charge, Seed Technology Laboratory
2. Dr. C. Hunter Andrews . . . . .Assistant Agronomist
3. Dr. Charles E. Vaughan . . . . .Assistant Agronomist
4. Dr. Kenneth Matthes. . . . . . . Assistant Agricultural Engineer
5. Charles C. Baskin. . . . . Assistant Agronomist
6. A. H. Boyd, Jr. . . . . Assistant Agronomist
7. Harold W. Byrd . . . . .Assistant Agronomist
8. George M. Dougherty . . . . .Assistant Agronomist
9. Charles Sciple. . . . . .Assistant Agronomist
10. James M. Beck . . . . Engineering Technician
11. Irene Caldwell . . . . Laboratory Technician
12. Sue Reed. Laboratory Technician
13. Dero Kinard . . . . Technical Assistant
14. Curtis Reed . . . . .Technical Aide
15. Cheryll DePoyster . . . . .Secretary
16. Sue Garrett . . . . .Secretary
17. Carol Kirschenbaum .Secretary


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GRADUATE

AND

UNDERGRADUATE STUDENTS

1. Augusto Aponte . . . . Venezuela
2. Gene Bates . . . . Mississippi
3. Udai Ram Bishnoi . . . . India
4. Joe Butler . . . . Mississippi
5. Cilas Camargo . . . . Brazil
6. Chia Chi Chen . . . . Taiwan
7. Rozane Coelho . . . . Brazil
8. Sergio Fagundes . . . . Brazil
9. Ernie Flint . . . . Mississippi
10. Fernando Gomez . . . . Colombia
11. L. Hanumaiah . . . . India
12. Joe Johnson . . . . Mississippi


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13. Chin-Shan Lai . . . . Taiwan

14. Roger Landers . . . . Illinois

15. Robert Munson . . . . Missouri

16. Sammie Newsom . . . . Mississippi

17. B. R. Phaneendranath . . . . India

18. Flavio Popinigis . . . . Brazil

19. Bettaiya Rajanna . . . . India

20. Maria Sartori . . . . Brazil

21. Prasoot Sittisroung . . . . Thailand

22. Carlos Vechi . . . . Brazil

23. JoAnn Wise . . . . Louisiana

24. Mohammad Zaher . . . . Afghanastan

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GUEST SPEAKERS

1.	Harvey W. Mauth	Rogers Brother Company Idaho Falls, Idaho
2.	Dr. Owen J. Newlin	Pioneer Hi-Bred Corn Company Des Moines, Iowa
3.	Duane W. Tyler	A. T. Ferrell & Co. Saginaw, Michigan
4.	Dr. Frank T. Bonner	USDA Forest Tree Seed Laboratory State College, Mississippi
5.	Gene A. Sullivan	North Carolina State University Raleigh, North Carolina

PROGRAM SCHEDULE
Monday, April 20

8:00 - 12:00	REGISTRATION - Seed Technology Laboratory Free: Coffee, Cokes, and Doughnuts (Supplied all week, courtesy of manufacturers and their representatives)
10:00 - 11:00	TOURS (Transportation Furnished) Forest Tree Seed Laboratory or Herschede-Hall Clock Company DEMONSTRATIONS OF EQUIPMENT (By Request)
12:00	LUNCH Presiding: Charles E. Vaughan
1:30	WELCOMES AND INTRODUCTIONS
2:15	SEEDS FOR THE 70's - Harvey W. Mauth, Rogers Brothers Company, Idaho Falls, Idaho.
3:00	COFFEE, COKES, AND DOUGHNUTS
3:30	GAMES SEEDSMEN PLAY - James C. Delouche, MSU Staff
4:00	QUALITY CONTROL AND THE SEEDSMAN - Charles C. Baskin, MSU Staff
7:00	BAR-B-QUE DINNER University Cafeteria Courtesy, Mississippi Seed Improvement Association and Mississippi Seedsmen's Association

Tuesday, April 21

Presiding: James M. Beck

8:30	ANALYTICAL APPROACH TO SEED SEPARATIONS - James C. Delouche, MSU Staff
9:15	BASIC SEED CLEANING - A. H. "Bill" Boyd, Jr., MSU Staff
10:00	COFFEE, COKES, AND DOUGHNUTS
10:30	COMPLEMENTARY SEED CLEANING - Charles E. Vaughan, MSU Staff
11:15	SPECIAL SEED CLEANING OPERATIONS - George M. Dougherty, MSU Staff
12:00	LUNCH
1:30	IMPROVING SEED QUALITY BY PROCESSING - Charles E. Vuaghan, MSU Staff
2:15	MANAGING THE PRODUCTION OF HYBRID SEED CORN FROM SEED FIELD TO BAGS - Owen J. Newlin, Pioneer Hi-Bred Corn Company, Des Moines, Iowa.
3:00	COFFEE, COKES, AND DOUGHNUTS
3:30	DEMONSTRATIONS OF SELECTED EQUIPMENT - Staff and Manufacturers' Representatives and SEED QUALITY CONTROL METHODS I

Wednesday, April 22

Presiding: James C. Delouche

8:30	METHODS OF CONVEYING SEED - James M. Beck, MSU Staff
9:15	THE SEED PLANT OF THE 70's - Duane W. Tyler, A. T. Ferrell & Co., Saginaw, Michigan
10:00	COFFEE, COKES, AND DOUGHNUTS
10:30	FOREST TREE SEEDS - Frank T. Bonner, USDA, Forest Tree Seed Laboratory, State College, Mississippi
11:15	EVALUATING SEED STORABILITY AND VIGOR - Harold W. Byrd, MSU Staff
1:30	WHAT FARMERS EXPECT FROM THE SEEDSMAN! - Gene A. Sullivan, North Carolina State University, Raleigh, North Carolina
2:15	SEED QUALITY AND CROP PERFORMANCE - C. Hunter Andrews, MSU Staff
3:00	COFFEE, COKES, AND DOUGHNUTS
3:30	DEMONSTRATIONS OF SELECTED EQUIPMENT - Staff and Manufacturers' Representatives and SEED QUALITY CONTROL METHODS II
7:00	MISSISSIPPI STYLE BAR-B-QUE Courtesy, Sawan Division, W. R. Grace Company, Columbus, Mississippi

Thursday, April 23

Presiding: C. Hunter Andrews

8:30	FACTS SEEDSMEN SHOULD KNOW ABOUT DRYING - Ken Matthes, James M. Beck, and A. H. "Bill" Boyd, Jr., MSU Staff -Properties of Air -Properties of Seed -Air Flow Rates and Temperature Measurements -The Seed Drying System
10:00	DRAWING FOR DOOR PRIZES
10:15	COFFEE, COKES, AND DOUGHNUTS
10:45	EFFECTS OF PACKAGING MATERIALS, STORAGE CONDITIONS AND SEED MOISTURE CONTENT ON SEED QUALITY - Charles C. Baskin, MSU Staff
11:30	SUMMARY OF COURSE
12:00	LUNCH
1:30	CONFERENCES OR SPECIAL DEMONSTRATIONS (As Requested)

SEEDS FOR THE 70'S

Harvey W. Mauth[1/]

The next decade in the seed business will be the most exciting and challenging period in the history of our industry. We have only to look back at the building blocks of the 1960's that make up the foundation and lauching pad for future developments to come to this conclusion.

While hybrid corn has been making its impact on our agricultural community for the last four decades, it was not until the 60's that we saw the effect in commercial channels of hybrid sorghums, and sudans, of hybrid carrots, onions, cabbage and other field and vegetable crops. Hybrid wheats and alfalfas were being developed as the 60's drew to a close. Gynoecious cucumbers revolutionized the pickle industry and our gardens were graced with hybrid flowers of dazzling beauty.

Truly the last ten years were hybrid oriented and the next decade will see a continuation and expansion of this trend. Just what is the basis for this headlong rush toward hybrid production of naturally open pollinated species? Obviously the seedsman was motivated by profit as a first consideration. With a hybrid he had built-in Breeder's Rights. Breeding efforts were protected from theft and propagation by competitors, and as long as he had a superior product desired by his trade, he could claim reasonable profit with less hazard of cut-throat price competiton from lower overhead non-breeding firms.

Hybrids offered greater uniformity of plants, fruits and flowers, greater crop yields, improved disease and insect resistance, a more concentrated period of harvest and a greater tolerance to heat, drought and other environmental adversity. Much progress has been made through hybrid seed production in the 60's, but much more needs to be accomplished, and will be accomplished, in the future.

Many species of self-fertilized plants and those involved in natural crossing will be hybridized in the future. Every self-respecting plant breeder working with such species is diligently looking for male sterile aberrations to provide a base for a breakthrough into a hybridization program. Such germ plasm will be found and the breeding of new and novel hybrid types will further revolutionize our industry.

1/ Mr. Mauth is Vice President of Rogers Brothers Company, Idaho Falls, Idaho.

Over the years great emphasis has been placed on breeding for improvement of crop yields, and rightly so. In the breeding of animal feed crops, much consideration has been given to the nutritional aspects of the grains and forages. Perhaps the greatest accomplishment of the 60's in this area was the breeding of high lysine corn hybrids with their high protein value for stock feed and their value as well as a protein supplement for the diets of those populations around the world where the goal for each day is to obtain enough food for survival.

The 1970's will see much greater emphasis in plant breeding for improvement of nutrient qualities of both animal feeds and human foods. Both the governmental officials of our country and the buying public are becoming more concerned with the food values of the groceries on the store shelves and the trend toward consumerism will continue.

In the near future we can look for regulations that will require the labels on the canned and frozen packages to list the complete food value information of the contents. Of course, some breakfast foods and baking products are already following this practice in their labeling and advertising. Unfortunately few of us are sufficiently concerned with the need for a properly balanced diet. We eat foods that tast good and have eye appeal. By the same token, if there was a choice in nutritional value between two cans of tomatoes on the store shelf, we would select the one with the best food value, if all other factors were equal. Such being the case, we should be breeding for nutritional value in our vegetables, grains and fruits. Sophisticated laboratory equipment, such as gas chromatography, will assist in selection in this upgrading program.

Mutants, both naturally occuring and those induced by irradiation and chmicals, have played a striking part in new varietal development in recent years. Disease resistance and improved yields have been produced in cereal grains through this plant breeding technique. As a result of this process, Pakistan is currently self sufficient insofar as its needs for wheat are concerned, and India hopes to be similarly self sufficient in its wheat needs in just a few more years. In Japan induced mutations were responsible for increased yields and higher protein content in rice to the extent that surpluses now exist there in that crop. A representative of a Japanese firm told me earlier this month that the national plan was to reduce the rice acereage in Japan by 10%, and they were looking for other crops to fill that acreage. Induced mutations as a breeding tool have not been used adequately by plant scientists to date. We can see much more wide-spread increase of this practice in the next decade.

Actually, I believe that insofar as "seeds for the 70's: are concerned, the pattern of varieties was largely set in the 60's in many species. It takes six to ten years, and even longer, to evolve a new variety. Add to that the years required to increase basic seed stocks to commercial quantities and the years required to promote a new variety into appreciable sales volume and we come to the realization that the new item that we are so proudly introducing today may well have been bred ten or more years ago. The necessary time lapse places increased pressures on the seed industry for accomplishment if we are to feed the masses of humanity in the next generations.

Let us pursue this line of thought further. What is the motivation for continued improvement in our seeds of the future? The strongest motivation possible -- survival! Survival in business against the keener competition of the future, but even more of consequence is the very survival of millions of people who are being brought into the world by the population explosion.

The world population now is around 3.2 billion. Thirty years from now, well within the lifetime of the majority of those in this room, the world population is estimated to be close to 7 billion -- more than twice the present figure. It is further estimated that two-thirds of the people living today lack adequate food, and great numbers die from malnutrition and actual starvation.

Let's bring the problem closer to home. The current census now underway is expected to show a U.S. population of 204 million. Just ten years from now that figure is expected to rise to an excess of 240 million. By the year 2000 the figure is estimated to be over 300million. We may say that this is no problem to us--that we can easily feed 300 million people here in our country. True, but we cannot ignore the fact that we are no longer an island unto ourselves. Hunger anywhere in the world is our problem. We must feed the starving wherever they may be, or as a preferred alternative, help them to feed themselves.

I repeat -- survival is our motivation for improved seeds of the future. If we are to insure that our children and our grandchildren will be enjoying an adequate food supply in their old age, the population explosion must promptly be controlled, and we in the seed industry will have to bend every effort in the development of better seeds to sharply augment the world's food supply. I don't want to be an alarmist, but these are the facts -- not speculation. The control of the population explosion in time to prevent hardship is wishful thinking, so the burden is on agriculture to plan now for an all out effort in years to come.

New varietal development in the future will follow several avenues of improvement. In addition to breeding for the increase yields and increased nutritional values mentioned previously, we will have to breed for greater disease resistance and insect resistance. It is becoming increasingly obvious that governmental regulations will drastically curtail the usage of chmical insecticides and fungicides in agriculture. With all of the emphasis now and in the foreseeable future toward improvement of thetotal environment, chemicals such as the chorinated hydrocarbons, with great longevity of effectiveness will either be eliminated entirely from commerce or will be tightly restricted in their usuage. It is difficult for me to believe, for example, that the application of 3/10 ounce of dieldrin as a seed treatment on 100 pounds of corn seed used to plant 10 acres of ground can constitute a pollution of our environment. Nevertheless, such seed treatment will be prohibited by law after December 31, 1970 unless extensions are granted.

There is no doubt that indiscriminate use of chemicals has, in some instances, polluted our streams and lakes and has threatened our wildlife. The total situation is emotionally charged and the words ecology, pollution and enviroment roll easily off the tongues of do-gooders and politicians who fail to realize the consequences of the total ban of the several cehmicals on their "black-list".

Unfortunately there are no presently availble substitutes of equal effectiveness for various of the chemicals planned to be eliminated. It behooves us all, therefore, to exert our influence in the Congress of the United States and in our own state legislatures to cause such legislation to be brought forth that will permit the restricted and controlled usage of these chemicals in agriculture in such a manner that environment pollution will be held to a minimum. As soon as other means of insect and disease controls can be effected through breeding of resistant varieties, through biological control of insects or through development of equally effective, though less offensive chemicals, the "hard" chemicals should be retired from commerce. Emotional and unscientific total banning of the chlorinated hydrocarbons at this time could work economic hardship on various segments of the agricultural community through reduction of crop potentials.

Breeding for the new varieties of the future must take into consideration the trends toward high density populations in field plantings. Such plantings may be in the form of closer row spacings, closer spacing within the rows or a precise and staggered planting with virtual elimination of the row effect. These higher density plantings offer greater yield potentials per acre, if all factors of nutrition, water and light are adequate. Since crop yields are directly related to the photosynthetic leaf area exposed to the sunlight, plants must be redesigned for high density plantings. The canopy effect of fewer broad top leaves must be replaced with smaller leaves and a more erect and open plant structure to allow light penetration to the lower leaf surfaces. Such a plant also allows better aeration within the mass of plants and a reduced fungal and bacterial disease potential.

Our row crop culture was largely built around the concept of the horse as a source of power for planting, weed control and harvesting. With the abandonment of that concept the redesign of the plants and farming equipment to permit precision planting higher density field population will result in greater per acre returns.

Feeding the increasing populations of the future will require the farming of land not considered marginal for agriculture. Varieties will have to be bred with greater tolerance to heat, drought, cold and to a wider range of soil types. To accomplish these ends we should take advantage of the germ plasm bank maintained by the Plant Introduction people in the U.S.D.A.,in our breeding programs and, as previously mentioned, utilize the tool of induced mutations to give us a new source of germ plasm.

With our expanding world markets for seeds we must plan our breeding programs of the future to provide varieties more suited to the environment of the foreign countries and the customs and tastes of their people. We have to recognize that our varieties are not always acceptable to them and, with that knowledge, try to match their requirements instead of attempting to arbitrarily foist upon them the items that are successful here at home. The sooner we recognize this fact and proceed to do something about it, the sooner our foreign sales volume will increase. The economic concept of consumer soverighty whereunder the will of the buyer is the ruling factor in marketing success applies overseas, as well as at home.

During the next decade we will see greater use of precision planting equipment of various designs and seeds so planted may be coated with nutrient materials, insecticides and fungicides to provide as ideal environment for early growth. Unless seed for such sophisticated planting is of high vitality and close to 100% germination, much of the benefits of such a planting program are lost. The pressure will be on the seed industry to provide the higher level of seed quality required.

To meet such requirements we will have to breed seeds that are genetically more vital under a wide range of growing and storage conditions and are less susceptible to mechanical injury in harvesting, processing and handling. Controlled drop tests whereunder the seeds are dropped a measured distance to a hard surface helps to reveal those seeds which can withstand the greater impact in these processes. Most seedsmen are breeding and selecting for such seed quality improvement and the varieties of the future will be of higher germination in many species.

Threshing techniques and equipment must be improved to minimize harvest damage to seeds. Perhaps the most significant development in this regard is the rubber belt thresher which offers real promise for reduction of thresher injury. A number of plot threshers embodying this new threshing principle have been in use by Federal and State experiment station personnel, as well as by private seed firms for some years and a full scale machine for field use has been constructed by the U.S.D.A. engineers in cooperation with Oregon State University at Corvallis, Oregon. In this machine the threshing cylinder has been replaced by two wide rough-surfaced belts running at different speeds in close proximity to each other. The threshing action closely simulates the rubbing out of the seed between the palms of your hands and the injury to the seed is minimal. Thorough and gentle threshing has been accomplished on seeds ranging from small grass seed to garden bean seed. Further refinements in this machine and encouragement of its usage for seed crops can go a long way toward assisting the seedsman in reaching his ultimate goal of seed with 100% germination.

I am sure that other speakers on this program will tell you about improved seed processing equipment for the 70's, so I will not inflict on you my thoughts on this subject. I would like to mention though the widespread usage and the value to our industry of the electronic color seed sorters of various designs. Perhaps the 1970's will witness the invention of an electronic device that will make a practical seed separation on the basis of vitality and germination. Such a breakthrough would be a great assist to our industry and to agri-business in total. We will soon have equipment and techniques that will obsolete our present germination equipment and give us immediate readings of germination and vitality. Seed plants will be automated to a much greater degree and the computer will become a standard tool in research, marketing and management.

The 1970's will see a continuation in the trend toward larger and more specialized farming operations. Such farms with "more eggs in one basket" are going to be more conscious of the need for quality seeds provided by a progressive seedsman who is a specialist in the seeds that he offers for sale. The farmer will expect to have expert advice regarding varieties and cultural practices and the seedsman who can offer such sound technical advice along with improved varieties is going to prosper.

Frequent reference has been made in my presentation to plant breeding as a solution to the ills of the seed business and the problems of feeding the added billions of mankind in the future. I firmly believe that the plant breeder with the vision and the courage to <u>make</u> trends rather than to <u>follow</u> them will open new avenues in the plant sciences. He will be the basis for the future success of our industry and the means by which the stomachs of the masses of humanity will be filled.

One vital ingredient is necessary, however, to make the efforts of the plant scientist possible. That ingredient is money. Money to pay salaries and to purchase the tools for research. In the hands of Congress in Washington now is the means by which research of the future will be financed -- not a massive appropriation funded by taxapayer's dollars, but a program of Breeder's Rights that will enable the fruits of the present breeding efforts to finance the enlarged scope of plant breeding in the future. We have only to look at the success story of hybrid corn to realize that the built-in Breeder's Rights that hybrid seed offers has created a new and vital industry that is built on research financed by legitimate profit margins.

Unfortunately the majority of our field and vegetable crops which are propagated by seeds are bred, produced and marketed without benefit of breeders' rights protection. A seed firm spending hundreds of thousands of dollars annually to breed new varieties has them stolen by other seed firms -- many of which do not have a breeding program of their own. Without the high costs of breeding and promotion of new varieties such firms soon buy a share of the market with reduced prices. It is not unusual for the breeding firm to claim only 50 - 60% of the market on its own new variety within three to five years after its introduction.

Obviously, the pyramiding costs of research will not permit this situation to persist without detrimental effects upon the future progress of our industry. The plant breeder must have the right to a just return on his inventions in exactly the same manner as the inventor of a machine or the composer of music is protected and rewarded.

Let's speculate for a minute on what changes may evolve in our industry when an effective breeders rights bill such as is now in the hands of Congress, or in some reasonably similar form, is enacted and becomes law. Almost certainly the tempo of plant breeding will be sharply increased as a result of the opportunity for the breeder to profit from his innovations, just as it has in Europe where breeders right protection has been established. New and improved varieties will be developed and the profits therefrom will finance a pyramiding effort toward greater volume of research - all to the benefit of all mankind.

Seed firms not now engaged in research may well elect to follow one of the following courses of action, any one of which will probably enhance their present condition.

a) Launch a breeding program of their own

b) Join with other small or large firms in a joint venture breeding program

c) Seek growing and marketing agreements with breeding firms.

With the existence of breeders rights protection, public agencies may either elect to concentrate on usage of public funds for much needed basic research and abandon actual commercial varietal development to private firms, or, emphasis might be put on varietal development with the hope that royalty payments generated therefrom might provide much needed funds for further research.

There will be problems of administration of any breeders rights that is passed. That is certain, but I believe that the thing that is of importance is that for the first time the agriculturally oriented segment of our country, both the public and private sectors, has taken concerted action on a program of breeders rights. I am confident that protection for the breeder will soon be an actuality here in the United States and the w orld will be a better place in which to live because of it.

The seed industry of the 70's and the decades to follow offers excitement and the promise of progress to all who have the foresight to plan now for the future.

THIS IS NOT QUALITY CONTROL
OR
GAMES SEEDSMEN PLAY[1/]

James C. Delouche[2/]

The attitude of management is the key factor in developing an effective quality control program. It is impossible to establish any sort of quality control program unless management is committed to certain quality standards. And, this commitment must be serious and consistent. All too often, management becomes mighty concerned about quality only when very serious problems arise and complaints are numerous, or when it is otherwise convenient. As things smooth out or as the season ends, the concern vanishes, the problems are forgotten, and the next season gets under way in the same old dubious manner.

A willingness to "just get by" is perhaps the real cause of most seed quality problems and attendent complaints. Getting by is one of the games that seedsmen play. Although, it takes many forms, the seedsman is always the protagonist and the seed analyst, seed control official, and certification inspector are bit players.

One popular game is called SHOPPING (Fig. 1). Samples are sent to various laboratories until the desired results (usually the highest) are obtained. These results are then used as a basis for labeling. Another, is a version of the old shell game NOW YOU SEE IT, NOW YOU DON'T. A sample is sent to a laboratory for both germination and purity analysis. If germination is good and purity is not, then the laboratory never gets another sample for germ. Resamples, however, are sent for purity only until by chance one turns out good. There are many variations of this game depending on which quality factor shows up low. Still another game might be called DIVIDE AND CONQUER . A seedsman has 500 bushels of wheat seed. A sample is sent to the laboratory and the results show good germ and purity but an excessive noxious weed seed. The lot is divided into two 250 bag lots, and two samples are sent for tests. The results of the tests might show that in one of the samples the noxious weed seed is within permissible limits, while in the other it is still excessive. The half of the lot that has the good test is

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[1/] Based in part on a column originally written for SEEDSMEN'S DIGEST, September, 1969.

[2/] Agronomist, In Charge, Seed Technology Laboratory, Mississippi State University, State College, Mississippi 39762.

labeled, while the other half with the bad test is divided again, and so on, until as much of the lot "passes" as possible.

Still another game is the "Tolerance Game". When germination of seed lots is somewhat lower than desired, the "tolerance" is added to the germination % and the lot is tagged accordingly.

We have referred to the above procedures used by some seedsmen as "games," but they are not usually intended as such. First, we should recognize that very few seedsmen play the games described. Secondly, the few who sometimes follow such procedures do so in good faith. They have the idea that if any test indicates that the seed are of reasonably good quality then they must be of good quality - regardless of tests results from other labs that indicate variable or low quality. This is a natural reaction - most of us want to believe the best things - even seed. Yet, the variability inherent is sampling and testing must be recognized and appreciated. If 10 germination tests of a lot of seed average 75%, the odds are good that at least one of the 10 tests will show a germ above 80%. And, if enough tests are made, one will probably give a 90% germ. The average germ, however, will still be about 75%.

During the 12 years I've been associated with the Mississippi State Seed Testing Laboratory, nearly 150,000 samples have been tested and I've been taken to task by seedsmen literally hundreds of times for reporting "low" test results. In only one case, however, have I received a complaint about our test results being too high.

This makes me believe that many seedsmen suspect that seed analysts are also addicted to certain games - games such as GERMINATION ROULETTE, GUESSING, and SEED SHUFFLING (Figure 2).

Seed Testing Laboratories do make mistakes and their interpretations do get out of joint with those of other laboratories. Seedsmen should keep them on their toes. However, if two laboratories test different samples from the same lot and one finds 500 dodder seed, while the other finds only 200, the test giving the low count is not always correct. The dodder count is probably somewhere in between. A similar situation might pertain when germination test results differ widely among laboratories.

We have spent some time discussing the philosophy of "getting by" because it is one of the first things that has to go before a quality control program can be effective. Since most seedsmen will have to depend on a seed testing laboratory for the information needed to make the quality control program go, an understanding of the nature of seed testing results is also important. Most laboratories simply report results, they do not comment on or interpret test results. This must be done by the person in the company responsible for quality control.

The quality control program is based primarily on timely and scheduled sampling, testing and interpretations of test results. Managerial decisions relative to disposition of seed lots, over-hauling of physical facilities to minimize quality problems, modification of procedures, etc., can then be taken from an enlightened perspective.

FIG. I GAMES SEEDSMEN PLAY

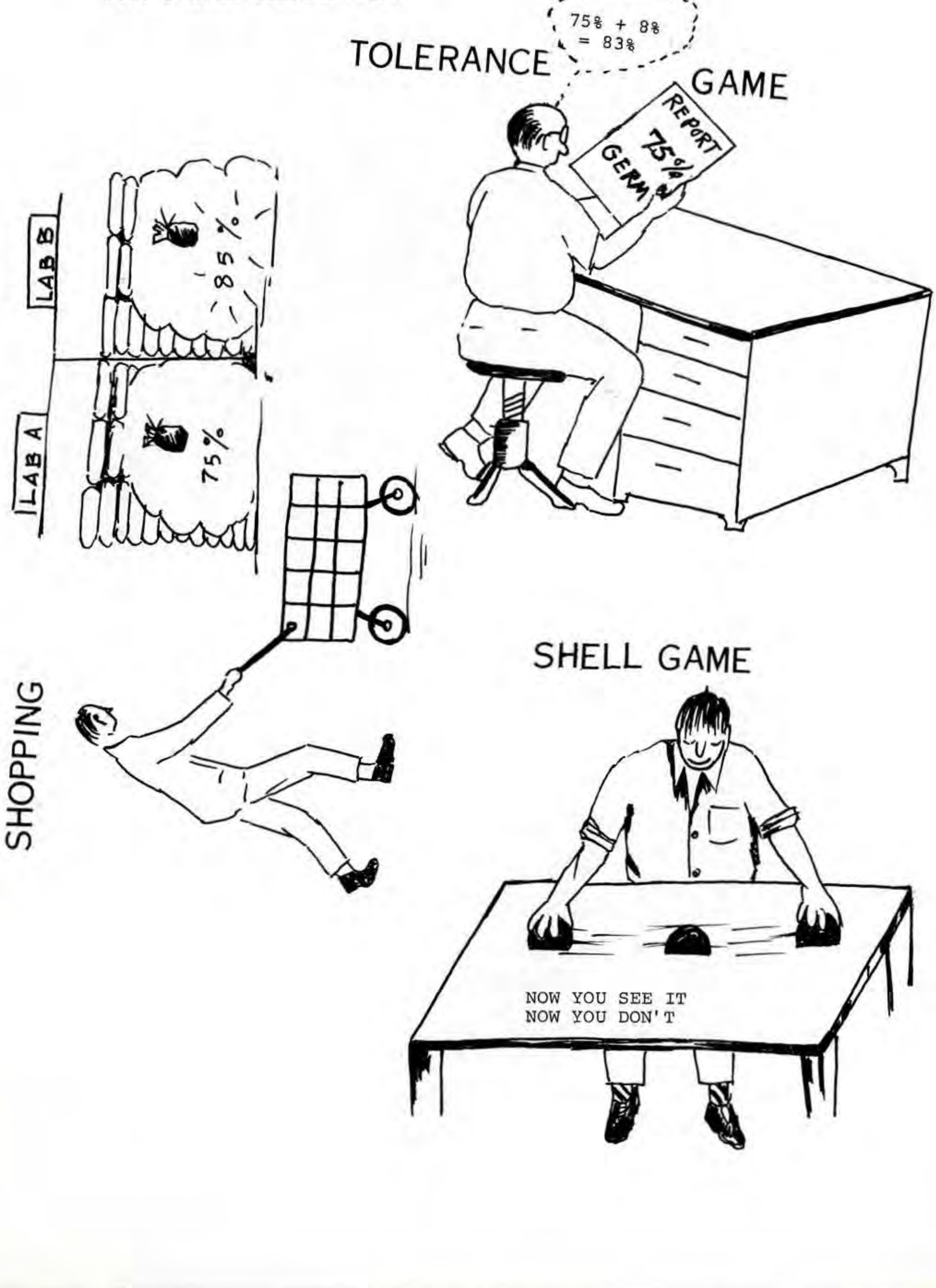
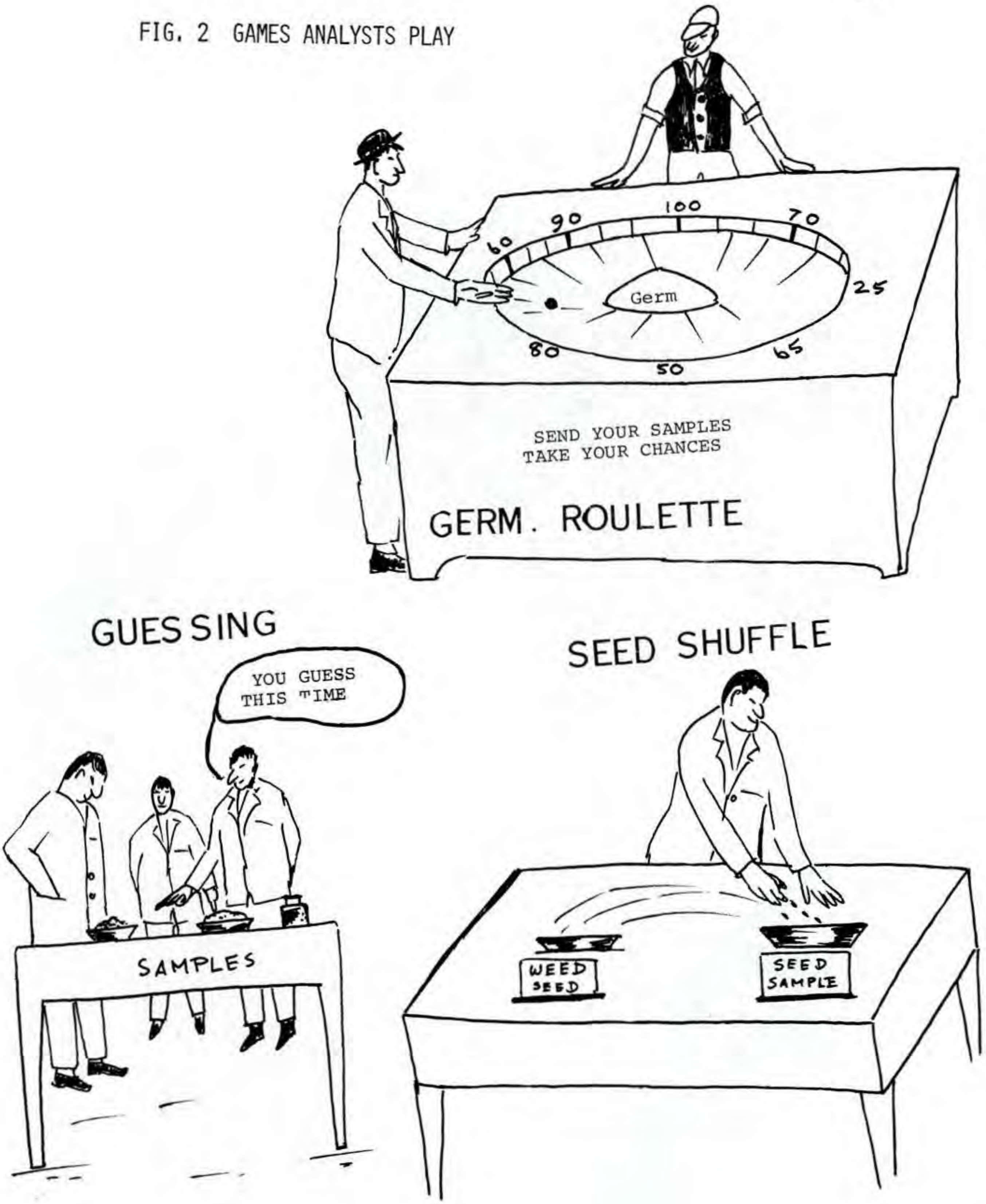


FIG. 2 GAMES ANALYSTS PLAY



QUALITY CONTROL IN THE SEED INDUSTRY

Charles C. Baskin[1/]

Why Emphasis on Seed Quality?

Changes in agronomic practices during the past 10 to 15 years, such as increased mechanization, increased use of agricultural chemicals (particularly herbicides), increased cost of seed, increased labor and production costs have all contributed to the farmer's awareness that the use of high quality seed will assure good stands, reduce the problems in replanting, produce more uniform stands that facilitate mechanization and reduce operation costs. Farmers have become quantity conscious.

Mechanization of seed production has been to the detriment of seed quality. In most instances anything done to mechanize seed production adversely affects the physiological quality of the seed. Monitoring the production system is necessary to minimize these effects.

The development of methods to identify quality problems and to measure seed quality have made it practical to employ quality control systems. Competition among seedsmen to produce better seed has led to emphasizing quality. Measurements of seed quality other than purity and standard germination are being used in sales promotions by some seed companies.

What is Seed Quality?

Seed quality embraces many facets. When quality is viewed in terms of a seed lot, we consider such things as physical purity, i.e. weed seed, inert matter and other crop seed content, moisture content, general appearance and uniformity. Quality in terms of the individual seed involves "genetic" purity, viability, vigor, performance potential, size, infections and infestations.

Some of these factors interact with others. For example, inert matter may mar the general appearance; insect and disease infestations may reduce vigor and viability. General appearance and uniformity may not affect planting quality but may enhance the saleability of the seed lot. Seed of mixed sizes may germinate and produce as well as if the seed were sized but certainly would not be as attractive to the buyer.

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Establishing and Utilizing Quality Control:

Many seedsmen employ some quality control techniques in their businesses. Far too often, however, these techniques are not organized into any system that will allow their use in a critical analysis of the seed production-processing program. A well organized quality control program can be a powerful management tool in any seed organization. Procedures must be critically analyzed to determine where the problems are and the necessary adjustments must be made to eliminate or minimize these problems.

Quality control is essentially a problem-solving process. The problem must be identified, its effect evaluated and its cause determined. Corrective action must be taken, the effectivieness of this action evaluated, and observations continued to prevent reoccurrence.

Quality control begins early in the seed production program. At planting time much can be done to enhance seed quality. Weed control begins at planting. Uniform stands of vigorous plants contribute to uniform maturity which facilitate harvesting, handling and processing. The field aspect of quality control continues through harvest. The evidence of a good or poor weed control program is apparent at harvest time. It is much easier in many instances to keep weeds out of seed than to remove them by processing. Another critical factor at harvest time is field exposure. Seed should be harvested as soon as possible to reduce field exposure time. Results of field exposure on cottonseed germination are presented in Table 1.

Table 1. Germination percentages of cottonseed in relation to the number of days of exposure in the field.

Boll No.	% Germination	Days of Exposure Before Harvesting
1	33.3	82
2	23.0	79
3	32.4	75
4	79.4	73
5	48.2	66
6	56.8	65
7	77.7	63
8	60.9	58
9	73.6	57
10	76.6	55
11	75.2	48
12	81.5	48
13	79.4	45
14	73.5	43
15	80.0	40

Similar effects may be experienced with other crops, such as frost damage in corn and weather damage in soybeans, etc. Field exposure is emphasized because once deterioration begins the process cannot be prevented- only retarded. If deterioration progresses far enough in the field, it will continue at a rapid rate under most storage conditions, and in a relatively short period of time the seed will be of little value for planting.

Quality control is a continuous process. It must furnish insights into all aspects of a seed business. The cleaning and processing procedures should be monitored. Regular checks should be made where problems are likely to occur and these may be different for different kinds of seeds.

Storage is an area often overlooked. Many seedsmen assume that once seeds are stored no further problems will occur until seed are moved. This is not necessarily the case. All seed are not stored in the same condition. Although these differences may be slight, they may become magnified in storage. Weather conditions change; thus storage conditions may change with the weather. A small amount of high moisture seed may have an adverse affect on a much larger quantity of seed at the proper moisture level. Observations of changes in seed quality during storage may be of great value in locating problems, planning changes in storage facilities or planning new facilities.

What are some of the tools that might be employed in a quality control program?

1. Moisture testing: This information is necessary for harvesting, processing, and storage in order to reduce damage and retard deterioration as much as possible.

2. Mechanical damage evaluation: Mechanical damage may occur throughout harvesting and processing. Incident and severity of mechanical damage adversely affects thequality of seed and adversely affects performance. Because of these advers effects, mechanical damage should be held to a minimum.

Table 2. Effects of mechanical damage on the germination of acid delinted cottonseed.

Lot No.	Germination Composite	Uncut	% Increase	Minor Damage	Major Damage	% Damage
1	78.5	88.0	9.5	77.0	34.0	8.5
2	70.5	81.0	10.5	66.0	40.0	10.5
3	82.0	84.0	2.0	76.0	43.0	10.5
4	75.5	85.0	9.5	89.0	50.0	12.5
5	80.5	86.0	5.5	72.0	35.0	16.5
6	76.5	92.0	15.5	70.0	37.0	17.5
7	71.0	80.0	9.0	72.0	16.0	17.5
8	83.5	92.0	8.5	75.0	45.0	18.5
9	67.5	88.0	20.5	57.0	21.0	19.5
10	82.5	89.0	7.5	87.0	37.0	20.5
11	70.0	87.0	17.5	82.0	47.0	24.0
12	79.5	89.5	10.0	68.0	33.0	26.5
AVG.	76.5	86.8	10.3	74.2	36.5	16.9

Table 3. Effects of severity of mechanical damage on the performance of acid delinted cottonseed.

Seed Damage Classification	% Std. Germ.	% Seedling Emergence Sand Test	Cold Test
Uncut	95.1	94.1	70.8
Pin-Hole	93.4	85.8	57.0
Minor	86.4	71.9	43.4
Major	63.0	44.4	28.0

3. Germination testing is basic in any quality control program: Certain lower limits must be surpassed before seed can be considered marketable.

4. Additional quality evaluation techniques: Since it has been repeatedly demonstrated that standard germination tests alone are not adequate measures of seed quality, some other measures of seed quality should be employed in a quality control program. The type of test will vary depending upon your objectives. The cold test is quite widely used for corn and to a lesser extent for several

other crops. The tetrazolium test and other enzyme tests may be applied to a quality control program. Growth rate measurements may also serve a purpose. Accelerated aging may serve to predict storability. It may be necessary to employ a combination of tests to fit a particular need.

5. Purity analysis is routine in the seed testing procedure: This can also be extremely valuable in determining processing procedures.

6. Weight per bushel or other density measurements can be of value in determining seed quality. Generally, as density increases seed quality increases.

These are some of the measurements of quality that might be employed in a quality control program. There are others. Many seedsmen have their "pet" ways of measuring seed quality. These vary with the species in question. Some have proved successful over the years and should be retained as long as they fit the need.

The complexity of organization of a quality control program will vary from one company to another. Costs and personnel required is also dependent on company size and complexity. Details must be tailored to fit particular needs. Standards must be established that fit individual needs and that are workable.

Value of Quality Control:

Most seedsmen look first at the expense involved in initiating or upgrading a quality control program. In many instances existing procedures may require only better organization. Some techniques can be included without additional personnel and at little increase in cost.

Quality losses are avoidable with little or no additional costs. Proper equipment adjustment or changes in processing technique provide basic means of upgrading quality. Others may be avoided with small expenditures such as equipment modification, adding accessory parts to equipment, using pallets in warehouses or changing bag types. Still other quality losses may be avoided only where costs exceed returns.

Small losses over extended periods of time may result in large losses of dollars when considered as a whole. These are some of the things that a well organized quality control program will reveal to a keen manager that are often overlooked. Quality control should be applied to the overall operation; otherwise, its value is severely limited.

