AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

Batch #24

1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture — AE70-0000-G358

B. SECONDARY: Distribution and marketing--Honduras

2. TITLE AND SUBTITLE

Recommendations for FECOAGROH grain storage and handling facilities in Honduras

3. AUTHOR(S)

Holmes,E.S.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1971	43p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Kan.State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(In Food grain drying,storage,handling,and transportation rpt.no.24)

9. ABSTRACT

10. CONTROL NUMBER

PN-RAB-422

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Grain crops
Honduras
Storage

13. PROJECT NUMBER

14. CONTRACT NUMBER

CSD-1588 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-71)

Food Grain Drying, Storage, Handling and Transportation

Report No. 24
July 1971

Recommendations for FECOAGROH Grain Storage and Handling Facilities in Honduras

FOOD & FEED GRAIN INSTITUTE
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SUMMARY OF REPORT/PUBLICATION

Title of Report/Publication: Recommendations for FECOAGROH Grain Storage and Handling Facilities in Honduras

Author: Elwyn S. Holmes

Period of Report/Publication: July 17, through August 6, 1971

Project Title: Technical Assistance in Food Grain Drying, Storage, Handling and Transportation

Contract Number: AID/csd-1588

Contractor: Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas

Principal Investigator: Elwyn S. Holmes

SUMMARY STATEMENT

Agricultural Cooperative Development International (ACDI) through USAID/Honduras requested the urgent assistance of a grain storage and handling engineer to assist in the development, design, and evaluation of rural grain collecting facilities and central grain conditioning and storage facilities for the National Federation of Agricultural Cooperatives (FECOAGROH) in Honduras.

Mr. Elwyn S. Holmes, Extension Agricultural Engineer at Kansas State University, a highly qualified grain storage specialist with 24 years experience in all aspects of grain storage including handling and conditioning facilities, provided the desired assistance under KSU's contract AID/csd-1588.

On arrival, Mr. Holmes was briefed on specific needs of FECOAGROH by ACDI, USAID, and FECOAGROH personnel. BNF facilities at Tegucigalpa and San Pedro Sula and three rural cooperative facilities were visited.

Lack of accurate figures on volumes of grain expected at rural and central collecting facilities made estimating equipment and facility sizing difficult. Estimates of receipts at rural and central facilities were made by consulting with FECOAGROH and other local personnel.

Written recommendations in letter form were prepared for FECOAGROH on the following:

1. A rural warehouse
2. A central office and warehouse
3. A rural grain handling and drying facility
4. A central grain handling and drying facility
5. A flow pattern for grain receiving, handling, drying, sacking, etc.
6. A list of suppliers of grain handling equipment
7. A list of grain testing equipment needed at each facility

8. An estimate of land required for facilities
9. A request for technical proposals on Stage II Rurals and Central facilities.

Recommendations were discussed in conference with FECOAGROH officials after they had an opportunity to review them. The various recommendations were also reviewed in detail with a Peace Corp Agricultural Engineer, David Handly. Mr. Handly's background should be of considerable help in providing FECOAGROH technical assistance.

Assistance that will be needed in the future includes:

1. Evaluating the awarding of contracts for Stage II facilities
2. Inspection of rural and central Stage II layouts before acceptance by the cooperative.
3. Training of managers and operators for rural and central Stage II facilities.

RECOMMENDATIONS FOR FECOAGROH GRAIN STORAGE AND HANDLING FACILITIES IN HONDURAS

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RECOMMENDATIONS FOR "FECOAGROH" GRAIN STORAGE AND HANDLING FACILITIES IN HONDURAS

INTRODUCTION

Agricultural Cooperative Development International (ACDI), through USAID/Honduras, requested the immediate services of a grain storage specialist to assist in the development, design, and evaluation of grain receiving, storage, and handling facilities for the National Federation of Agricultural Cooperatives (FECOAGROH) in Honduras.

PROBLEM AND SCOPE OF WORK

The ACDI representative in Honduras, Mr. Ray L. Wiggins, outlined the problem and scope of work, in general, as follows:

I. <u>The Problem</u>

1. FECOAGROH has no grain storage expert available to advise and supervise the projected grain warehouse construction program.

2. Honduras has a few engineers with some experience in building but none in grain handling. However, they do not want to be supervisors and inspectors as this disqualifies their firms from the design and construction phase.

3. FECOAGROH has the services of a Peace Corp volunteer who is a graduate agricultural engineer and can advise on basic warehouse design, structural stress and support requirements but who lacks experience in grain drying, fumigation, and storage.

4. There seem to be two (and maybe more) methods of drying grain: (1) bin drying, (2) flow-through dryers. USAID/Honduras feels there is no one in Honduras or FECOAGROH with sufficient knowledge or experience to state which method of drying is best for FECOAGROH and to see that it is done in the required manner.