What can be expected from a quality control program?

1. A Better product.

2. Greater profits by reducing losses.

3. Satisfied customers.

4. Repeat customers.

A quality control program is a management decision. As you begin the 1970's, ask yourself: without an effective quality control program, where will I begin the 1980's?

BASIC SEED CLEANING

A. H. Boyd, Jr.[1/]

Basic is defined by the dictionary as "essential" or "fundamental" and surely basic seed cleaning is the fundamental or essential step in preparing seeds for market or for additional specialized processing. Management must not be neglected at any point in the processing job.

Some management factors are concurrent with basic cleaning are:

1. Identification of the seed lot

2. Prevention of mechanical mixtures

3. Identification of the processing problem

These must be accomplished before we can tackle the nuts and bolts problem of seed handling.

After we have identified the problem, only then are we prepared to do even the most rudimentary basic cleaning. Now we are ready to attempt removal of trash, weed seeds, other crop seeds and inferior seeds of the same crop.

Obviously it is time to more clearly define basic cleaning. As the communists insist that all men are equal but by their actions they declare that some are more equal than others, so some cleaning processes are more basic than others. For the purpose of our discussion let us define basic cleaning as ending with the air-screen cleaner and a basic processing plant as one having an air-screen cleaner and such accessory equipment as is necessary for proper operation. We realize that there are special plants that do not have an air screen cleaner, but this machine is the basic machine in the majority of operations.

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For most of us this is an acceptable premise for basic seed cleaning and we have belabored the point of fundamental and essential steps. This concept, while suggesting a minimum process, does not necessarily mean inadequate cleaning. Your ability to do an adequate job of cleaning with the basic machines will be related to:

1. The processing problem
2. The capabilities of the equipment
3. The capabilities of the operator
4. Economics

Basic seed cleaning must not mean poor or sloppy seed cleaning. Sometimes operators have a tendency to say "oh, what the heck! What I miss here the next machines will take care of." You can't hope for others to "Bail you out." Aside from the fact that such an attitude will be apparent all through the processing plant if it is allowed at this point, sloppy ineffective cleaning can leave trash, sticks, pods, weed seeds, etc., in the seeds which may prevent subsequent cleaning and sizing machinery from doing the job they were designed for. Even if such material did not prevent effective performance of the other machinery the mere presence of the additional material that should have been removed will reduce the capacity of the processing line by forcing these machines to handle material that should never have reached that point.

To do the job of cleaning with the basic machines that will be required to meet the competition of the 70's it will be necessary for the operator to know the components of his equipment in detail and be able to operate these components so that they complement each other in obtaining the most efficient separation and capacity.

Let us look at some of the equipment in the basic processing line and comment on their function and operation.

Scalper

The scalper is very useful in a precleaning operation to remove excess trash, sticks, straw, etc. This machine usually has only a top screen and may or may not have an air system. The scalper's main function is to enhance the flowability of the seeds and reduce the bulk, thus helping increase the capacity of the air-screen machine. Of course the scalper is useful in removing the same materials before drying or storage if such steps are necessary.

Huller and Debearder

These are mentioned together since we do not have time to elaborate on their detailed operation but simply to point out that their function is to change the physical characteristics of some part of the seed lot to make the air-screen separation possible or at least more effective. This also points up the fact that with basic cleaning as well as more elaborate processes it is important to identify the problem for a sound decision on the processing flow air-screen cleaner.

Air Screen Machine

The air-screen machine is manufactured in many sizes, capacities, and screen configurations. All are essentially the same in principle of operation so we will quickly review some of the salient points the operator must check for efficient operation. For our review we will assume that the cleaner has 4 screens and is equipped with top and bottom air.

Parts and Their Function

Feed hopper

Gives a uniform feed rate evenly distributed across the width of the screen. There are several specialized feed hoppers for specific feed problems.

Top air

As the seed are discharged from the feed hopper a blast of air is pulled through them to remove light chaff, hulls, etc. Any material that can be removed without removing good seed will aid in capacity because of reduction in bulk that would otherwise be handled by the screens. This is not an extremely precise separation since size is a factor and no sizing has been done as yet.

Top scalping screen (1st screen)

The function of this screen is to remove materials larger than the seeds such as pods, stems and sticks not removed by the top air. It further reduces bulk for more effective separation farther down the flow.

Top grader (2nd screen)

This screen removes the weed seeds and foreign material smaller than the good seeds. This screen has the smallest opening of any screen in the cleaner.

2nd Scalper (3rd screen)

This screen removes the material only slightly larger than the good seeds. In practical operation it is almost always necessary to accept loss of some of the largest good seed for an acceptable cleaning job.

2nd Grader (4th screen)

The openings in this screen are only slightly smaller than the good seeds as with the 2nd scalper it will almost always be necessary to lose some good small seed to get an acceptable cleaning job.

The manufacturers of air-screen cleaners offer an amazing array of screen perforation sizes and shapes as well as wire mesh screens. They also offer hand screens to help you work out your processing problem without too much disassembly and reassembly of equipment. Use of these aid in reducing down time since the screens can be selected for the next lot while one is running.

We have not even touched on such things as screen tilt adjustment, screen dams, clay crushing rolls, cross slot screens, etc., but it is important for an operator to be familiar with operating techniques and accessories to overcome problems as they arise in the processing plant.

A good job of balancing all the problems inherent in processing a seed lot to this point will often result in a finished product acceptable to the trade. However, there are limitations to all machines and it is essential to a profitable operation that you recognize these limitations. Some separations that are possible with the air screen machine may not be practical due to low capacity or excess loss of good seed while other machines can make the separation effectively.

Therefore, it is also important to a good efficient operation to know when to quit and let the next team take over.

COMPLEMENTARY SEED CLEANING

Charles E. Vaughan[1]

Processing is a vital stage between the producer and the user of seed. Most field-run seed have trash, inert material, weed seed or other crop seed in them that would make them illegal to sell, or at least difficult to plant. They are in no condition to be planted, and are not desirable from the buyer's standpoint. Seed processing is the step between the seed producer and the distributor which takes seed as they come from the field, removes undesirable material, and puts them into condition for marketing and planting.

The first actual cleaning and upgrading step is the basic cleaning operation. The air-screen machine is probably the most common basic cleaner. It makes both size separations and aspirates the seed. Seed lots may come from the field in good condition with few contaminating seeds, and will require only cleaning on the air-screen machine.

However, it is usually necessary to send the seed over one or more special separating or upgrading machines to remove a specific contaminant. These complementary machines separate different crop seeds, or crop seed and weed seed according to their differences in a physical seed characteristic. To be separated completely, the crop seed and the weed seed must differ in this physical characteristic widely enough so that the machine can distinguish between each crop and weed seed.

WIDTH AND THICKNESS SEPARATOR

The first complementary seed cleaner to be considered is the width and thickness separator. Width and thickness, as special size dimensions, are used in several specialized operations. A common use is to size hybrid seed corn into specific widths and thicknesses for space planting. Several seed separations are also made using width and thickness sizings. Width or thickness separations are made by turning the seed on edge or standing it on end to present it's width or thickness dimension to a sized perforation. If the seed is below a certain width or thickness, it will drop through the perforation; if it is above a selected width or thickness, it will not go through the perforation and will be routed out a different discharge spout. A thickness separation is made by passing seed

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over a circular or flat surface in which grooves are pressed into the sheet metal. Slotted perforations are in the bottom of these grooves. The shoulders of the grooves turn the seed on edge. When seeds are presented edgewise to the slotted perforations, thin seed fall through, while thick seed are rejected and ride out a separate discharge spout.

Width separations are made by perforations at the bottom of indents or cup-like depressions. The shoulders of the cup-like indent cause the seed to tilt and stand on end, thus it must present its width dimension to the perforation. If the seed is narrow, it drops through the perforation; if it is wider than the perforation, it is rejected. A series of width and thickness separations can be combined in a single machine to produce several different width and thickness grades in the same operation. For example, corn seed can be graded into different flat and round sizes.

Rice processors in the southern region of the United States also use these machines to separate red rice, a noxious weed, from varieties of long grain rice. Other common uses of width and thickness separators include: (a) the removal of splits from soybeans, edible beans, and peanuts; (b) the removal of chips and splits from sorghum seed; (c) the removal of cheat from wheat; (d) the removal of cockleburs from cottonseed, wild onion from fescue, and the removal of wild oats from barley. Other agricultural, but non-seed, uses include size-grading of barley, oats, wheat, nuts and coffee beans for quality factors important in the feed, food or milling industries.

LENGTH SEPARATORS

The second group of complementary seed cleaners to be considered are the length separators. Length differences are common between different crop seed and between crop and weed seed. Many processors use length separations to upgrade and improve their seed. The indented cylinder separator and disc separator are widely used to make length separations.

Indented Cylinder:

The indented cylinder separator consists of a long round cylinder whose walls have thousands of small indents. Inside this indented cylinder are other parts that help the indented cylinder make a separation. These will be an auger or other means of keeping the seed mass level, a liftings trough to remove short lifted material; and an auger to remove lifted seed from the lifting trough.

An end view of the indented cylinder shows the mass of seed inside the cylinder. As the cylinder turns the seed mass turns so that each seed has an opportunity to fit into one of the indents and be lifted. The relationship of the length of the seed and location of its center of gravity to the depth or size of the indent determines whether the seed will be lifted. Long seed will not fit completely into the indent, and as the cylinder rotates they fit into the indents but do not remain in the indents long enough to be lifted. Seeds intermediate in length will be lifted slightly above the edge of the seed mass by the indents. Shorter seed will be lifted higher up the arc of the cylinder's rotation. Therefore, the length of the seed determines the degree to which they fit into the indents. Seed that fit into the indents are lifted up as the cylinder revolves. Shorter seed are lifted higher in the arc of the cylinder's rotation; longer seed fall out sooner.

Mounted in the center of the revolving indented cylinder is a trough with an edge that can be moved up or down to allow seed lifted to a different level to be carried over and dropped into the trough. Seeds not lifted up past the edge of this trough fall back into the seed mass in the cylinder and are discharged out the end of the machine.

A seed's length determines how it fits into the indented pockets in the wall of the cylinder. The location of the seed's center of gravity also effects the seed's fit into an indented pocket. A round, short seed whose center of gravity is near one end will not be lifted.

Indented Disc:

The disc separator also separates seeds by differences in length. A disc is a cast iron wheel with many small undercut pockets cast into each face of the disc. As the disc turns through a mass of seed, each seed will have an opportunity to fit in one of these pockets. If the seed is too long, it will fall out of the pocket. If the seed is short, it will sit inside this pocket and be lifted out of the seed mass. Lifted seed are carried up and deposited into a separate discharge spout.

There are square shaped pockets to make separations between different crop seeds; pockets with rounded lifting edges to lift round seed types and pockets with flat lifting edges to lift flat-sided or rectangular seed.

The heart of the disc separator is a revolving shaft on which many different discs are mounted. The seed mass enters the machine at one end, and moves through the center of the discs and comes in contact with the pockets on the side of each disc. These pockets reject or lift out seed as the mass moves through the machine. By using several sections of discs with different pocket sizes on the same shaft, several different length grades can be made as seed pass through the machine.

Uses of Length Separators:

The range of each type of machine is wide, and these ranges overlap, giving rise to the question, "Which type of machine should be used?" The answer depends on several factors. However, generally speaking, lightweight seeds, whose bushel weight is less than 45 pounds cannot be separated as efficiently as heavier weight seed. For this reason the cylinder is more practical to use with small grains, corn and soybeans rather than with grasses. Corn, soybeans and similar seed which might wedge in the pockets should not be cleaned in a disc. An explanation of the principles used by each separator in effecting its separation may help answer the question "Which machine should be used?"

Both disc and cylinder separators effect separations on the basis of length, but the principles involved in obtaining results are somewhat different. The disc lifts uniformly shaped and sized undersize particles out of a mass of seed. The machine's speed is relatively constant--it can be varied only a few RPM from its normal setting or the efficiency of the separation is affected. A disc separation is not affected by seed-coat texture, weight per bushel, or moisture content.

Cylinder separators perform similar separations but in a different manner. Cylinders operate on the centrifugal force principle, in which the speed of the cylinder holds seed in the indents, lifting them out of the mass until the indents are inverted to the point where gravity causes the particles to fall. Shape and size of the indents, seed-coat texture, moisture content and weight of seed all combine to affect separation.

Both the cylinder-type and the disc-type machines have their advantages and disadvantages. One advantage of the cylinder-type separator over the old model discs is the rapidity in which the cylinders can be changed. Only a few minutes are required for changing cylinders in most of the cylinder separators. In the old model discs, all the discs have to be unbolted and the shaft slipped out and sometimes several hours are required to change discs. However, in the late model disc separators, the top cover can be removed and the discs and shaft lifted out as a unit.

An advantage of the disc separator is that it is possible to have several different sizes of pockets in the same machine. With this arrangement, a number of separations can be made without having to make changes. Also, with a combination of different sizes, it is possible to make several separations in one operation.

The cylinder separator is more effective for such jobs as oat sizing, rice sizing, length grading of hybrid corn, and separating minute quantities of contaminating material such as traces of dock or sorrel seed in orchardgrass of fescue seed. The disc separator can be used to an advantage where a large mass of material is to be lifted. An example would be the separation of a small amount of Canada thistle from alsike clover. The disc separator is also widely used for removing elongated particles of foreign material such as sticks, stems and straws from seed.

As to comparative capacities, each type of length grader has its own advantages, but in the field for which the disc separator is found to be particularly suited, capacities of the disc type have been found to be much greater.

These, then, are some of the machines available to the seedsman to complement the basic seed cleaning done by the air-screen cleaner. Often the basic cleaning and further processing by one or more of these machines will remove all contaminants in a seed lot. When this is the situation no further seed cleaning is necessary. However, since these machines only make separations on the basis of certain definite seed characteristics, futher processing may be necessary with other special seed cleaning machines.

IMPROVING SEED QUALITY BY PROCESSING

Charles E. Vaughan[1/]

Often the stage is reached in the processing of seed where all of the contaminants, such as weed seed, other crop seed and inert material have been removed. At times, however, the quality of the seed lot may still be below par because the germination percentage is sub-standard or for other reasons. In such situations the processor may still have several possibilities for improving the overall quality of the lot.

One way in which the quality of a seed lot can be improved is by the use of a specific gravity separator. There has been much research work lately that has shown that there is a close and consistent relationship between specific gravity and viability and vigor. For example, Bill Gregg of our staff and Gordon Tupper at Texas A & M has shown that gravity grading can be used to great advantage in upgrading quality of cottonseed.

Bill Gregg worked with nineteen lots of acid-delinted cottonseed, including nine varieties grown in six states. These were gravity-graded into ten fractions each, according to discharge position from an Oliver Model 160 gravity separator. Twenty physical and biological measurements were made on samples from each position to determine their interrelationships, the effectiveness of the gravity separator in upgrading seed quality, and to identify and characterize associations between specific physical and biological seed parameters.

The gravity separator graded the seed into fractions according to differences in volume and total weight of individual seed, which appeared to be the majorfactors contributing to bulk density. Differences among the fractions were most easily measured in terms of their bulk density (weight per bushel). Seed of lowest bulk density discharged from the lowest side of the deck, and bulk density increased as sample or discharge position moved toward the high side of the deck.

Viability and vigor, as indicated by germination percentage of both untreated and treated seed, cold test reaction, field emergence, 3-week field survival, and accelerated aging response, followed the same trend as bulk density, i.e., lowest germination-emergence was obtained from the lightest bulk density seed discharging at the lowest side of the deck, and increased as discharge position moved toward the high side of the deck, in porportion to the increase in

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bulk density. The only difference was a slight decline in germination-emergence of the heaviest fraction of seed discharging from the highest position on the deck. Bulk density was positively correlated with the various germination-emergence parameters. Specific gravity and compatibility of the seed were not closely correlated with the other test parameters and varied only slightly with sample position.

Average length of seedlings and dry weight of radicle-hypocotyl axes and cotyledonary leaves 7 days after planting, generally increased with increasing bulk density and germinability, but correlation values were not consistent with those of germinability or bulk density.

Free fatty acid content was highly and negatively correlated with both bulk density and germinability. It was higest in seed from the low sample positions and decreased to minimal values in seed from sample positions 8 to 9. There was slight increase in free fat acidity in seed from sample position 10, corresponding to the slight decrease in germinability of seed from that position. Seed from different lots with a given free fatty acid content varied considerably in germinability; however, a high fatty acid content was consistently associated with low germinability and bulk density, vice versa.

Incidence of mechanical injury was highest in seed of low bulk density from the low side of the gravity separator deck, and declined to a minimal level in seed from sample positions 6 to 8, after which it slightly increased. However, the percentage of injured seed among sample positions did not parallel either bulk density or germinability closely enough to produce high correlation coefficients.

Based on his results, Bill Gregg recommended that all acid-delinted cottonseed with bulk density below 42 pounds per bushel be rejected during gravity grading of a seed lot and diverted to commercial use. In this manner, the accepted fraction of the lot would generally germinate above 80%. For higher quality seed the rejection point should be about 44 pounds per bushel, and the very heaviest seed discharging from the extreme high side of the gravity separator deck should also be rejected.

Gordon Tupper's work revealed generally the same information; however, he did point out two other ways in which gravity-grading can improve seed quality. First, the heaviest seed within a gravity group gave consistently higher yields than the lightest seed in that group. Second, seed density exerted a strong influence on the earliness of germination. High density seed, on the average, emerged first. It has also been shown that the first seed to emerge contribute more to yield than those that emerge later.

The trends reported here with cottonseed have also been found with other crops. For example, two of our graduate students, Ernie Flint and Billy Rainey, have found that significant increases in germination percentages could be obtained in sorghum and millet with the use of a specific gravity separator.

Another machine that can be used to great advantage for improving seed quality is the air separator. Air separators are widely used in seed processing as separate systems or structurally incroporated in other cleaning devices. Indeed, air separation systems have been so well integrated in other separators that they have almost lost their identity. The basic seed cleaner, the air-screen machine, has one, two, three or more air systems that assist in the separations made on the machines.

Air separators - as considered here - can be classified as pneumatic separators, aspirators, and scalping aspirators. Although these tree types of air separators are different in appearance, they utilize tha same principle of separation.

Air separators are used in three different and distinct ways:

1. General cleaning: Air separators are widely used to clean seed by removing dust, chaffy inert material, pices of broken seed, immature and shriveled seed, and other light contaminating material. Air systems in an air-screen cleaner perform this type of general cleaning operation.

2. Specific seaprations: In some cases an air separator can be used to remove a specific contaminant that was not removed in previous cleaning operations. The seed mixture should be closely pre-sized before the air separation is attempted.

3. Close grading: Air separators are used to "grade" seed for density or volume weight. Removal of light weight seed or insect damaged seed from grass, grain, vetch, or cottonseed increases bushel weight (volume weight) and may upgrade germination. The effectiveness of this separation depends on the purity of the seed to be upgraded. For best results the seed should be thoroughly cleaned on other machines before the final air separation is attempted. It is this close grading that offers the greatest possibilities for improving seed quality.

In a study several years ago the air separator proved to be an effective machine for improving the germination of various clover seed lots. Specific gravity, as determined by an air separator, was consistently related to viability. An increase in specific gravity of the seed was accompanied by an increase in germination percentage. The range in average germination percentage from seeds of low specific gravity to seeds of high specific gravity was as follows for the different crops in the study: red clover 15.9 percent, white clover 29.3 percent, and crimson clover 30.0 percent. The greatest difference in germination percentage between any two specific gravity groups always occurred between the lightest and next heavier specific gravity group.

The electric color sorter is another machine that can be used in improving seed quality. Mr. A. H. Boyd, Jr. of our staff has done a lot of work in determining the potential applications of electric color sorting in seed technology. He determined that electric color sorters have potential application in three area of seed processing: research, purification of seed stock, and upgrading seed quality. He reported specific data in five different applications to show that the color sorter is an effective tool in upgrading seed quality. These are:

Damaged corn seed:

Four lots of corn seed - two white seeded and two yellow seeded - were mechanically damaged by passing the seed through a Crippen Model Scarifier. After mechanical treatment, 5-pound samples of each lot were briefly soaked in a 0.1 percent solution of fast green to stain damaged areas on the seed. The effectiveness of the color sorter in separating the mechanically damaged, stained seed from undamaged, unstained seed was then evaluated.

Standard germination percentage of the acceptable (undamaged) seed was 1 to 6 percent higher than that of the composite, and 5 to 21 percent higher than that of the rejected seed. The effectiveness of color sorting for removal of damaged seed was even more evident when cold test germination results were considered. The accept fraction had a cold test germination 22 to 29 percent higher than the reject fraction. These data indicated that color sorting after pretreatment of the seed with fast green was effective in removing mechanically damaged seed, and upgrading both standard and cold test germination percentage.

Mechanically damaged soybeans:

A lot of Lee soybeans was obtained from Foundation Seed Stocks at Mississippi State University. These seed had been damaged at harvest by excessive threshing cylinder speed. Normal processing procedures could not remove the seed with cracked seed coats, broken cotyledons and fractures extending into the cotyledons. Also, there was not enough color difference in the damaged areas for detection with electric color sorters. To induce a color difference the seed were immersed in a solution of indoxyl acetate, removed immediately to an electric dryer where ammonia fumes, introduced into the intake air stream of the dryer, developed a blue-indigo stain on the damaged areas of the seed.

After drying the seed were processed on a color sorter to remove the stained seed. Germination percentages of the original and stained seed before sorting indicated a reduction in germination of 12 percent. This reduction was caused by the staining and drying processes. The damage, however, appeared to be more attributable to seed coats sloughing-off from wetting and drying than to any toxic effect of the indoxyl acetate. After electric color sorting the "accepts" germinated 98 percent and rejects germinated 36 percent.

Green seed from Lee soybean seed:

Four lots of Lee soybeans that contained 18 to 36 percent green colored seed was obtained from seed stocks in the Seed Technology Laboratory. Seed of Lee are normally buff colored but in some seasons some of the seed of Lee and other varieties retain a green color in the cotyledons. It is not known what prevents the cotyledons of these seed from changing to the normal light yellow color during maturation.

The green seed were separated using a color sorter and germination tests were made to determine if there was any difference in the quality of the green and normal colored seed. The normal buff colored seed germinated 22 to 32 percent higher than the green seed. These results indicated that there is a pronounced difference in germinability of the buff colored and green seed, and that a color sorter can separate them and upgrade germination.

Weathered cowpea seed:

Two lots of cowpeas were obtained from Foundation Seed Stocks, Mississippi State University. One lot, Bunch Purple Hull, a white seeded variety had been moderately weathered, while the other lot, Mississippi Silver, was more uniformly damaged by frequent showers and humid weather at harvest time. Both lots failed to meet minimum germination standards for foundation seed (80 percent).

Weather damaged seed were removed from both lots and germination tests run on each separate. The germination of the Bunch Purple Hull lot was increased from 68 to 84 percent with a loss of 34 percent of the lot, and qualified as foundation seed. Germination of the Mississippi Silver lot was increased only 6 percent with a loss of 28 percent of the lot. Thus, it did not meet standards even after sorting. The electric sorter performed well where there was a visible difference due to weathering. However, when weathering was severe and uniform, effective separation was not possible.

Deteriorated clover and alfalfa seed:

Lots of crimson clover and alfalfa seed were separated into three fractions in two passes through a color sorter. In the first pass the lightest colored seed (light) were rejected. The accept fraction was further divided in the second pass into rejcts (tan seed) and accepts (brown seed).

Germination of crimson clover seed was increased by 8 to 18% over the composite at the expense of seed losses of 24 to 42 percent. The light colored seed separates germinated 30 to 67% higher than the brown seed separates. Color sorting alfalfa seed increased germination by 11 to 20 percent over the composite at the expense of seed losses of 26 to 49 percent. The light colored seed separates germinated 21 to 67 percent higher than the brown colored seed separates.

The electric color sorters can be a valuable tool for research and commercial processing. They are extremely versatile and accurate when operated properly. Their principle disadvantages are high cost, low capacity, and the need for some specialized trainig for operators.

A successful processor, then, should look beyond the removal of contaminants in normal cleaning operations to operations that will help in improving the overall quality of the seed.

MANAGING THE PRODUCTION OF HYBRID SEED CORN FROM SEED FIELD TO SEED BAG

Owen J. Newlin[1/]

I have been asked to speak to you about managing the various activities and operations involved in the production of hybrid seed corn. Throughout the discussion of some of the practical aspects of these operations, I shall assume that the seed is being produced in the Midwest and that freezing temperatures will occur in early October. In relation to the theme of this Short Course "Seeds for the 70's", it has been suggested that I comment on possible changes in methods, procedures, and equipment for producing hybrid seed corn in the future.

Managing the production of hybrid seed corn from seed field to seed bag primarily involves three basic factors: 1) the quantities of seed needed by hybrid; 2) the quality standards which have been specified; and 3) the budgeted production costs per bag as influenced by the quantities needed and the quality standards specified. The main objective is to prooduce the requested number of bags of seed by hybrid with seed quality equal to or above the standards specified at budgeted production costs per bag...which avoid spending money for seed production operations that do not result in giving economic value to the customer.

Planning:

The quantities of seed by hybrid needed may be established from joint meetings of sales, service, research, production and management personnel. From these discussions sales requirements are translated into specific quantities needed by hybrid. Hybrids are usually grouped by maturity so that there is a balance of quantities needed for each maturity area. Once the needed quantities of each hybrid are established, production management personnel then calculate the required female and gross acres. In making this calculation, good records of past hybrid performance with respect to yield per acre, size-out by kernel size, and bags of seed per female acre are extremely important.

Seed acreage can then be allocated to the various production units depending on their bushel capacities, their growing areas, and the relative maturities of the hybrids to be grown. The production units usually have the responsibility for contracting with farmers to produce the seed acreage that has been assigned to them. Contract

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[1/] General Manager, Pioneer Seed Division, Des Moines, Iowa. The speaker acknowledges associates in the Pioneer Seed Division, Robert W. Dahlberg and Donald Lininger, who assisted in preparing the contents.

terms for various hybrids are established and usually set at a level that will provide the grower with an equitable income plus a reasonable incentive for producing seed corn. The wide variation in yield between inbreds, sister-line crosses, and single crosses used as seed parents makes the job of determining contract terms difficult. There are two common contracts. One provides for compensation to the farmer on the basis of the bushels of seed he delivers to the seed plant. The other contract compensates the farmer at a specified dollar rental fee per acre. In both cases the grower is responsible for growing the crop of corn and performing the necessary tillage, planting, and harvesting work that he would do for a field of crop corn.

Seed Field Corn Growing Program and Specifications:

An agronomist usually assumes the responsibility for the contracting arrangements. The grower agrees to a specified corn growing program which has been outlined by the agronomist. This includes the kinds and rates of application of fertilizers, insecticides, and herbicides. Isolation requirements for the seed fields are discussed and agreed to. Specifications for male and female row ratios, populations per acre, and planting dates are agreed to. The corn growing program and seed field specifications are probably the most important factors in the production fo hybrid seed corn. The highest achievable yield of high quality seed is the goal. The compensation to seed growers represents a high percentage of the total cost of each bag of seed produced.

The performance of the seed grower and the productivity experience from his farm over a period of years greatly influence the quantity of seed that is produced each year. Both the seedsman and the grower benefit from consistently good yield experience.

Planting:

Timely planting of seed fields in early May is a very important factor in minimizing the probability of freeze damage in the fall, and in making early harvest possible. Also,higher seed field yields are usually correlated with early planting. Many hybrids require delayed planting of either the male or female parent to achieve a good pollination nick. Timing of a delayed planting is very important, and accurate records of shedding and silking dates of each seed parent are vital in achieving good nicks and resulting yields.

Roguing:

The removal of off-type plants and volunteer corn needs to be timed for each field to maintain the genetic purity of the seed at the lowest cost possible. Normally, roguing of seed fields can be done better and with less expense if it is done before the corn is shoulder high. The number of times to rogue a field and when each field should be rogued are imporatnt decisions with respect to both quality and cost. Good supervision of the crew doing the work is the key to a successful roguing operation.

Detasseling:

As with roguing, supervision is the key to successful detasseling. This includes all levels of supervision from the plant manager to the crew foreman. Planning ahead for detasseling with respect to recruiting of labor, preparing equipment, lining up transportation, tagging of the seed fields, are all important to keep the operation working smoothly. Again, the objective is to preserve the genetic purity of the hybrid and to do the job at the lowest cost possible.

Timing is the critical factor in getting the female tassels pulled before the female silks are receptive, and keeping the percentage of shedding female tassels below established maximum levels for the balance of the season. Availability of labor in the area of the seed fields and unfavorable weather in the form of rain and mud contribute to the difficulties involved in detasseling. Foot crews, machine crews and contractors are all used by the industry. Many seedsmen have either eliminated or greatly reduced detasseling by use of restorer male parents and male sterile female parents.

Harvesting:

The entire harvesting operation should be geared to achieving maximum drying bin utilization. Successful management of the harvest operations means keeping the drying bins full of seed corn being dried. Insuring that filling bins is not a limiting factor involves having an adequate number of pickers, an adequate number of trucks, a smoothly running unloading and sampling facility, a balanced husking capacity, and an adequate number of sorters.

In addition, shelling, conveying the shelled corn, storing the shelled corn, and disposing of cobs and husks should run smoothly with adequate capacities so that emptying the drying bins is not a limiting factor. A desirable goal to maximize bin utilization is to have the capacities balanced so it is possible to fill or empty a drying bin in one to two hours, depending on the bin size.

It's desirable to be able to fill from 40 to 50 percent of the drying bins in one day, in case there has been a delay in harvest because of rain and mud. Thus, it should be possible to fill all the drying bins in about two days to minimize the loss in drying capacity caused by rain. In order to achieve some of these goals, additional capital investments are often needed to improve present facilities.

Loss of seed in the field is a serious problem with inbred ears and relatively low yielding females. Adjustment of pickers and slower operating speeds can sometimes help. The period from September 15 to October 6 is normally free from freezing temperatures, but the entire harvesting operation is a race against time to harvest the seed crop before freeze damage occurs.

In harvesting seed corn, many factors can affect the quality of the seed. If the seed is harvested at too high moistures, the cold test performance may be affected on certain hybrids. Usually 30-32% kernel moisture is a safe level at which to begin harvesting. But this must be weighed against the risk of freeze at the end of the season because seed quality is also affected by how long seed is exposed to wet weather and freezing temperatures as well as the incidence of ear diseases.

Husking and Sorting:

Husk removal from hybrids with tight husks may take more sorters and time, reduce the flow of corn, and reduce harvest capacity. This can be a serious problem. Also, special disease problems may occur, requiring extra care in sorting and discarding moldy, damaged, or wet ears. This, too, can reduce the volume which can be handled. The successful management of these operations involves maintaining volume without sacrificing quality.

Drying:

The management of drying is important to both quality and capacity. Temperatures must be carefully controlled according to standards which vary with the moisture of the seed.

The most commonly used drying system for seed corn is the two-pass system. The air from the fan at 110°F or 115°F is passed through a partially dry bin into a tunnel, and this second pass air then goes up through a freshly filled bin and is exhausted outside. Once thepartially dry bin is dried to about 12%, the doors are closed, and the air reversed so that the air with the highest temperature is always being used on seed with the lowest moisture. A one-pass system is also used by some seedsmen.

Maximum capacity is achieved by maintaining the heated air temperature at the upper limit. Air reversal in the two-pass system needs to be timely to minimize over-drying. Remote temperature sensing and recording equipment utilizing a potentiometer and remote measurement of static pressures to estimate air volume are efficient and effective aids in the management of the drying operations.

Shelling:

Specially modified shellers are used to minimize damage in removing the kernels from the cob. It is important to feed the sheller adequately and uniformly. Based on cold test performance, as much damage occurs in the shelling operation as in all other handling activities put together.

After the seed is shelled, some type of bulk storage is usually needed to hold the shelled corn prior to cleaning and sizing. This bulk storage should be adequate so that it does not limit shelling and the emptying of drying bins. The bulk storage facilities should provide high levels of aeration to remove heat from the recently dried seed corn.

Cleaning and Sizing:

The primary purpose of sizing seed corn is to separate the shelled corn into kernel sizes on the basis of the dimensions of width, length, and thickness so they can be planted with the major brands of corn planters. The proper selection of equipment and screens can influence the quality of seed and the percentage of the total seed produced that is put into the seed bag. It is important to remove as high a percentage of moldy, cracked, and damaged kernels as possible from each seed lot.

The basic equipment for this job consists of air and screen cleaners, cylinder sizing equipment to separate for width and thickness, cylinder length sizers, and gravity separators to remove moldy and damaged kernels.

At this point I would like to state the case for using the word "sizing" instead of "grading". We separate the shelled corn according to size of dimensions of width, thckness, and length, and therefore from sizing we obtain kernel sizes. Grade usually refers to quality, such as No. 1 or No. 2 grade corn, and the word "grading" is a misnomer when applied to sizing seed corn. For these reasons I suggest you use the words size, sizing, and kernel sizes, instead of grade, grading, and grades.

Quality control samples should be taken on a scheduled basis to determine the performance of each machine while the equipment is operating. Quality control counts on the percentages of moldy and damaged kernels in each lot should also be made on a regular basis. Plantability tests on each kernel size of a lot give the ultimate measure of the performance of the sizing operation. Samples of the final treated kernel sizes should be taken for conducting warm test and cold test germination.

The handling of shelled corn and seed through the sizing system is very important. Wherever possible, rubber conveyor belts, slow speed self-cleaning elevators, and special spiral let-down devices which eliminate long drops of seed into bins should be used to minimize kernel damage.

Cleaning and sizing facilities should have flexible capacities. To give maximum efficiency of the labor force running the sizing operation and to achieve desired capacity, there should be sufficient flexibility in storage bin combinations and machine capacities to allow the maintenance of a given volume of shelled corn when sizing seed from small-seeded seed parents as well as seed from large seeded seed parents.

Treating, weighing, and bagging facilities need to have capacities which accommodate the sizing flow from either the small-seeded parents or the large-seeded parents. With a flexible sizing system, all operations can be balanced and managed so that they work smoothly.

Once the seed is bagged and palletized, it must be moved out promptly to a place where it can be stored in an orderly manner. If bagged warehouse capacity is limiting, this can cause delays and inefficiencies in the entire sizing operation.

The treating operation requires attention to assure that a uniform application of fungicide is applied at the proper rate. Seed appearance can be enhanced by good treating practices. Daily charting of the application rates help provide control over this operation. The seed is usually put in bags through automatic weighing equipment, and in some cases, automatic bag hangers and automatic packaging equipment are used.

The selection of the bag can have an influence on the quality of the product. When the customer buys a bag of seed corn, he expects a good strong package that won't tear easily. The bag should also have resistance to moisture penetration in periods of high humidity. Labels need to be clearly legible and comply with the various state and federal regulations related to seed corn.

Warehousing:

Seedsmen usually warehouse the bagged seed for a period of time before it is delivered to salesmen and customers. Good bag warehousing practices and buildings can have an important effect on seed quality. We believe that palletizing bags of seed is an efficient and economical way of handling and storing seed corn. In this operation the key is a good fork truck operator. Usually one man operates the fork truck taking the pallets from the bagger to the warehouse. He makes the piles, moves them, and keeps inventory records. His performance can be the major factor in minimizing broken bags, loss of seed, broken pallets, and dirty bags.

Cold Storage Warehousing:

Most seedsmen cannot anticipate customer preference for hybrids precisely, nor can they predict how the weather will influence whether they will get the quantities of each hybrid as planned. For this reason, most seedsmen have a policy of maintaining a surplus at a desired level. This planned surplus needs to be handled properly to maintain its seed quality for distribution and sale the following year. In our operation, we feel it is important to warehouse this seed under controlled temperature and humidity conditions. Our cold storage warehouses are designed to maintain 50^{o}F and 55% relative humidity. One could use lower levels of temperature or lower levels of relative humidity, but the operating costs and the investment in buildings and equipment seem to indicate a reasonable balance at about 50^{o}F and 55% relative humidity. With single crosses, the value of the seed is much higher than in the past, and some seedsmen may decide to maintain 40^{o}F and 50% relative humidity. Hybrids differ in their ability to be carried over and utilized a second year. There are additional costs in cold storage warehousing, but in the long run the seedsmen and the customer benefit from having seed stored under favorable temperature and humidity conditions.

Shipping:

Shipping bagged seed to salesmen needs to be planned and scheduled for efficiency. It is importantthat all hybrids are available when shipping starts so it is not necessary to ship some hybrids short. Palletized procedures save both time and money in delivering seed to salesmen. Increased use of computers will improve the matching of inventories against sales needs, and will improve delivery instructions.

Production Research:

Research in production methods related to the production of hybrid seed corn both in the seed field and in the seed plant are vital to making continuous progress in the preservation of the inherent genetic capability of the seed. For many years Pioneer and other seed corn firms have conducted research in these areas. We have found it to be a very valuable program, not only in terms of maintianing and improving seed quality, but also in making our production operations more efficient and less costly.

Factors Which May Influence the Production of Seed Corn in the 70's:

1. The plateless planter which will plant any kernel size or unsized seed is having, and will continue to have, an effect on sizing procedures and marketing of seed corn. All the effects of the plateless planter are not yet known, but the introduction of these planters will have far reaching effects on the seed corn industry. They eliminate the need for planter plates to plant various sizes of seed corn, and make it possible for farmers to select a hybrid on the basis of the hybrid's performance instead of bein influenced by the kernel size available. During the transition from plate to plateless planters, a seedsman producing a special unsized seed lot for plateless planters will probably have increased costs since he will be adding another item to prepare, handle, and inventory.

2. In the future, the production of high-lysine seed corn will introduce new problems for seedsmen. Isolation requirements and the softer, lighter test weight seed may increase quality and handling problems.

3. Seed corn may be dried in the future by dehumidifying the drying air with a desiccant. One can speculate that using dehumidified air for drying of seed corn would allow the use of lower air temperatures and increase the capacities of existing drying buildings.

4. Those seedsmen with stationary dryers using the two-pass system will probably build concrete drying buildings when replacing old wooden building or when building new ones. Lower insurance rates and less fire hazard favor the concrete dryer.

5. Predicting when bins of seed corn will be dry based on airflow measurements, in-going and exhaust temperatures, wet bulb temperature of the heated air, initial moisture, and drying characteristics of the hybrids will occur in the 70's. With these predictions it would be possible to

project ahead 24 to 48 hours, and know quite precisely when a bin will be at 12% kernel moisture. This would permit closer scheduling of the harvest operation.

6. I expect an increasing number of new hybrids to involve sister-line corsses as female parents in order to get higher and more dependable seed field yields under varying environmental conditions.

7. In the 70's there will continue to be intensification of land use in seed corn production, particularly wth low yielding females where the entire seed field is planted to the female parent and male parents are planted in the centers of the rows and cut out after pollination.

8. The use of computers will continue to increase in all operations of hybrid seed corn production.

9. Automatic handling, packaging, and palletizing will increase in the 70's. Increased use of electronically operated bin controls and flow control in the entire sizing system could occur. Also, automatic sampling devices for taking quality control samples may be used in the 70's.

10. In the 70's more seedsmen are likely to build warehouses with controlled temperature and humidity to preserve the quality of the carryover seed. Considerations will be the higher value of the product with increasing amounts of single cross seed, and the importance of the seed reserves because of yield variability of inbred and sister-line females.

11. In the 70's, I anticipate that techniques for measuring seedling vigor and germination will be perfected and more widely used. The use of the cold test as an indicator of germination and seedling vigor under cold wet conditions in the farmer's field will be supplemented and perhaps replaced by techniques such as measuring glutamic acid decarboxylase activity and the accelerated aging test.

12. There may be improvements in shellers that further reduce damage to kernels when they are removed from the cob.

13. In the future, machines may be perfected to pull tassels. There is such a machine on the market today, and I would expect it to be improved in the future. Any operation such as detasseling which must be done with hand labor and at a specific time is likely to become more hazardous. Unless practical alternatives to present detasseling methods

are developed, the seed corn industry could be faced with serious problems in the future.

14. Changes in the container for seed corn may occur in the next 10 years. Increasing paper costs may force the seed corn industry to use plastic bags or some other kind of package.

15. In the 70's, more seed firms will be considering the use of insurance for freeze and hail damage because of the increased value of the crop and greater concentrations of acreage in order to achieve adequate isolation for the inbred and sister-line seed parents.

Summary:

We have discussed the operations in the production of hybrid seed corn from seed field to seed bag with comments on the practical aspects of capacity, flow, efficiency, and quality control. In line with the theme of this Short Course, some ideas on the effects of new equipment, new practices, and trends in the future have been presented. I hope some of them will be worthwhile to you.

We face the continuing challenge of rising costs in all production operations, and the need to discover new ways of improving seed quality and introducing efficiencies. These challenges have to be met if our companies are to continue to be profitable.