II. The Requirements

1. Two Central Grain Drying and Storage Facilities (one in San Pedro Sula and the other in Tegucigalpa). The Central facilities should be capable of handling, grading, drying, and storing a total of approximately 1,400 tons (four types of grains: white and yellow corn, beans, rice, and sorghum) at any one time. Part of it will be handled and stored in sacks, while the remainder will be handled in bulk. The plan is to use the Banco Nacional de Fomento (BNF) storage silos (500-ton capacity, each tube) for long-term storage, while using the FECOAGROH Central storage facilities to accumulate stocks and prepare smaller quantities for direct sales.

2. Rural Warehouse and Storage Facilities. At the Rural level, cooperatives will require a warehouse and equipment designed to receive sacked grain that can be cleaned, fumigated, and dried. Part of the grain will be retained for local use, while the remainder will be forwarded to the Central storage facilities. Volume will vary from about 250 to 700 tons. Proper equipment will also be required for these installations.

3. Both Rural and Central facilities must be designed so that they can be expanded (doubled) without interfering with existing plant operations.

III. Suggested Solution

1. ACDI immediately secure the services of an expert in design and use of grain drying and storage facilities. The expert should be secured within the limits of the present AID/ACDI Task Order, possibly on a contract AID has with Kansas State University to supply technical assistance in food grain drying, storage, handling, and transportation. This expert is required in Honduras as soon as possible.

2. The grain storage expert must:

a. be thoroughly acquainted with all types of storage for yellow and white corn, beans, rice, and sorghum.

b. be acquainted with the various types of equipment used in grain cleaning, handling, drying, fumigating, and storage.

c. review present work and line drawings, recommend the best facilities, write the necessary scope of work for the architectural designs, review bids and help FECOAGROH to select the most qualified bidder.

d. draw up the construction contract specifications and assist FECOAGROH in selection of the most qualified contractor.

e. visit construction sites, at appropriate intervals, to determine:

(1) compliance with equipment specifications.

(2) verify proper installation of equipment.

f. assist in initial start-up of equipment and training of FECOAGROH personnel.

In response to the request from ACDI through USAID/Honduras, the Food and Feed Grain Institute provided the services of Mr. Elwyn S. Holmes, Extension Agriculture Engineer, under Kansas State University's Contract AID/csd-1588 to provide technical assistance in food grain drying, storage, handling, and transportation. Mr. Holmes was selected for this specific assignment because of his many years' experience in grain conditioning (wheat, sorghum, and rice) and his knowledge of equipment and planning of grain handling facilities.

Mr. Holmes' evaluation of the situation and recommendations are in the following paragraphs.

EVALUATION OF THE SITUATION

On arriving in Honduras, I met with Ray Wiggins of ACDI; Carlos Zacarias, Cooperative Manager; Bill Gardner, Engineer for AID; and David Handly, Peace Corps Agricultural Engineer assigned to the project.

It was immediately evident that accurate estimates of amounts of grain to be handled by the cooperative were not available. The cooperative extensionists were meeting in Tegucigalpa during the week of my arrival and we proceeded to quiz them for volumes expected in their areas.

With the help of all concerned, including the cooperative marketing manager, it was decided that each Rural cooperative needed a store and warehouse; that Stage II-Rurals needed four 60-ton storage units, a dryer, and handling facilities; and that two Stage II-Centrals would be needed.

It became immediately evident that improvisions would have to be made in receiving the grain because practically all would come to the Rurals in sacks and inspection would be necessary for each sack. Conventional cleaners and graders would not solve the problem because sacks could be expected to have rocks, sand, and pieces of wire in them. Since no electricity is availale at the Rural cooperative and labor is comparatively cheap, recommendations will be made on this basis. It was evident that a simple bulk weigher was needed to pay the grower for the actual grain delivered. See recommendations.

Because of low volumes of beans and rice to be handled, they would continue to be sack handled (exception would be bulk rice at Cortes). This would be sack dried in the warehouse as shown in Figure 3, included in Stage I-Rural recommendations.

The lack of knowledge in grain handling, drying, and quality control was evident among all working with this program in Honduras and I anticipate

the need for two more short visits, one to give them guidance in selecting the right contract for their needs for Stage II-Rural and Central storage, handling, and drying, and a later trip to check construction as meeting the cooperative needs.

Success of the Stage II-Rurals and Stage II-Centrals will depend on the manager's and operators' understanding of the capabilities and limitations of the facility. They must be trained in operation and maintenance and be given a good understanding of quality grain, as well as how the plant is designed to maintain this quality if properly operated and maintained.

RECOMMENDATIONS

FECOAGROH Stage I Warehouses - Rural

A review of the developments on this planned program revealed warehouses were needed immediately for receiving white corn, yellow corn, rice, and beans. Specific volumes of each at each Rural cooperative is not available, but estimates reveal that each warehouse should store 150 tons of sacked grain. With the exception of Cortes, 70% of the grain would be expected to be corn, primarily white corn. Cortes would be expected to market 50% rice.