HOW TO CONVEY SEEDS TO MINIMIZE MECHANICAL INJURY

James M. Beck[1]

Since all of you are interested in quality seed and because most seed are considered fragile GIVE YOUR SEEDS A GENTLE RIDE . . . . wherever they're going.

MECHANICAL INJURY

Mechanical injury is a damaging thing that happens to a seed in a direct, positive manner. I think we can say that pressure is the big enemy in conveying seed. Anytime extreme pressure is applied we have damage. Place a seed under your foot and press, or slam one against a hard surface; the pressure exerted by your weight or the pressure from the change in velocity ruptures the seed and renders it useless.

Every time anything is required to change direction and velocity, a pressure is exerted on one side of it. The shock transmitted to a seed is in direct proportion to the velocity of the particle and object struck and the extremeness of the angle.

In order to reduce or eliminate damage to seeds, we must do two things: reduce velocity and change the direction of the material only as often as necessary.

The one thing most affecting the material being handled, as far as damage and contamination are concerned, is design of the complete conveyor unit including hoppers, discharge spouts, clean-outs and that part of the conveyor that comes in contact with the seed.

SEED CONVEYORS

The conveyor selected for any step in a seed processing line should: (1) minimize damage to the seed, (2) have adequate capacity to serve the receiving, processing or storage requirements, and (3) be self-cleaning or easily cleaned.

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[1] Mr. Beck is Engineer Technician, Seed Technology Laboratory, Mississippi State University.

Figure 1 shows a bean storage facility at Selkirk, Kansas, designed to meet these three requirements. The receiving, elevating transfer, distribution and outloading are handled by seven Beltveyor units. Beans are brought in by truck and dumped into an undertruck conveyor which feeds a tubular unit. The beans then go through a cleaner which dumps in a horizontal conveyor which carries the product to the bucket elevator. A shuttle-veyor distributes the beans into hopper bottom bins. Unloading is accomplished with a trough-veyor running underneath the bins which discharge into the tubular conveyor (which serves double-duty) to load trucks. A grain auger is used to move the waste materials from the cleaner. Figure 2 shows the new 8 inch Beltveyor Tubular Conveyor that operates from gas, electricity, PTO, or hydraulic power. It is built by Speed King Manufacturing Company, Inc., Dodge City, Kansas.

A conveyor is a mechanism that moves material from one location to another in a continuous manner. This definition includes horizontal conveyors and vertical conveyors (elevators) as well as conveyors operating on a inclined plane.

A short description of several types of conveyors particularly suitable for handling seed follows.

Flight Conveyors:

A flight conveyor consists of one or two endless power driven chains carrying properly spaced scrapers or flights for moving material along the length of a stationary trough. Material fed into this trough is thereby pushed along its length for discharge at the end of the trough or through intermediate discharge gates.

Flight conveyors are used for either horizontal or inclined paths and are frequently installed where the angle of inclination is comparatively steep. Some flight conveyors can be made so that they are reversible, but it is necessary to modify the terminals to handle the maximum chain tension under different circumstances of conveying. When only one discharge spout is required at the end of this type conveyor, it is practically a self-cleaning mechanism; however, when a number of intermediate discharges are needed there can be a slight carry-over of material from one spout to the next. If the manufacturer is advised of the seed being handled, certain steps can be taken to combat this situation. One thing that can be done is to locate brushes over each outlet where the biggest part of the carry-over occurs. It is usually desirable to have any surplus material carried out the last spout to prevent mixing.

Figure 1 and 2 from photographs supplied by Speed King Manufacturing Company, Inc.

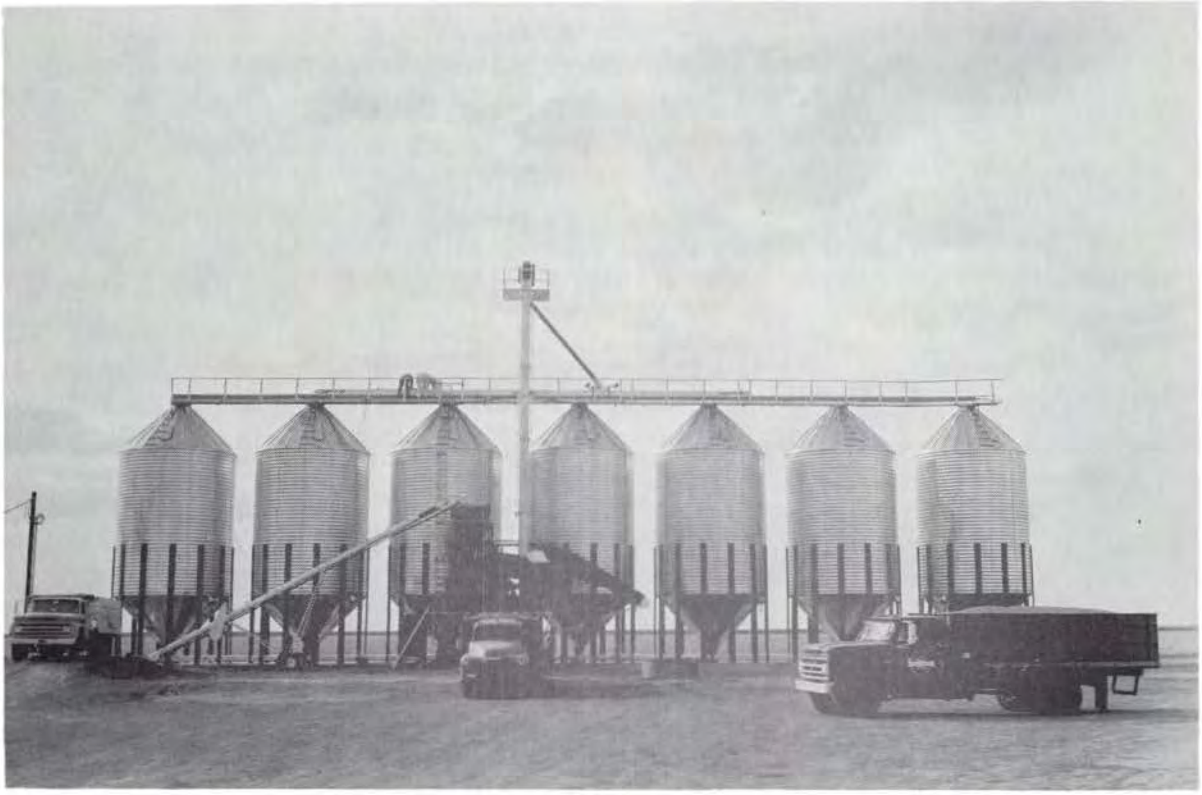


FIGURE 1

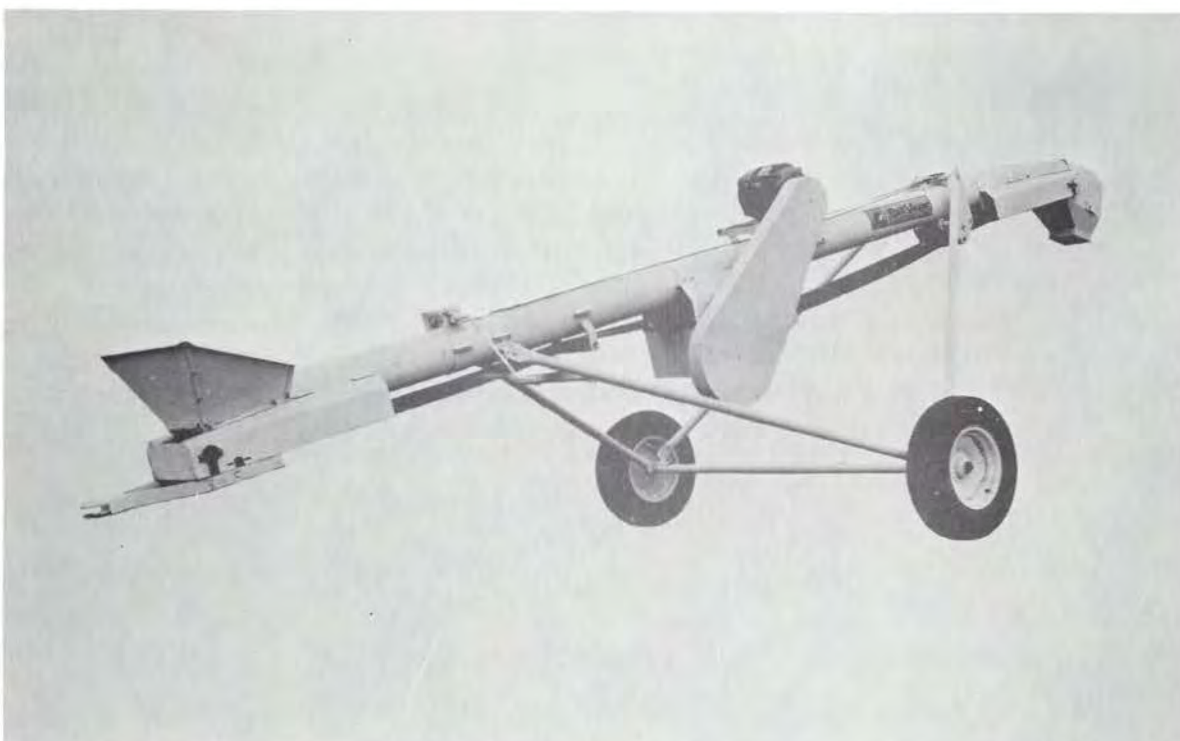


FIGURE 2

Figure 3 and 4 shows a standard take up connected to a divided inlet spout and intermediate trough section and a cross section of a Super-Flo trough. The flights are shaped to the contour of the trough. The flanged cover fits snugly over the double flanges of the trough and a gasket is continuously fitted between the trough and cover. The Barron clamp can be released quickly by finger pressure to allow immediate access for inspection or maintenance. Figure 5 illustrates a combination horizontal and inclined conveyor which includes a special bend section to accomodate the transition between horizontal and inclined conveying. Super-Flo flight conveyors are manufactured by Screw Conveyor Corporation, Hammond, Indiana.

Belt Conveyors:

A belt conveyor is an endless belt operating between two pulleys with idlers to support the belt and its load. Belt conveyors handle bulk and packaged material in large or small volume and can carry up slopes to 27^{o}, depending upon the nature and condition of the material handled. They are low in power and maintenance costs, deliver uniform volumes at high or low speed, have few parts subject to wear, and are simple, quiet and reliable. The initial cost of a heavy duty, high capacity installation is rather expensive, but utilization of a belt system often results in surprisingly low over-all costs per ton handled.

Essential parts of a belt conveyor are the belt, the drive, and driven pulleys, tension adjustment mechanism, idlers and loading and discharging devices. Material may be discharged over the end of the belt, or along the sides by using diagonal scrapers or by tilting the belt. The most satisfactory way to discharge seed along the length of a troughed belt is with a tripping mechanism consisting of two idler pulleys that divert the belt into the shape of an S. The material is discharged over the top pulley into a side chute. Trippers are usually mounted on tracks so that they can be moved to any position along the length of the belt. A compact Tripslinger with high-speed reversing belt that gives left or right 90^{o} discharge is available for Troughveyors. With its low-profile design and extended slinging ability, storage capacities can be substantially increased with this unit.

Figures 3, 4, and 5 from photographs supplied by Screw Conveyor Corporation.

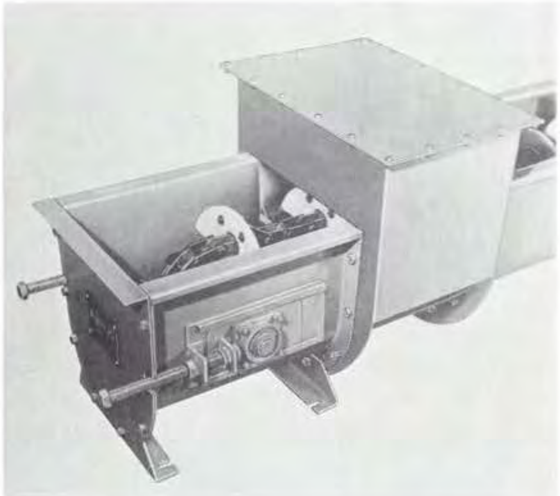


FIGURE 3

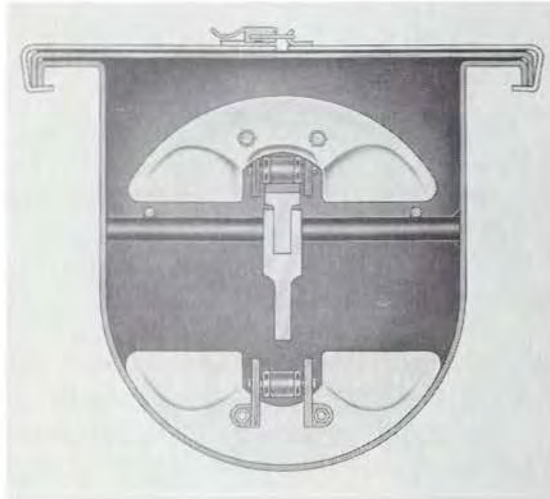


FIGURE 4

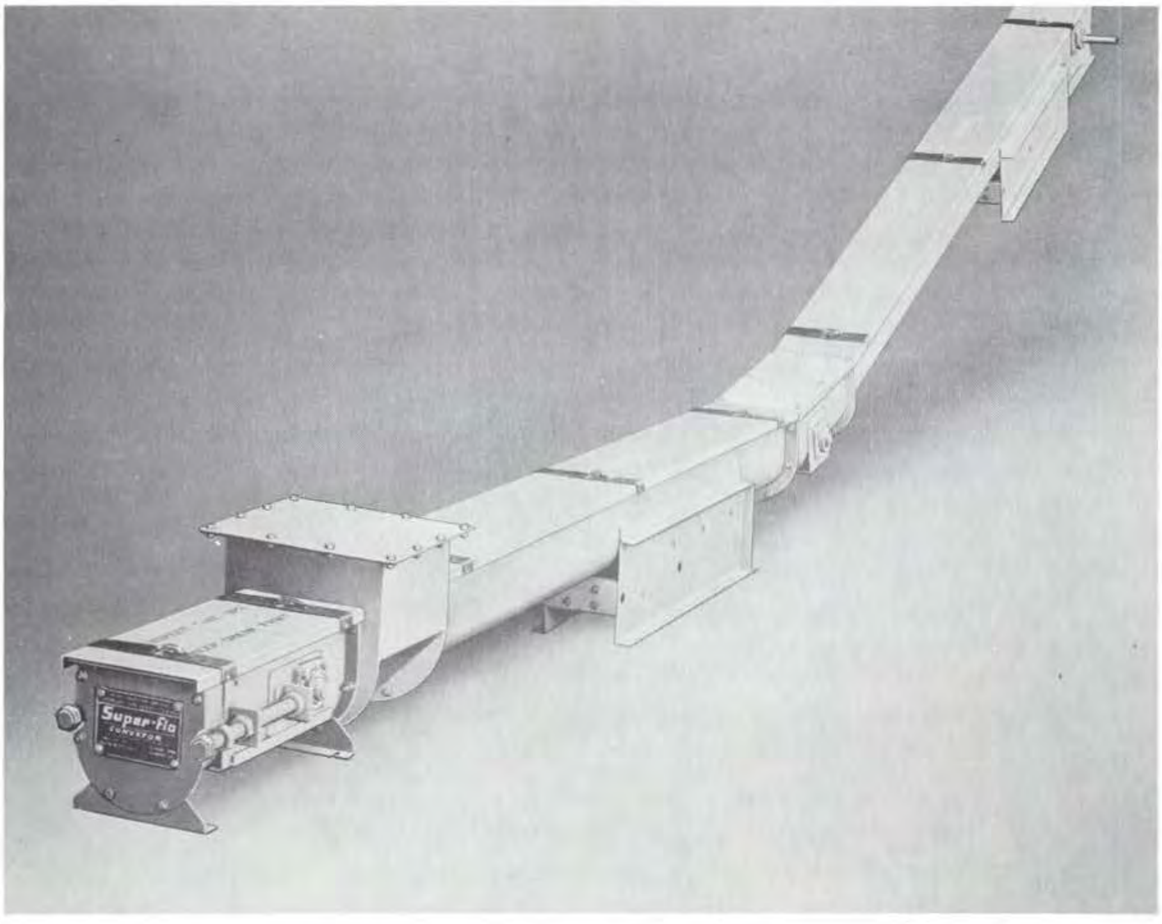


FIGURE 5

Figure 6 illustrates a belt conveyor where the load-carrying portion of the belt is supported by a smooth trough shaped steel surface. Figures 7 and 8 show the conventional methods of discharging material from a belt conveyor - tripper and end discharge.

Vibrating Conveyors:

Vibrating conveyors, also called oscillating or shaker conveyors, move materials uniformly in a continuous flow along a metal trough or tube. The trough is mounted on rigid inclined toggles and is usually driven by a constant stroke eccentric drive. The horizontal motion resulting from the eccentric is transformed into an upward and forward pitching action by the inclination of the toggles. The material moves up and forward with each vibration while the trough returns backward and down. The result is a series of rapid pitching actions which produce a total net movement of the material toward the discharge end of the trough. Short feeding-type conveyors are sometimes powered by an electromagnet that can produce different vibrations depending upon the rate of feed desired.

One of the outstanding advantages of the vibrating conveyor to the processor of pure seed is that it is completely self-cleaning and easily inspected. They are often used to convey seed from beneath a cleaner to an elevator leg on the same level. Figure 9 illustrates a unit of this type.

The vibrating conveyors shown in Figure 10 have a unique design to transmit force in a longitudinal direction only. The drive assembly is not directly connected to the conveying tube or trough: this virtually eliminates vibration transmission to the supporting structure. These units can be installed "as is" in nearly all building - even wooden structures - without extra bracing or reinforcing.

Carter-Day Company, Minneapolis, Minnesota, can supply these vibrating conveyors in length up to 90 feet with provision for multiple feed and discharge points.

Bucket Elevators:

Bucket elevators are probably the most widely used method for elevating bulk materials. Various types and designs are available to meet the requirements of different materials and operating conditions.

Figures 6, 7, and 8 from Universal Industries brochure. Figure 9 from A. T. Ferrell Company brochure. Figure 10 from Carter Day Company brochure.

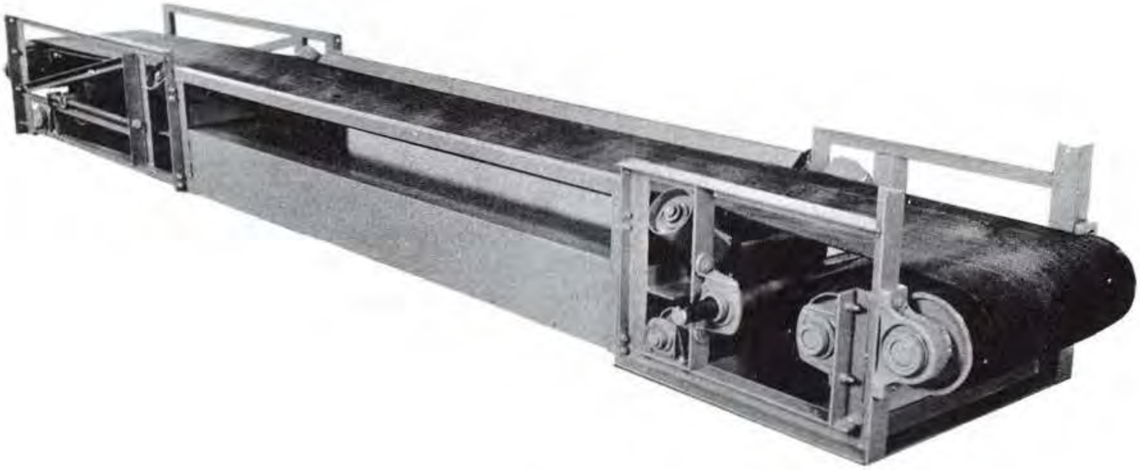


FIGURE 6

FIGURE 7

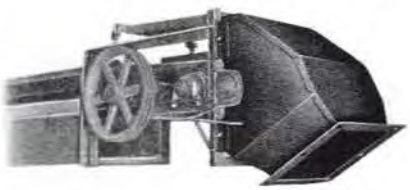


FIGURE 8

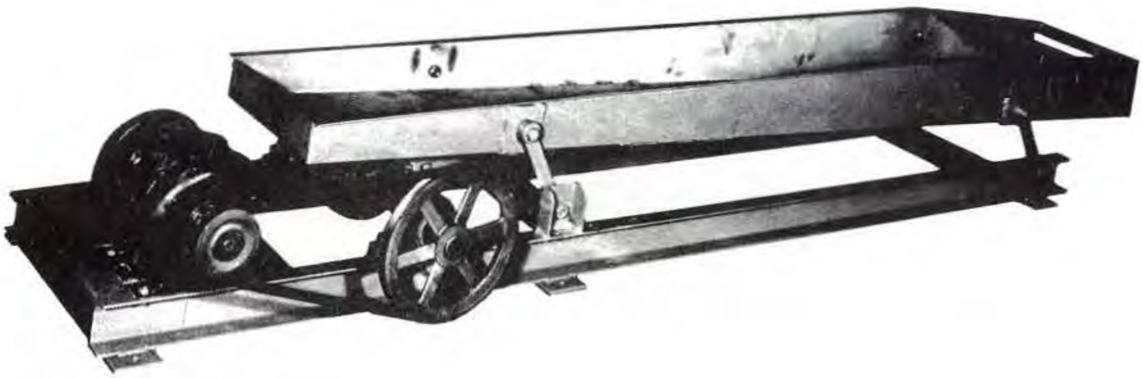


FIGURE 9

FIGURE 10

Buckets are mounted on a chain or belt. They receive material at the boot and discharge it over the head pulley by centrifugal action or by gravity. The centrifugal discharge types are normally used for free-flowing, fine to medium size materials. Those discharging by gravity, which comprise positive discharge, continuous bucket and internal discharge types, are generally used for materials more difficult to handle due to fluffiness, sluggishness, fragility or similar characteristics.

Belt type bucket elevators are quiet, efficient and long lasting. The chief disadvantage of some designs are that speed may damage seed and the enclosed units are difficult to clean out.

Based upon the method of discharge, bucket elevators can be classified into four types:

1. Centrifugal Discharge

Elevators of this design have buckets mounted on a belt or chain at spaced intervals. The buckets are loaded by scooping up material into them. Material is discharged by centrifugal action as the buckets pass over the head pulley. Since discharge from the buckets is dependent upon both centrifugal force and gravity, the shape of the bucket, the speed and radius of the head pulley and the position and angle of the chute must be in proper relationship for efficient operation. Elevators operated slower or faster than the speed for which they were designed to handle a particular type material causes back-legging, or the material is thrown against the discharge spout. Figures 11 and 12 illustrate the principle of operation and the construction of this type elevator.

2. Positive Discharge

Elevators of this design operate successfully at low bucket speeds and are suitable for handling light, fluffy and fragile materials and those having a tendency to stick in the buckets. Buckets are mounted at spaced intervals on a pair of chains. They are loaded by scooping up material from the boot or by feeding the material into them. After passing over the head pulley, the buckets are inverted over the discharge spout, thus providing a positive discharge of material. Figures 13 and 14 illustrate the principle of operation and the consturction of this type elevator.

3. Continuous Buckets

Elevators of this design are made in a number of types for handling many bulk materials ranging from light to heavy and from fine to large lumps. Buckets are spaced continuously and loaded by direct feeding.

Spillage between buckets is prevented by their close spacing. As buckets discharge, the material flows over the preceeding bucket whose front and projecting sides form a chute. Figures 15 and 16 illustrate the principle of operation and the construction of an "Easy Dump" Universal elevator.

4. Internal Discharge

Internal discharge elevators provide excellent means for the continuous, gentle handling in bulk of relatively small, fragile material. Buckets are internally loaded from a chute extending through either side of the casing. They are so designed and positioned that they overlap during loading and are inverted to discharge the material into a chute at the top of the elevator. Some elevator designs use one foot and one head shaft; others are equipped with one foot and two head shafts, and still other have two foot and two head shafts. Some are cased, some are not. Figure 17 illustrates an open type with a metering hopper driven from one of the two lower shafts. This type elevator is gaining in popularity among seedsmen because of its gentleness in handling seed and ease of cleaning.

Since the seed is fed into the slowly moving overlapping buckets of an internal discharge elevator no boot is needed. With no boot, the friction caused by the buckets moving through the mass is eliminated, no seed can become crushed between pulley and belt or chain and sprocket and the seed need not fall any further than the depth of the bucket during feeding. Since the buckets move too slowly to exert an appreciable centrifugal force, the seed is discharged from each bucket by gravity into a chute which may be spouted to either side. When the chains are lubricated with graphite, the unit is practically self-cleaning. If it is not cased, inspection for cleanliness is simple.

Figure 18 shows the Universal "El-Con", a combination elevator and conveyor that replaces the need for two separate pieces of equipment. . . a bucket elevator and conveyor. It can be manufactured in a number of different configurations from the model shown to the Z, C or other shapes to fit exact requirements.

One of the main features of the El-Con is its gentle handling characteristics, allowing you to handle the most delicate products without breakage or damage.

Figures 11, 12, 13, 14, and 15 from Link-Belt Catalog 1050. Figure 16 from Universal Industries brochure. Figure 17 from J. L. Mitchell Company brochures.

In handling seed we must keep in mind that there is no way for injuries to seeds caused by conveying equipment to be healed once they occur. GIVE YOUR SEEDS A GENTLE RIDE. . . wherever they're going.

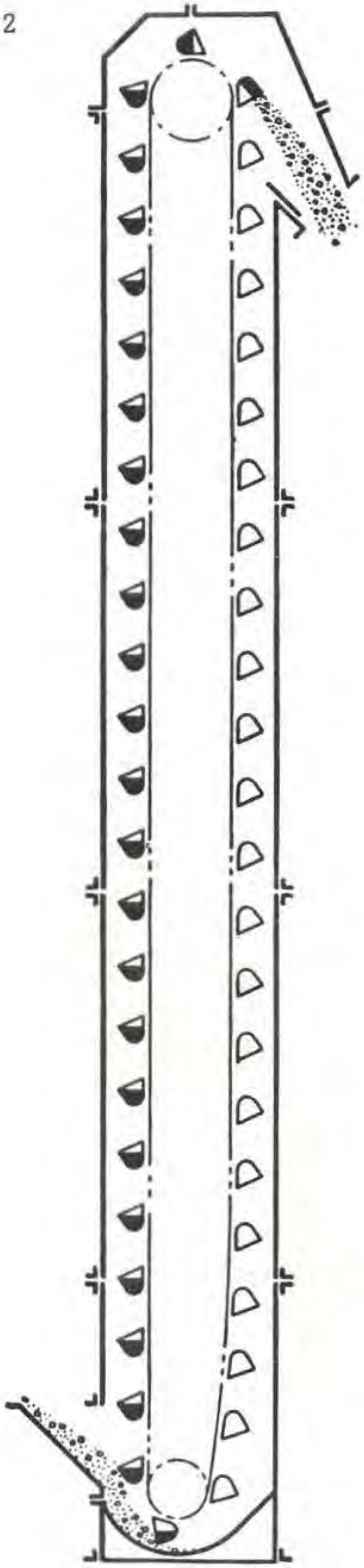


FIGURE 11

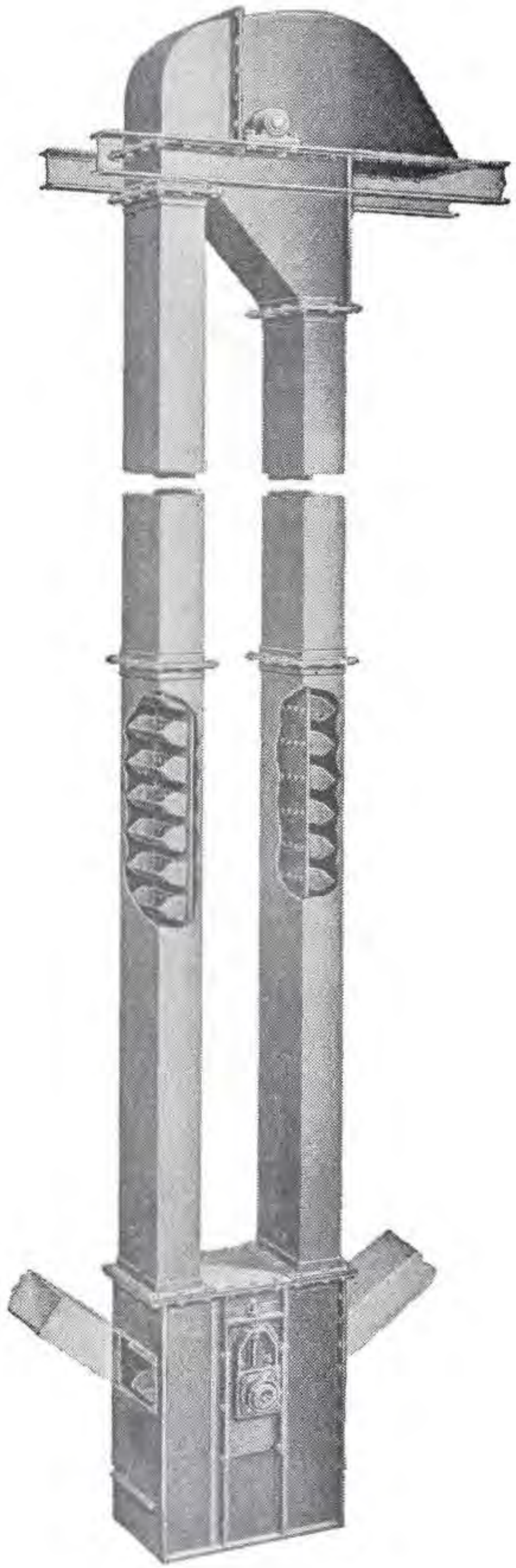


FIGURE 12

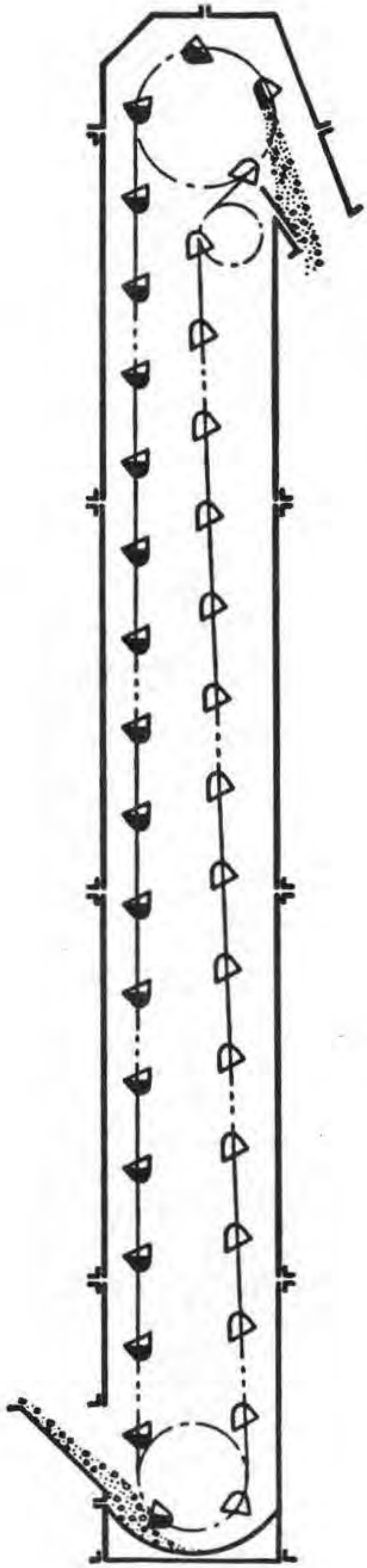


FIGURE 13

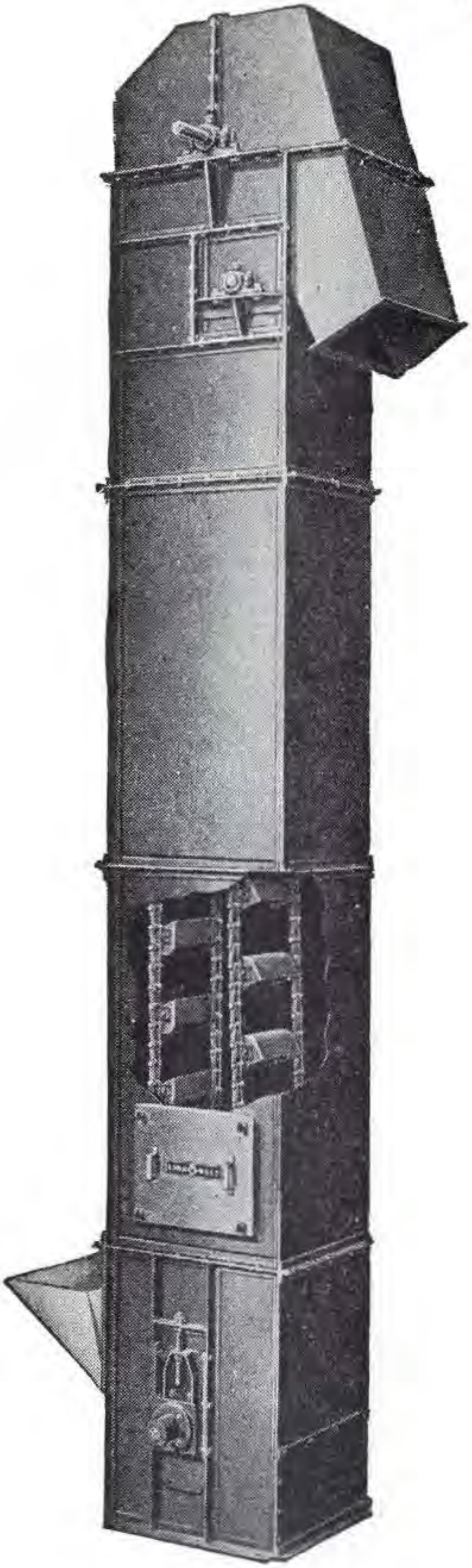


FIGURE 14

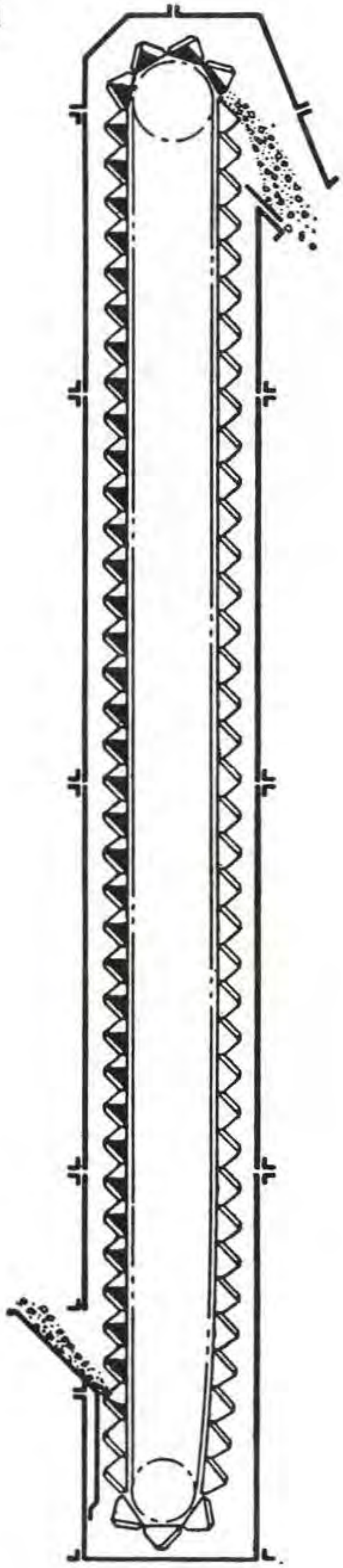


FIGURE 15

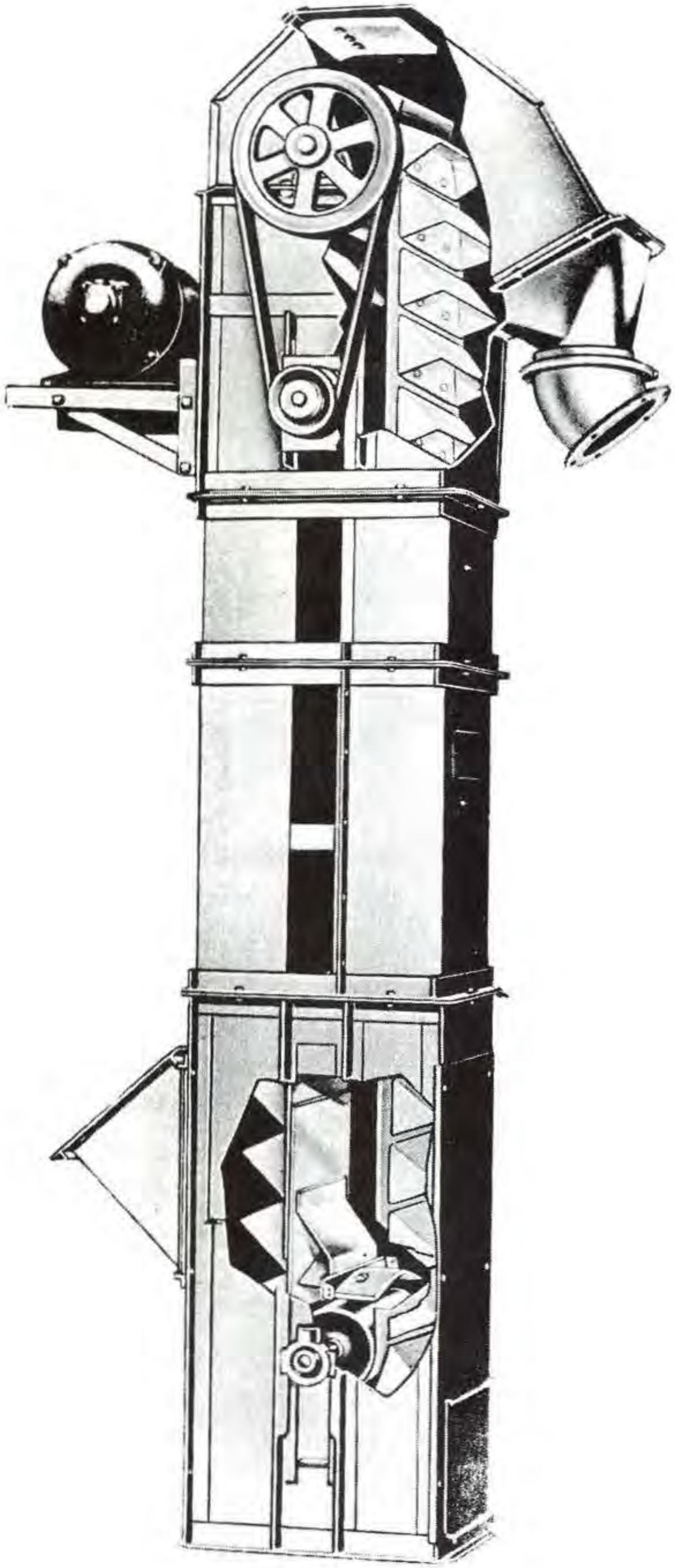


FIGURE 16

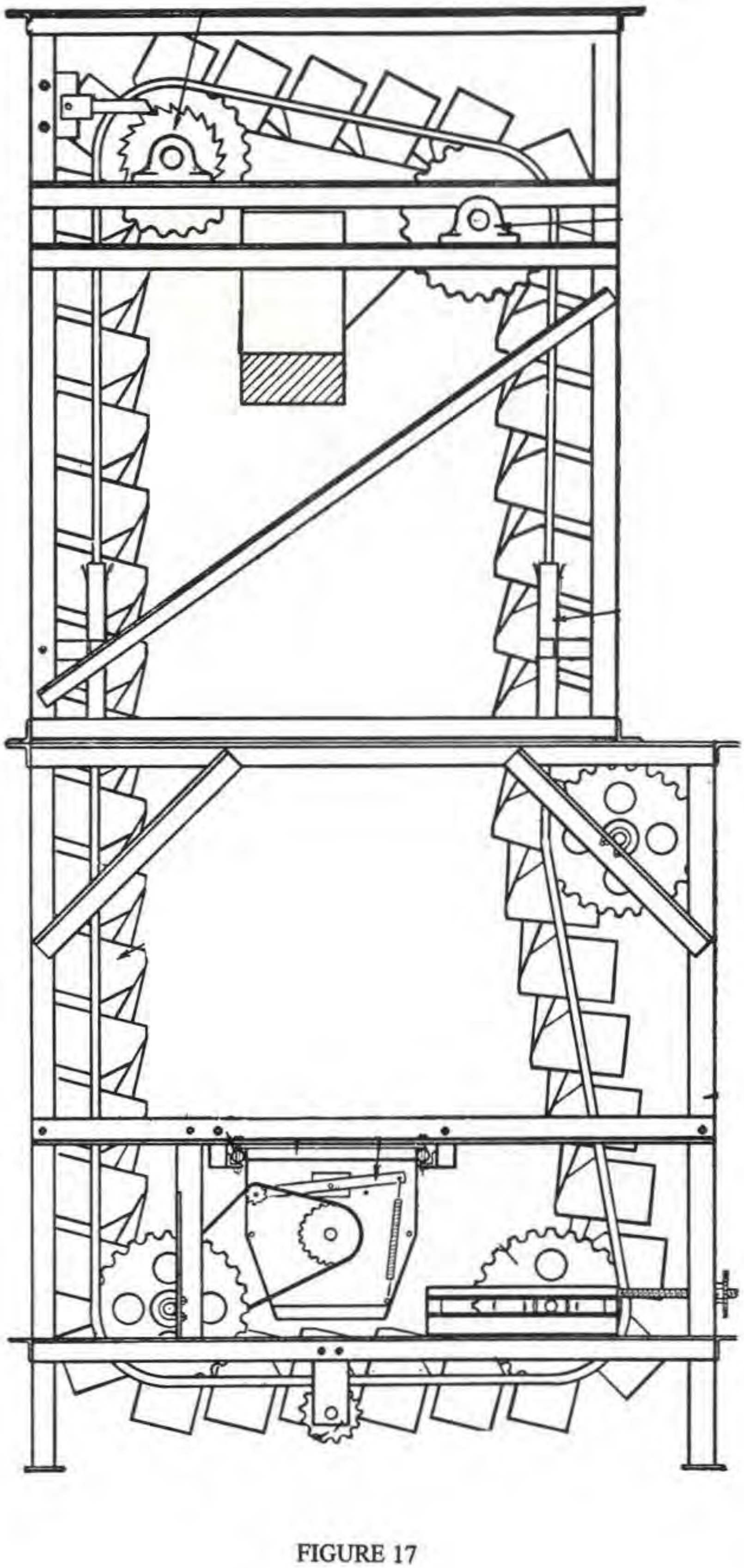


FIGURE 17

FIGURE 18

THE SEED PLANT OF THE 70'S

Duane W. Tyler[1/]

If changes made in agriculture in the last couple of years are multiplied over the next ten years, by 1980 we may truly be in a new era. However, since hindsight is better than foresight, and because history is our most reliable source of information, we can best draw our conclusions by what we observe today.