Recommended basic warehouse design. The basic 40'-x-40' warehouse would be constructed of concrete or brick with approved pilasters to support each roof truss. The truss shall be of clear-span steel with steel purlins and cement-asbestos roof and one transluscent panel on each side in each section. The rear wall shall be constructed of wood to allow expansion with growth. There shall be a 10-foot sliding door in the rear for receiving. Two screened ventilators are to be placed

along the ridge of the roof to remove excess heat and moisture and/or a continuous under-eave ventilator between pilasters with ½-inch mesh screen. The use of a 24-mesh screen (Tyler scale), which will exclude all insects except the lesser grain borer and saw-toothed grain beetle, will be an option to those cooperatives desiring strict insect exclusion. The front 12 feet of the building will be used as office and store as shown in Figure 1. The separating wall shall be of concrete block or brick with a close-fitting door.

Eight companies have been pre-qualified and requested to submit technical proposals on the Stage I-Warehouse. The final architectural plan will be adjusted to the needs of each cooperative by FECOAGROH and submitted to local contractors for construction.

Equipment recommendations. Not to be a part of the basic warehouse, but optional to location, will be a floor sack drier for rice and beans sized to the expected volume. The drier shall be indirect-fire type using fuel oil capable of moving 5 cfm per 100-lb. bag and not exceeding 100° F temperature (95° F after rice heated) in the lower bags. Drying air temperature must not exceed 130° F. The rice is to be dried in porous bags not to exceed 4 feet in depth. Two, at the most three, points of moisture are to be removed at one drying and then allow 6 to 12 hours for tempering. All bags are to be loose fill and stacked in zig-zag fashion to prevent air channels to surface. Figure 3 shows a sack drier that can be fabricated.

An inspection and screening table (see Figure 4) was designed for receiving grain in Stage I and Stage II-Rurals. For Stage I-Rurals, two platform scales should be used to weigh grain received. One scale should be positioned under each spout of the grain cleaner. (See Figure 4)