Automation and computer control are taking over at unbelievable speeds, but farming, seed production, seed cleaning and seed sales are governed by, and proportional to human attributes and ability. I do not mean to imply that scientific achievements do not play a very important role in our agricultural development. They do, but I am saying that the timing and use of scientific tools insofar as seed is concerned depends largely upon human judgement.

Following are some of the guide lines which govern what we do or must aim for in the supply of seed of all kinds:

1. Purity - pound for pound of good healthy seed.

2. Noxious weeds, if present in crop seed, must be separated or must be field controlled.

3. Pesticides in terms of changed laws and the effect these will have on the seed crops we must produce.

4. Weed control by burning fields, now either highly restricted or even prohibited, and what can be the expected results or alternatives.

5. Where are our markets - and what does the customer expect to have tailored to his exact needs?

6. The effect of our technical know how given to other countries who may or may not have land and/or the best growing conditions, but have decidedly lower labor costs, thus demanding our best efficiency techniques if we expect to be competitive.

7. The bright hope, and surely very important to all seed business, is the hybrids now available with yet more to be developed at increasing speed.

[1/] Mr. Tyler is Vice President for Sales, A. T. Ferrell & Company, Saginaw, Michigan.

These are but a few key factors to which we must pay close attention.

My field of endeavor is primarily concerned with seed processing after, and in whatever condition, it comes to you - the processor. Nevertheless, what the grower does with seed from planting to harvest, with the aid of science, industry and mother nature, and until it reaches your processing facility, tells us what we must attempt to provide with mechanical equipment to enable you to have pure seed to sell. Here again we face human as well as mathematical and physical abilities. Unfortunately, no matter how flexible or well built a piece of equipment is, it will not do the same job on the same seed in two different plants.

No, we cannot computerize a Clipper Seed Cleaner. The operator has the last word. He alone must exercise judgement and mathematical ability (that is, size, shape, weight, seed coat, color, etc.) plus common sense in order to achieve the best results. Seed cleaning is not an art as some would have us believe, but rather it is the logical use of the proper equipment to do the precise job required.

For at least 25 years I have observed some of the "old-timers" in seed cleaning. They may not have had the education we sometimes associate with success, nor were they as well versed with technical knowhow as some of you, but m;ost of us would do well to learn as much as they have forgotten about the cleaning of seed.

It is indeed encouraging that more and more colleges are establishing credited courses in Seed Processing, using commercial equipment operating in plant-like conditions. We can only hope that our young men will have the vision of the future of the seed business and that plant owners will seek out and use these men who have been pre-trained. This should reduce the owners expense in the training of men for the requirements of their individual operation.

In planning seed plants for the 70's, it seems fair to assume that we do not have before us exotic new machines with which to do magical things. To be sure we shall continue to see improvements or refinements of equipment to be adapted to new varieties and crop conditions. Improvements possibly for easier operation, plant flexibility and even longer life. However, I could say at this point that I doubt if anyone can find equipment for any other industry that will last as long or show better return for the investment than equipment used today in seed and grain cleaning plants.

Therefore, if we are not looking for revolutionary processing equipment changes, what might we expect in plant changes in the 70's?

We can expect more accuracy in cleaning requirements. We can expect new and select varieties of seeds, as well as more and specialized lots to deal with. As all costs of doing business and transportation of the finished product increases, we can less afford to make mistakes. This includes not only processing, but segregating, handling, labeling and selling.

Plant location will assume larger importance due to higher costs in congested areas, and restrictions due to air pollution and transportation both to and from your plant - just to name a few. With higher costs of doing business, the plant of the 70's must be built for the highest degree of efficiency.

We talk about efficiency, but what do we mean? Efficiency is the ability to reap the greatest benefit from effort expended and money invested. How is this to be best accomplished in our plants?

1. Designing or modifying plants for maximum flexibility to meet the ever changing conditions of our areas.

2. Utilizing the latest equipment, methods and labor saving devices.

3. Automating to the point of foolproof plug-ups and requiring the maximum use of every machine. Such would include:

    (a) Bin level protective devices.
    (b) Remotely operated equipment to save labor and to get full production instead of trusting safe human visual limits.
    (c) Interlocking of electrical controls.
    (d) Better flowing bins, spouts and feeders.
    (e) Workmen's safety features as well as conveniences.

In planning for a seed plant for the 1970's, let us review this from some practical angles. In the first place, if any seed processor could build his plant over, he surely would make many changes. The true fact is that neither you as a processor, nor we as an equipment manufacturer can necessarily walk out of an old plant and build that dreamed of new one. Nevertheless, we all know we cannot stand still without sliding backwards, so what must we choose as our options? We have three choices:

1. Rebuild our plant.

2. Modernize the old one.

3. Update our equipment.

Maybe our 4th choice would be to stay as is and see what happens; although, one might find the germination of business may slowly die away only to be replaced by soneone's healthier variety. Let us review the three choices named:

Rebuilding: Not all will be able to build new facilities but all should weigh these factors:

1. What are existing property or tax costs apt to be in the next few years?

2. How readily accessible is your plant to customers and growers, as well as to available labor market?

3. Are the inefficiencies of your plant or equipment eating too much out of profits?

4. Where are fixed costs headed?

5. Is the present plant expandable without compounding fixed costs?

Modernizing: If you have physical space and need to modernize, doing so may be the finest investment you can make. You cannot afford the use of poor, worn out or low capacity machines. Because as your fixed costs continue to rise, you must increase both your efficiency and unit production to simply hold your own or hopefully gain a little profit.

Updating: It is difficult to wear out seed processing equipment if it is given even reasonable care. Thus, it is hard to say to yourself, "Let's replace it". But have you ever added up what obsolete units may be costing you?

By thorough review of the before mentioned options you will likely be able to see more clearly the direction you must follow for the plant of the 70's.

In the area of designing a new, or modernizing existing facilities, let us review some of the phases that have proven of greatest benefit to production and profits.

BULK

Provide a group of bulk holding bins for uncleaned seed, usually a group of two or four works out nicely. As shown on the model flow board displayed, these bins holding over 600 bushels each are used to good advantage. When friable seed is handled, let-down ladders should be used.

PRE-SCALPING

A pre-scalping machine can prove to be a distinct advantage for greater production. In a modern plant such as the flow displayed, it is easy to see how a pre-scalper, particularly the balanced construction design unit like our TT and TR models, could be installed above the bins ahead of the primary cleaning machine. Precleaning or scalping of grass seed or grains can have many advantages in most plants.

The use of a Debearder is best suited ahead of the main cleaning system. This unit in the model plant is mounted on top of the first bulk bins.

RECOVERY SYSTEMS

In the processing of small seeds, the use of a screenings recovery system will boost production and often result with better purity and less seed loss. With this type system the primary cleaner may be set to take out all the foreign seed, plus about 10% of good seed. This portion then, of maybe up to 20% range, is passed to the screenings recovery unit on stream and the clean seed from the recovery unit is spouted directly to the flow system of good seed, so you have a blending operation instead of two separate grades of seed. In such a system bypasses should be provided to be able to bypass either the recovery unit, when not needed, or following the recovery unit to be able to bin separately if producing an offgrade of seed not wanted to be blended in the number one grade.

BAGGING

Another step-up of production can be accomplished by improving the bagging operation. By the use of bulk holding bins of 400 to 600 cubic feet, and preferably a group of four bins ahead of the bagging scale, allows for the accumulation of several hours run ahead of bagging. This enables better use of man power for other plant operations. When the bagging system is started, the best speed can be accomplished by using one man on the scale, one on the sewing unit and one stacking bags on pallets. With good bagging scales a speed of 10 to 14 bags per minute is realized. At this rate bagging will catch up in a few hours, thus releasing these men again for other duties.

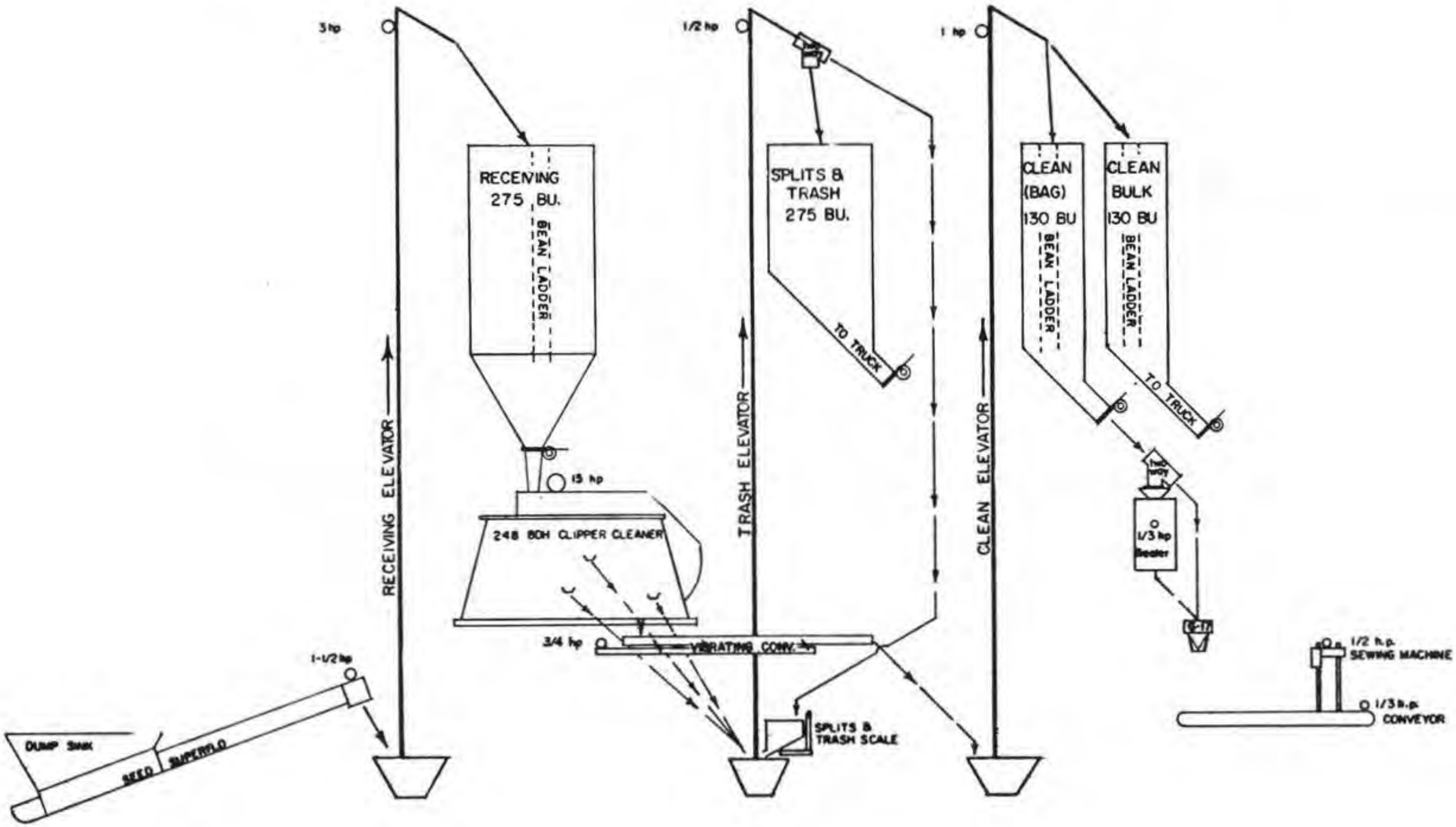
In all new plant designing it is becoming mandatory to provide dust control. This not only improves working conditions and plant efficiency, but reduces insurance costs. Air pollution is also a key public factor these days and many plants are apt to be forced to clean up their operation. Therefore, such a system, if designed in a plant modernizing program, will be more effective and likely cost less when done originally.

Finally, in thinking of plants of the future, more and more emphasis will be placed on good management. Processing plants built for efficiency will allow management to pre-determine his output and proper use of labor more accurately. The more reliable his production records, the more effectively he can plan for overall budgeting of business operating costs and investments. Good operating records should be maintained and from which, periodic review can properly be made to evaluate areas of unbalance, production and inefficiencies. Also, since more financing is needed to conduct businesses today, the use of good records will enable better and more orderly financing programs.

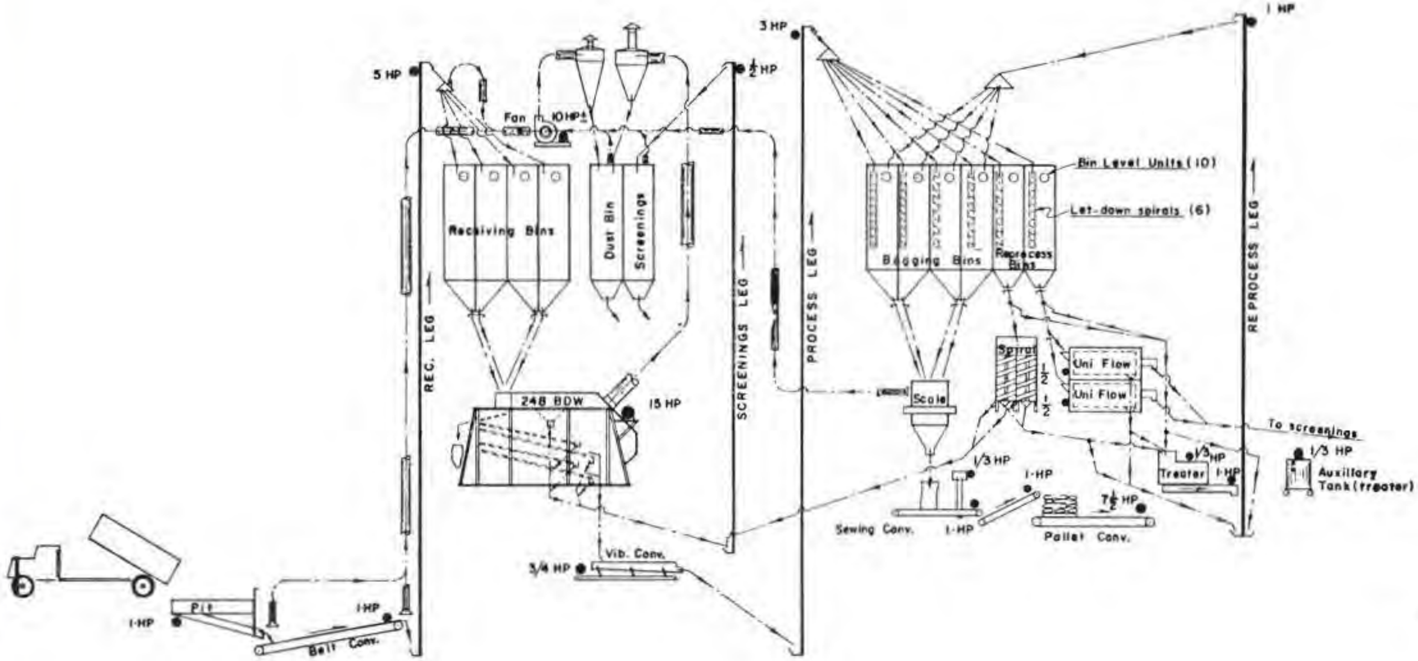
You will recall I said the human element is a large significant factor in the seed business, and so it is between management and plant personnel. The success of a seed plant extends from the top down to the men that load out to your customers' trucks. One of the toughest, yet most important phases of management, is to convince all workers in your plants to understand that the more secure, the more efficient, the more competitive your operation is, the more secure each individual employee is.

Never minimize the importance of a "thank you" for a job well done. Enthusiasm must be established before ambitious results can be accomplished. The records of the 70's are yet to be realized, but the spoils will go to those who are willing to accept and conquer the challenges.

FLOW DIAGRAM



UNITIZED PACKAGE PLANT DWT 362-2 SOLD ONLY AS A COMPLET UNIT		
SCALE: NONE	APPROVED BY:	DRAWN BY: JDW
DATE: 8/28/69		REVISED
PLANNED BY	THE D.W. TYLER COMPANY 3803 NORTH VERMILION, DANVILLE, ILL	
FLOW DIAGRAM		9A-362-2b



SCHEMATIC FLOW DIAGRAM

NO SCALE

ELECTRICAL SPECS.

CLIPPER MONOTROL PANEL for: 440 V. 3 wire w/50% spare circuit capacity

1 - Panel to be located in maintenance shop
2 - All starters to be Westinghouse or Cutler Hammer
3 - No lights or P. B. in panel
4 - Provide Cutler Hammer Class II P. B. for each remote start stop station
5 - Interlock as follows -
  a) - Pit w/ - Belt conv. w/ - Rec. leg
  b) - Process leg w/ - Vib. conv. w/ - Clipper 248 BDW
  c) - Re process leg w/ - Treater conv. w/ - Treater

All others separate operation - namely:

Suction fan
Screenings leg
Sewing machine (its own starter and controls)
Sewing belt conv. (" " " " ")
Inclined bag conv. (" " controls) starter only in panel
Pallet conv. (" " ") " " " "
Uni - Flow Graders (2)
Auxiliary treater solution tank

Note:

Provide starter connection in panel for Air Comp. (not shown) w/ push pull in panel - (shop area - HP - ½)

6 - Provide (10) high level bin indicators (Class II) w/ lights and retiring alarm w/ cabinet located in center of operating area (No interlocking)

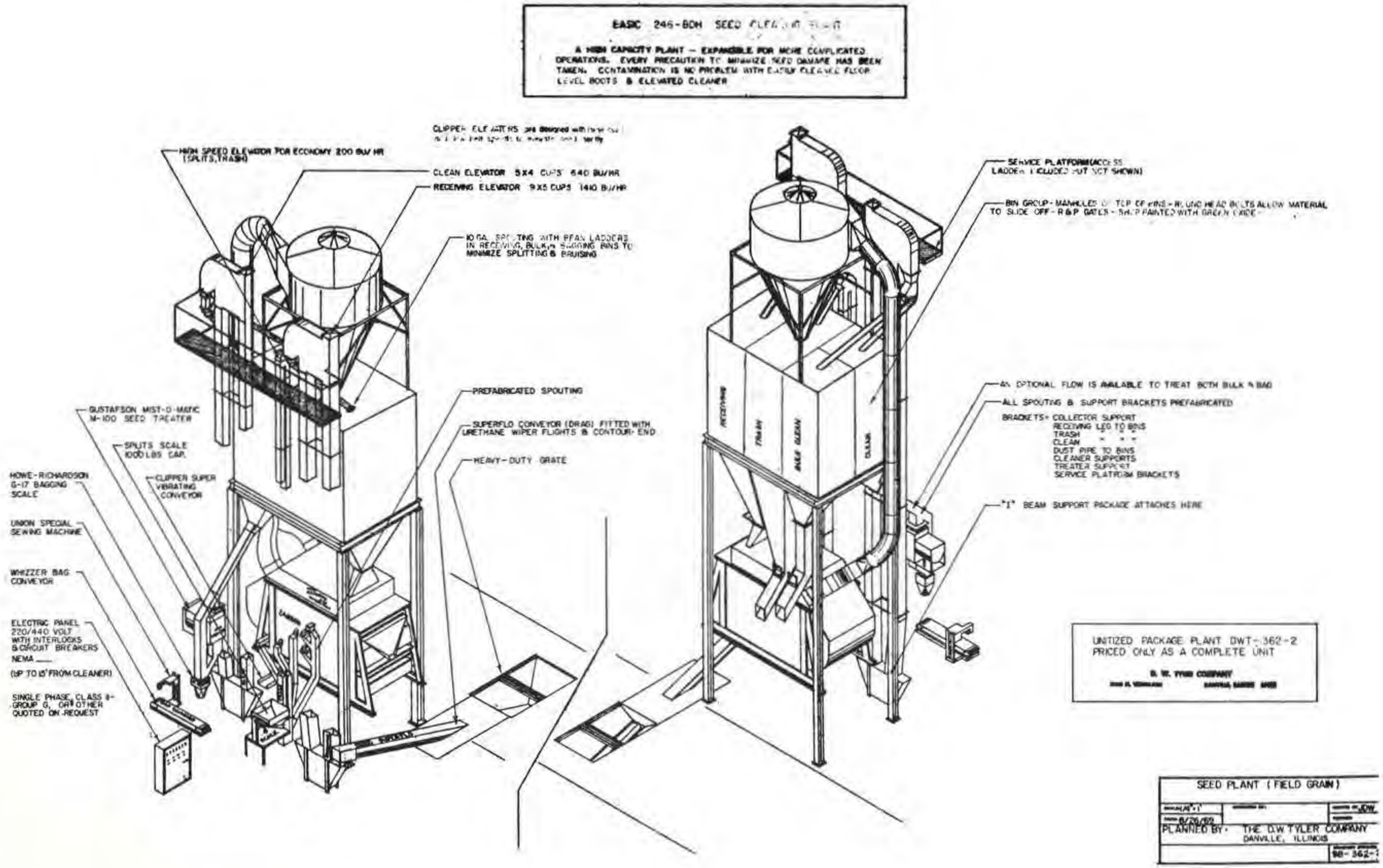
7 - Provide lighting circuit for entire plant area w/ 100% spare capacity - See separate details

MOTORS:-

● To be Class II Gp. G. and to be Fairbanks Morse if available othwise eqivilant all of same make per units involved

THIS IS A REVISED PRINT
DESTROYS PREVIOUS
PRINTS OF THIS NUMBER
DATE 2-17-67

F.S SERVICES, INC. — CISCO, ILLINOIS		
SCALE: None	APPROVED BY:	DRAWN BY DWT
DATE: 11-15-66		REVISED
D. W. TYLER COMPANY 1506 N. LOGAN AVE. DANVILLE, ILLINOIS		
SEED PROCESSING PLANT "Cisco, Illinois - AFE 229"		DRAWING NUMBER 6-181-3


EASIC 246-BDH SEED
A HIGH CAPACITY PLANT — EXPANDIBLE FOR MORE COMPLICATED OPERATIONS. EVERY PRECAUTION TO MINIMIZE SEED DAMAGE HAS BEEN TAKEN. CONTAMINATION IS NO PROBLEM WITH EASILY CLEANED FLOOR LEVEL BOOTS & ELEVATED CLEANER
HIGH SPEED ELEVATOR FOR ECONOMY 200 BU/HR (SPLITS, TRASH)
CLEAN ELEVATOR 5X4 CUPS 640 BU/HR
RECEIVING ELEVATOR 9X5 CUPS 1410 BU/HR
10 GA. SPOUTING WITH BEAN LADDERS IN RECEIVING, BULK, & BAGGING BINS TO MINIMIZE SPLITTING & BRUISING
PREFABRICATED SPOUTING
SUPERFLO CONVEYOR (DRAG) FITTED WITH URETHANE WIPER FLIGHTS & CONTOUR END
HEAVY-DUTY GRATE
GUSTAFSON MIST-O-MATIC M-100 SEED TREATER
SPLITS SCALE 1000 LBS CAP.
CLIPPER SUPER VIBRATING CONVEYOR
HOWE-RICHARDSON G-17 BAGGING SCALE
UNION SPECIAL SEWING MACHINE
WHIZZER BAG CONVEYOR
ELECTRIC PANEL 220/440 VOLT WITH INTERLOCKS & CIRCUIT BREAKERS
NEMA ___
(UP TO 15' FROM CLEANER)
SINGLE PHASE, CLASS II-GROUP G, OR OTHER QUOTED ON REQUEST
SERVICE PLATFORM (ACCESS LADDER INCLUDED BUT NOT SHOWN)
BIN GROUP - MANHOLES ON TOP OF BINS - ROUND HEAD BOLTS ALLOW MATERIAL TO SLIDE OFF - R & P GATES - SHOP PAINTED WITH GREEN OXIDE
RECEIVING
TRASH
BULK CLEAN
CLEAN
AN OPTIONAL FLOW IS AVAILABLE TO TREAT BOTH BULK & BAG
ALL SPOUTING & SUPPORT BRACKETS PREFABRICATED
BRACKETS: COLLECTOR SUPPORT
RECEIVING LEG TO BINS
TRASH " " "
CLEAN " " "
DUST PIPE TO BINS
CLEANER SUPPORTS
TREATER SUPPORT
SERVICE PLATFORM BRACKETS
"I" BEAM SUPPORT PACKAGE ATTACHES HERE
UNITIZED PACKAGE PLANT DWT-362-2
PRICED ONLY AS A COMPLETE UNIT
D. W. TYLER COMPANY
SEED PLANT (FIELD GRAIN)
6/26/69
PLANNED BY: THE D.W. TYLER COMPANY DANVILLE, ILLINOIS
98-362-

FOREST TREE SEEDS

F. T. Bonner[1/]

The trade in tree seeds is a minor activity when compared with that in agricultural seeds, but its importance is likely to increas. The current trend to more intensive forestry with genetically improved stock will increase the demand for seeds. Genetic gains will force us to intensify efforts to improve methods for seed collecting, cleaning, processing, storing, and testing.

Most work with tree seeds is done by government agencies. The USDA Forest Service, the largest single collector and user in this country, collected or bought more than 212,000 pounds of tree seeds and produced over 113 million seedlings between July 1, 1967, and June 30, 1968.[2/] These figures are higher than average because of the bumper seed crop that year. Combined total for Federal, State, and private concerns are not available.

Although major quantities of seeds from about 130 tree species are collected and processed, 25 species, mostly conifers, account for about 90 percent of the work (5). Private dealers have three types of operation. Many southern companies deal primarily with seeds of the southern pines. Many western companies deal with western conifers, primarily Douglas-fir. Companies throughout the country supply small lots of seeds of many species, primarily to ornamental nurseries. Some States have also been known to sell seeds when they have a surplus. Certain foreign countries sell tree seeds, but not usually in the United States.

Large quantities of conifer seeds are exported. Governments and industrial concerns in South America have been buying large lots of southern pine seeds for several years. European countries are good customers for conifer seeds from the Pacific Northwest, particularly Douglas-fir.

[1/] Stationed at the Forest Tree Seed Laboratory maintained at State College, Mississippi, by the Southern Forest Experiment Station, USDA Forest Service, in cooperation with Mississippi State University.

[2/] Hixon, H. J. Annual reforestation and timber stand improvement report, FY 1969. USDA Forest Serv. Unpublished Rep. 1969.

The greatest domestic use of tree seeds is by State and Federal nurseries in production of seedlings for planting. For example, USDA Forest Service figures show that 1.4 million acres were planted to trees in 1969. More than 814 million seedlings were shipped from Federal, State, and private nurseries to plant these acres (7). Another 220,000 acres were seeded directly. Many large timber and paper companies collect seeds, usually from their own lands. Many of them also run their own nurseries; others contract with State nurseries to obtain seelings.

IMPACT OF GENETIC IMPROVEMENT

Genetic improvement programs will have a big impact on the tree seed business. Development of improved strains is a slower process in forest trees than in agronomic species. Yet research results already show potential gains in volume production alone of 10 to 20 percent; major gains in disease resistance and wood qualities can also be made (8). While a 10-percent gain for wood production does not sound like much when compared to a doubling of corn yield, you must remember that these programs are just getting started.

Within a few years a major part of forest management in the South will be carried out on stands that have been regenerated with selected or genetically improved stock. To furnish the seeds, foresters are establishing seed production areas and seed orchards. Seed production areas are in natural stands of good phenotypes that bear good seed crops; the stands are carefully tended to stimulate seed production. Seed orchards are established with clones selected for production of improved seeds.

The acreage devoted to such efforts is increasing. In 1967, seed production areas covered 10,068 acres nationally, an increase of 500 acres over the previous year; seed orchards covered 5,706 acres, up 1,780 acres (7). A large portion of these area are on State and private lands. The 13 Southern States contain 87 percent of the seed orchards, and 68 percent of the seed production areas in the United States. In the planting season just ending, two out of every three seedlings planted in national forests were grown from seeds harvested from seed production areas. As tree improvement programs progress, seed orchards will replace seed production areas.

Most Southern States now include tree and shrub seeds under their labeling laws. So do New York and some other Northern and Western States. Despite periodic attempts at inclusion, the present Federal Seed Act does not cover tree and shrub seeds.

Voluntary certification programs have been established for forest tree reproductive material--principally seeds--in most Southern States and some Northern ones. The State of Georgia grows seedlings from certified pine seeds and sells the seedlings as certified stock (at increased prices). This program has been well received by landowners. Certain Populus clones are certified as rust resistant in South Dakota. Many States with certification programs have not received requests for certification yet. Certification programs for tree seeds will be increasingly common in the coming years, however. In Mississippi, a committee of professional foresters is currently working on a certification scheme for seeds, seelings, and cuttings of forest tree species. It will soon be ready for submission to the Mississippi Crop Improvement Association.

HARVESTING TREE SEEDS

The size of seed-bearing trees presents collection problems not normally faced with other crops. Large, single-seeded fruits, such as acorns, walnuts, and hickory nuts, and some multiseeded fruits, such as osage-orange, honeylocust, and persimmon, can be gathered from the ground after they fall from the trees. This procedure requires hand labor, and is therefore expensive.

Many valuable species have small seeds, some in multiseeded fruits, and collection from the ground after dispersal is impossible. These fruits must be collected after maturity is reached, but before the seeds are disseminated. Important species in this group are sweetgum, sycamore, yellow-poplar, and most of our conifers. Handpicking from standing trees of these species is difficult. Someone must either climb the trees or collect the fruit from "cherrypickers" or elevated platforms.

Such devices as ballons, climbing nets, and large ladders have been tested here and in Europe, but none have been very successful. Tree shakers may solve harvesting problems for many species in areas where trees cannot be cut down, as in seed orchards and seed production areas. Tree shakers are now being operated in the South to harvest unopened cones of slash and longleaf pines. Cone characteristics of loblolly pine have prevented widespread use with this species so far, but research is underway to solve the problems. Tree shakers will do wonders with some hardwoods, such as the oaks. We are sure to see increased use of this machine in the near future.

Most seeds are still collected by hand from trees downed in logging operations. When only hand labor is available, this method will get the most seeds per dollar, but there is little or no control over quality of the parent tree. Many State and Federal agencies still buy lots of seeds from private, free-lance collectors. These people almost exclusively collect by hand from downed trees.

A major problem in collection is how to know when tree seeds are mature. The standard method for southern pines is based on specific gravity of the cone. If the cone floats in SAE-20 motor oil, then specific gravity is below 0.89, and collection should start immediately. At a specific gravity of about 0.70, cones start opening (9). We use fruit and seed color changes to determine maturity on most hardwood species (2,3), but improved methods are needed. In the Pacific Northwest, one large company makes maturity decisions on several conifers on the basis of chemical analyses of sample cones (4). We could do the same here in the South on certain species (3), but widespread use of this principle is not likely with hardwoods.

DRYING, EXTRACTING, AND PROCESSING

Once tree seeds have been collected, they must be treated in ways similar to those for crop seeds. They must be dried, extracted if they are in multiseeded fruits, cleaned, and processed. Seeds are usually spread in shallow layers on sheets, shelves, or racks for initial drying. Seeds are frequently extracted from fruits during drying. A common method is to spread the fruits on screening through which the seeds can pass. The fruits are turned occasionally and seeds are caught as they fall through the screen. In large-scale operations with conifers, such as southern pines, Douglas-fir, or true firs, seeds are extracted in kilns that dry the cones.

Various types of equipment are available for extracting and cleaning small lots of tree seeds. Berry-like fruits, such as mulberry, can be thoroughly macerated in kitchen blenders and the pulp removed by flotation in water. The same procedure can be applied on a large scale and on larger fruits, such as osage-orange, wild plums, and black cherry, with motor-driven macerators (6). One type of macerator can be used with water to clean pulpy fruits or without water to shatter dry, multiseeded ruits, such as yellow-poplar, sycamore, and sweetgum.

Some winged seeds, such as those of certain southern pines and western conifers, are dewinged after extraction to facilitate sowing. The usual dewinger is similar to a debearding machine, but the inside arms are more flexible and the action is softer. Improper dewinging can badly damage tree seeds. Ashes and maples are good examples of fragile, winged hardwood seeds that cannot normally be dewinged.

The ratio of empty to full seeds is very high in some species; yellow-poplar and sycamore are prime examples. Without a procedure to separate full from empty seeds, the nurseryman has to sow what he gets; this practice usually results in very poor control over seedling density in the nursery bed. We have recently developed a promising technique to solve the problem for yellow-poplar, a species whose seeds are often only 5 to 10 percent full. We simply dewing the yellow-poplar seeds in a debearder, remove the trash with a large aspirator, and then separate by density on a gravity separator. We are still running tests, but the results look very promising.

There are probably many other crop-seed processing machines and methods that could be used on tree seeds, but the size of the operation has not required them. Cleaning and separating by hand is still best for small lots.

STORAGE

Irregularity of tree seed crops has led foresters to depend on seed storage probably more than farmers do. We can find small amounts of seeds of most species almost every year, but regionwide seed crop failures do occur. Furthermore, collection when the crop is small is very expensive. Seedling production for large-scale regeneration efforts, such as those with southern pines, frequently must depend on stored lots to produce the seedlings. When bumper seed crops do occur, as with the southern pines in 1967 and sweetgum in 1969, large collections must be made to stockpile seed against lean years.

Foresters generally aim to store tree seeds longer than farmers do for crop seeds. As a result, the storage environment for tree seeds is more exacting. Standard storage conditions recommended for southern pine seeds are 0^{o}F. and a seed moisture content of no more than 10 percent (1). Under these conditions, there should be no significant loss in viability for at least 10 years.

Seeds of most tree species can be dried to low moisture contents and stored at about 32^{o}F. for several years without significant loss in viability. Certain seeds, such as beechnuts and acorns, cannot be readily dried to low moisture contents without killing them. Acorns usually are killed if dried below 25 percent moisture. At higher moisture contents, temperature below freezing kill the acorns. Consequently, we cannot store acorns longer than 6 or 7 months without great losses in viability. Our best storage results with acorns have been at 35°F. and a seed moisture content of 40 to 50 percent. Unfortunaltely, these conditions promote sprouting. We are currently searching for treatments that will prevent germination during storage but assure rapid germination after sowing.

DORMANCY

Many seeds that mature in the fall exhibit a delayed germination, or dormancy, and some treatment is required to secure prompt germination. For those that are hardseeded, acid scarification is the answer. This method is commonly used on redbud, black locust, honeylocust, basswood, and the sumacs.

We usually place other dormant seeds in a cold, moist environment for an extended period in a treatment called stratification. The treatment was once carried out by storing seeds over winter in layers with alternating layers of moisture-holding materials, such as peat or sand, in large pits in the ground. As refrigerators became available, we substituted large cans or drums in cold storage for outdoor pits and put the seeds in cheesecloth bags. Now we often place fully imbibed seeds in polyethylene bags not over 4 mils thick, omit the moisture-holding medium, and add a small amount of water. This technique has been give the apt description of "naked stratification."

The common stratification temperature range is 33° to 40°F. Length of treatment varied by species and by geographic source within species. Sweetgum seeds may require only 2 to 4 weeks of stratification, while 4 to 5 months is not too much for green ash or some of the hickories. Seeds from northern sources usually require longer periods than southern seeds.

Many seeds that mature in the spring show no dormancy and require no pretreatment for prompt germination. Examples are cottonwood, willow, red maple, and American elm.

If we can learn enough about dormancy, we may be able to control it with chemical regulators. In the future we may be able to turn dormancy on when we want to hold seeds in storage and turn it off when we are ready to plant--all with chemicals.

I foresee rapid advances in techniques for handling forest tree seeds. We have many problems in common with agricultural seed workers, and we have many problems that are unique to forest tree seeds. Our research is increasing rapidly along with consumption of tree seeds.

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EVALUATING SEED STORABILITY AND VIGOR

Harold W. Byrd[1/]

Seedsmen are often faced with the decision of which seed lots of each crop to market first and which lots to hold for possible carry-over if the market is weak, or to guard against shortages the following year. If seedsmen have at their disposal only the information from the standard germination test, they have no way of knowing how much deterioration has occured in the various seed lots although the germination percentage is high in all of them. Very often seed lots are selected at random for carry-over or seedsmen simply carry over whatever is remaining in the warehouse at the end of the planting season. Inevitably, they find the next planting season that many lots did not carry over very well. Several lots had decreased in germination and were no longer marketable as seed, while others were still marketable but performed very poorley when planted in the field. This, of course, is damaging to the seedsmen's reputation and thus to his pocketbook. All of this illustrated the tremendous need for a reliable quality test to furnish seedsmen with valuable information concerning the quality status of their seed lots.

At the present time, there is no widely accepted method for measuring the storage potential of seed lots. However, there are several so called "vigor tests" which show some potential for predicting the longevity of seed lots and for detecting the progress and extent of deterioration during storage. Brief descriptions of four promising tests are as follows:[2/]

GADA (glutmic acid decarboxylase activity) is a test whereby the activity of the glutamic acid decarboxylase enzyme is measured quantitatively. Glutamic acid solutions are added to finely ground seed samples. The amount of carbon dioxide evolved from these mixtures in 30 minutes is an index of the enzyme's activity in these seeds. Seeds with the highest rate of carbon dioxide evolution are the most vigorous.

The accelerated aging test is a stress test used to measure the ability of seed lots to maintain their germinability under extremely

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2/ Complete procedures for these tests are available upon request from the Seed Technology Laboratory, P. O. Box 5267, State College, Mississippi 39762.

detrimental storage conditions for short periods of time. A sample of each seed lot is subjected to a temperature of 40-45°C. and a relative humidity of 100% for a period of 2-10 days. The lots that germinate well following the accelerated aging treatment are considered to be highly vigorous.

Seedling growth tests are sometimes used to measure the rate of seedling growth. Seeds are germinated in upright rolled towels for 3-5 days and the length of the primary root and/or shoot measured. Seedlings with the fastest growth rates are the most vigorous.

The cold test determines how well seeds perform under cold, wet conditions. Seeds are planted in a mixture of sand and unsterilized soil, and the soil moisture content adjusted to 60% of saturation. Tests are held at 10-13°C. for 3-8 days, then transferred to 30°C. for emergence. This test reflects the ability of seed lots to perform in the field or during storage.