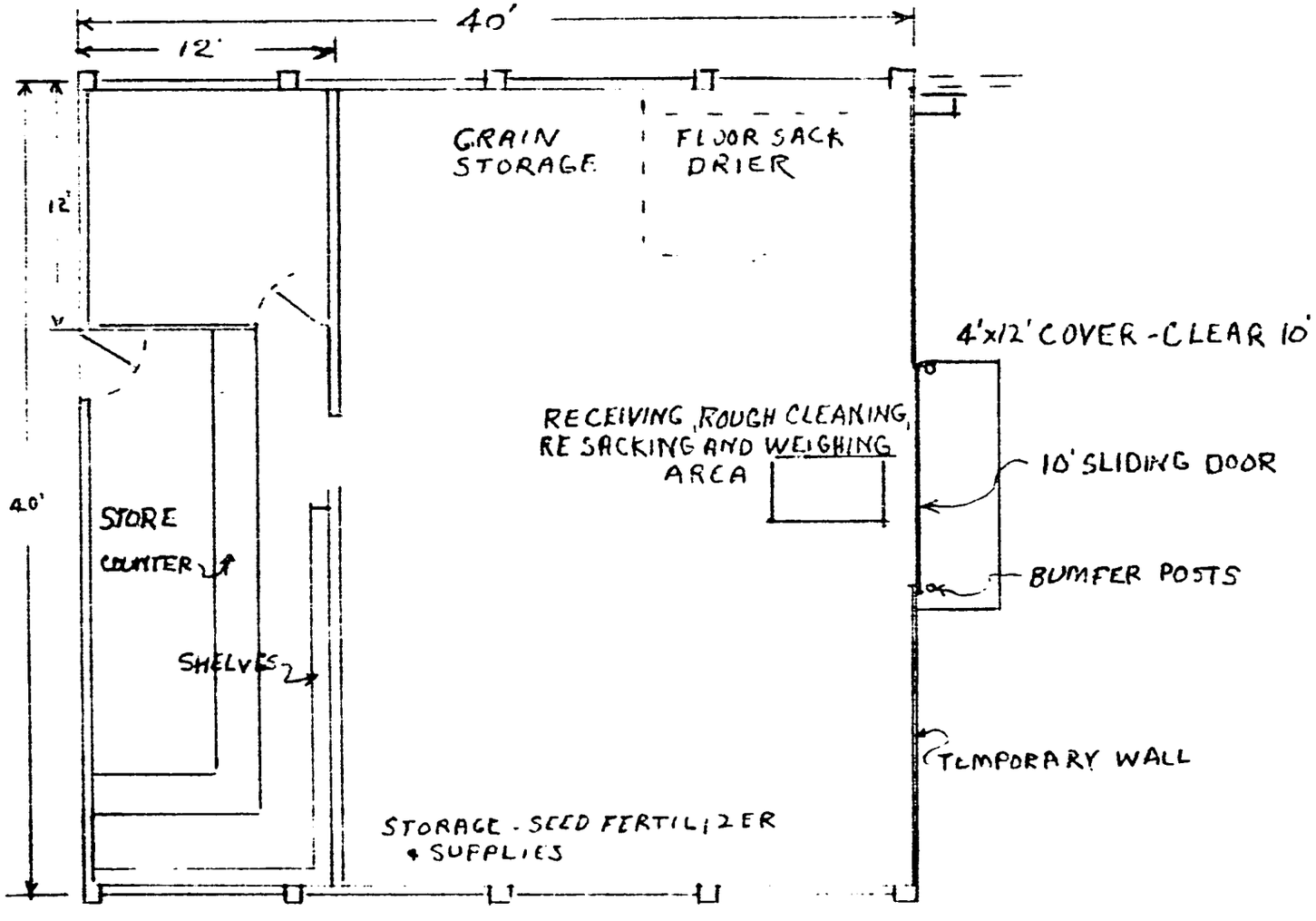


FIG. 1 - FLOOR PLAN OF FECOAGROH

STAGE I EXPANDABLE WAREHOUSE

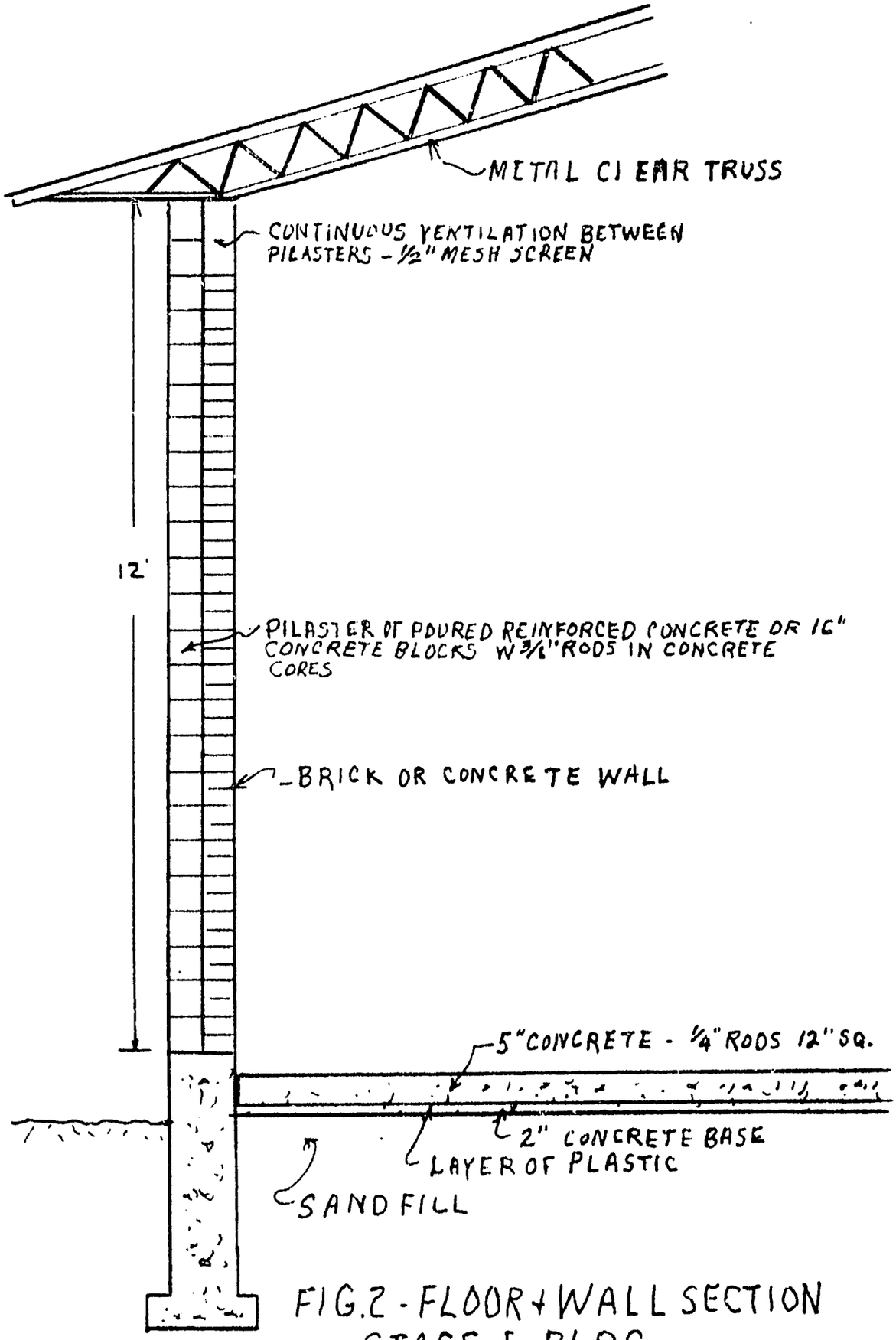
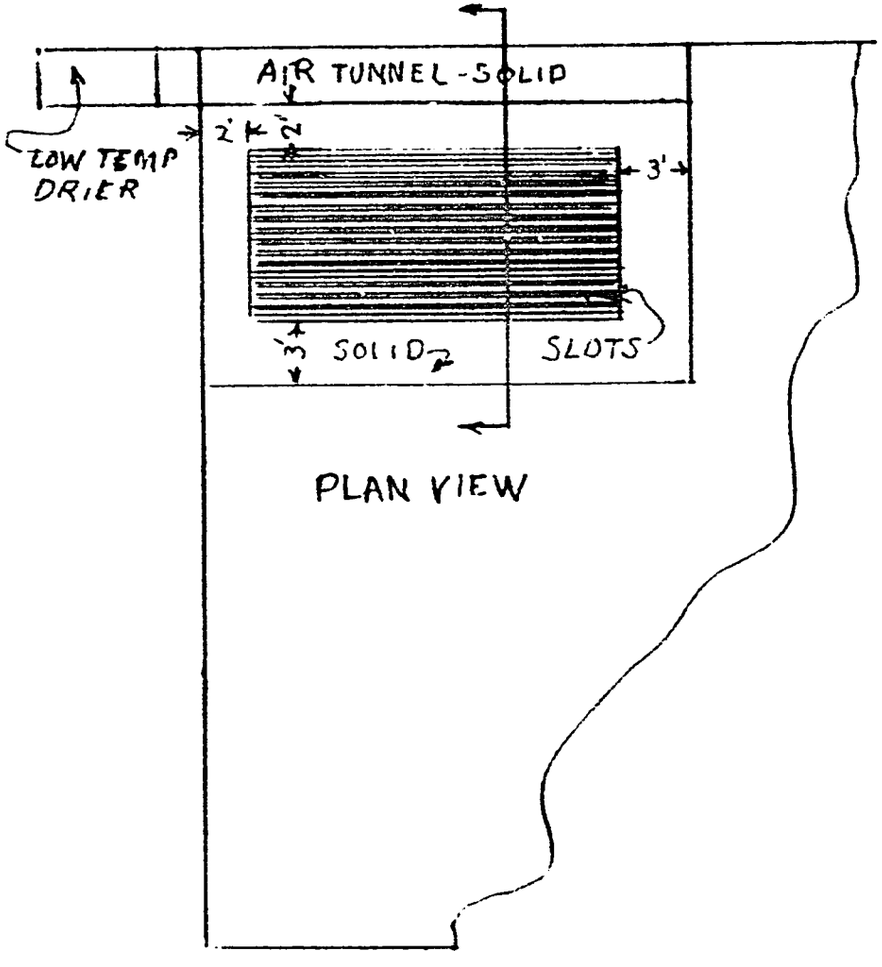