EFFICIENCY OF DIFFERENT QUALITY TESTS

The cold test which is in wide use for determining the planting quality of seed corn is also an effective test for predicting the storage potential of some seed lots (Table 1 and 2). Cold test emergence of soybean seed lots was highly correlated with germination following 3-6 months storage. Extremely high correlation coefficients of .96 to .99 were obtained indicating that the cold test was very effective in measuring the storage potential of these seed lots. Initial standard germination percentages were significatly correlated with germination after 3-6 months storage; however, these correlation coefficients were considerably lower than those of the cold test.

Measuring the progress and extent of deterioration in seed lots during storage can also be done by utilizing the cold test. Significant drops in cold test performance were obtained after only 2 and 6 months storage for soybean and corn lots, respectively. (Tables 3 and 4). This compares to 6 and 12 months for the standard germination test. This would indicate that the cold test in very effective in detecting deterioration during storage.

Table 1. Comparison of initial germination, cold test emergence, accelerated aging performance and 3-day root growth with germination after 6 months storage at 20°C.-75% R.H. for soybean seed from 6 different lots.

Lot No.	Initial Germ.	Cold Test	A.A.	Root Growth (3 days)	Germ. After 6 mo. storage
0	97.0	88.5	93.0	45	77.5
5	94.5	86.0	88.5	50	79.5
10	96.5	63.5	67.5	45	66.0
15	94.5	45.5	36.0	38	29.0
20	86.0	9.5	14.0	30	19.5
25	82.0	4.5	10.0	36	14.5
Correl. Coeff. Test vs. 6 mo. Germ.	.82*	.96**	.99**	.92**	---

*Denotes significance at 5% level of probability.

**Denotes significance at 1% level of probability.

Table 2. Simple correlation coefficients between several quality tests and germination of soybean seed lots after storage intervals at 30°C.-50% R.H.

Quality Test	3 months	4 months	5 months	6 months
Std. Germ.	.87*	.86	.87*	.85*
Cold Test	.97**	.99**	.99**	.99**
Accel. Aging	.98**	.99**	.99**	.99**
R. G. (3 days)	.78	.85*	.87*	.83*

* Denotes significance at 5% level of probability.

** Denotes significance at 1% level of probability.

Table 3. Standard germination percentages, cold test emergence, accelerated aging performance and length in mm. of 3-day-old roots of soybeans seed stored for 9 months at 30°C.-50% R.H.

Months In Storage	Std. Germ.	Cold Test	A.A	Root Growth (3 days)
0	94.5	86.0	88.5	50.0
1	98.0	79.0	78.0**	45.0
2	95.5	64.0**	64.0**	35.6**
3	97.0	28.5**	47.0**	37.4**
4	95.0	38.5**	56.0**	40.2*
5	90.0	9.5**	18.5**	26.9**
6	82.0**	0.5**	15.0**	28.4**
7	89.5	1.0**	9.8**	20.4**
8	53.5**	0.0**	0.0**	12.0**
9	42.0**	0.0**	0.0**	3.6**

* Denotes significance at 5% level of probability.
** Denotes significance at 1% level of probability.

Table 4. Standard germination percentages, cold test emergence, glutamic acid decarboxylase activity in mm. / 30 grams seed and length in mm. of 3-day-old roots of corn seed stored for 18 months at 30°C.-55% R.H.

Months In Storage	Std. Germ.	Cold Test	GADA	Root Growth (3 days)
Control	95.5	88.6	145	118
2	99.0	89.4	114**	92**
4	95.0	84.0	106**	92**
6	94.0	63.4**	88**	80**
8	93.0	47.4**	86**	65**
10	91.5	20.7**	78**	60**
12	84.0*	18.0**	69**	44**
14	62.0**	4.0**	63**	30**
16	29.0**	0.0**	58**	16**
18	9.5**	0.0**	50**	6**

*Denotes significance at 5% level of probability.
** Denotes significance at 1% level of probability.

An exhaustive study is being made at the Mississippi Seed Technology Laboratory to measure the ability of the recently developed accelerated aging test to predict the storability of seed lots. Tables 1, 2 and 5 show that this test is very effective for determining the storability of these soybean and bromegrass seed lots under various storage conditions. In all cases, seed lots germinating poorly after accelerated aging were the first to decline in germination during storage. In addition, this test detected a significant increase in seed deterioration of soybean seed after only 1 month storage at 30°C.-50% relative humidity (Table 3). These and other data indicate that the accelerated aging test is very sensitive for measuring the extent and progress of seed deterioration during storage.

While seedling root growth measurements were significantly correlated with the germination of soybean seed lots after various storage intervals (Table 1 and 2), the correlation coefficients were much lower than those of the accelerated aging and cold tests. Root growth rates in most cases were only slightly superior to the standard germination test for predicting the storability of soybean seed lots. On the other hand, root growth measurements were very effective in detecting seed deterioration during storage (Tables 3 and 4). Significant reductions in 3-day root growth tests occurred after only 2 months storage for both corn and soybean seed lots.

Glutamic acid decarboxylase activity is an extremely sensitive test for measuring the rate of seed deterioration in storage (Tables 4 and 6).

Table 5. Comparison of initial germination, accelerated aging performance and germination following 9 months open storage of 10 lots of bromegrass seed.

Lot No.	Initial Germ.	45°C.-100%R.H. 72 hrs.	Germ. After 9 mos. Open Storage
6***	96	68	96
7	92	64	83
11	90	45	77
12	83	42	48
8	84	34	55
10	79	26	39
13	93	24	30
3	88	9	26
9	78	8	34
5	96	7	6
Correl. Coeff. A.A. vs. Open Storage			.94**

** Denotes significance at 1% level of probability.

*** Ranked according to germination after A. A.

Table 6. Standard germination percentages and glutamic acid decarboxylase activity in mm. $C0_2$/30 gm. of rice seed stored at 2 storage conditions for 9 months.

Months In Storage	20°C.-75%R.H.		30°C.-75%R.H.	
	Germ.	GADA	Germ.	GADA
0	94	130	94	130
1	94	95	94	68
2	93	72	88	35
3	93	64	71	17
4	92	55	50	10
5	92	35	6	2
6	92	22	0	2
7	87	15	0	1
8	76	9	0	1
9	57	6	0	1

An increase in deterioration was detected after only 1 and 2 months storage for rice and corn see, respectively. In addition, it has been found that the storability of monocots such as corn is closely related to the prestorage glutamic acid decarboxylase activity.

WHICH IS THE BEST QUALITY TEST?

Experience has shown that at the present time there is no quality test which can accurately measure the performance of all crop seed lots. However, the accelerated aging test appears to be adaptable to most crop seeds. Procedures have been determined for many kinds of seed and research is now underway to find the best testing procedures for several others.

Other tests such as the cold test and GADA are very good for measuring the seed quality of a limited number of crops. For example, the GADA test is very accurate for determining the seed quality of many monocot species, such as rice, corn, wheat, and etc. where the seeds have a large endosperm (high in starch). However, very little success has been obtained with this test on dicot species where there is no endosperm (high in lipids and proteins).

Very good results have been obtained with the cold test, but it has been limited primarily to corn, soybean, peanut and cotton seed lots. Results with some other crops are promising; however, it is doubtful that this test will ever be in wide use for a large number of seed kinds.

It might be well to note that more than one seed quality test will probably be needed to measure all of the performance attributes of all seed kinds. For example, the cold test may be very accurate for predicting field emergence of seed corn while the GADA test might be better for measuring seed corn storability. It is also doubtful that any one quality test can ever be adapted to suit all seed kinds.

WHAT FARMERS EXPECT FROM THE SEEDSMAN

Gene A. Sullivan[1/]

Farmers expect numerous and varied, but not impossible, things from the seedsman. Expectations of each farmer are dependent mainly on his managerial ability. Managerial ability is to be considered one of the most important characteristic of today's successful farmers.

A high level of managerial ability has not always been a characteristic of the American farmers. One indication of poor management was that farmers previously expected very little from the seedsman because the farmer lacked interest in seed quality.

With the farmer, homegrown seed (uncleaned and untested) has all too often been the rule rather than the exception. Purchasing seed seemed unnecessary. But times are changing rapidly.

This earlier farmer occasionally picked up seed of a new variety from the seedsman. The farmer often talked about high quality seed but never bought high quality seed. He wanted variety purity, but not if it meant paying a few cents more for certified seed. He wanted clean seed, but could get along with a few weed seed if clean seed cost more. In short, he talked about quality, but was never willing to pay the price for high quality seed. And sadly, he never really knew or enjoyed the benefits of good seed.

Furthermore, he failed to make pressing demands concerning seed quality. He frequently complained about the seedsman getting rich at the expense of the farmer. He smiled and boasted about homegrown seed if by chance he got a good plant stand, but he condemned everyone and everything, but himself, if he had a stand failure. Hopefully, we are completing this era of mismanagement and misunderstanding by so many farmers.

Many of these careless farmers are no longer farming. Their farms have been sold to better informed and more progressive farmers. The more progressive farmers are often young and well educated. These farmers have up to date managerial ability, and they are interested in using the practices that will make farming a profitable business.

Consequently, the farmers of today are turning theory into practice. They are willing to pay the price for high quality in order to obtain outstanding results. Most of these farmers are as adept in

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business practices as are the seedsmen with whom they deal. This is the kind of farmer that the "seedsmen of the 70's" must be able and willing to serve.

Farmers demand good seed:

As a matter of fact, the commercial farmers of today are beginning to demand good seed from the seedsman. Yes, demand good seed. They realize the need to use each proven practice in order to make a profit at farming. They know that good seed quality is one of those profit-proven practices. It is no accident that all the national winners in a 1969 soybean production contest used certified seed. In North Carolina, the top five soybean producers planted their crops with certified seed.

Farmers are beginning to realize the loss that results from using low quality seed.

> "From a North Carolina county agent came this experience. A man, who on a 30 acre corn field got only an 80 percent stand because of poor seed, reckoned his cost this way. He lost the equivalent of six acres on which he was out \$90 land use, \$54 in mixed fertilizers and \$72 in nitrogen, \$18 worth of seed and \$235 for labor and machinery. The total averages \$78 per acre on the six acres. Averaged over 30 acres, it still comes to over \$15.60 per acre. This he charges to carelessness in the purchase of seed, the least costly item of all."

At one time, farmers were more concerned with what seed became than what seed were. Farmers were interested in production from plants, not realizing that the productiveness of each plant is often limited by the quality of the seed.

However, farmers today are no longer willing to accept any lot of seed that is available at the market place, regardless of the quality. Our commercial farmers are beginning to place special demands upon the seedsman. The fact that farmers are willing to pay the price for seed guaranteed to be good should provide a fresh impetus to seedsmen to supply even higher quality seed. Getting by is no longer an accepted practice in buying and selling planting seed.

Zero defects:

You can be assured that farmers will be placing more and more precise demands upon the seedsman in relation to seed quality characteristics that are currently important. High germination, low weed seed percentage, varietal purity, and other quality characteristics are becoming increasingly important to the farmer. Within a few years farmers will be demanding quality levels and quality protections that are rare today. They will be looking for "zero defects" when they are choosing seed.

Experience has shown that many seedsmen are not as interested in placing top quality seed on the market as they are in meeting minimum standards. Such seedsmen make no real effort to strive for "zero defects". They have been happy to supply just what the law permits or what they were able to peddle. Unfortunately, such seedsmen have remained in business by making farmers price conscious rather than quality conscious. But times are changing.

An article by Dr. Delouche in the January, 1970 issue of "Seedsman Digest" stated, "molecular biologist can selectively separate the components of the cell, but we can't always separate weed seed from crop seed. Instrumentation in a satellite can differentiate between highly productive and poor fields of wheat, or diseased and healthy fields from several hundred miles in space, but we can't distinguish between vigorous and non-vigorous seed, or even dead and viable seed under a microscope at less than an inch without using elaborate tests that require hours of time." Some of these things we are able to accomplish, but we are reluctant to enter new programs of seed evaluation.

The reason that some of these things are not being used is that the final user, the farmer, has not yet organized so as to make unmistakable demands for such high quality. Thus, the seedsman has not given the desired incentive to market seed which approach "zero defects".

However, the seedsman may soon find that it is necessary to change the procedures used in harvesting, processing, and marketing seed. Farmers are demanding procedures that do not excessively reduce the quality of the seed. We are not yet knowledgeable of all the changes that will be required, but we have the technical ability in several areas to reduce seed damge. The practice of cleaning and processing at harvest time, for example, is usually less damaging than the same cleaning and processing after a storage period.

Consequently, the practice of the seedsman to produce seed at the lowest possible cost without regard to quality is being outmoded. It is true that the price conscious farmer and competition from "run-of-mill" seedsmen has forced many quality conscious seedsmen to market substandard seed.

Quality conscious farmers will reverse this trend. Quality will become the dominant factor rather than price. Price will be important, but the businessman-farmer of the 70's will be able to place each in perspective. The seedsmen of the 70's should already be striving for "zero defects".

Demands for varietal purity:

Seedsmen have the responsibility to provide the farmer the best in adapted varieties. The farmer expects such seed to be truthfully labeled. Certified seed will have an increasingly important role in assuring the farmer of genetic quality.

Some people expect a deluge of new varieties with passage of the "Breeders Rights" legislation. This is going to place here-to-fore unknown pressures upon the seedsmen. Can the seedsman afford to depend solely on the statement of a producer-supplier as to variety of a seed lot? Certainly, the certification program for varietal purity has to be an important part of each seedsman's quality control program. Seedsmen who market uncertified seed will need an inspection program that will guarantee varietal purity. Farmers are going to demand it.

Plant breeders are developing and releasing varieties that have a specific final use. For example, you may have heard discussions concerning high lysine corn. Also, recent articles have indicated that a particular variety of sorghum may have a higher food conversion in feeding animals than other varieties. Several cotton varieties are available which have superior fiber characteristics. As varieties become more specific in product use, farmers will demand that more attention be given to variety purity. Thus, the demand for certified seed will increase.

A one-variety gin program is now operating in North Carolina and many other southern states in cotton seed production. This program of pure seed production is under the supervision of crop improvement officials. A ginner contracts with cotton producers in his area to produce a specific variety of cotton on a farm unit. At harvest time, the ginner accepts only the agreed upon variety of cotton for ginning. The problem of contamination by other varieties during ginning is thus eliminated. Perhaps other crops could be more pure if one-variety production areas were utilized. Naturally, there are certain hazards associated with one-variety areas. A poor production season or natural calamities may limit the supply of seed.

The one-variety gin idea has carried over into the marketing of the lint, also. In North Carolina, for example, a verified cotton variety producer program permits identification of the lint by variety. Thus, the lint user is able to purchase large lots of cotton by variety. The spinner utilizes his knowledge of variety fiber characteristics in deciding which variety his plant will most satisfactorily process.

Participants in the one-variety cotton program are required to use foundation, registered, or certified seed. They carry out a cultural program designed to produce uniform quality. These farmers plant only one variety of cotton on a farm unit in order to maintain physical separation of varieties. Such a program is of enormous merit and its workability is based on variety purity.

Seed companies with plant breeding programs may become involved in the marketing of commercial crops. Such a marketing program may prove to be beneficial to the farmer and the seedsman as varieties with specific end uses are developed.

The point of this discussion was to stress the importance of varietal purity. We have seen contamination of soybeans with crotolaria species. We are entering an era when contamination by other varieties is becoming of increasing concern.

Demands for seed uniformity:

Precision planting of today places a considerable burden upon the seedsman. Farmers are looking for once-over planting that results in adequate and uniform plant stands. The vegetable producers have led the way in demonstrating the need for uniformity in seed. Stand uniformity is especially important in today's vegetable production programs.

Therefore, farmers will expect precision grading of seed in order to insure uniform field emergence. Uniformity of size and shape in seed is important if precision planting techniques are to be developed. Even more important and more difficult to obtain will be acceptable uniformity in germination and vigor. Only recently have farmers begun to place a high priority on the importance of seed vigor.

F-1 hybrids are helping in our efforts to obtain field uniformity in plant growth, maturity and quality. Seed tapes and other mechanical devices aid in uniformity of stands. Perhaps breeding programs will be reoriented so as to help us obtain uniformity in seed size, shape, vigor, and overall quality.

One aspect of seed uniformity relates to uniformity within a given seed lot. Farmers deserve and expect seed lot uniformity. The farmer often finds that a few bags of seed from a supposedly uniform lot are substandard in germination or contain excess contaminants. Such non-uniform seed lots result in poor uniformity in the field. The farmer has trouble solving the riddle of poor plant stands in small areas of the field. Therefore, farmers expect seedsmen to improve their methods of producing and processing to provide uniform seed lots.

At a recent annual meeting of the North Carolina Crop Improvement Association, George Spain (Director, Seed Testing Division, N. C. Department of Agriculture) discussed representative sampling and seed lot uniformity. He stated that the accuracy of quality statements on the analysis label is highly dependent on accurate and representative sampling. He also stressed that the statement of quality is never absolutely factual but is only an estimate based on probabilities.

Most farmers expect and believe such estimates as those on the label and to purchase seed according to the information provided. We all agree that this is the best information available, but efforts should be made to improve the accuracy of information on the analysis label.

Furthermore, Mr. Spain pointed out that a 200 bushel lot of soybeans contains approximately 38 million seeds. An official germination test is made on 400 seeds from the seed lot. This requires a quality projection in the magnitude of 96,000 to 1. Two seeds are used to estimate performance in an acre of planted soybeans. A germination test from a 200 bag lot of tall fescue requires a quality projection even in the magnitude of 5,000,000 to 1.

Representative sampling must be a planned part of each seedsman's quality control program. The farmers expect seedsmen to identify correctly the quality characteristics of a seed lot.

<u>Farmers want more information</u>:

Farmers expect the seedsman to take advantage of new techniques that may provide additional information about seed quality. Considerable research effort has been devoted to developing tests to estimate seed vigor. Dr. R. P. Moore of N. C. State University has been a leader in developing the tetrazolium test for measuring seed vigor. Other researchers have promoted other vigor testing methods. Vigor tests are sound and workable, but seedsmen have been slow to provide vigor information to the farmer. Some seed companies have their own vigor testing programs, but little or no effort has been made to indicate vigor on analysis labels.

It has been estimated that 6 to 7 billion people will inhabit this earth by 2000 A.D. Farmers will have to take advantage of all technology in order to produce the food and fiber needed. Seed vigor is becoming one facet of technology of extreme importance.

Seed of high vigor can be planted earlier and thus extend a limited growing season. Vigorous seed will be needed in double cropping systems so that the second crop grows rapidly. Seed of uniform vigor will provide additional plant uniformity that will aid in precision harvesting.

In his inaugural address, President Johnson made the statement "Harvest sleeping in unplowed ground." He was referring to unused human abilities.

We can think of this statement in relation to seed. How much harvest is lost because seeds of low to average quality are used? What is the magnitude of the "harvest sleeping" in unused seeds of superior quality?

A 1969 peanut field test in North Carolina showed the importance of seed vigor. Samples from over 100 different seed lots were planted in field plots. Seed lots that gave the quickest emergence in the field also produced the highest yields at harvest times.

Farmers are becoming more knowledgeable about seed and seed quality. Before long, farmers will demand a seed testing program that measures more than one (germination) of the many important characteristics of seed life.

Changes in cultural practices:

We continue to hear about high density planting and the changing shape of the corn plant, the cotton plant, and other species. How will such changes affect the need for high quality seed?

Perhaps our first impulse is that with so many plants, the importance of a single seed is lessened. However, close examination reveals that seed quality will be even more important. In many crops, our plant breeders are developing varieties that are more determinant in fruiting habit. We're speaking of such things as cotton with a maximum of three bolls. Such determinant varieties will not have the ability to compensate for missing hills. Today, many of our varieties will compensate for missing plants by heavier fruiting on plants adjacent to the skip. Varieties with determinant fruiting will be less able to compensate.

Seed quality will be even more important with high density planting. If a farmer gets only a 90 percent stand, he immediately loses ten percent of his potential yield. Each seed must produce a plant which will contribute a small, but important part to total production. High density planting will make it easier to show an economic return from good seed.

Attitude changes:

The farmer today is dressing up and going uptown. He will soon be demanding additional cleanliness around seed processing plants and in seed stores. The farmer's personal values and attitudes are changing. Seedsmen must add eye appeal to their processing operations and add eye appeal to their product-seed. This must be accomplished while maintaining or even upgrading high levels of seed quality.

Seedsmen and farmers of the 70's will establish a more personal relationship among themselves. There will have to be mutual efforts and benefits if the farmer and the seedsman survive. Each will have an important task in supplying this nation and world with adequate food.

The seed producer:

The farmer expects the seed producer to be a professional. Producers who decide at the last minute to convert feed into seed are unacceptable. The seed producer must continue to gain additional knowledge that will help in producing high quality seed.

The seed producer has the potential of being the most important individual in supplying high quality seed. Farmers expect seed producers to be proficient in the technical aspects of seed production. Seed producers will have to become more specialized and quality conscious if seed quality is to be upgraded.

Many seed producers are currently not concerned about the use of the product they produce. They think of it only as another crop. Our agriculture has given the highest returns to quantity rather than quality. Therefore, the seed producer has not shown an adequate interest in quality. This is changing as more and more seed growing contracts are being used by seedsmen. To be able to sell his production, the seed grower has to produce seed which meet specific contract requirements.

In addition, the seed grower must accept the responsibility of producing variety pure and weed free seed. He is the first link in maintaining variety purity and physical quality. The managerial ability of most seed producers is good, but improvements, with emphasis on quality, can still be made.

The farmer expects the seed producer to become less involved in speculative merchandizing and more intent on producing a quality product.

The seedsmen:

Seedsmen can be classified into several categories; namely, (a) the breeder-grower-merchandizer, (b) the grower only, (c) the wholesaler and (d) the retailer. The basic responsibility of each seedsman is to provide high quality seed of the right variety in the proper quantity at the appropriate place and time. This is not an easy task when you consider the crops and varieties available.

The "1970 Directory and Buyers Guide" of the Southern Seedsmen's Association list about 75 field crops and over 400 varieties. This does not include corn hybrids, cotton, tobacco, and rice varieties, and sorghum and sorghum-sudangrass hybrids. Therefore, it is not an enviable task to have the right variety at the right place and time.

Truthfully, the farmer many times expects more from the breeder-grower-merchandizer than from wholesalers and retailers. Ultimately the responsibility for seed quality is placed upon this seedsman. Farmers expect these companies to continually supply better varieties which are tailor-made to meet the specific needs of certain regions. Many farmers believe that seed from name-brand seedsmen are always higher in quality than non name-brand seed. Therefore, the breeder-producer-merchandizer must accept the responsibility to produce and market high quality.

Seed wholesalers and retailers are primarily merchandizers. Seed may be only one of many items sold. These seedsmen are less involved in the production and processing of seed. Therefore, wholesalers and retailers must make special efforts to keep up to date, also.

Farmers do expect these seedsmen to keep up to date, not only with the improved varieties, but with performance information on each variety. The seedsman is an important source of information for the farmer. The seedsman is expected to supply the seed and reliable information on cultural practices for producing the crop.

Seedsmen of the 70's:

The successful seedsmen of the 70's will be those who can best meet the demands of the farmers. Such seedsmen will supply the best varieties of pure and vigorous seed in uniform seed lots. Such seedsmen will strive to supply seed with zero defects and to provide reliable production information.

What kind of quality will be demanded for the first seed that travels to the moon? Can we afford to take along a few weed seed, a varietal mixture, or a few non-germinative seed? Seed with "zero defects" will be required for this quarter of a million mile trip. Such seeds are also needed on earth by farmers who want to "blast off" for maximum profits.

If you are a seedsman that could routinely supply these first "moon" seed to NASA, then you are a seedsman of the 70's. Such high quality is an indication of the kind of demands the farmer will place upon the seedsman of the 70's.

SEED QUALITY AND CROP PERFORMANCE

C. Hunter Andrews[1/]

We are in the midst of a great American agricultural revolution, whether we like it or not. Today agricultural statistics reveal that a "farmer" produces for himself and 42 additional people, whereas 100 years ago he produced for himself and only 3 people. Indeed, with the anticipated doubling of the earth's present 3.6 billion people in the next 35 years, this fantastic agricultural revolution is quite timely.

The decade of the 70's may not bring to fulfillment all of the revelations recently suggested in the February issue of National Geographic - automated and radio controlled farm equipment, complete weather control, automated irrigation systems, and the development of various chemicals to regulate crop growth to enable optimum marketing. However, already past the research stage and into current agricultural practice we find tape planting of seeds for uniform stands and capsulated seeds for regulating fertilizer and water availability to sprouting seedlings.

A prime requisite for the ultimate success of such agricultural achievements MUST be the development, production and maintenance of the highest quality agricultural seed possible. A critical look back over the past ten years reveals considerable technological developments concerned with the betterment of crop production, i.e., various herbicides for chemical weed control and insecticides for insect control. Indeed, there are sprays for practically all unwanted grasses, weeds and insects, but possibly we have overlooked improvements in the very obvious---THE SEED ITSELF!

Yes, quite obviously our agricultural technology is rapidly changing, but our present concept of a seed will more than likely remain unchanged throughout this decade. The basic purpose of a seed is that of reproducing one of its kind. Indeed a seed is a natural survival mechanism devised by nature for insuring survival of the species; however seeds of most of our cultivated agricultural crops must be protected and maintained in a manner to insure fulfillment of their basic objectives.

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The reproductive process of agricultural species was viewed by early botanists as an infinite process,i.e., these early scientists considered new generation plants to arise from completely developed miniature plants within a seed or a preceding generation. And within each plant there was another miniature plant ---and so on until infinity. This philosophy fitted the needs of that time; however, now we know that this concept is not entirely true, that is, within a seed there is not a fully developed tiny plant, but within each seed there are certain essential structures, which when properly developed and subsequently maintained in a healthy condition will produce a normal healthy plant. The condition of these essential structures - their quality - has a marked influence upon the total performance of the resultant plant.

Now, just what is seed quality? Quality is a relative term and means the degree of excellence. In other words, the quality of seed may be expressed as a rating or level or degree of excellence which seeds assume only when compared to an acceptable standard. Therefore, seed may be superior, good, medium or poor in quality, depending upon the selected descriptive adjective and the criterion used for classification.

Seed can assume a particular quality rating according to numerous criteria----appearance, uniformity, germination, purity, contamination by weed seed, insects and inert matter, disease association, degree of mechanical injury, treatment injury, degree or level of deterioration, stage of maturity and no doubt many others. Certain of these seed quality attributes are routinely evaluated in standardized laboratory tests, and consequently the general overall quality of a particular seed is readily ascertainable. Other qualities are more difficult to assess in routine laboratory tests, but current research convincingly illustrates the value of interpreting these quality factors in that they exert a definite influence upon the resulting plant performance.

In many cases low quality seeds can be detected by the distinct abnormal seedling types which they produce. Research on selected seeds (Melilotus, Lotus, Trifolium and Medicago) has shown that certain abnormal seedling types, i.e., those with watery, glassy or translucent hypocotyls, cracks or splits of the hypocotyl, browning of the hypocotyl caused by fungi, granular tissue beneath the epicotyl, short or attenuated roots, bound roots and partially decayed cotyledons produced inferior plants when compared to normal seedlings. Additional evidence similar to this was also obtained for peanuts and soybeans. No doubt the inferior plants were incapable of performing as well as normal healthy plants from strong vigorous seedlings.

Considerable loss in seed quality stems directly from mechanical injury sustained by seeds during the numerous mechanical operations from harvest to final bagging. Certainly, you, as seedsmen, are quick to recognize that mechanically injured seed produce various types of abnormal seedlings: baldheads, deformed roots, seedlings missing some essential structure and other types. In ideal conditions these seedling types may survive, but seldom do they grow as rapidly and produce as well as normal healthy seedlings. Some research with corn has shown a decrease of approximately 8 bushels of seed per acre from broken kernels, and normal pea and bean seedlings outyielded abnormal ones by as much as 8 percent. Indirectly, mechanically injured seed, lower in quality, are more susceptible to invasion and infection by fungi, virus and bacteria. Ultimately, plants from such seeds are significantly reduced in size, vigor and productivity.

Seed quality also declines as seeds undergo the natural aging processes which is inevitable in all biological systems. Quite recently exhaustive investigations have been conducted concerning this very aspect of seed quality and its effect upon plant performance. One such study was concluded recently by one of our international graduate students. Dr. Gill evaluated selected quality expressions of dent and flint corn seed which had been stored for as long as 10 months at 30°C. and 55% r.h. which produced differential levels of seed deterioration. Of importance here is the data available on plant performance and yield. Plant height was measured 4 times during the growing season, 25, 50, and 75 days after planting and at harvest. The deteriorative effects of extended storage, which lowered seed quality, was only evident in plant height during the early growth stages (Table 1). The slower growing seedlings, those of greater deterioration and thus lower quality, "caught up" in growth rate to plants from lesser deteriorated seed so that differences were insignificant when evaluated 75 days after planting.

Table 1. Average plant height measured in mm. at various intervals after planting of dent and flint seed corn stored at 30°C. and 55% r.h. over a period of 10 months.

Seed	Storage Months	25 Days	50 Days	75 Days	Harvest
		Average Plant Height (mm.)			
Dent	Control	588	1512	2632	2740
	2	550	1459	2576	2658
	4	558	1512	2652	2761
	6	506**	1439	2682	2767
	8	480**	1397**	2644	2713
	10	483**	1437	2645	2740
Flint	Control	482	1504	3000	3423
	2	485	1492	2977	3358
	4	466	1432	2961	3371
	6	452	1425	2897	3307
	8	459	1443	2958	3278
	10	419*	1361**	2839	3224

* Denotes significance at 5% level of probability
** Denotes significance at 1% level of probability

Yield from these treatments was converted to kilograms per hectare at 15.5% moisture on a wet basis and adjusted for equivalent stands by the use of convariance analysis (Table 2.)

Table 2. Yield of dent and flint seed corn stored for 10 months at 30°C. and 55% r.h. (kg./ha. at 15.5% moisture - wet basis).

Storage	Dent		Flint	
Months	kg./ha.	%reduction	kg./ha.	% reduction
Control	4279.22	---	5539.41	---
2	4352.03	---	5231.72**	5.6
4	4103.91	4.1	5357.55*	3.3
6	4083.74*	4.6	4733.23**	14.6
8	3905.71**	8.7	4817.55**	13.0
10	3659.76**	14.5	4505.92**	18.7

* Denotes significance at the 5% level of probability
** Denotes significance at the 1% level of probability

Compared to that of the control, the yield of the dent hybrid was decreased by 4.6% after 6 months storage at $30^{o}C.$-55% r.h., 8.7% after 8 months and 14.5% after 10 months storage. Yield reductions in the flint hybrid were more variable, and the maximum reduction of 18.7% was recorded after 10 months storage. In this research differences in shelling percentage accounted for the yield reduction from plants of the deteriorated seed of the dent corn; however, only about one half of the yield reduction from plants of deteriorated seed of the flint hybrid was accounted for by a reduction in shelling percentage.

Additional investigations have been conducted by members of the Seed Laboratory staff. Mr. Harold Byrd, a current candidate for the Ph.D. degree, has recently completed a detailed study of soybean seed relating seed quality to plant performance. In this study hand-harvested Lee 68 soybean seed with a moisture content of 12.3 percent were artificially aged in sealed containers at $38^{o}C.$, thus producing different levels of seed quality after different intervals within the aging environment. Performance of unequal stands of soybean plants from seed of differential quality levels is shown in Table 3.

Table 3. Comparison of field emergence, plant height, yield, leaf area index (LAI) and plant dry weight means for the May 15 planting as determined by Duncan's New Multiple Range Test.[1]

Seed Quality[2]	Emerg. %	Ht.6/7 -mm.	Ht. 6/27 -mm.	Yield gm/plot	LAI 7/11 -cm2/m	Dry wt. 7/11 -gm/m.
0	88.2a	17.5a	45.1a	1204a	34,850a	321a
5	87.7a	16.1ab	42.9a	1114ab	33,572ab	292a
10	77.3b	15.3b	39.1b	1099ab	21,989bc	185b
15	47.9c	14.5bc	39.1b	993b	19,591c	143b
20	40.7cd	13.7cd	37.2bc	843c	14,742c	186b
25	38.2d	12.9d	34.6c	820c	13,271c	130b
CV.	11.7%	8.0%	7.0%	9.4%	33.8%	24.7%

[1] Within each column any two means not followed by the same letter are significantly different at the 5% probability level.

[2] No. days stored in sealed jars at $38^{o}C.$ at 12.3% seed moisture.

Plants from the highest quality seed, those which were not stored, achieved the highest performance ratings for all characteristics evaluated. As seed quality declined over extended storage periods, plant performance declined. Plants from seed stored for only 10 days were significantly inferior to plants from the top quality seed. Plant performance from seed stored 25 days was extremely poor.

Table 4 shows plant performance based on equal stands from seed of different quality levels.

Table 4. Comparison among field emergence, plant height and yield means for the June 6 planting as determined by Duncan's new multiple Range Test.[1/]

Seed Quality[2/]	Emergence (%)	Plant Height (6/30-mm.)	Yield (gm./plot)
0	96.3ab	23.2a	850a
5	98.9a	23.9a	888a
10	97.7ab	22.9a	795*
15	89.5bc	22.0ab	838a
20	81.7c	20.2bc	852a
25	84.4c	20.0c	848a
C.V.	7.4%	7.0%	

[1/] Within each column any two means not followed by the same letter are significantly different at the 5% level of probability.

[2/] Number days stored in sealed jars at 38^{o}C. at 12.3% seed moisture.

* Plants severely disease damaged

Slight but significant differences began to show up in field emergence percentage and plant height for plants from seed stored 15 days as compared to plant performance from the highest quality seed. These differences were recorded only during early plant growth, and, as reported previously, plants from the lower quality seed appeared to "catch up" in plant performance. Under the conditions of this work no differences were recorded in yield from <u>equal</u> stands of plants from seed of different quality levels.

A similar study with rice by one of our international students from Thailand, Mr. Prasoot Sittisroung, has produced additional data concerning performance of plants from seeds of varying quality levels.

Differential seed quality was obtained by subjecting rice seed to storage environments of 20°C.-75% r.h. for 7 and 12 months, 30°C.-75% r.h. for 7 months and 40°C.-100% r.h. for 5 and 9 days. The highest quality seed were those stored at optimum conditions of 7°C.-50% r.h. Performance of rice plants from these seed is shown in Table 5. These data are based on equal plant populations.

Table 5. Comparison of plant height, number of tillers, plant dry weight and yield means for plants of Bluebonnet 50 rice seed of different quality levels as determined by Duncan's new multiple Range Test.[1/]

Seed Quality[2/]	Ht. 6 wk. mm.	Tillers 19 wk.-No.	Dry wt. gm/plt.	Yield (gm/plt.)
7°C/50%r.h.(control)	53.5a	9.8a	49.7a	39.4a
30°C/75%r.h.(7 mo.)	47.2b	8.0b	40.5b	34.9ab
40°C/100%r.h.(5 da.)	47.4b	8.0b	40.8b	35.4ab
40°C/100%r.h.(9da.)	45.1b	7.7b	38.2b	33.5ab
20°C/75%r.h.(7 mo.)	49.4ab	7.7b	38.5b	33.0b
20°C/75%r.h.(12mo.)	48.2ab	7.9b	40.3b	32.9b

[1/] Within each column any two means not followed by the same letter are significantly different at the 5% probability level.

[2/] Storage conditions and storage time for producing differential quality levels.

Without exception plants from the highest quality seed (those stored at 7°C.-50%r.h.) were superior to plants produced from lower quality seed. Plant height differed significantly in the early plant stage (6 weeks), and number of tillers were significantly different at 19 weeks after planting. A final analysis revealed that plants from the best seed differed significantly from all others in per plant dry weight production; however, significantly lower yields were recorded only for plants produced from seed stored at 20°C.-75% r.h. for 7 and 12 months.

Some information on peanuts is available through the courtesy of Charles Baskin, a current Ph.D. candidate in Seed Technology. Samples from seven commercial lots of peanuts exhibited initial seed quality differences as judged by germination and other selected tests. These lots were field planted for evaluation of plant performance.

Table 6. Comparison of initial germination, plant stands and yield for 7 lots of peanut seed.

Seed Quality	Germ. (%)	Plant stand (no.) 5/19	5/21	6/4	Yield gm./plot[1/]
1	98.7	105.3	129.3	133.3	1342.5a
2	94.0	56.2	101.5	118.5	1324.5a
3	92.7	70.0	108.8	127.7	1257.5a
4	89.3	63.5	99.0	116.5	1133.8ab
5	88.0	48.2	71.3	80.0	1008.0b
6	80.0	56.2	96.8	110.5	1227.3ab
7	79.3	56.0	111.5	128.7	1014.7b

[1/] Any two means not followed by the same letter differ significantly at the 5% level of probability.

The highest quality seed with respect to germination produced the highest plant survival (stand), and these plants produced the highest yield. When germination declined to 88%, plants from those seed produced significantly lower yields.

As a result of our expanding international graduate program, we have recently become involved in research with vegetable seed. The relationship between carrot seed quality and plant performance was studied in considerable detail by a recent Brazilian graduate student. Results from these investigations revealed that carrot seed from different order umbels, harvested when each umbel order was considered initially mature, were of different quality. Field tests indicated that seed quality had a significant effect on the resultant plant performance (Table 7).

Table 7. Comparison of selected quality parameters of Chantenay carrot seed from different order umbels harvested at initial maturation and at the final combine date with selected parameters of the commercial seed.[1/]

Umbel order	Harvest Date	16-Day % Field Emerg.	Root Measurements Fresh wt.(gm)	Diameter(mm.)
1st	Initial Maturity-7/26	45.6a	16.070a	22.9a
1st	Combine date-8/31	46.0a	15.025ab	21.9ab
2nd	Initial Maturity-8/9	39.6ab	14.570ab	21.5ab
2nd	Combine date-8/31	38.4ab	13.707ab	21.3ab
3rd	Initial Maturity-8/23	25.6bc	11.135b	19.8b
3rd	Combine date-8/31	21.8c	14.640ab	21.2ab
Comm.	Combine date-8/31	42.2ab	16.437a	23.2a

[1/] Any two means not followed by the same small case letter within each column are significantly different at the 5% level of probability.

Green weight and diameter of roots from plants grown from seeds of the first order umbel seed harvested at initial maturation was significantly greater than that of the roots of plants grown from seeds of the third order umbels harvested at initial maturation.

Carlos Vechi, a graduate student from Brazil, evaluated seed quality and plant performance of cowpeas. Seed quality levels were determined by root growth tests even though germination differed very little between the quality levels.

Table 8. Evaluation of performance of plants from seeds of different quality levels for cowpea seed.

Seed Quality	Root Length (mm)	Germ. (%)	Pods (per plant)	Yield (gm/plant)
Check	63.2	85	992.3	2634
High	66.7	81	990.1	2491
Medium	53.7	79	925.8	2491
Low	51.0	78	901.3	2422

Although performances were not extreme, approximately 10 percent fewer pods were produced on plants from the lowest quality seed as compared to the check. This observation held true for final seed yield.

A graduate student from Taiwan is interested in seed quality and plant performance of other vegetable seed, i.e., squash, radish and turnips. Mr. Chen imposed artificial aging conditions on these seed in order to select differential quality levels. Consequently he obtained seeds of each crop expressing high, medium and low vigor or quality. Field plantings of these seed revealed interesting results.

Table 9. Germination and subsequent plant performance of radish, turnip and squash as influenced by seed quality.[1/]

Crop	Seed Quality	Std. Germ.	Root Lgth (cm.)	Yield	
				gm/10 plts.	
Radish	High	97.5	62.8	154.0a	
	Med.	90.5	35.0	97.1a	
	Low	31.5	8.0	54.3b	
				Avg. Wt.(gm/root)	
Turnip	High	97.0	62.3	108.1a	
	Med.	71.0	29.5	90.7ab	
	Low	61.5	19.1	60.8b	
				Total No. Fruit	Total Wt.(kg.)
Squash	High	98.0	65.7	804a	61.28a
	Med.	82.0	34.4	596b	51.83b
	Low	72.0	26.3	590b	48.49b

1/ Any 2 means not followed by the same small case letter are significantly different at the 5% level of probability.

This work substantiates previous investigations in that the plants from higher quality seed were significantly superior to plants from poorer quality seed.

A slightly different aspect of seed quality and plant performance has been reported by two research workers in England, Abdalla and Roberts. Initially they worked with seed of barley, broad beans, and peas in an attempt to evaluate possible morphological abnormalities resulting from losses in seed viability or quality. To obtain various levels of seed quality, they artificially aged the seed at various combinations of temperature and moisture content until the viability of some was reduced to about 50%. Their cytological observations revealed that the aging treatment which leads to 50% viability loss usually leads to some degree of chromosome damage, especially in beans and peas.

Additional research in this area by Abdalla and Roberts was devoted to evaluating plant growth and yield as influenced by seed quality. The same seeds were subjected to storage environments of various combinations of temperature and moisture content which actually produced differential quality levels. Field plantings enabled evaluation of plant performance as related to seed quality. (Table 10).

Table 10. Yield comparison of pea, bean and barley plants from surviving seed of various quality levels.

Bean		Pea		Barley	
Germ%	Yield-Kg/Ha	Germ.%	Yield-Kg/Ha	Germ.%	Yield-Kg/Ha
100	7000	90	6300	100	4300
85	7000	75	6100	81	4100
80	6500	70	6200	79	4400
67	6000	55	6100	65	4200
60	6600	54	6000	60	4200
45	4500**	37	4800**	40	4200
40	5000**	32	4000**	37	4000
24	4200**	15	3200**	21	3000**
20	4300**	13	3900**	15	3800

These researchers contend that the percentage of viability of a population of seed indicates the level of performance of the surviving seeds no matter what the rate of deterioration or which factors contributed to it. Conforming to results of various investigators, they suggest the main effects of deterioration (and thus lower quality), both in roots and shoots, are manifested only during early growth stages. During later stages of growth, differences observed earlier tend to be partially compensated. These workers have concluded that final yield may not be significantly affected unless seed deterioration is so severe that germinability declines to 50% or lower. Their yield data in Table 10 confirms this concept.

I have heard it said that farming is just one big poker game, and that all farmers are just gamblers. But I believe that a good seedsman will not gamble his success on poor quality seed. I am confident that quality of planting seed will become increasingly important in the 1970's. Even now a survey of top seed organizations reveals that many have quality control programs and others are continuing to incorporate such programs into their overall operations.

HOW A PSYCHROMETRIC CHART IS USED TO DETERMINE AIR PROPERTIES

James M. Beck[1/]

In seed drying air has two functions: (1) it supplies the heat that is necessary to evaporate moisture and (2) it is the vehicle for transporting moisture away from seed being dried and exhausting it into the atmosphere.

Under storage conditions seed attain a rather characteristic moisture content when subjected to given levels of air temperature and relative humidities. This equilibrium moisture content is directly related to the properties of the air surrounding the seed.

A knowledge of the terms used in psychrometrics and use of the psychrometric chart is essential for an understanding of the processes involved in seed drying and in analyzing individual requirements for controlled temperature and humidity seed storage.

PSYCHROMETRIC CHART

The psychrometric chart is a device which simplifies the measurement of air properties and eliminates many time-consuming and tedious calculations which would otherwise be necessary. Different air-conditioning manufacturers have slightly different forms of this chart which may differ in the location of information. All, however, are basically the same in that any psychrometric chart is simply a graphic presentation of the conditions or properties of air, such as temperature, humidity, and dewpoint. (A psychrometric chart supplied by Log E, Dryomatic Division, Springfield, Virginia, is attached.)

PSYCHROMETRIC TERMS

The essential terms which are most commonly thought of in connection with the psychrometric chart are: dry-bulb temperature; wet-bulb temperature; relative humidity; dewpoint; and grains of moisture.

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Dry-bulb Temperature is the temperature of the air as measured by an ordinary thermometer such as a househould thermometer. (See Figure 1)

Wet-bulb Temperature is the temperature of the air as measured by an ordinary thermometer whose glass bulb is covered by a wet cloth or gauze. (See figure 2) The temperature is recorded after the thermometer has been moved rapidly in the air.

A wet-bulb thermometer is so called because the bulb of the thermometer is wet when a temperature reading is taken. This is accomplished by slipping a cloth "sock" on the bulb end of the thermometer and then dipping both into water. Except for the "sock", a wet-bulb thermometer is the same as a dry-bulb or ordinary thermometer. To measure wet-or dry-bulb temperatures, a sling psychrometer is used.

A sling psychrometer (See figure 3) has two thermometers mounted on a base plate. The one with the "sock" is the wet-bulb thermometer; the other is the dry-bulb. The wet-bulb extends below the dry-bulb. This is done purposely so that the "sock" can be dipped in water without wetting the dry-bulb thermometer.

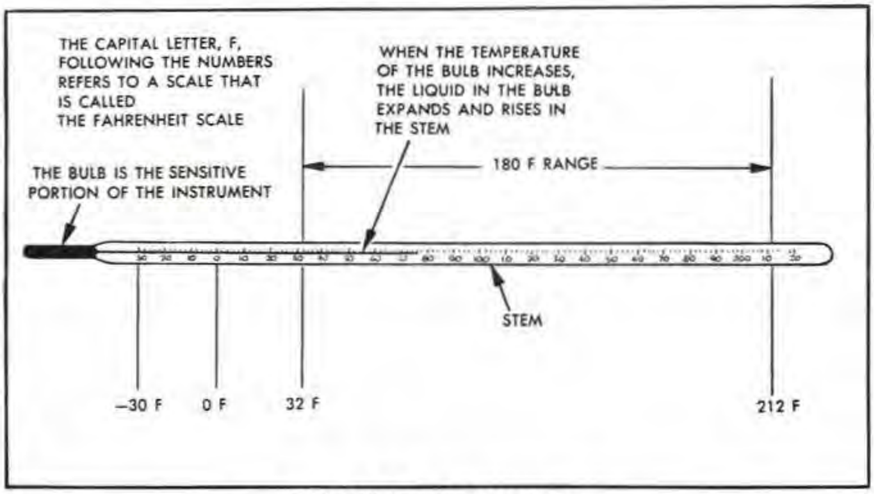
If the "sock" is wetted as described, and the two thermometers are moved quickly through the air until the water evaporates from the "sock" the thermometer with the dry-bulb will register the dry-bulb or ordinary temperature, and the thermometer with the wet sock on the bulb will register a wet-bulb temperature.

Although the air passing over the dry-bulb is the same temperature as the air passing over the wet-bulb, the temperature registered by the two thermometers is not the same. The dry-bulb always registers the actual air temperature, the wet-bulb registers a temperature that is lower than the dry bulb reading.

The key to the seemingly apparent discrepancy in temperature readings is the word "evaporation." As moisture evaporates from a surface, it removes heat from that surface.

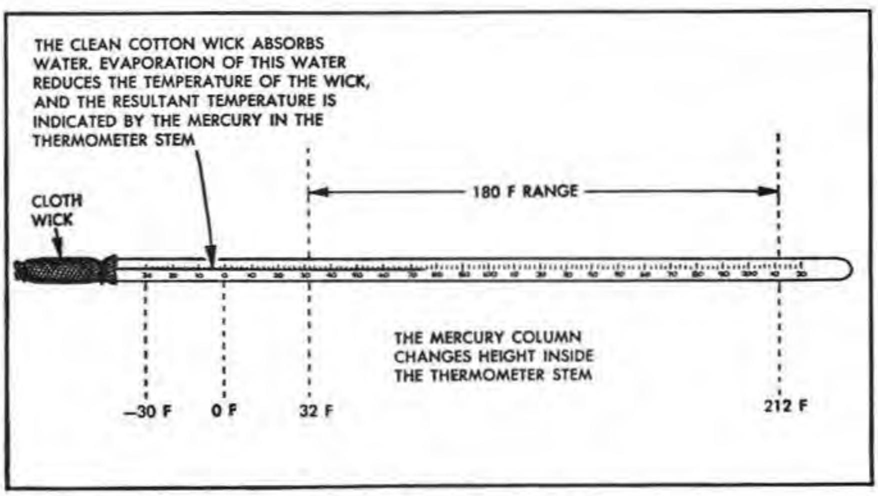
In this instance, moisture evaporates from the wet "sock" on the wet-bulb thermometer and consequently cools the surface of the thermometer bulb. This is primarily the reason for a lower wet-bulb thermometer reading.

The temperature spread between the dry-bulb and wet-bulb readings depends upon the amount of moisture in the air. If moisture content is high, evaporation at the "sock" on the wet-bulb takes place at a slower rate. If the moisture content of the air is low,



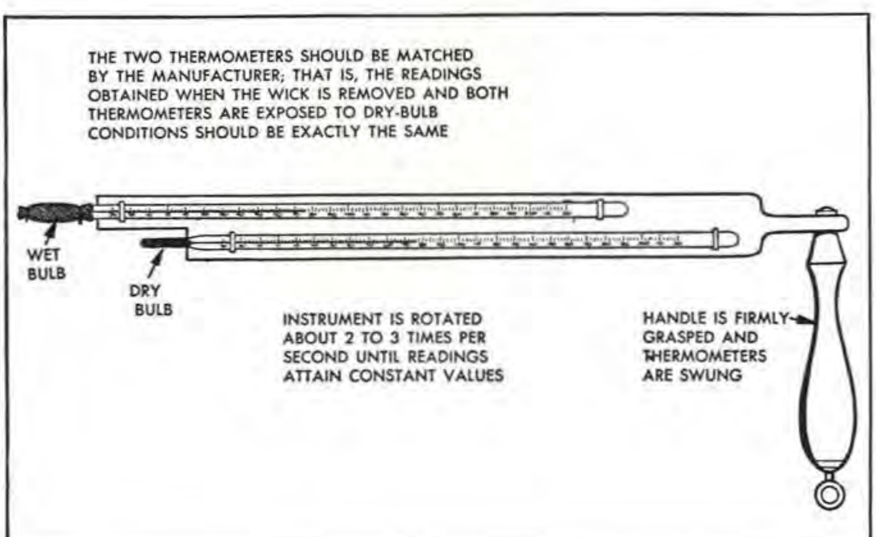
DRY-BULB THERMOMETER

Figure 1



WET-BULB THERMOMETER

Figure 2



SLING PSYCHROMETER

Figure 3

the air is dry and can readily absorb moisture. Therefore, evaporation at the "sock" takes place at a rapid pace and heat is removed in larger quantities. This makes the surface of the wet-bulb cool rapidly. As a result, the reading on the wet-bulb thermometer is lower than for air that has a high moisture content.

Dry air, or air that has low moisture content, therfore, has a low wet-bulb temperature; humid air, or air that has a high moisture content, has a high wet-bulb temperature. In fact, when the moisture content reaches 100% or 100% relative humidity, the wet-bulb temperature becomes the same as the dry-bulb temperature. This can be readily seen on the psychrometric chart. At this condition evaporation ceases because the air cannot absorb more moisture. Therefore, it is not possible to remove heat by evaporation from the "sock" on the wet-bulb, and the two thermometers register the same temperature.

Relative Humidity is the actual amount of moisture in the air compared to the total or maximum moisture the air can hold.

Grains of Moisture is the unit of measurement used to determine the amount of moisture in the air. 7000 grains equals 1 lb. of water.

Dewpoint Temperature is the temperature at which moisture condenses on a surface.

In relation to the Psychrometric Chart, these terms can quickly tell many things about the condition of the air, for example:

If the dry-bulb and wet-bulb temperatures are known, the relative humidity can be read from the chart.

If dry-bulb temperature and relative humidity are known, the wet-bulb temperature can be determined.

If wet-bulb temperature and relative humidity are known, the dry-bulb temperature can be found.

If wet-bulb and dry-bulb temperature are known, the dew-point can be found.

If wet-bulb temperature and relative humidity are known, dewpoint can be read from the chart.

If dry-bulb temperature and relative humidity are known, dewpoint can be found.

The grains of moisture in the air can be determined from any of the following combinations:

Dry-bulb temperature and relative humidity (rh)
Dry-bulb temperature and dewpoint
Wet-bulb temperature and relative humidity
Wet-bulb temperature and dewpoint
Dry-bulb and wet-bulb temperatures
Dewpoint alone

IDENTIFICATION OF LINES AND SCALES ON THE CHART

Picture the chart as a shoe or boot with the toe on the left and the heel on the right. Refer to the skeleton psychrometric charts, A-F, to clarify the following:

A. The dry-bulb temperature scale extends along the sole from toe to heel. The dry-bulb lines extend straight up from the sole... one for each degree of temperature.

B. The wet-bulb scale extends along the instep from the toe to the top of the shoe. The wet-bulb lines extend diagonally downward to the sole and the back of the shoe...one for each degree of temperature.

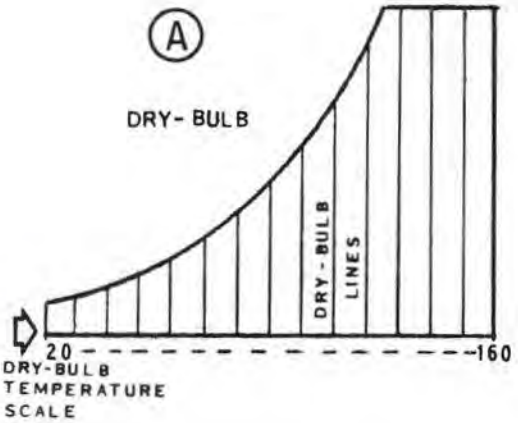
C. The condensation or dewpoint scale is the same as the wet-bulb scale. However, the dewpoint lines extend horizontally to the back of the shoe...one for each dewpoint temperature.

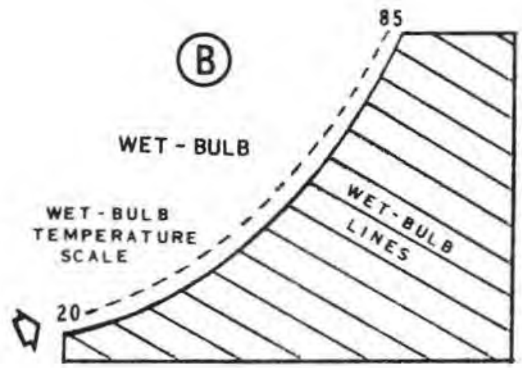
D. The relative humidity lines are located along the side of the shoe and follow approximately the same curve as the instep. The instep line is actually the 100% relative humidity line.

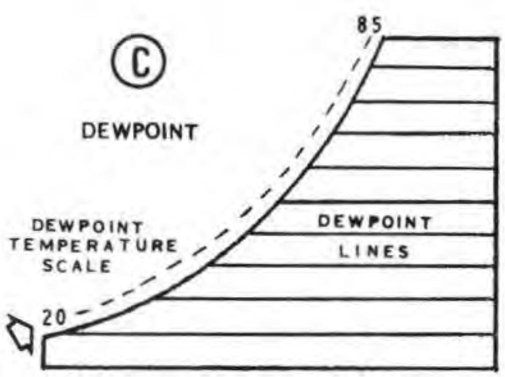
E. The grains of moisture scale follows along the back of the shoe from the heel to the top. The lines are the same as the dewpoint lines.

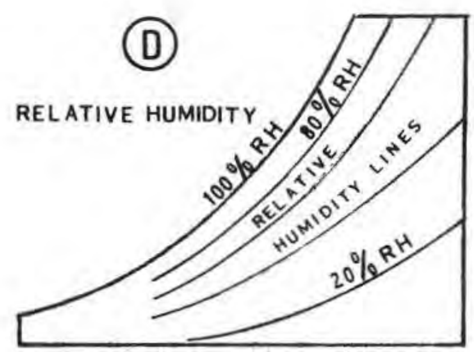
F. All the properties of air at any given condition can be represented on a psychrometric chart by plotting a single point.

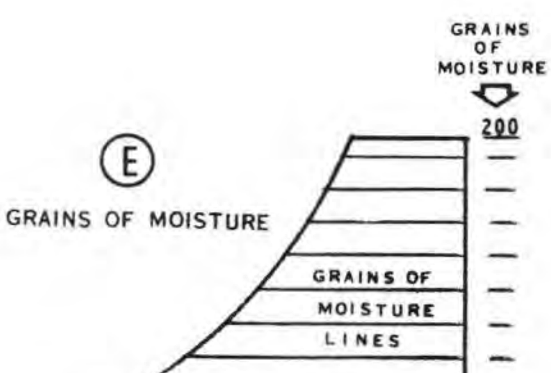
SKELETON PSYCHROMETRIC CHARTS

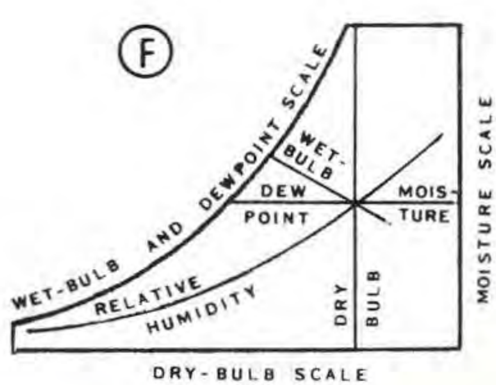












RELATIONSHIP OF TERMS

A few examples will illustrate all of the foregoing relationships. Each example will directly relate to the psychrometric chart, therefore, the chart should be used to clarify the solution to each example. By using a sling psychrometer it is determined that the dry bulb temperature is 78^{o}F. and the wet bulb temperature is 65^{o}F.

Example 1: Dry-bulb, Wet-bulb--Relative Humidity

Given: Dry-bulb-78F.
Wet-bulb-65F.

Find: Relative Humidity

Solution: (See skeleton chart No. 1)

1. Locate 78F. on dry-bulb scale at bottom of chart.

2. Draw a line straight up the 78F. line to the curved line at the instep.

3. Follow down the instep (wet-bulb scale) to 65F.

4. Draw a line diagonally along the 65F. wet-bulb line until it crosses the 78F. dry-bulb line.

5. Read 50% relative humidity at the intersection of the dry-and wet-bulb lines.

So, at 78F. dry-bulb and 65F. wet-bulb temperatures, the relative humidity is 50%. Relative humidity can be read at the intersection of the dry- and wet-bulb lines.

Example 2. Dry-bulb, Wet-blub--Dewpoint

Given: Dry-bulb-78F.
Wet-bulb-65F.

Find: Dewpoint

Solution: (See skeleton chart No. 2)

1. Find the intersection of the 78F. dry-bulb line and the 65F. wet-bulb line.

2. Proceed horizontally to the instep line.

3. Read 58F. dewpoint temperature.

At 78F. dry-bulb and 65F. wet-bulb, the dewpoint temperature is 58F.

Example 3: Dry-bulb, Relative Humidity--Dewpoint

Given: Dry-bulb -78F.
Relative Humidity 50%

Find: Dewpoint

Solution: (See skeleton chart No. 3)

1. Find the intersection of the 78F. dry-bulb and 50% r.h. lines.

2. Proceed horizontally to the instep line.

3. Read 58F. dewpoint temperature.

At 78F. dry-bulb and 50% r.h. the dewpoint temperature is 58F.

Example 4: Dry-bulb, Wet-bulb--Grains of Moisture

Given: Dry-bulb-78F.
Wet-bulb-65F.

Find: Grains of Moisture

Soulution: (See skeleton chart No. 4)

1. Find the intersection of the 78F. dry-bulb and 65F. wet-bulb lines.

2. Proceed horizontally along the grains of moisture line, to the back of the shoe.

3. Stop at the first column of numbers. This column is the grains-of-moisture scale. Read 72 grains.

At 78F. dry-bulb and 65F. wet-bulb, the moisture in the air is 72 grains.

This example shows how to find grains of moisture by using dry-bulb and wet-bulb temperature. Grains of moisture can also be found on the psychrometric chart by using other combinations of psychrometric properties. These combinations are listed below. Simply find the intersection of the lines listed here and then follow across the chart to the grains of moisture scale.

Dry-bulb and Relative humidity
Dry-bulb and Dewpoint
Wet-bulb and Relative humidity
Wet-bulb and Dewpoint

Grains of Moisture Per pound of Dry Air or Per Cubic Foot of Air

Notice at the top of the scale the words "grains of moisture per pound of dry air." This means that at 78F. dry-bulb and 65F. wet-bulb, the air holds 72 grains of moisture per pound.

Moisture can be measured per pound of air or per cubic foot of air. To find the moisture in a cubic foot of air, using the same conditions (78F. dry-bulb and 65F. wet-bulb), proceed as follows: (See skeleton chart No. 5)

1. Find the intersection of 78F. dry-bulb and 65F. wet-bulb.

2. Proceed horizontally along the grains of moisture line to the grains of moisture scale.

3. Read 72 grains.

4. Find the cubic foot scale along the sole of the shoe. The scale starts at 12.5 cubic feet and ends at 14.0 cubic feet. The cubic feet lines extend diagonally from the sole of the shoe to the instep.

5. Again locate the intersection of the 78F. dry-bulb and 65F. wet-bulb lines.

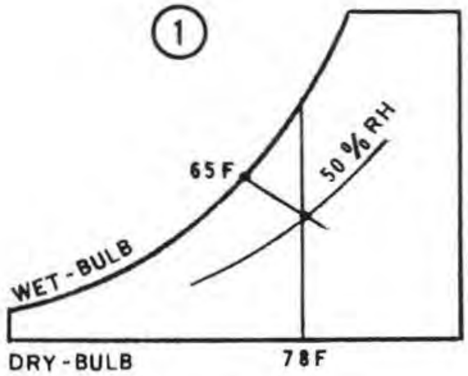
6. Draw a line parallel to the cubic foot line, from intersection located in Item 5, to the sole of the shoe. The line crosses the sole at a point that is over halfway between 13.5 and 14 on the cubic foot scale, say 13.8 cubic feet.

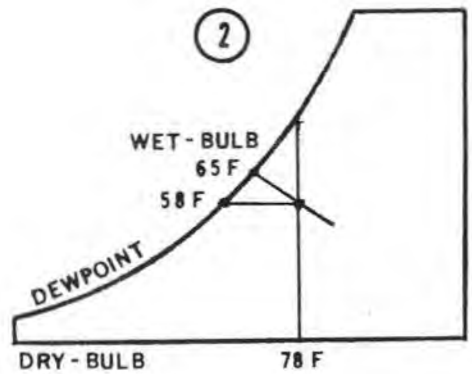
7. Divide 72 grains by 13.8 cubic feet.

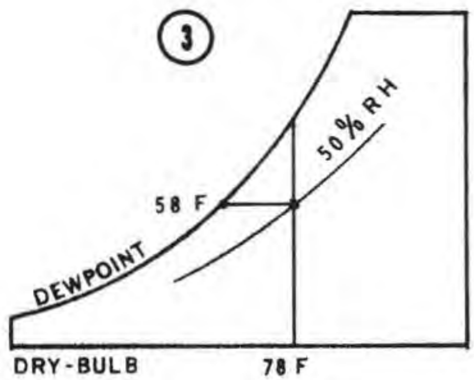
8. Moisture in air = $72 \div 13.8 = 5$ grains per cubic feet (approximately)

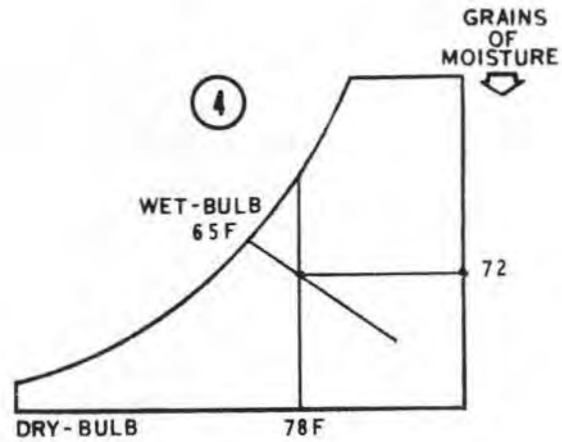
So, at 78F. dry-bulb and 65F. wet-bulb, the moisture in air can be read as 72 grains per pound, or, 5 grains per cubic foot.

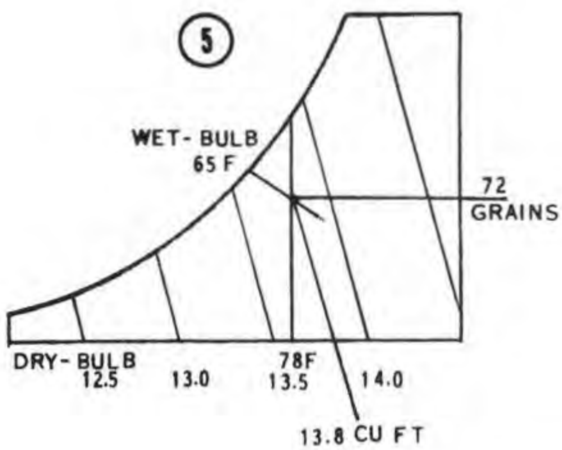
SKELETON PSYCHROMETRIC CHARTS











SUMMARY

1. Psychrometrics is the study of the properties of air.

2. The Psychrometric chart simplifies the measurement of air properties.

3. The chart is a picture or graphic presentation of air properties and air conditions.

4. Dry-bulb, wet-bulb, relative humidity, dewpoint and grains of moisture are common psychrometric terms.

5. If the value of any two of the psychrometric terms is known, the value of any other term can be found on the psychrometric chart.

6. The psychrometric chart is shaped like a boot. The sole is the dry-bulb temperature scale; the instep curve is the wet-bulb and dewpoint temperature scale; the humidity lines are approximately parallel to the instep curve, and following along the side of the shoe; the grains of moisture scale is along the back of the shoe.

7. The dry-bulb lines are in a vertical position on the chart; the wet-bulb lines are diagonal; the dewpoint and grains of moisture lines are horizontal.

8. A wet-bulb thermometer is so called because the bulb end of the thermometer is kept moist by a wet "sock" when the temperature reading is taken.

9. A wet-bulb thermometer registers a lower temperature than a dry-bulb thermometer except at 100% r.h.

10. The bulb surface of a wet-bulb thermometer is cooled by the effect of moisture evaporating from the wet "sock".

11. The wet-bulb temperature is higher in "wet" air than it is in "dry" air of the same temperature.

12. The amount of cooling that takes place at the bulb depends upon the amount of moisture in the air. At 100% r.h., cooling ceases because the air is saturated and can no longer absorb moisture from the wet "sock".

PROPERTIES OF SEEDS

A. H. Boyd, Jr.[1/]

This morning we have already heard a discussion of the properties of air and some comments concerning these properties as they effect the cost of drying, drying rate and other factors involving the drying of seeds. Now let us take a few minutes to consider the properties of seed also considering these properties as they effect the rate of drying, possibly your cost of drying and your seed quality. Seeds, as all organic materials, are characterized by a very complex and heterogeneous structure. They consist mostly of high molecular weight compounds primarily carbohydrates, protiens, and lipids with water as a fundamental and ubiquitous part of this structure.

When we speak of the water content of the seed we must recognize that microscopic regions within the seed may be largely lipid and contain much different concentrations of water from adjacent areas that are largely protein or largely starch. When we deal with drying the seed we must deal with the average effect of all these coumpounds. In addition to this we must consider that the seed is also of cellular structure and that the characteristics of different cell walls also affect the rate that water can pass through them. Different seeds with different types of seed coats and cellular structure may have quite different drying characteristics at the same moisture contents.

Seeds also have very different physical properties. Their drying rates and characteristics are affected by their size, shape, and chaffiness. In addition to their physical and chemical properties, we must not lose sight of the fact that they are alive and that the major reason for our interest is to preserve this condition. It will do us no good to do the cheapest and fastest possible job of drying and come out with dead seed. This is one of the major differences in the problems of the seedsmen as opposed to those of the chemical or even the grain industries whereby it is unimportant whether or not the product is alive at the end of the process. They can put very large amounts of heat to their product, handle it quite roughly and not bother too much about its final physical condition. We do not have this priviledge. We must handle the seeds gently enough that we have a quality product that is alive and vigorous when we finish drying.

1/ Mr. Boyd is Assistant Agronomist and Foundation Seed Manager, Seed Technology Laboratory, Mississippi State University.

All the above factors interact to make the process of removing enough water from the seed for safe storage much more complex than simply drying water from the surface of a granular solid. If a wet non-hygroscopic particle is exposed to a stream of warm dry air, the heat absorbed by evaporation will be balanced by the flow of heat from the warm air, and equilibrium will be quickly established at approximately wet bulb temperature. So long as there is enough water at the surface of the particle to balance the heat in the air flow, drying will progress at a constant rate. This is called the constant rate of drying. It can be quite long or extremely short depending upon the amount of water available on the surface of the particle. The surface tension of the water tends to cause a uniform film of water to be maintained around the surface of the particle. When this film has evaporated down to a point where it is about 4 molecules thick, another phenomen, which is caused by the physical attraction of the water molecules to the surface of the particle itself rather than to the surface tension of the liquid, enters the picture. As these molecules are continually driven off, progressively more energy is required to overcome the attraction of the water molecules to the surface of the particle. The rate of drying begins to slow down as the particles become more nearly dry. This is called the falling rate phase of drying. The drying continues at an ever decreasing rate so that the drying rate curve gets continually flatter until all the moisture has been driven from the particle.

Now let us compare the drying of grandular non-hydroscopic material, such as wet sand, to the drying of seeds which is our real problem. Seeds are hygroscopic, cellular in nature, and the moisture is distribued throughout the seed. This immediately complicates the matter. As we mentioned the seeds, being organic material, consist of extremely long chain molecules of many branches with water distributed throughout the intercellular and intermolecular spaces. With seeds the constant drying rate phase may be extremely short. This constant rate could only occur when the surfaces of the seeds are completely saturated with water. This would obviously apply only when the moisture content of the seed is extremely high. After this first short constant drying rate, we have the first falling rate stage of drying. This is characterized by the evaporation of water in the tissues at the surface of the seed, in the seed coat and moisture movement from inside the seed to the surface by capillary action. The rate will continue to drop as the distances involved continue to get greater and a moisture gradient is established within the seed. The seeds will shrink a small amout during drying; thus, reducing the distance water must move. However, this reduction in distance by shrinkage is negligible compared to the other factors involved. Remember we said that the seeds are of a cellular nature. This makes each cell wall another barrier to be negotiated by a water molecule as it tends to move from an area of high moisture content near the center of the seed to an area of low moisture content at the side or seed coat.

We must also consider that the phenomenon of bound water or the attraction of water molecules to the long chain organic molecules is a complicating factor. Think of these long chain organic molecules as a mass of threads pushed together with water molecules dispersed among them and attracted to the surface of each molecule. As the water molecules are excited by thermal vibrations they break loose one at a time and move at random until they are attracted to the surface of another molecule. In this manner they eventually move from the area of high concentration to low concentration and eventually are taken away by the outside air. Considering the molecule in this manner when we get to a comparatively low moisture content, say 15% or below, water removal in terms of vaporization and evaporation is no longer relevant.

Considering all of these factors in drying, it is easy to see why we have constant rate and falling rate phases of drying. Also in reality there are several falling rate phases of drying. The rate will obviously vary among kinds of seed, each seed having its own characteristics. Having this knowledge of the properties of seeds we can understand many problems in seed drying that may not have been clear to us previously.

We often hear the term "case hardening." This term comes to us from the metallurgical field and originated with the practice of heating a piece of steel in lime to harden the outside; thus, "case" hardening. Early food dehydrators observed that sometimes the outside of pieces of food would dry rapidly and then form a barrier restricting the transfer of heat into the particle and passage of water molecules out. They applied the term "case hardening" which has been passed on to us.

There is disagreement among researchers in drying as to how much of a problem this rapid drying on the outside really is. There must be a moisture deficit for moisture from a high concentration or wet area to move into a low moisture area and eventually be evaporated since this is what drying is all about. There have been experiments in food dehydrating where moist air was used for initial drying in an attempt to maintain less of a moisture gradient. In all cases these experiments indicated that the rate of evaporation was lower. You must have a moisture deficit to produce drying. The greater the moisture deficit, the more rapid the drying rate. "Case hardening" can occur but it is not nearly so common as we generally think.

However, there are other things to consider. Let us consider the physical stresses involved with extremely rapid drying. When the outside of the seed is dried there is a shrinkage of tissue due to loss of moisture. The shrinkage is not as great as the amount of moisture loss, but never-the-less there will be some shrinkage. Also when this outer tissue or cellular material dries there will be a corresponding loss in elasticity. The wet material on the inside does not shrink. As this tissue shrinks and loses its elasticity the stresses encountered may exceed the strength of the materials in seed coats and outer layers of the seed causing fractures in the seed. This is one explanation for sun checking when rice is dried too rapidly.

The "rule of thumb" that 1000 B.T.V. is required to evaporate one pound of water is adequate for most design problems but actually at different temperature and moisture conditions the heat requirement may vary as much as 15% as indicated by the following table.

*Latent heat of vaporization for corn and wheat, Btu. per lb. water

Moisture % W.B.	Temperature of evaporation of				
corn	32	50	70	100	150
10	1265	1250	1240	1220	1180
11	1220	1210	1200	1180	1140
12	1175	1165	1155	1135	1105
13	1145	1135	1125	1105	1070
14	1120	1110	1100	1080	1050
15	1095	1085	1075	1055	1025
Wheat	--	--	--	--	--
11	1250	1240	1225	1200	1170
12	1200	1190	1175	1155	1120
13	1160	1150	1140	1120	1090
14	1130	1120	1110	1090	1060
15	1110	1100	1090	1070	1040
Water					
	1075	1065	1055	1037	1008

*Thompson, H. V. and C. K. Shedd. Equilibrium moisture and heat of vaporization of shelled corn and wheat. "Agricultural Engineering" 35:786-788, Nov. 1954.

Notice that the "rule of thumb" is closely approached only at comparatively high moisture contents, or by free water. This increasing heat of vaporization is due to the physical attraction of the water molecules to the surface of the molecules in the seeds. This is commonly referred to as bound water. It is obvious from the above data that the drier the seeds the more tightly bound the remaining molecules become.

The above table relates only to heat requirements. There is also the mass transfer problem of moving the molecules from the center of the seeds to the ambient air. The problem of heat transfer into the seeds and mass transfer of water through the partially dried area accounts for the slowest part of the falling rate phase of drying and relate back to the old term of "case hardening."

Drying is an old art only recently developing into a science. Seedsmen, grain handlers, food dehydrators, etc. have been taking the above factors into consideration as a matter of experience. I suspect that practical seed drying management will continue to be, to a greater or lesser extent, art as well as science because of the many uncontrollable variable involved. However if we will remeber to relate our knowledge of the properties of seeds to the problems as they exist at the seed dryer we can more closely approach the exact science that we must master if we are to produce the quality product that will be required of us in the next decade.

MEASUREMENT OF AIR VELOCITY AND TEMPERATURE

R. Kenneth Matthes[1/]

Many factors are affected by the air flow rate and temperature of the air in seed drying. The faster air is moving the more moisture it can pick up in a given time period. The higher the temperature of the air the greater capacity it has for holding moisture and the more heat it has available to evaporate the moisture in the seed.

Air flow rates are recommended usually in terms of CFM/Bu.

Since 1 Bu. = 1.25 ft^3 the toal number of bushels is obtained by:

$$N\ bu = Area\ (ft^2) \times Depth\ (ft.) \times .8\ bu/ft^3$$

$$Total\ CFM = CFM/Bu. \times N\ Bu.$$

$$CFM/ft^2 = \frac{Total\ CFM}{Area} = \frac{\not{Area} \times Depth \times .8 \times \frac{CFM}{Bu}}{\not{Area}}$$

Thus: $CFM/ft^2 = .8 \times Depth \times \frac{CFM}{Bu}$

CFM is air flow; however, most of the instruments we use are calibrated in terms of air velocity but $CFM/ft^2 = \not{ft^3}/min - \not{ft^2} = ft/min$ - air velocity or Vel x Area = Air flow

Therefore, if air is flowing through a pipe or duct in which the cross-sectional area changes, the velocity must change since the air flowing trhough one section of the duct is the same as the air flow through the other section. Figure 1 illustrates this point.

There are several methods available for measuring air flow. Some methods are extremely accurate and extremely complex. These methods are sometimes required for laboratory work which requires such accuracy. There are other methods which are not as accurate but which have the advantage of being simpler to use. These are used by heating and air conditioning companies to evaluate the air flow rates from newly installed systems. These types of instruments are more applicable for seedsmen.

The different methods of measuring air flow rate are based on one of three different principles. The first is that moving air has a kinetic energy in a similar manner that a moving bullet contains

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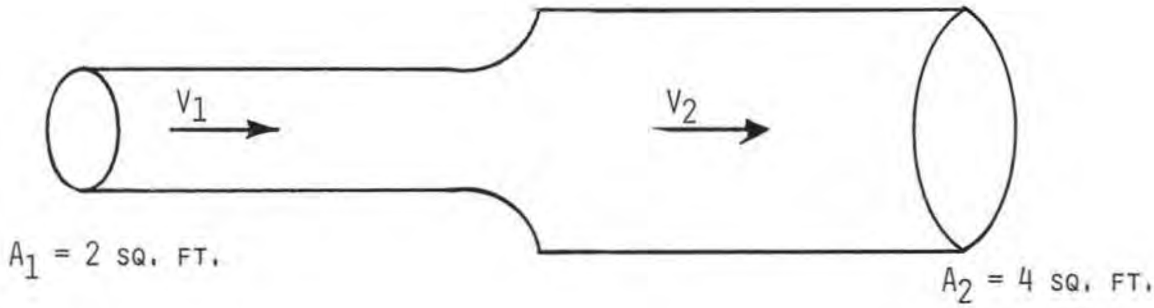
1/ Dr. Matthes is Associate Professor, Agricultural and Biological Engineering Department, Mississippi State University.



IF $V_1 = 2000$ FT/MIN.

THEN $Q_1 = V_1 \times A_1 = 4000 \ \frac{\text{CU. FT.}}{\text{MIN.}}$

$Q_1 = Q_2 = 4000 \ \frac{\text{CU. FT.}}{\text{MIN.}}$

THUS $V_2 = Q_2/A_2 = 1000$ FT./MIN.

Figure 1. Air flow is the air velocity times the cross-sectional area.

energy. If this moving air is stagnated by an obstruction such as a tube, the stagnation pressure will result. From an apparatus such as shown in Figure 2, the static pressure, p_o, and stagnation pressure, p_s, can be measured.

For an incompressable fluid such as water the following equation holds:

$$P_s = P_o + 1/2 \rho Vo^2$$

Where: P_s is the stagnation pressure

P_o is the static pressure

ρ is the density of the fluid.

and Vo is the velocity of the fluid.

The solution Vo is:

$$Vo = \sqrt{2 (p_s - p_o)/\rho} \ .$$

Keep in mind that this holds for an incompressible fluid such as oil or water. However, for a compressible fluid the velocity equation is somewhat more complicated but it can be solved for the velocity.

Pitot-static tubes are designed to measure p_s and p_o simultaneous as shown in Figure 3. Acutally, value of interest is $(p_s - p_o)$; therefore, if p_s and p_o are connected to different sides of a u-tube manometer the difference between the fluid levels in the tube will indicate the difference between these pressures. Figure 4 is a standard pitot tube.

There are many variations of the pitot tube idea which result in devices of various shapes and correction coefficients. One widely used is the Cole Pitometer, which consists of two similar pitot tubes, one facing upstream, the other facing downstream.

The tube facing upstream measures the stagnation pressure properly, but the one facing downstream measures the pressure in the turbulent wake behind itself, which is considerably less than the true static pressure. Therefore, a correction factor must be applied.

The velocity of the air is not entirely dependent upon differences between these pressures, but it is also dependent upon the shape of the pitot tube and the temperature. Therefore, it is important to use a pitot tube which has been calibrated for the general conditions for which it is used.

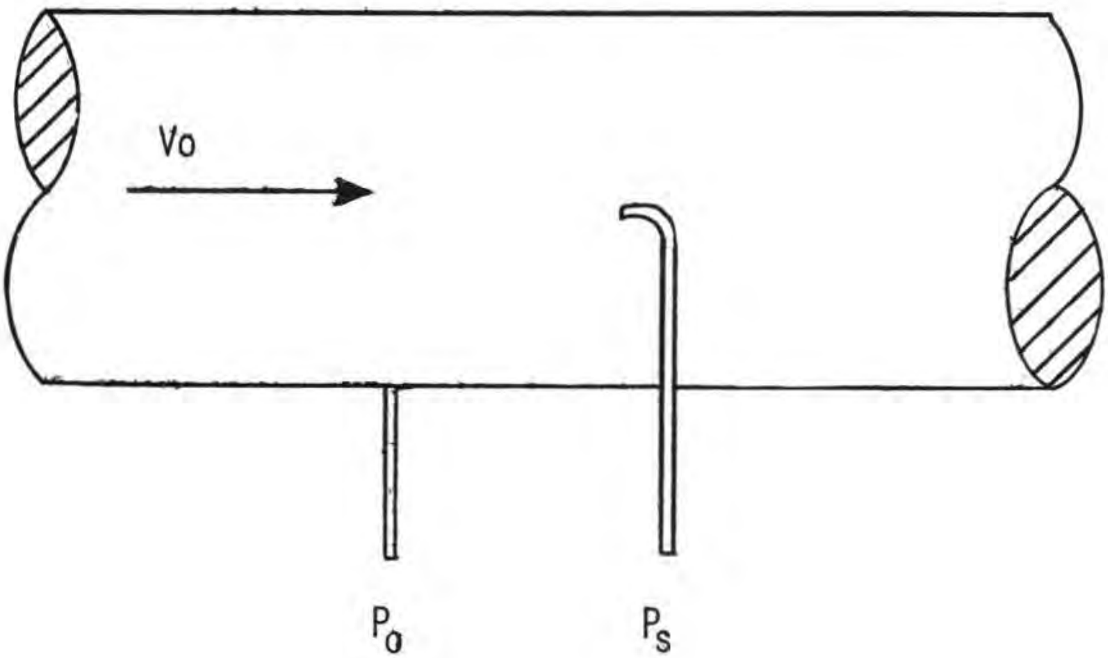


Figure 2. Apparatus illustrating points to measure static pressure, P_o, and stagnation pressure, P_s.