FIG.2 - FLOOR + WALL SECTION
STAGE I BLDG.



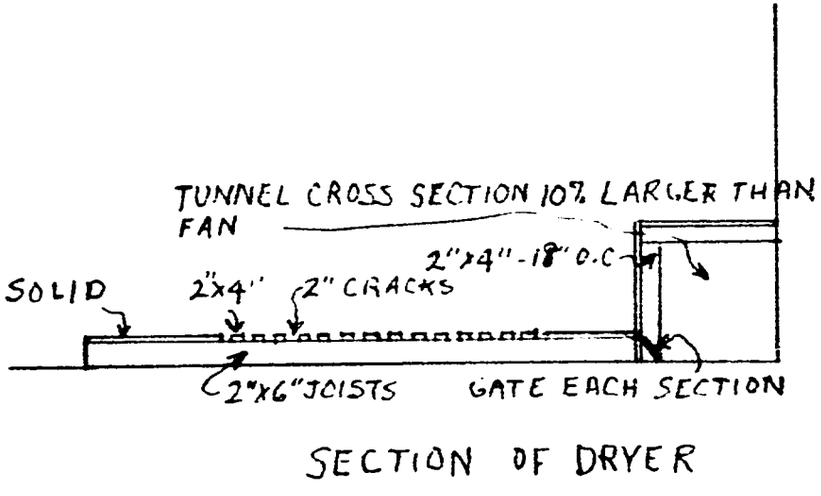


FIG. 3 - SACK DRIER

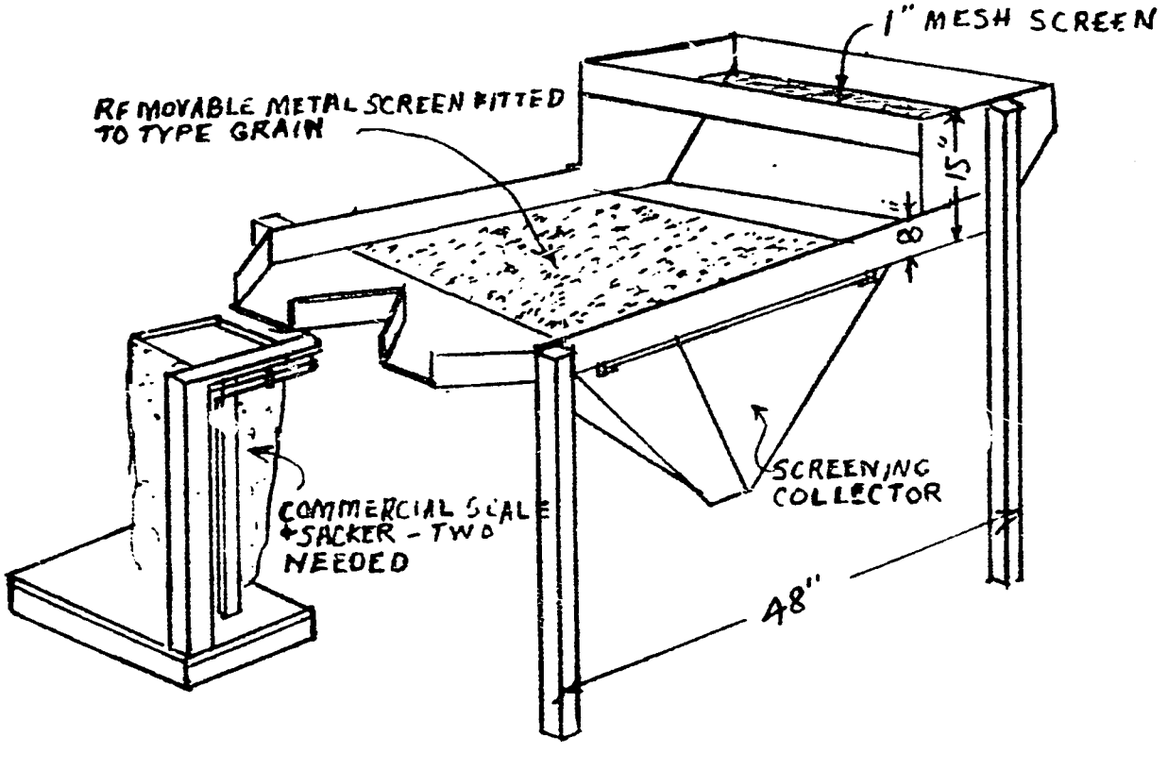


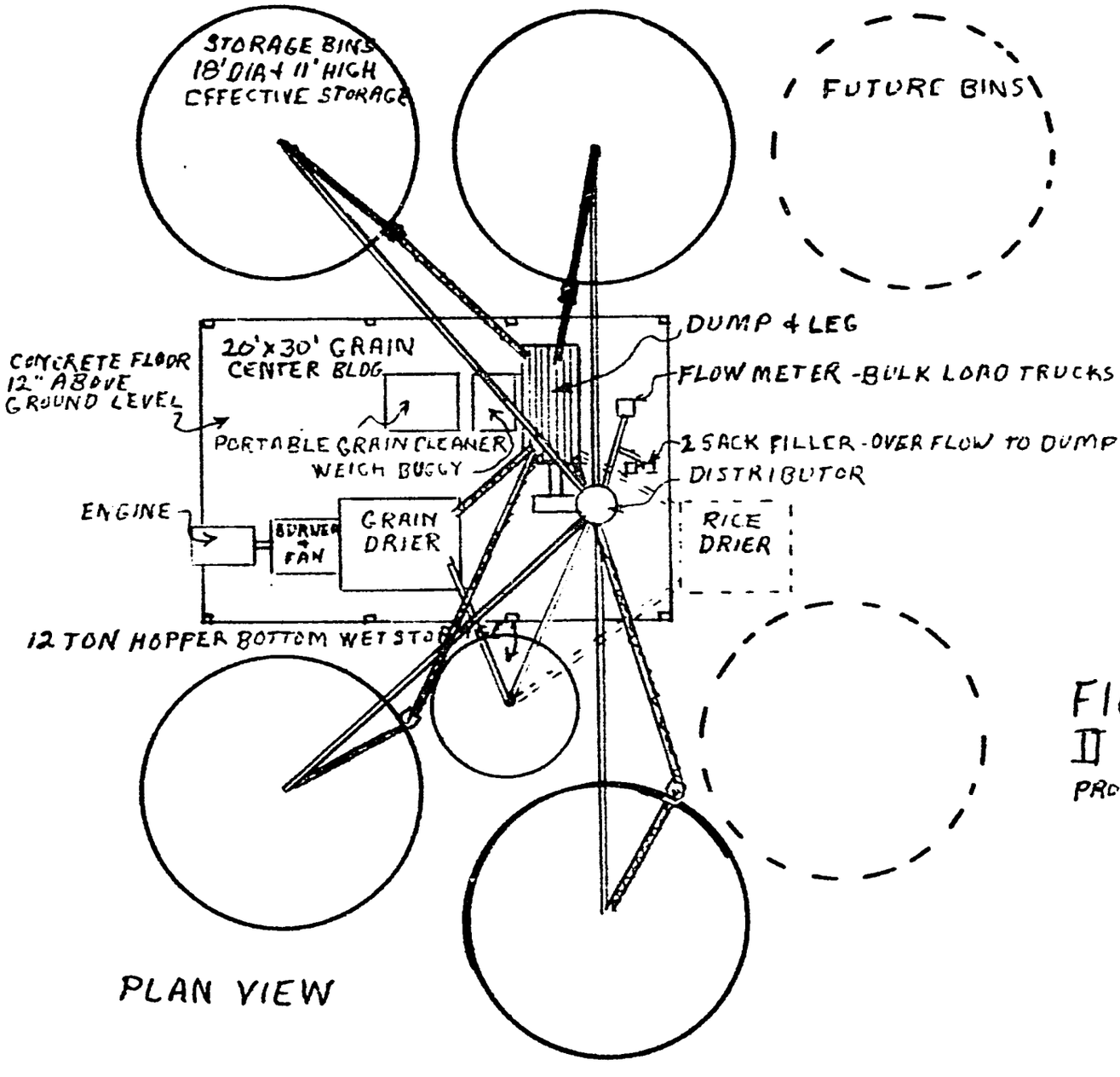
FIG. 4 - FECOAGRO ROUGH GRAIN CLEANER

When Stage II-Rurals are ready, a bulk weigher is available commercially with an inclined bottom to allow quick unloading into the elevator dump.

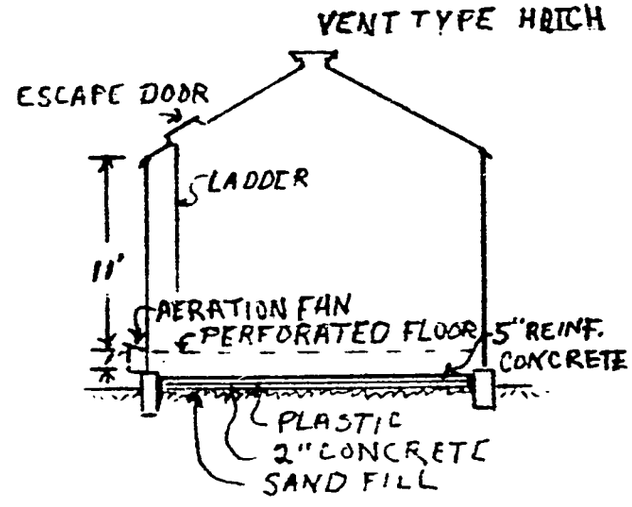
FECOAGROH Stage II Facilities - Rural

Grain is expected to be received in sacks and handled in bulk (except beans and rice which are to be rebagged in FECOAGROH sacks after cleaning and grading). At Cortes, rice will be run through a conventional rice drier and the bulk moved to San Pedro Sula for milling.

Each Rural shall have four 60-ton corrugated galvanized round bins, each 18 feet in diameter and effective storage 11 feet high. All bins shall have perforated floors and aeration fans capable of delivering 250 cfm (1/10 cfm/bu.) of air through 11 feet of grain. Each bin shall have a peak loading door ventilator to allow air to escape and prevent trapped moisture from accumulating above grain. An escape ladder shall hang from the loading opening or escape hatch. The bins shall be watertight with all joints carefully caulked and fitted. The floor and foundation shall be watertight as shown in Figure 5. The floor must be at least 10 inches above the surrounding ground level. All bins must be separated by 24 inches to allow construction, repair, etc. Aeration fans should run every day when humidity is below 65%. Each bin should be random probed twice weekly when containing grain (more often in areas of continuous high humidity). When probed spots are found to be at least 15° F greater than atmospheric air temperature with aeration fan operating, a random moisture sample should be taken. It should be recycled through the drier if found to be 14% moisture or higher. For moisture lower than 14%, changing from one bin to another usually breaks up any hot spots without drying.