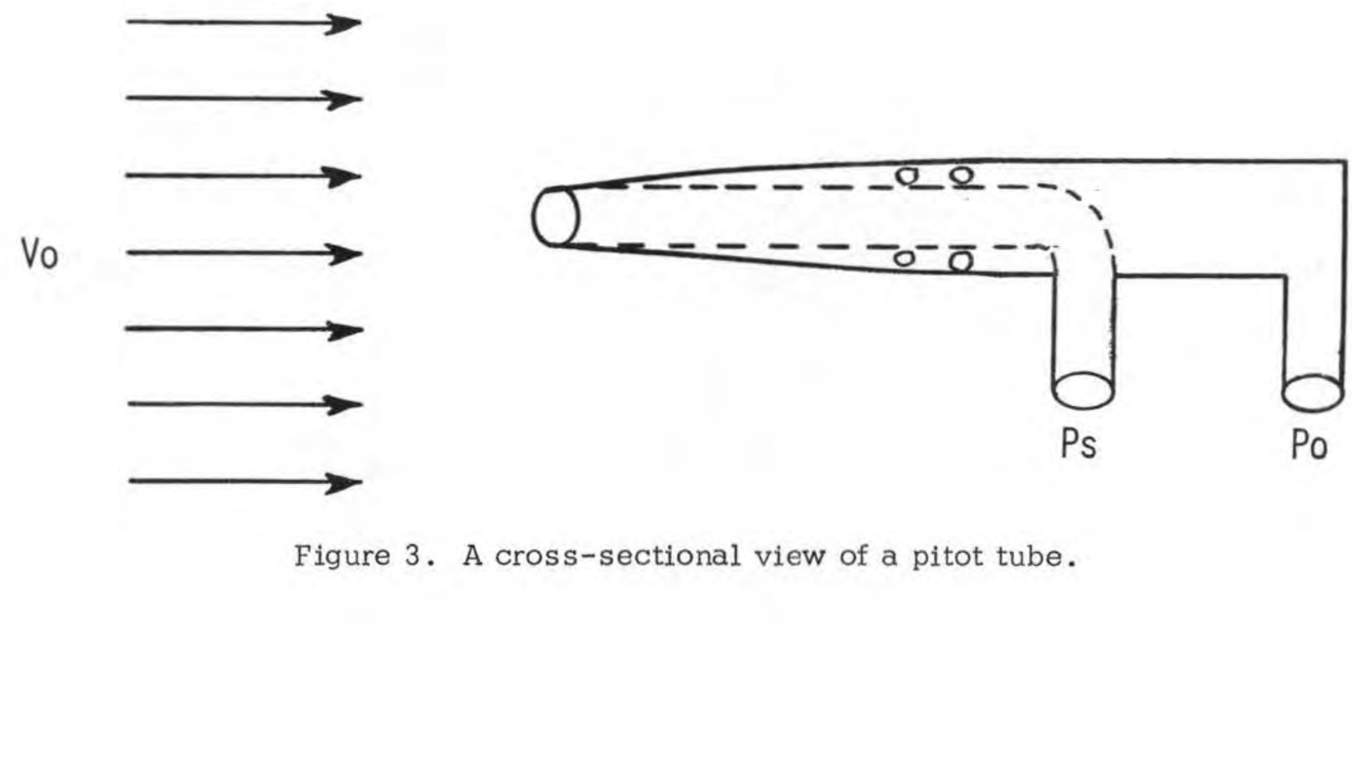


Figure 3. A cross-sectional view of a pitot tube.

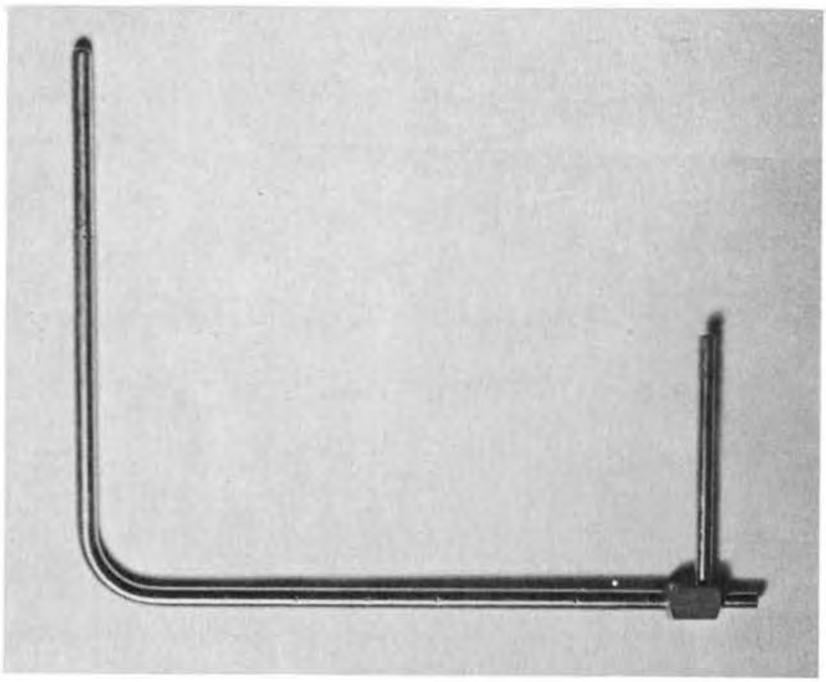


Figure 4. A standard pitot tube.

For accuracy of plus or minus 2%, as in laboratory applications, extreme care is required and the following precautions should be observed:

1. Duct diameter 4" or greater.

2. Make an accurate traverse per sketch (Figure 5) and average the readings.

3. Provide smooth, straight duct sections 10 diameters in length both upstream and downstream from the pitot tube.

In making an air velocity check select a location as suggested in Figure 5, connect tubing leads from both pitot tube connections to the manometer and insert in the duct with the tip directed into the air stream. If the manometer shows a minus indication reverse the tubes. With a direct reading manometer, (Figure 6) air velocities will now be shown in feet per minute. In other types, (Figure 7) the manometer will read velocity pressure in inches of water and the corresponding velocity will be found from the curves in Figure 8. If circumstances do not permit an accurate traverse, center the pitot tube in the duct, determine the center velocity and multiply by a factor of .9 for the approximate average velocity. Field tests run in this manner should be accurate within plus or minus 5%.

The velocity indicated is for dry air at 70°f., 29.9" Barometric Pressure and a resulting density of .075#/cu. ft. For air at a temperature other than 70°F. refer to the curves in Figure 9. For other variations from these conditions, corrections may be based upon the following data:

$$\text{Air Velocity} = 1096.2 \; \frac{P_V}{D}$$

where: P_V = velocity pressure in in. of water

D = Air density in #/cu. ft.

$$\text{Air Density} = 1.325 \times \frac{P_B}{T}$$

where: P_B = Barometric Pressure in in. of mercury

T = Absolute Temperature (indicated temperature °F plus 460)

Flow in cu. ft. per min. = Duct area in square feet x air velocity in ft. per min.

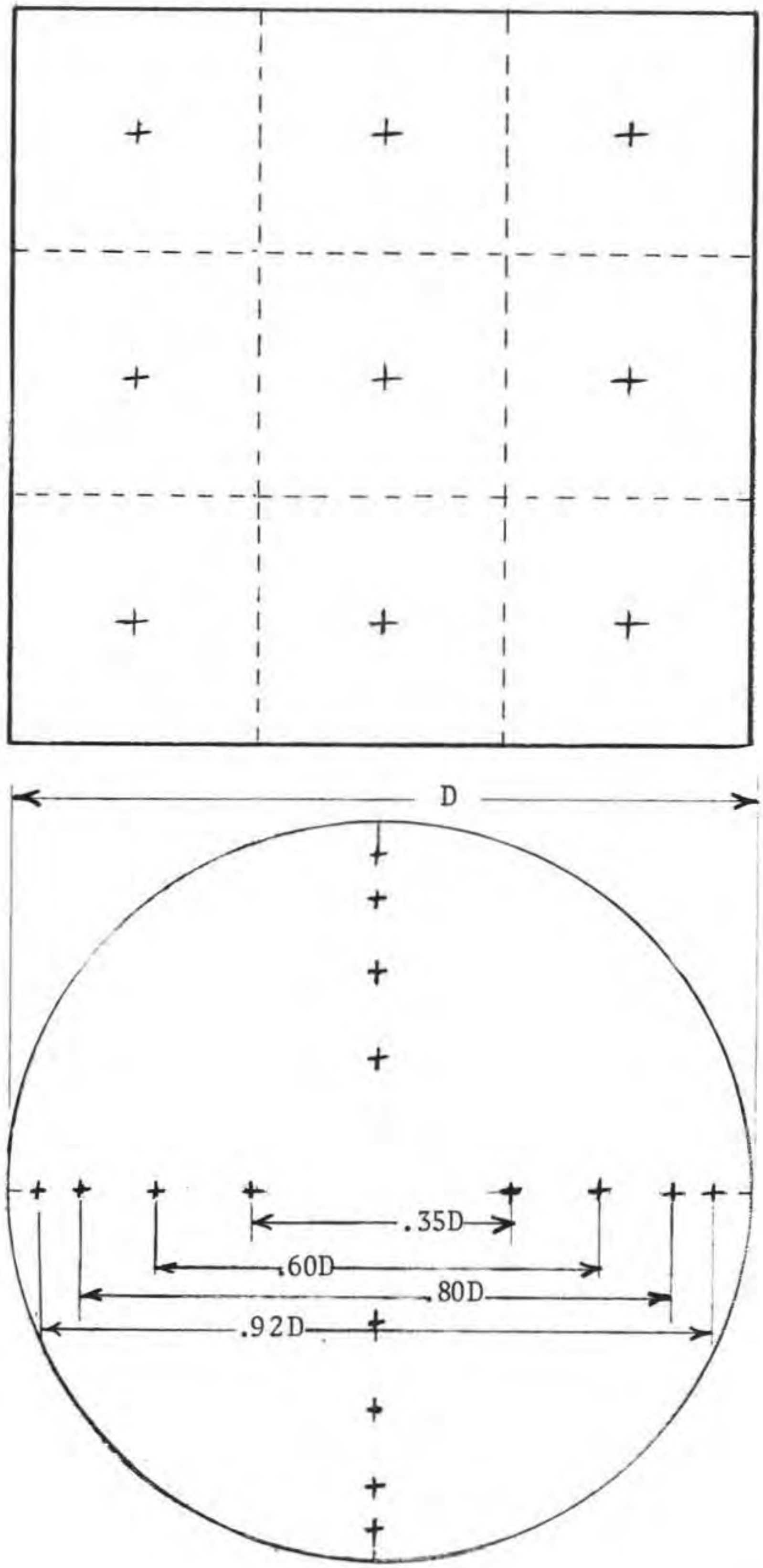


Figure 5. Location of pitot reading for accurate velocity determinations.

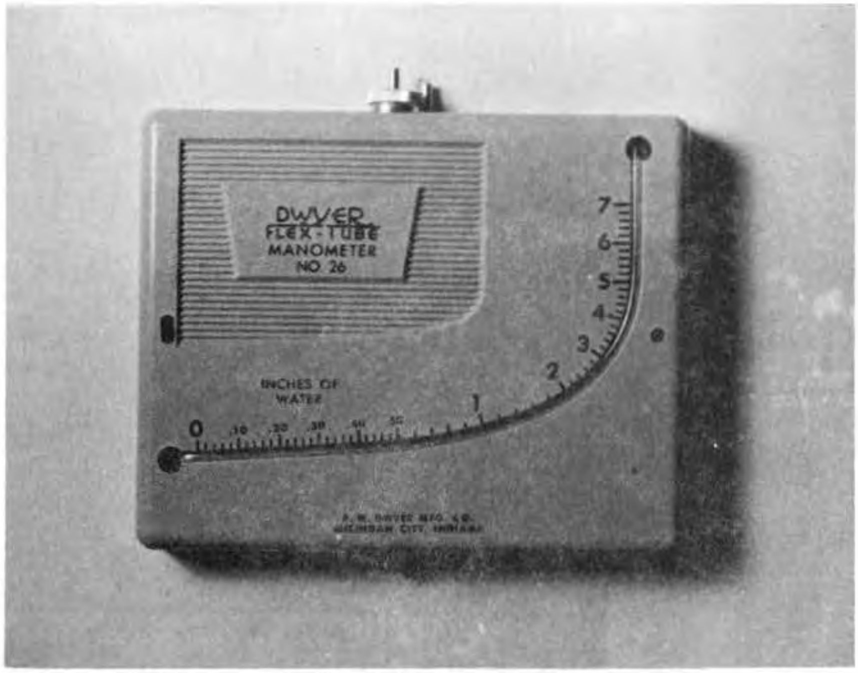


Figure 6. A manometer calibrated for pressure.

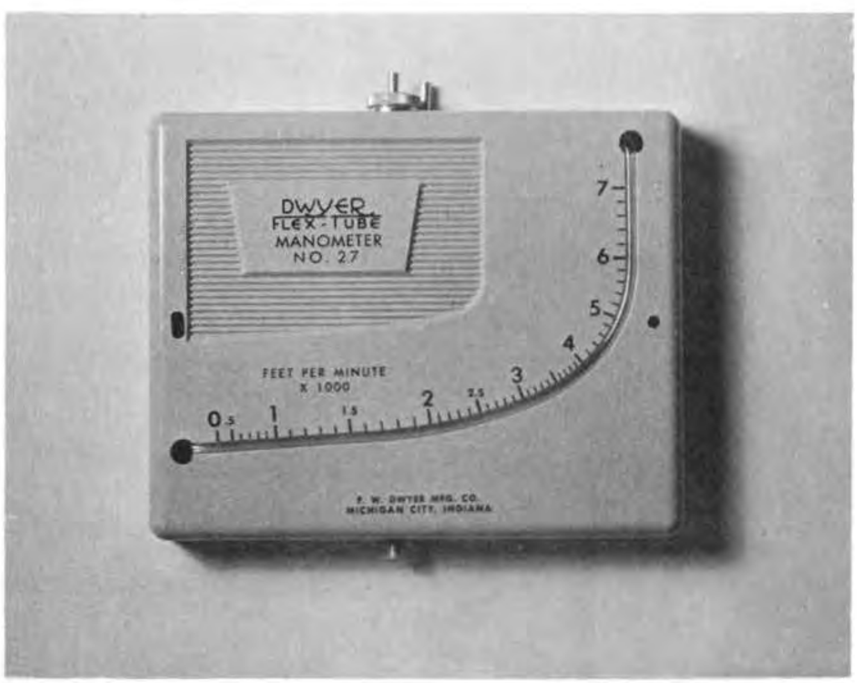


Figure 7. A manometer calibrated for velocity.

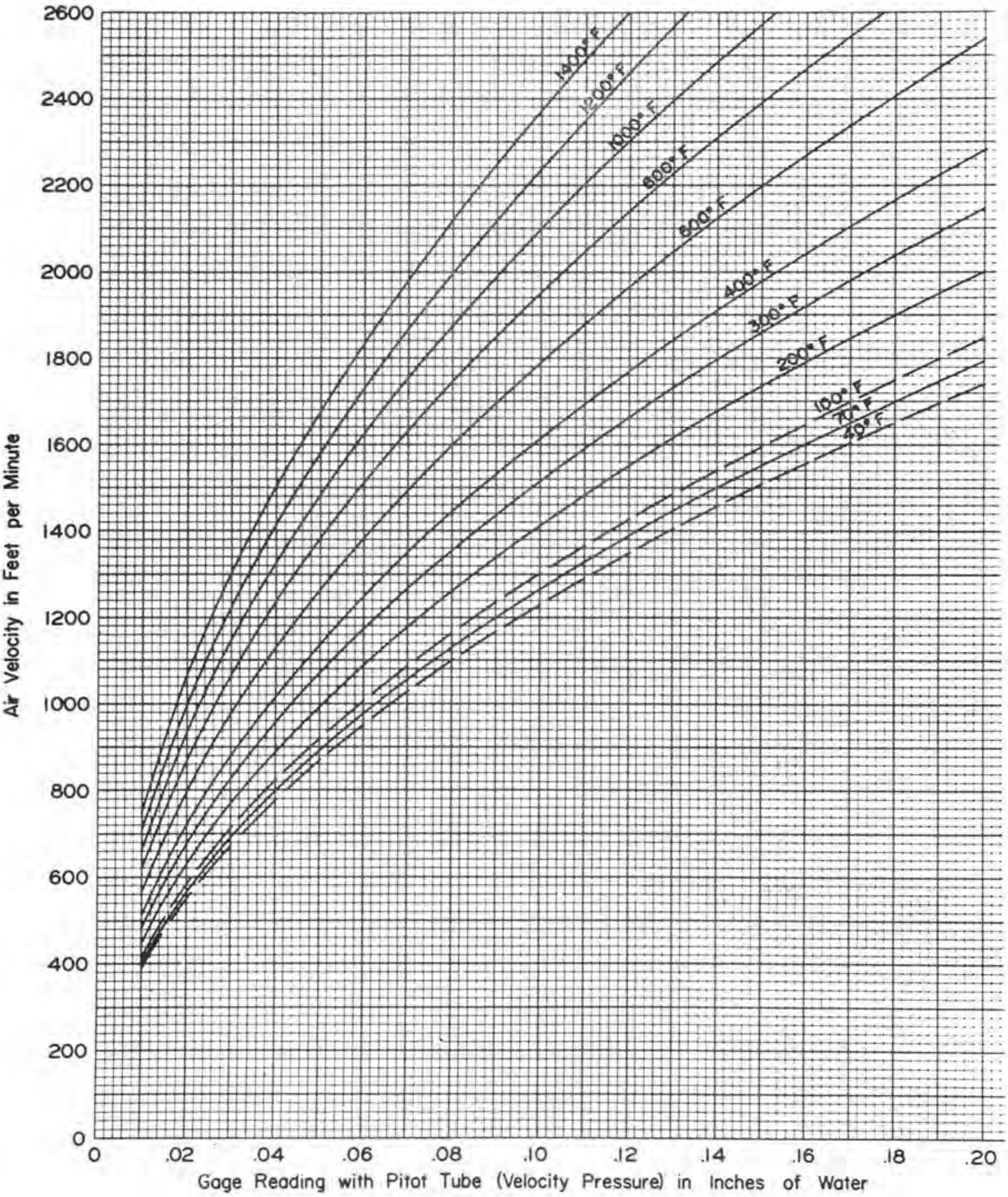


Figure 8. Pitot tube calibration curves

An air velocity calculator computes velocity based on air density corrected for conditions of temperature and pressure which eliminates tedious calculations. (Figure 9). The calculator ranges frcm .01 to 10 inches of water corresponding to 400 to 20,000 FPM. A calculator is furnished with each pitot tube by F. W. Dwyer Manufacturing Co.

Anemometers are also used for measuring air velocity. An anemometer consist essentially of a rotating element whose speed of rotation varies with the local velocity of flow, the relation between these variables being found by calibration. Anemometers fall into two main classes, depending upon the design of the rotating elements. These are the cup type and vane (propeller) type. The cup-type anemometer for the measurement of wind velocity is usually mounted on a rigid shaft; the vane-type anemometer is held in the hand while readings are taken.

Another type of anemometer which has been very successful in the field of aeronautical research is the hotwire anemometer, one type of which is shown schematically in Figure 10. The device consists of a fine platinum wire exposed to the velocity V_o which is to be measured. The fact that various velocities will have various cooling effects upon the hot-wire, which will change its resistance, allows (by calibration) relating the velocity V_o to certain electrical measurements. The hot-wire anemometer of Figure 10 is of the constant-voltage type, and during its operation the drop in electrical potential across its terminals is maintained constant. Variation of velocity will change the resistance of the wire and, thus, the ammeter reading; the ammeter reading thereby becomes, after calibration, a measure of the velocity. The advantage of the hot-wire anemometer lies in the fact that it may be built in extremely small sizes and so may be employed in measuring the velocity variations in turbulent flow, velocity profiles in boundary layers, etc., where a pitot-static tube cannot be used. It must always be calibrated before use, and calibration is generally made against pitot-static tube measurements of velocity.

Temperature Measurements

What is temperature? It is a measure of how hot or how cold a material is. Our temperature scale is based on a set of reference points: freezing temperature ($0^oC.$, $32^oF.$) and boiling temperature. ($100^oC.$, $212^oF.$).

There are two acceptable scales of temperature measurement-centigrade and fahrenheit. The following diagram indicates how each of these two scales are based on the difference between freezing and boiling temperature.

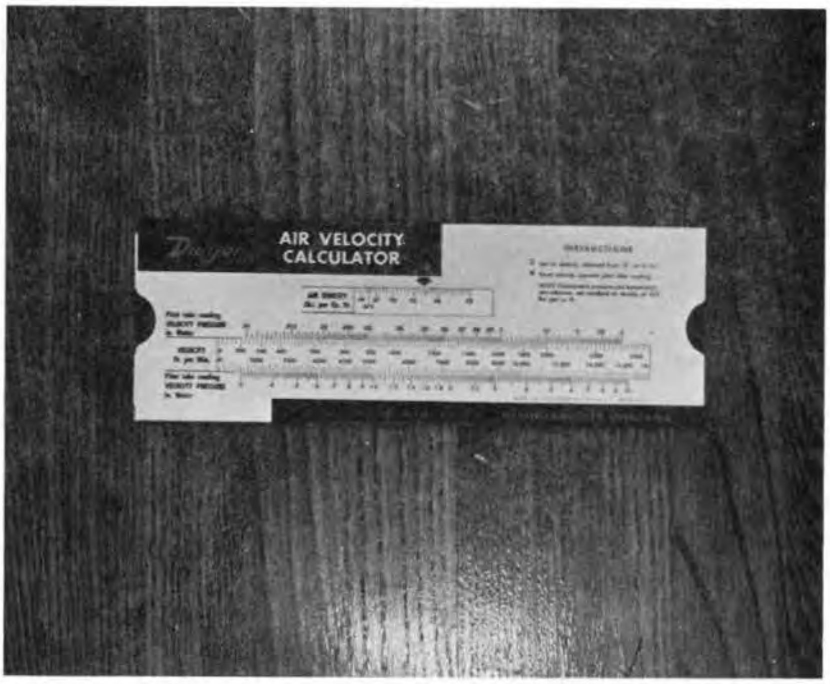


Figure 9. Air velocity calculator.

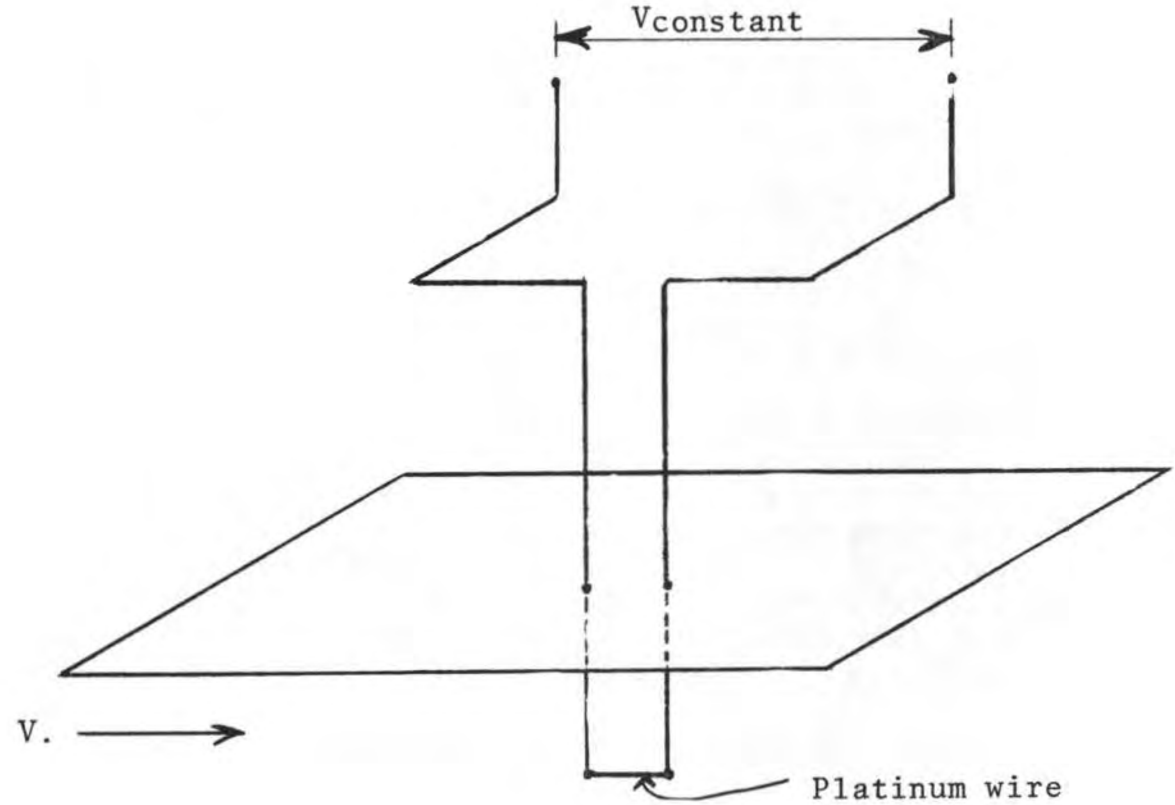


Figure 10. Picture - Hot wire anemometer.

	Centigrade	Fahrenheit
Boiling	100	212
	75	167
	50	122
	25	77
Freezing	0	32

Temperature scales can be converted by the following equations:

$$^{o}C. = \frac{5}{9}\ (^{o}F. - 32)$$

$$^{o}F. = \frac{9}{5}\ ^{o}C. + 32.$$

The most common method of measuring temperature is with a mercury thermometer in which the mercury expands with temperature in a calibrated tube. A mercury thermometer is an old standby in terms of reliability. When there is some doubt of an electrical thermometer it can be roughly checked with a mercury thermometer. The major disadvantages of a mercury thermometer are problems in reading closer than one degree, little flexibility in placing the thermometer in difficult-to-reach places, large size limits access in some cases, slow response time in changing temperature conditions, and does not lend itself to automatic recording.

Another method of measuring temperature is with a metallic strip composed of two metals bonded together which have different coefficients of expansion with temperature. As the temperature increases the compounded strip curves with the metal of the highest expansion being on the outside curve. In some cases the strip is made into a coil to increase the sensitivity of the displacement to a small temperature change. Bi-metallic strips are frequently used in thermostatic controls since they actually produce a displacement which can be used to control a relay which can turn on or off the heat. The disadvantages of this type thermometer is that the dial indicator is located adjacent to the point of sensing the temperature and the mechanism is not easily adapted for recording.

There are essentially two types of temperature sensing devices which are adaptable to electrical recording. One is a thermocuple and the other is a thermistor.

The thermocouple works on the principle that when two different types of metal such as iron-constantan or copper-constantan comes in contact, there is an EMF set up between the metals in the order of microvolts. This EMF is dependent upon temperature. Thus, it is possible to use a voltage recorder which has been properly calibrated to record temperature. The thermistor (Figure 11) works on the principle that the electrical resistance of the thermistor changes with temperature, and with proper circuitry this can be measured by a change in voltage. In a smiliar fashion to the thermocouple this change in voltage can be recorded as temperature.

A recorder can be built to record as many points as desired by going through the proper switching mechanism. Of course if the recorder handles more than one point, each point is intermittantly recorded since only one point can be printed at a time. Under normal conditions a recorder requires about 15 seconds per point. It is possible to record one point after another until all points are reached and then complete the cycle or record the complete set of points once each hour or other predetermined time period by using a timer. The recording can be performed on a strip-chart recorder (Figure 12) or a print out tape (Figure 13).

One of the major advantages of the thermistor and the thermocouple is the small sensing element (about a 3/16 inch junction on the end of a wire). Thermocouples have been made under a magnifying glass from hairsize #40 thermocouple wire, and used to determine the temperature inside a seed or a xylem vessel of a corn stem. Another advantage is the ability to locate the sensing element remotely from the recorder. If you can reach the point where you desire to measure the temperature with a wire you can use a thermistor or a thermocouple.

The electrical circuit of a thermocouple is such that any number of thermocouples can be connected in parallel and the voltage output will indicate the average temperature of the thermocouples.

The following is a list of instrument manufacturing companies. Chances are that several of these companies have representatives in your area who would be glad to discuss the use of their instruments in your seed operation.

Air Measurement Instrument Companies

F. W. Dyer Mfg. Co., Inc.
Box 373
Michigan City, Indiana 46360

Alnor Instrument Co.
420 N. La Salle Street
Chicago, Illinois 60610

Janis Equipment Co.
4711 Poplar Street
Memphis 17, Tennessee

United Sensor & Control
89 Church St.
East Hartford, Connecticut

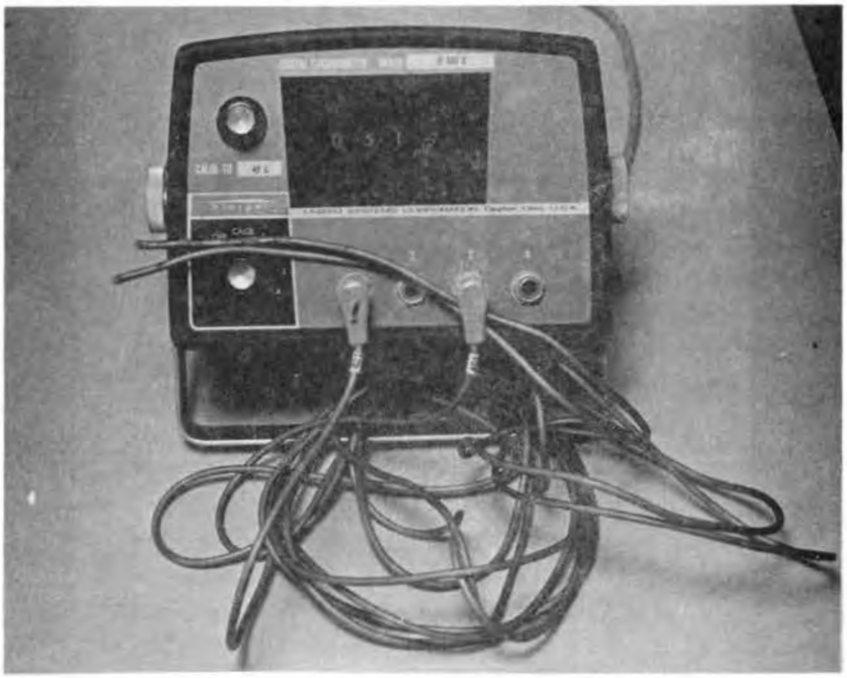


Figure 11. A digital thermometer using thermistors.

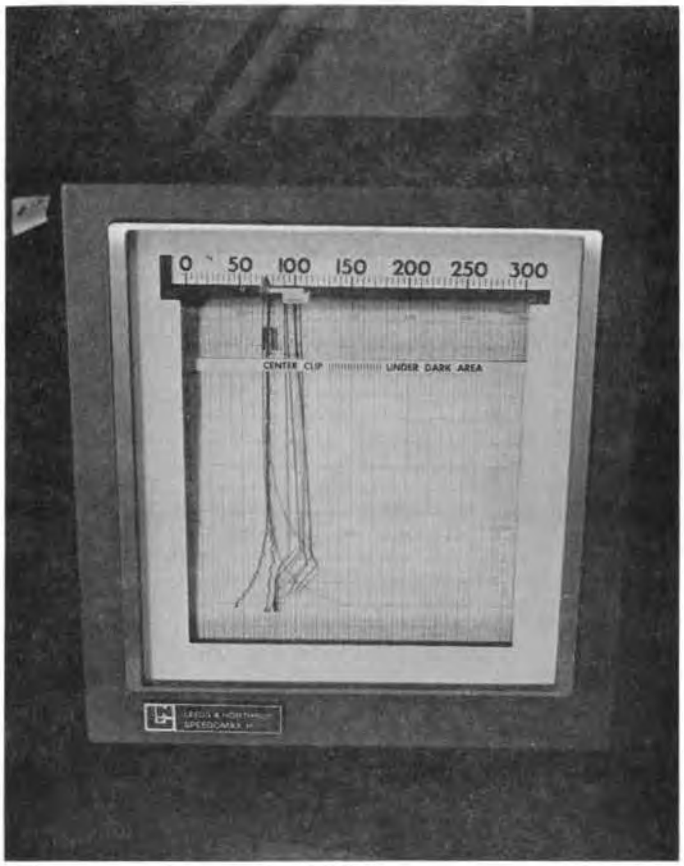


Figure 12. A strip chart recorder.

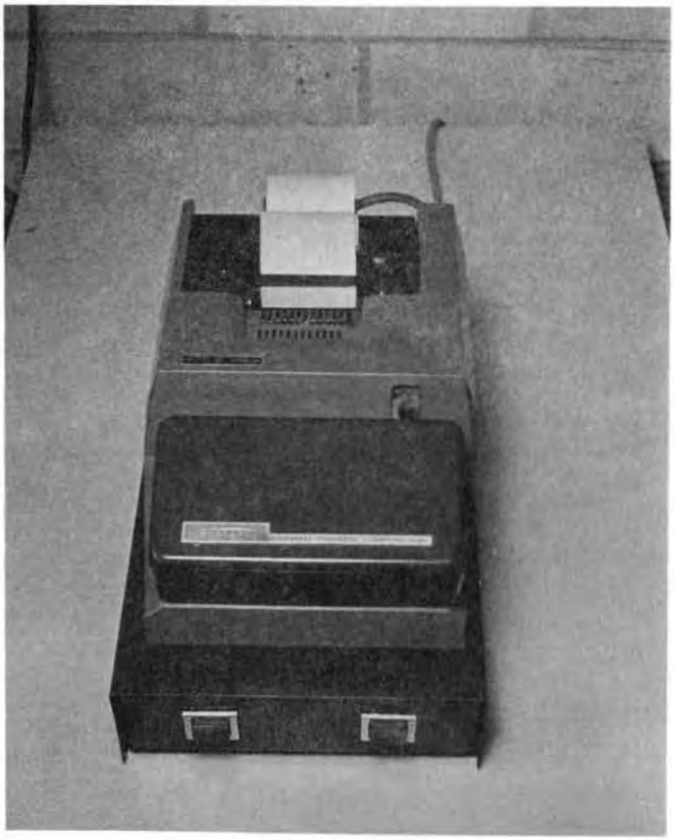


Figure 13. A print-out recorder.

E. V. Hill & Company
Box 189
Lake Geneva, Wisconsin

Airflow Development
244 Newkirk Road
Richmond Hill
Ontario, Canada

Temperature Measurement Instrument Companies

Marshalltown Mfg. Inc.
Marshalltown
Iowa

Leeds and Northrup
4901 Stenton Avenue
Philadelphia 44, Pennsylvania

Temtech
2202 S. Wright Street
Santa Ana, California 92705

Rustrak Instrument Co., Inc.
Municipal Airport
Manchester, New Hampshire

United Systems Corporation
918 Woodley Road
Dayton, Ohio 45403

United Electric Controls Co.
85 School Street
Watertown, Massachusetts

Thermo-Electric Co., Inc.
Saddle Brook
New Jersey 07663

Alnor Instrument Co.
420 N. La Salle Street
Chicago, Illinois 60610

Honeywell
2701 Fourth Avenue, S.
Minneapolis, Minnesota

Victory Engineering Corp.
Box 187
Springfield, New Jersey 07081

Omega Engineering, Inc.
Box 4707 Springdale Station
Stanford, Connecticut 06907

If you cannot measure the air velocity or the temperature in your drying operation, then you cannot control these factors. If this is the case, the success of your drying operation is not what it can be.

DRYING SYSTEMS

R. Kenneth Matthes[1/]

If you are not mechanically drying your seed, you are probably losing some profits through harvest loss and field loss prior to harvest. Seed reach maturity from one to three weeks before they are dry enough to store. The seedsmen with his own drying facilities can save those weeks, minimizing the risks of losing all or part of his time and money investment to bad weather.

The earlier in the season harvesting is done, the better working conditions usually are. The longer crops are left in the field to dry after maturity the lower the yield. Shattering losses in small grains drying in the sun may run as high as two bushels per acre. Moreover, field dried seeds are subjected to flattering by winds and rain which introduce additional loss because harvesting machinery does not work as efficiently. As yields go up, field losses take an increasingly high percentage of the total.

What methods are available to seedsmen for drying their seeds? Generally, there are two types of seed drying systems; a continuous-flow tower dryer and a batch-type bin dryer. The continuous flow tower has been used by corn producers when seed corn is harvested by combine. The tower dryer presents problems in controlling the maximum temperature of the seed and the rapidity at which the seed is dried. The more popular method used by the corn seed growers is to harvest the corn on the ear, dry it in a bin, and then shell it.

The bin dryer has the advantages of slow drying of the individual seed, inexpensive initial outlay, and the bins double for storage until the seed is ready to be processed. The bin dryer is normally constructed with a false floor in the bin overlying a plenum chamber into which heated air is blown. The air passes through the seeds and exhausts out of the top of the bin.

Moisture is removed by drying air from the surface of the seed first. The air provides a medium by which the moisture is removed from the bin and also provides heat to evaporate the moisture in the seed. When the surface of the seed has been dried, there is an imbalance in the moisture equilibrium within each individual seed kernel. This moisture gradient causes the moisture to flow from the inside of the seed to the surface of the seed, and then this moisture is removed by the drying air. There is a maximum temperature to

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[1/] Dr. Matthes is Associate Professor, Agricultural and Biological Engineering Department, Mississippi State University.

which the seed can be subjected without lowering the viability of the seed. It is normally recognized that the maximum drying temperature is 110°F. and in some cases, for high moist seed in excess of 30%, this drying temperature must be lowered as far as 95°F. The optimum air flow required for bin drying is sufficient air to remove the moisture available at the surface of the seed and to provide sufficient heat for evaporating that moisture. In other words, air in excess of that required for moving the moisture from the surface will not be capable of picking up moisture from the seed until it can move to the surface. Thus, excessive air will result in increased output from fans and heaters and the cost of drying will go up. Therefore, we are interested in obtaining a sufficient air flow, but not an amount greatly in excess of the optimum air flow. It is recommended that a minimum air flow of 10 cu. ft./min./bushel be provided for sufficient bin drying.

The depth of seed is important in bin drying. The air flow rate is dependent upon the total number of bushels in the bin, and the static pressure required to move a given air flow through a seed bed is greatly increased as the depth of seed is increased. Generally, the maximum depth of drying of seed is approximately 8 feet. For samll seed this is decreased, and for large seeds it can be increased. If a static pressure is required in excess of 2 inches to obtain the desired air flow, the price of the blower system is greatly increased.

To make recommendations for all types of drying systems and all types of seed at various moisture conditions is virtually impossible. The best advice one can give in drying recommendations is for the seedsmen to keep good records on his drying operations. These records will provide him with reliable information which he can use in further drying operations in the coming years. By keeping good records in the power requirements, time required for drying, depth of drying, air flow rate, and drying temperatures, the seedsman will make optimum use of his drying experience. All of these factors will contribute to his knowledge rather than having unreliable data to be used for later drying operations. Nobody should know more about a seedsmen's dryer than the seedsmen himself. Every drying system varies somewhat, and every locality has different conditions; thus more reliable drying data a seedsmen can collect the more value his drying experinece will be to him in coming years. Therefore, the main recommendation I would make to the seedsmen is know your dryer, keep good, accurate records on your dryer, and modify your drying from time to time based on the experience that you've gained from previous drying data.

SUMMARY

In summary, the following recommendations can generally be made for drying.

1. Maximum drying air temperature 110^{o}F.

2. A minimum of 10 cfm/bushel for bin drying.

3. A maximum depth of eight feet for bin type drying.

4. Keep accurate drying records and make each year's drying experience improve next year's drying operation.

EFFECTS OF PACKAGING MATERIALS, STORAGE CONDITION AND SEED MOISTURE CONTENT ON SEED QUALITY

Charles C. Baskin[1/]

Preserving viability and vigor of seeds in storage presents a problem in many areas for many seedsmen. Dehumidified, low temperature storage will provide ideal, or near ideal, conditions. However, these conditions are not always avaliable and are not always feasible.