PLAN VIEW



BIN CROSS SECTION

FIG. 5 - FECOAGROH STAGE II RURAL UNIT

PROCESSING & BULK STORAGE

GRAVITY SPOUT

SCREW CONVEYOR

BELT CONVEYOR

When fumigation is necessary, the aeration fan opening, top vent, and auger opening must be sealed with heavy plastic covers. Phostoxin is one of the good grain fumigants and treatment recommendations must be followed carefully. It has a 3-to-4-hour delay time before acting. No one should go into the treated area for five days.

At the center of the perforated floor in each bin, a draw-off opening adaptable to a bin self-unloading auger will be used. The self unloader shall not be purchased as a part of the initial Stage II plan. One underfloor auger and motor shall be a part of the project. It will unload the bin down to the angle of incline of the bin and workers will then finish unloading the bin manually by raking the grain to the auger opening. The one auger and motor shall be used to unload all bins. Care must be used to keep permanent equipment from being located directly in front of each bin auger hole opening so that the auger might be freely inserted when a bin needs unloading. One 8-foot and one 20-foot auger having the capacity of the bin auger or slightly greater shall be used to move the grain over to the dump or directly to a truck. If bin positions are changed, these augers must be changed in length to fit maximum and minimum distance. When at all possible, all augers should be operated at full capacity to prevent excess wear and minimize grain breakage. At Cortes, bins storing rice shall be equipped with belt unloaders instead of augers.