In many instances uncontrolled storage conditions can be improved by manipulation of the microenvironment. Selection of the proper packaging material and adjusting seed moisture contents will allow packaging of seeds in moisture resistant containers. This can prolong viability for various lengths of time depending on the storage conditions.

There is an interrelationship between packaging material, seed moisture and storage condition. How long seed remain viable in storage depends on the moisture content, the storage cpndition and the type of material in which the seed are packaged.

Corn, wheat, and soybeans were stored under the following conditions:

A. 85°F.-85% relative humidity
B. Open warehouse conditions (at Windfall, Indiana)
C. 0°F.-no humidity control

Packaging materials in storage were:

A. At 85°F. - 85% relative humidity
   1. Cloth
   2. Multiwall paper
   3. 7-mil polyethylene
      a. Umpunctured
      b. Punctured
      c. Maze opening

All polyethylene bags were heat sealed. Punctured bags contained several (4 to 6) small pin-hole size punctures. Maze opening is a design to allow air to escape after sealing and is illustrated in Figure 1.

1/ Mr. Baskin is Assistant Agronomist, Seed Technology Laboratory, Mississippi State University.

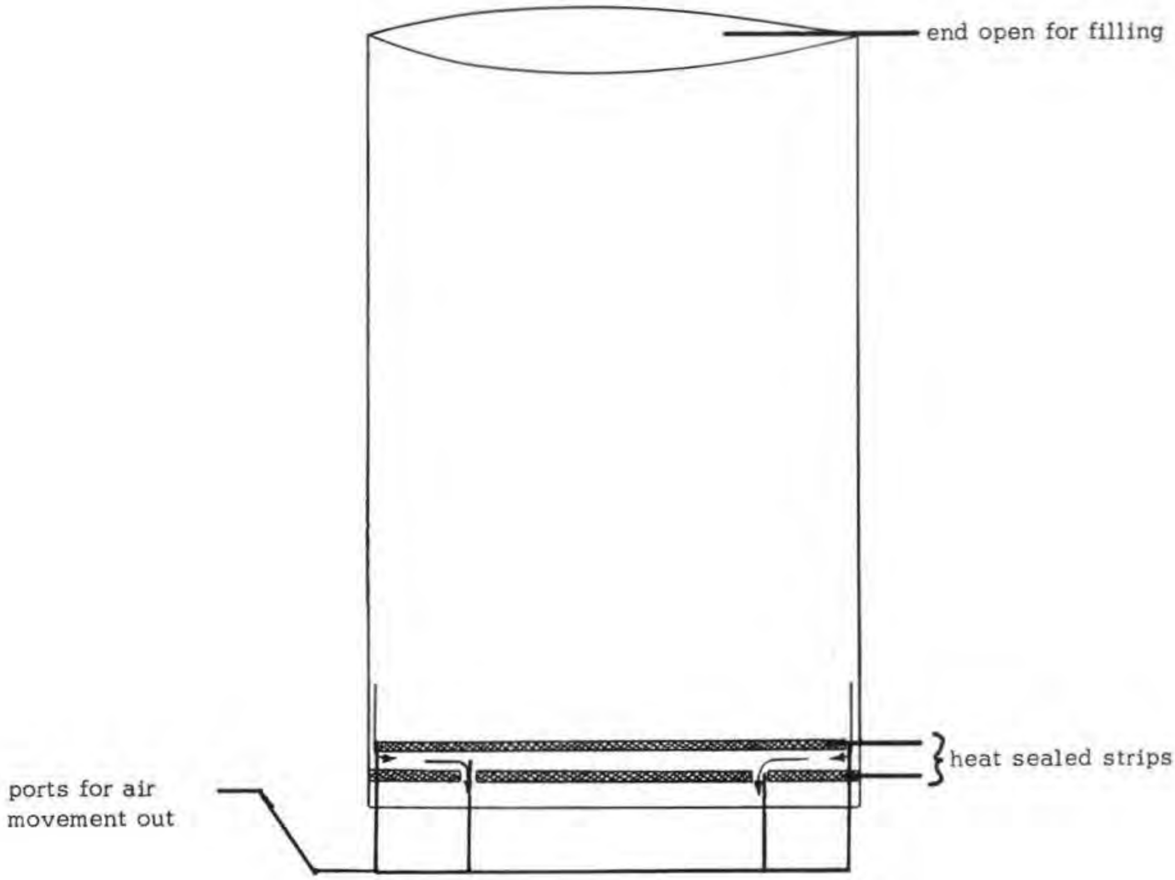

Figure 1. Diagram of "Maze" opening to allow air movement out of the filled, sealed bag and restrict air movement back into the bag.

B. In open warehouse storage packaging materials were:
   1. Multiwall paper
   2. 7 mil polyethylene
      a. Punctured
      b. Unpunctured

C. In frozen storage (0^{o}F.) packaging materials were:
   1. 7 mil polyethylene - unpunctured

Moisture contents were:

A. At 85^{o}F.-85% relative humidity
   1. Corn - 9.2% and 11.2%
   2. Soybeans - 9.0% and 11.2%
   3. Wheat 12.0%

B. In open warehouse storage
   1. Corn - 8.5% and 11.2%
   2. Soybeans - 9.0, 9.4 and 11.2
   3. Wheat - 12.6 and 10.7

Beans at 9.4% moisture were treated with a mecurial fungicide.

Wheat at 10.7% moisture was hot water treated.

C. In frozen storage
   1. Corn - 8.5%
   2. Soybeans - 9.0%
   3. Wheat - 12.6%

When seed were stored at 85^{o}F.-85% relative humidity, polyethylene bags were far superior to multiwall paper and cloth bags. Seed of all three crops stored in multiwall paper and cloth bags were greatly reduced in germination after 2 months storage and were dead, or nearly so, after 4 months storage. Moisture content of corn at 2 months had increased to 16.7 to 18.4% moisture; soybeans had increased to 18.0-23.7% moisture and wheat to 27.7% moisture. The increase in moisture at this high temperature clearly explains the rapid drop in germination.

Seed packaged in polyethylene responded differently depending on the kind, percent moisture and type of package.

Corn packaged at 8.5% moisture maintained a higher percent germination and a higher relative percent cold test emergence than did corn packaged at 11.2% moisture. This again can be attributed to differences in moisture content. Corn packaged at 11.2% moisture had increased to approximately 12.0 to 12.5% moisture after 11 months storage, while corn packaged at 8.5% moisture did not reach a comparable moisture content until after 16 to 18 months storage. Corn packaged at 8.5% moisture did not decrease in germination until the 16-month testing period, while corn packaged at 11.2% moisture decreased in germination at the 8-month testing period.

Within moistue contents there was a difference in polyethylene bags. Punctured bags were inferior to unpunctured and maze opening type bags. Seed moisture content increased slightly faster in punctured bags than in other types. With corn packaged at the 11.2% moisture content, the maze opening type bag appeared to be slightly superior to the other polyethylene bags. Germination of corn seed in the maze opening type bag was 75% while seed in unpunctured bags germinated 48% after 12 months storage.

There was a steady decline in cold test emergence at both moisture contents and in all polyethylene bag types during the storage periods. Seed in punctured polyethylene bags declined faster than the other 2 bag types. Corn packaged at 11.2% moisture dropped below 50% of the original cold test emergence approximately 4 months earlier than did corn packaged at 8.5% moisture. Soybeans followed the same general trends as corn, although the decline in germination was much earlier than in corn. Beans packaged at 9.0% moisture maintained germination for 6 months while beans packaged at 11.2% moisture had declined slightly in germination after 2 months storage. Again punctured polyethylene bags were inferior to other types. This was more pronounced in beans packaged at 9.0% moisture. Apparently, 11.2% moisture is too high for soybeans packaged in moisture resistant containers. As with corn, cold test emergence declined as time in storage increased.

Wheat maintained good germination for 6 to 8 months in all polyethylene bags, but was severely reduced in germination after 11 months storage. Germination percentages after 8 months were 82, 83 and 92 for punctured, unpunctured and maze opening bags, respectively. As with corn the maze opening type bags appeared to be slightly superior to other polyethylene bags.

Seed in warehouse storage responded quite differently. Corn packaged at 8.5% moisture stored no better than did corn packaged at 11.2% moisture. Polyethylene bags were only slightly, if at all, superior to multiwall paper bags in maintaining germination. Germination of corn packaged in multiwall paper bags at 11.2% moisture was slightly lower than corn packaged in polyethylene bags after 40 months storage. Cold test emergence followed the same pattern. Moisture content of seed in multiwall paper bags increased faster and was higher at the 40 month test period than seed in polyethylene bags.

Corn did not decrease below 84% germination at either moisture content or in any bag type during 40 months storage.

Soybeans responded quite differently to packaging materials and moisture content than did corn. Beans packaged at 9.0% moisture maintained high germination (93 to 96%) throughout the 40 month storage period, regardless of bag type. Beans packaged in multiwall paper bags tended to fluçtuate in moisture content and were slightly higher in moisture (1.0%) at the end of the storage period than beans packaged in polyethylene. Beans in polyethylene increased approximately 0.5% in moisture content during the storage period.

When beans were packaged at 11.2% moisture, multiwall paper bags were superior to polyethylene bags in preserving viability. Beans packaged in multiwall paper bags maintained a high germination (90%) for 32 months while beans packaged in polyethylene were considerably reduced (50 to 60%) in germination after 24 months storage. This difference can be attributed to multiwall paper bags allowing moisture to move out of the bag to a greater extent than 7 mil polyethylene. The process of respiration produces water, thus increasing the moisture content of the beans in the moisture resistant polyethylene bags, whereas this moisture would pass through the multiwall paper bags. Further evidence of this fact is that beans in unpunctured polyethylene attained a higher moisture content earlier than beans in punctured polyethylene. Moisture content of beans in punctured and unpunctured polyethylene and multiwall paper bags after 32 months storage were 11.7, 13.8 and 10.9 respectively, and after 40 months storage were 13.4, 13.3 and 12.1 respectively.

Cold test emergence decreased as time in storage decreased regardless of moisture content or bag type. The addition of a mecurial fungicide before packaging markedly improved cold test emergence through 32 months storage. Treated beans packaged at 9.4% moisture emerged 87.7% in cold test after 32 months storage when emergence was averaged for bag types, while untreated beans packaged at 9.0% moisture emerged 13.3% in cold test when emergence was averaged for bag types. This pronounced difference was not evident after 40 months storage.

Bag type had little if any influence on storability of wheat. Under warehouse conditions wheat stored at 12.6% moisture germinated 90%, 92% and 87% when packaged in punctured and unpunctured polyethylene bags and multiwall paper bags respectively after 40 months storage. Moisture content increased faster and was higher (1.5%) in multiwall paper bags than in polyethylene bags after 40 months storage.

Hot water treatment had an adverse affect on wheat storability. Initial germination was reduced 9.0% by hot water treatment. Germination after 40 months storage was 89.7% for untreated wheat when germination was averaged for bag types while hot water treated wheat germinated only 56.3% when germination was averaged for all bag types.

Seed of all kinds stored at $0^{O}F$. maintained high germination throughout the 54 month testing period. Corn, soybeans and wheat germinated 96.5, 95.0 and 92.0% respectively after 54 months storage. Germination percentages flucturated to the same extent during the storage period, as much as 8.5% for corn 4.5% for soybeans and 7.0% for wheat. Flucturations of this magnitude are to be expected as seed age. Cold test emergences of corn and soybeans tended to decrease as time in storage increased. This decrease, coupled with the fluctuations in germination, indicate that deterioration progressed to some extent in frozen storage.

In summary we may make the following observations:

1. Polyethylene containers are superior to cloth and multiwall paper containers in extending the storage life of seed under storage conditions of high temperature and high relative humidity.

2. There is little or no advantage of polyethylene over multiwall paper containers in packaging corn, wheat, or soybeans for storage in open warehouse conditions if conditions are similar to those encountered in central Indiana and if seed are sufficiently low in moisture at the time of storage.

3. Soybeans must be dried to approximately 9.0% moisture if they are to be packaged in moisture resistant materials.

4. Hot water treatment of wheat reduces the overall seed quality, therefore reducing storability.

5. High germination can be maintained at $0^{O}F$. for extended periods of time.

6. Seed deterioration occurs in all storage conditions, only the rate changes.

CONTRIBUTORS

Door Prize Fund

Seedboro Equipment Company
618 W. Jackson Blvd.
Chicago, Illinois 60606

Sanders Seed Company
807 University
Cleveland, Mississippi 38732

Stults Scientific Eng. Corp.
3133 S. 66 Freeway
Springfield, Illinois 62703

Riverside Chemical Company
Marks, Mississippi 38648

The Wax Company
Box 60
Amory, Mississippi 38821

MFC Services (AAL)
Box 449
Jackson, Mississippi 39205

Delta and Pine Land Company
Scott,
Mississippi 38772

Jordan Wholesale Company
Box 867
Cleveland, Mississippi 38732

Burrows Equipment Company
1316 Sherman Avenue
Evanston, Illinois 60201

Mercator Corporation
Suite 504-514, Box 142 R
Reading, Pennsylvania 19603

Hollandale Seed & Delinting Co., Inc.
Box 397
Hollandale, Mississippi 38748

Rose Seed Company
Box 849
Clarksdale, Mississippi 38614

Refreshment Fund

Carter-Day Company
655 Nineteenth Avenue, N.E.
Minneapolis, Minnesota 55418

Gustafson Manufacturing Co.
6600 South County Road 18
Hopkins, Minnesota 55343

Crippen Manufacturing Co. Inc.
Alma,
Michigan 48801

A. T. Ferrell & Company
1621 Wheeler Street
Saginaw, Michigan 48602

NOR-AM Agricultural Products, Inc.
20 N. Wacker Drive
Chicago, Illinois 60606

Triple/S Dynamics
1031 South Haskell
Dallas, Texas 75223

REGISTRATION

LIST

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REGISTRATION LIST
1970 SEEDSMEN'S SHORT COURSE

ALABAMA

1. Bob Burdett
   Alabama Crop Improvement Assn.
   Auburn, Ala.

2. Charles Hall
   Moorer Seed Co.
   Prattsville, Alabama

3. Frank Kyle
   Spencer Seed and Grain Co.
   Box 71
   Athens, Alabama

ARKANSAS

4. Charles Naff
   Hampton-Tugh Co.
   Box 761
   McGehee, Arkansas

5. Sid Stephens Morton Chemical Co.
   6511 Big Oak Lane
   Little Rock, Ark.

CALIFORNIA

6. Clark Barker
   Asgrow Seed Co.
   Box 716
   Gonzales, Calif.

7. John L. Cato
   J. G. Boswell Co.
   P. O. Box 457
   Corcoron, Calif.

8. R. H. Cummings
   Chevron Chemical Company
   940 Hensley
   Richmond, Calif.

CALIFORNIA (CONT'D)

9. David Fraysher
   Klean Seed Delinting Co.
   P. O. Box 1595
   Shafter, Calif.

10. Richard Holloway
    Cornut Inc.
    10229 Pear Main St.
    Oakland, Calif.

11. Stanley Jenanyan
    Keystone Seed Co.
    1508 Rogers Street
    Madera, Calif.

12. Shigeru Tabata
    B. C. Seeds
    P. O. Box 1804
    Salinas, Calif.

COLORADO

13. William D. Munroe
    Oliver Mfg. Co.
    Rocky Ford, Colorado

DELAWARE

14. T. C. Ryker
    DuPont Company
    I & B Dept.
    Wilmington, Del.

FLORIDA

15. Ralph Clark
    Clark Seed Co.
    Rt. 3, Box 382
    Bradenton, Fla.


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FLORIDA (CONT'D)

16. W. W. Evans
    St. Regis Paper Co.
    Bag Packaging Div.
    P. O. Box 1591
    Pensacola, Fla.

17. A. E. C. McIntyre
    Florida Foundation
    Seed Producers, Inc.
    P. O. Box 14006 U. Sta.
    Gainesville, Fla.

18. Dallas White
    Clark Seed Co.
    Rt. 3, Box 382
    Brandenton, Fla.

19. Jim Wilgus
    Clark Seed Co.
    Rt. 3 Box 382
    Bradenton, Fla.

GEORGIA

20. Darrell A. Benson
    Box 819
    U. S. Forest Service
    Macon, Ga.

21. Algie Denham
    Cotton Producers Association
    P. O. Box 2210
    Atlanta, Ga.

22. Darrell Gibbs
    Cotton Producers Association
    P. O. Box 2210
    Atlanta, Ga.

23. T. O. Hall
    Ga. Seed Development Comm.
    Athens, Ga.

GEORGIA (CONT'D)

24. Gilbert R. Lovell
    USDA-SCS
    Plant Materials
    Center P. O. Box 688
    Americus, Ga.

25. E. Mederos
    T. E. Stivers Co.
    P. O. Box 1008
    Decatur, Ga.

26. Sammie B. Parkman
    Ga. Seed Development
    Commission
    Athens, Ga.

27. R. J. Smith
    Cities Service Company
    Custom Farm Services
    3445 Peach Tree Rd. N.E.
    Atlanta, Ga.

IDAHO

28. Harvey W. Mauth
    Rogers Brothers Co.
    Seed Div.
    Box 2188
    Idaho Falls, Idaho

ILLINOIS

29. Lowell Cooper
    Ill. Crop Impr. Assn.
    508 South Broadway
    Urbana, Ill.

30. Mrs. Lowell Cooper
    Ill. Crop Impr. Assn.
    508 South Broadway
    Urbana, Ill.

31. A. F. Crow
    Crow's Hybrid Corn Co.
    Milford, Ill.


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ILLINOIS (CONT'D)

32. Charles Crow
Crow's Hybrid Corn Co.
Milford, Ill.

33. Benard Dahlquist
Funk Bros. Seed Co.
Bloomington, Ill.

34. Mrs. Benard Dahlquist
Funk Bros. Seed Co.
Bloomington, Ill.

35. James T. Gildersleeve
Gildersleeve Seed Co.
Hudson, Ill.

36. Fritz Onken
Ainsworth Seed Co.
Mason City, Ill.

37. John A. Scroggin
Bo-Jac Hybrid Corn Co.
Rt. 2
Mt. Pulaski, Ill.

38. Mrs. John A. Scroggin
Bo-Jac Hybrid Corn Co.
Rt. 2
Mt. Pulaski, Ill.

39. Byron Steel
Ainsworth Seed Co.
Mason City, Ill.

40. H. A. Stults
Stults Scientific Eng. Corp.
3313 S. 66 Freeway
Springfield, Ill.

41. Mrs. H. A. Stults
Stults Scientific Eng. Corp.
3313 S. 66 Freeway
Springfield, Ill.

ILLINOIS (CONT'D)

42. George D. Varner
F. S. Services Inc.
P. O. Box 131
Cisco, Illinois

43. Mrs. George D. Varner
F. S. Services Inc.
P. O. Box 131
Cisco, Illinois

INDIANA

44. Francis Beck
Beck's Superior Hybrid
Atlanta, Indiana

45. Mrs. Francis Beck
Beck's Superior Hybrid
Atlanta, Indiana

46. Claude Butt
Ind. Crop Imp. Asso.
R. R. 6 Box 25
Lafayette, Ind.

47. John Gerard
Syler Inc.
3028 Maryane Dr.
Lafayette, Ind.

48. Charles Hendrix
Ind. Crop Imp. Asso.
RR 6 Box 25
Lafayette, Ind.

49. Robert Kinsell
Silver-Lane Hybrids, Inc.
Remington, Ind.


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IOWA

50. Dennis Anderson
Cargill, Inc.
Grinnell, Iowa

51. John Baker
Funk Bros. Seed Co.
Traer, Iowa

52. Arlyn Holden
Corn States Hybrid Service, Inc.
P. O. Box 2706
Des Moines, Iowa

53. L. A. Kuchenmeister
Cargill, Inc.
Box 349
Mt. Pleasant, Iowa

54. Charles F.(Fred) Malone
Malone Seed Co., Inc.
305 Chestnut St.
Atlantic, Iowa

55. David S. McClure
ACCO Seed
Div. of Anderson Clayton Co.
515 River Ave. North
Belmond, Iowa

56. Owen J. Newlin
Pioneer Seed Div.
Des Moines, Iowa

57. Mrs. Owen J. Newlin
Pioneer Seed Div.
Des Moines, Iowa

58. Curt Palmer
Corn States Hybrid Service, Inc.
P. O. Box 2706
Des Moines, Iowa

IOWA (CONT'D)

59. Mr. Richard E. Thomas
Farmers Hybrid Co. Inc.
Box 157
Perry, Iowa

60. Mrs. Richard Thomas
Farmers Hybrid Co.Inc.
Box 157
Perry, Iowa

61. James Willeke
Mike Brayton Seed Inc.
1107 Airport Road
Ames, Iowa

KANSAS

62. Terry Reynolds
Speed King Mfg.
Dodge City, Kan.

63. Murland Taylor
Taylor Seed Co.
RR 3
Parsons, Kansas

64. Mrs. Murland Taylor
Taylor Seed Co.
RR 3
Parsons, Kansas

KENTUCKY

65. T. Wayne Still
University of Ky.
Lexington, Ky.

LOUISIANA

66. Ragan Brewster
Tyner Petrus Co. Inc.
P. O. Box 157
West Monroe, La.


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LOUISIANA (CONT'D)

67. Hubert Gremillion
Louisiana Seed Co. Inc.
P. O. Box 1112
Alexandria, La.

68. John Meredith, Jr.
Southern Seedsmen's Assn.
2036 Line Ave.
Shreveport, La.

69. Mrs. John Meredith Jr.
Southern Seedsmen's Assn.
2036 Line Ave.
Shreveport, La.

70. W. C. Normand
La. Agri. Exp. Sta.
9468 Kingcrest Pkway.
Baton Rouge, La.

71. Mrs. W. C. Normand
La. Agri. Exp. Sta.
9468 Kingcrest Pkway.
Baton Rouge, La.

72. Carter Percy
Carter Percy Farms
Weyanoke, La.

73. Mrs. Carter Percy
Carter Percy Farmes
Weyanoke, La.

74. Charles A. Petrus
Tyner Petrus Co. Inc.
P. O. Box 157
West Monroe, La.

75. Roland Smith
Louisiana Seed Co. Inc.
P. O. Box 1112
Alexandria, La.

MICHIGAN

76. James H. Colabine
Sortex Co. of North America
P. O. Box 160
Lowell, Mich.

77. Vergil D. Frevert
Crippen Mfg. Co. Inc.
P. O. Box 350
Alma, Mich.

78. Mrs. Vergil D. Frevert
Crippen Mfg. Co. Inc.
P. O. Box 350
Alma, Mich.

79. Duane W. Tyler
A. T. Ferrel and Co.
Saginaw, Mich.

MINNESOTA

80. W. S. "Bill" Acheson
Gustafson Mfg. Inc.
6600 So. County Rd.18
Hopkins, Minn.

81. Ed Commers
Carter-Day Co.
655 19th Ave.N.E.
Minneapolis, Minn.

82. George Durkot
Carter-Day Co.
655 19th Ave.N.E.
Minneapolis, Minn.

83. Paul Mickelson
Minn. Crop Imp. Assn.
U. of Minn.
St. Paul Campus
St. Paul, Minn.


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MINNESOTA (CONT'D)

84. H. J. Pluth
Forsbergs Inc.
Box 510
Thief River Falls, Minn.

85. Jerry Revier
Trojan Seed Co.
Olivia, Minn.

86. Stanley Ringeisen
Minn. Crop Imp. Assn.
U. of Minn.
St. Paul Campus
St. Paul, Minn.

87. Chuck Ritter
Trojan Seed Co.
Olivia, Minn.

88. Allen E. Swanson
Hart-Carter, Int. Inc.
655 19th Ave. N.E.
Minneapolis, Minn.

89. Ralph Vauble
Trojan Seed Co.
Olivia, Minn.

MISSISSIPPI

90. Johnny Baxter
Jordan Wholesale Co., Inc.
Box 867
Cleveland, Miss.

91. Charles P. Berry
USDA Forest Tree Seed Lab.
State College, Miss.

92. Frank T. Bonner
USDA Forest Tree Seed Lab.
State College, Miss.

93. Frank E. Burns
Burns Bros. Co.
Box 162 Rt. 2
Bogue Chitto, Miss.

MISSISSIPPI (CONT'D)

94. Lloyd Dahlem
Planter's Gin Co.
Indianola, Miss.

95. Burton Goodman
Whittington Wholesale
Tunica, Miss.

96. John W. Howell
Screw Conveyor Corp.
Winona, Miss.

97. Loren LeLeux
Delta and Pine Land Co.
Scott, Miss.

98. Leo Magee
Gunninson Plant and Seed
Gunninson, Miss.

99. Kenneth S. McClain
Delta and Pine Land Co.
Scott, Miss.

100. Kyle Rushing
Delta & Pine Land Co.
Scott, Miss.

101. Mrs. Kyle Rushing
& Lisa
Delta & Pine Land Co.
Scott, Miss.

102. Rex Rutland
Delta and Pine Land Co.
Scott, Miss.

103. Travis Salley
Sanders Elevator
Box 520
Cleveland, Miss.

104. Charles Smith
P. O. Box 449
MFC Services (AAL)
Jackson, Miss.


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MISSISSIPPI (CONT'D)

105. Pat Smith
Stoneville Pedigreed Seed Co.
Stoneville, Miss.

106. Allen Spragins
Refuge Seed Co.
Rt. 2, Box 335
Greenville, Miss.

107. G. F. Vaughan
State Dept. Agri.
Box 1609
Jackson, Miss.

108. Earl Watson
Route 1
Ellisville, Miss.

109. Aubrey Weems
MFC Services (AAL)
P. O. Box 101
Canton, Miss.

110. Jack Wilson
Hollandale Seed & Delinting Co.
Box 297
Hollandale, Miss.

MISSOURI

111. Charles J. Black
MFA Seed Div.
Box 550
Marshall, Mo.

112. J. T. Charmella
W. R. Grace & Co.
Rudy Patric Seed Div.
1212 West 8th St.
Kansas City, Mo.

113. Virgil Palmer
MFA Seed Div.
Box 550
Marshall, Mo.

MISSOURI (CONT'D)

114. Viola M. Stanway
University Missouri
18 Waters Hall
U. of Mo.
Colombia, Mo.

NEW YORK

115. Gordon J. Miller
Stanford Seed Co.
560 Fulton St.
P. O. Box 366
Buffalo, N.Y.

NORTH CAROLINA

116. Raymond G. Gurley
Gurley Milling Co.
Box 388
Selma, N.C.

117. Ronnie Hucks
McNair Seed Co.
Box 706
Laurinburg, N.C.

118. Mrs. Ronnie Hucks
McNair Seed Co.
Box 706
Laurinburg, N.C.

119. Thomas H. Nunalee III
North Carolina Crop
Improvement Assn.
Box 5155 N. C. State
University
Raleigh, N.C.

120. Donnie Patterson
Watson Seed Farm
Rocky Mount, N.C.

121. Bruce Shands
N.C. State Dept. of Ag.
Raleigh, N.C.


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NORTH CAROLINA (CONT'D)

122. Gene Sullivan
N. C. State Univ.
P. O. Box 5155
Raleigh, N.C.

OKLAHOMA

123. Ray Brunkhurst
El Reno Seed and Feed Co.
Box 639
El Reno, Okla.

124. Jack Eckroat
Eckroat Inc.
P. O. Box 307
Hennessee, Okla

125. James E. Graves
Okla. Crop Imp. Assn.
OSU
Stillwater, Okla.

126. Charlie Howard
Hobart Seed Co.
P. O. Box 778
Hobart, Okla.

127. Milton Smith
Eckroat Seed Co.
Oklahoma City, Okla.

OHIO

128. Mike Fulton
O. M. Scott & Sons Co.
Marysville, Ohio

129. John Walkup
O. M. Scott & Sons Co.
Marysville, Ohio

PENNSYLVANIA

130. Vincent J. Palau
Mercator Corp.
P. O. Box 142
Reading, Pa.

SOUTH CAROLINA

131. Donald B. Clark
Coker's Pedigreed Seed
Hartsville, S. C.

132. Henry H. Odom
Cokers Pedigreed Seed
Hartsville, S. C.

TENNESSEE

133. Joe Dudney
Tenn. Crop Imp. Assn.
5201 Merchant Dr.
Nashville, Tenn.

134. James Guthrie
Tenn.Seed Producers Inc.
5201 Merchant Dr.
Nashville, Tenn.

135. David Hurt
Hurt Seed Co.
Halls, Tenn.

136. Mrs. David Hurt
Hurt Seed Co.
Halls, Tenn.

137. Bill Latimer
Quality Seeds, Inc.
Box 666
Union City, Tenn.

138. David Parrish
Hurt Seed Co.
Halls, Tenn.


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TENNESSEE (CONT'D)

139. Bill Wallace
Hagan Manuf. Co.
P. O. Box 6020
Memphis, Tenn.

TEXAS

140. Warren Dulin
Agriculture Unlimited, Inc.
1920 Ave. E.
Lubbock, Texas

141. Chris L. Hacker
USDA-Soil Conservation Service
P. O. Box
Knox City, Texas

142. John Hanselka
Johnston Seed Co.
Terrell, Texas

143. Mrs. John Hanselka
Johnston Seed Co.
Terrell, Texas

144. Peter J. Pettey
Triple S. Dynamics
1031 S. Haskellans
Dallas, Texas

145. Gerald L. Proctor
Bronco Seed Co.
Box 789
Stamford, Texas

146. Don Robinson
Robinson Seed Farms
1107 Yonkers St.
Plainview, Texas

147. Ken Skarien
Seedsman's Digest
1910 W. Olmas Dr.
San Antonio, Texas

TEXAS (CONT'D)

148. Mrs. Ken Skarien
Seedsman's Digest
1910 W. Olmas Dr.
San Antonio, Texas

149. Tom Vannerson
Route 3, Box 296
Ennis, Texas

VIRGINIA

150. William B. Simmons, III
Va. Dept. of Ag.
& Commerce
P. O. Box 1
Courtland, Va.

151. Mrs. William Simmons, III
Va. Dept of Ag.
& Commerce
P. O. Box 1
Courtland, Va.

WASHINGTON

152. Charles Dutt
Quincy Farm Chemicals
P. O. Box 307
Quincy, Wash.

WISCONSIN

153. Bruce Holland
Blaney Farms, Inc.
Madison, Wis.

154. Mrs. Bruce Holland
Blaney Farms, Inc.
Madison, Wis.

WASHINGTON D.C.

155. W. W. Turner
FEDS/FTD/USDA
Washington, D.C.

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CANADA

156. Bene Wiebe
Maple Leaf Mills
Ltd., Seed Div.
P. O. Box 1259
Winnipeg A
Manitoba, Canada

JAPAN

157. K. Fukano
Yamada Trading Co.
Tokyo, Japan

158. M. Meyazaki
Yamada Trading Co.
Tokyo, Japan

LIST OF PROCESSING EQUIPMENT

IN THE SEED TECHNOLOGY LABORATORY

Air and Screen Cleaners

Clipper, Model Super X-29D	A. T. Ferrell and Company 1621 Wheeler Street Saginaw, Michigan
Clipper, Model M-2B	A. T. Ferrell and Company 1621 Wheeler Street Saginaw, Michigan
Crippen, Model H-534-A Model NW-334	Crippen Manufacturing Co. Alma, Michigan
Vac-A-Way, Farm Model	J. W. Hance Mfg. Co. 235 E. Broadway Westerville, Ohio

Aspirator

Pneumatic Separator	Mandrel Industries Electric Sorting Machine Div. 6909 Southwest Freeway Box 36306 Houston, Texas

Blender

Ross TRH 1/4 Size Ultra Rapid Turbo Square Mixer	Ross Machine & Mill Supply 12 N.E. 28th Oklahoma City, Oklahoma

Color Separators

Mandrel, Model Selexo	Mandrel Industries Electric Sorting Machine Div. 6909 Southwest Freeway Box 36306 Houston, Texas

Conveyors

Burrows Belt Converyor Model R-13-3/4 HE	Burrows Equipment Company 1316 Sherman Avenue Evanston, Illinois
Carter-Day Vibrating Conveyor	Carter Day Company 655 19th Ave. N.E. Minneapolis, Minnesota
Clipper Vibrating Conveyor	A. T. Ferrell & Company 1621 Wheeler Street Saginaw, Michigan

Debearder

Clipper	A. T. Ferrell & Company 1621 Wheeler Street Saginaw, Michigan

Dehumidifiers

Dryomatic, Model 105	Dryomatic Division of Logentronics 7001 Loisdale Road Springfield, Va. 22150
Una-dyn, Model A30LT	Universal Dynamics Corp. 120 Belmont Road Woodbridge, Va. 22191

Electrostatic Separator

Carpco, Model HL118	Carpco Research & Eng.Co. 4120 Haines Street P. O. Box 3272 Jacksonville, Florida

Elevators

Burrows Bucket Type, Model 50	Burrows Equipment Co. 1316 Sherman Ave. Evanston, Illinois
Clipper "Series 100"	A. T. Ferrell & Co. 1621 Wheeler Street Saginaw, Michigan

Elevators (Continued)

Gordonbilt Airlift, 1-H.P.	Gordon Machinery Corp. P. O. Box 1452 Maryville, California
John F. Grisez	John F. Grisez Company Crows Landing, California
Lift Master Airlift, 2-H.P.	Holzinger Brothers 10140 South Shoemaker Ave. Santa Fe Springs, Calif.
Mitchell 3-compartment Bucket type	J. L. Mitchell 2268 North Oxnard Blvd. Box 1069 Oxnard, California
Seedburo Bucket Type Model 200	Seedburo Equipment Co. 618 West Jackson Blvd. Chicago, Illinois
Universal Bucket Type Model B2	Universal, Incorporated 245 South Washington Hudson, Iowa
Universal Bucket Type Model C2	Universal, Incorporated 245 South Washington Hudson, Iowa

Gravity Tables

Forsberg, Model 40-V	Forsberg, Incorporated Thief River Falls, Minnescta
Oliver, Model Hi-Cap 50	Oliver Manufacturing Co. Box 512 Rocky Ford, Colorado
Sutton, Steele & Steele Model AX-250	Sutton, Steele & Steele, Inc. 1031 South Haskell Dallas 23, Texas

Huller and Scarifiers

Clipper, Eddy-Giant	A. T. Ferrell & Company 1621 Wheeler Street Saginaw, Michigan
Crippen, Model S	Crippen Manufacturing Co. Alma, Michigan

Length Graders

Carter Disc Separator Model 1522	Carter-Day Company 655 19th Avenue, N. E. Minneapolis, Minnesota
Carter Disc Separator Model 1547	" "
Carter Disc Separator Model 1827	" "
Hart Uni-Flow Cylinder Separator, Model 3	" "

Magnetic Separators

John F. Grisez	John F. Grisez Co. Crows Landing, California

Mixers

MacLellan Batch Mixer	Burrows Equipment Co. 1316 Sherman Avenue Evanston, Illinois

Roll Mills (Dodder)

Clipper, 10 rolls	A. T. Ferrell & Company 1621 Wheeler Street Saginaw, Michigan
Warsco, 8 rolls	W. A. Rice Company Jerseyville, Illinois

Scales

Apex Bagging Machine Model D-100	Burrows Equipment Co. 1316 Sherman Ave. Evanston, Illinois
Fairbanks-Morse 1000# Platform Scales	" "
Fairbanks-Morse 2500# Warehouse Scales	" "
Waymatic	Waymatic Welding and Fabricating Company Fulton, Kentucky
Howe-Ricardson UNIPAK	How-Richardson Co. Clifton, New Jersey

Scalper

Clipper, Model 1297-1	A. T. Ferrell and Co. 1621 Wheeler Street Saginaw, Michigan

Seed Treaters

Gustafson Mist-O-Matic Model M100	Gustafson Manufacturing Co. 6600 S. County Road 18 Hopkins, Minnesota
Gustafson Mist-O-Matic Model M400	" "
Panogen Augomatic Model MC	Morton Chemical Company 20 North Wacker Drive Chicago, Illinois
Panogen Automatic Model US 60-C	" "

Spiral Separator

Krussow Double Spiral	Cleland Manufacturing Co. 2800 Washington Ave. N. Minneapolis, Minnesota

Width and Thickness Grader

Carter Precision Grader Model 1VT	Carter-Day Company 655 19th Avenue, N.E. Minneapolis, Minnesota

LIST OF LABORATORY MODEL

SEED PROCESSING AND TESTING EQUIPMENT

Air and Screen Cleaner	
Clipper, Office Model	A. T. Ferrell & Company 1621 Wheeler Street Saginaw, Michigan
Aspirator	
Superior, Fractionating	Carter-Day Company 655 19th Avenue, N.E. Minneapolis, Minnesota
Dielectric Heater	
Thermex High Frequence Unit Model CP 10 A254	Votator Division, Chemetron Box 43 Louisville, Kentucky
Dockage Tester	
Carter, Model XT 1	Carter-Day Company 655 19th Avenue, N.E. Minneapolis, Minnesota
Electrostatic Separators	
Carpco, Model HP-16	Carpco Research & Eng. Co. P. O. Box 3272 4120 Haines St. Jacksonville, Florida
Coronatron	Ding's Magnetic Separator 4740 West Electric Ave. Milwaukee, Wisconsin
Gravity Tables	
Forsberg	Forsberg Incorporated Thief River Falls, Minnesota
Sutton, Steele & Steele Model V-135A	Sutton, Steele & Steele, Inc. 1031 South Haskell Dallas, Texas

Gravity Tables (cont'd)

Oliver Stoner	Oliver Manufacturing Co. Rocky Ford, Colorado
Kvarnmaskiner Laboratory Cleaning Plant Type KM	Aktiebolaget Kvarnmaskiner Box 7015 Malmo, Sweden

This plant consists of the following equipment:

Scourer (Huller)
Air Separator (Aspirator)
Shaking Sieve Sifter (2 Screen Cleaner)
Table Separator (Gravity Separator)
Trieur (Cylinder Separator)

Length Graders

Carter, Test Cylinder	Carter-Day Company 655 19th Avenue, N.E. Minneapolis, Minnesota
Carter, Test Disc	" "
Kvarnmaskiner, "Pedigree" Cylinder	Aktiebolaget Kvarnmaskiner P. O. Box 7015 Malmo, Sweden
Superior, Test Cylinder	Carter-Day Company 655 19th Avenue, N.E. Minneapolis, Minnesota

Magnetic Separator

Gompper-Maschinen Gesellshaft "Lilliput"	Buderich Bei Dusseldorf Grustr 32, Postfach, Germany U. S. Distributor: Ulbeco, Incorporated 484 State Highway 17 Paramus, New Jersey
Grisez	John F. Grisez Co. Crows Landing, California

Moisture Testers

Burrows Moisture Recorder	Burrows Equipment Company 1316 Sherman Avenue Evanston, Illinois
Burrows Safe-Crop	" "
Motomco Moisture Meter Model 919	Motomco, Incorporated 89 Terminal Avenue Clark, New Jersey
Steinlite Moisture Tester Model, RCT, S,G	Seedburo Equipment Co. 618 West Jackson Boulevard Chicago, Illinois
Universal, Model EH	Burrows Equipment Company 1316 Sherman Avenue Evanston, Illinois

Roll Mill (Dodder)

W. A. Rice	W. A. Rice Seed Company Jerseyville, Illinois

Scarifier

Forsberg, Sample-Seed Model	Forsberg, Incoporated Thief River Falls, Minnesota

Screens

Complete set of Clipper 9"x9" Hand Screens	A. T. Ferrell & Company 1621 Wheeler Street Saginaw, Michigan

Spiral Separator

Krussow Spiral	Cleland Manufacturing Co. 2800 Washington Ave. N. Minneapolis, Minnesota

Thresher

Head Thresher	Allen Machine Shop

Width and Thickness Grader

Carter Test Precision Grader	Carter-Day Company 655 19th Avenue, N. E. Minneapolis, Minnesota

Vibrator Separator

Mat-Osu	Mater Machine Works 520 South 1st Street Corvallis, Oregon

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Additional equipment includes: bag holders, sewing machines, seed probes, germinators, ovens, purity boards, seed dividers, seed counters, balances, microscopes, seed sample cabinets, the Vitascope, and other laboratory equipment.

Some of this equipment was contributed by:

Burrows Equipment Company
E. L. Erickson Products
Gustafson Manufacturing Company
Paul Hattaway Company
Redhead Bagholder Corporation
Seedburo Equipment Company

Psychrometric Chart

TEMPERATURE RANGE 0° - 160° F

BAROMETRIC PRESSURE 29.92 IN. MERCURY

LogE — Dryomatic Division

SPRINGFIELD, VIRGINIA