The dump pit shall be a horizontal auger (except where rice is to be handled) with liftable cover doors to control flow and prevent overloading the auger. In case rice is to be handled, the dump shall have a belt conveyor, also with liftable cover doors. The dump pit shall be made of watertight concrete.

The bucket elevator shall be of a low-speed gravity discharge size and load on the up movement of the cups. It shall have a minimum capacity of 600 bushels per hour with a 9-spout distributor.

The grain drier shall have a capacity of 80 to 100 qq. per hour. Its holding hopper shall hold one-hour's capacity. A 240 qq. hopper bottom wet storage bin (9 feet in diameter, approximately 17 feet high) must be part of the drying system to effectively use the system elevator leg when drying or recycling through the drier.

Only those Rurals handling a large amount of rice will have a rice drier. This drier will be capable of taking two points of moisture per hour from 80 to 100 qq. of rice. Driers of this type are low volume in comparison to units used in the United States. Conventional high-heat grain driers of the needed capacity are much cheaper than special driers that are capable of both high-heat and rice drying capability. A rice drier is needed only at the Cortes Rural and such is proposed in addition to the high-heat grain drier. Two separate driers are recommended because of economy. In addition, labor for operating the driers will not have the background to fully understand necessary adjustments if only a dual-purpose drier was used. When rice is the main crop and a rice drier is installed, a wet storage bin must be unloaded with the belt conveyor below the hopper. This belt will move rice over to a small cup elevator which is to be an integral part of the drier. A belt conveyor shall also extend from the drier back to the dump.

The elevator spout returning to the dump shall have a "Y" cutoff to feed grain to a bag filler when desired. The bag filler shall be two-way, with automatic cutoff at the 100-lb. level.

Where the volumes of rice and beans are small, handling of these grains shall be in bags in the Stage I facility. The sack drier proposed in Stage I will continue to be used. If the warehouse is expanded, the sack drier may be moved into the building addition to have the drier at the rear of the building.

By this time, if expansion justifies, a sack-handling elevator may become a part of the equipment to stack bags to the full building height. If expansion is great enough, pallets and a pallet lift truck might be considered at this time.

Heat for the driers must be of the fuel-oil type using an indirect fire. The drier will be operated by a fuel engine (diesel) until such time as electricity is made available to Rural stations. For the augers, cup elevator, other small motors, and lighting, an electric generator (with KW capacity of the total needs) will be used at each Rural. It will operate only during the time of actual need to operate the Rural.

The building (20 feet wide) shall be open side, with concrete floor 12 inches above ground level, cement-asbestos roofing and steel clear-span rafters. The roof will require two spout openings (a third when a rice drier is used).

The grain receiving shall be in sacks, inspected and graded, as shown in Figure 5.

Any bulk trucks received can be shoveled out directly to the dump through a 1-inch mesh screen to catch any large objects. If truck bulk grain is not reasonably clean, it can be run over the cleaning unit in Figure 5. Weighing of bulk trucks would not be possible until truck weighing scales could justifiably be installed.

All driers, augers, bins, and motors shall be standardized among all the Stage II installations to facilitate stocking repair parts.

In time, when electric power is more economically available to the facilities, a mechanical spreader will be installed in each bin.

For loading bulk trucks, a separate spout from the distributor will be used with a flow meter (Example: bottom of page 121, Burrows Catalog No. 16) to check the load being sent. Calibration of the meter will be necessary for each material handled. This bulk loading spout will necessitate another hole in the roof of the grain center.

Patterns of Flow - Rural Stage II

1. From farmers' sacks to grader inspection table, to bulk weigh bin, to dump. From this point, the cup elevator can move to wet bin, to appropriate drier, and back to dump. After drying, grain may be moved to any bin or sacked.
2. If grain needs no drying when received, it can be moved directly to any bin or sacked.
3. When and if redrying is necessary, move grain with bin unload augers to dump and through leg to wet bin storage (12-ton limit each time). Dump dried grain back through leg to empty bin and then repeat cycle until wet bin is dry.
4. Portable augers to move grain from bin to dump or to truck are to be stored on post hangers along edge of building. Suggest that augers and corresponding bins to be used be numbered to make match-up easy.
5. When truck leaves Rural unit for Centrals with bulkload, check will be through meter.

FECOAGROH Central Facilities

Stage II-Centrals have been designed to maximize use of storage available from BNF and to store only small lots plus amounts needed to keep a flow to the market.

Grain received at the Centrals will have been checked and rough cleaned at Rurals. It is expected that grain coming to the Centrals shall be in bulk, except beans and rice from areas having low volumes. It is also expected that much of this grain will be only partially dried or brought in at 15% moisture. Final drying will occur at the Centrals or BNF. Any appreciable volumes being received at Centrals will not stop but will go directly to BNF silos. Grain being received at Centrals will be first weighed over truck scales and backed up to hopper of drum cleaner. Grain will be scooped into hopper of cleaner.

The cleaner shall be one with easily removed screens to adjust to rice, corn, or any future grain.

If the Rurals are doing a good job, the amount of broken kernels and fine material will be small. This can be swept up periodically and sacked for animal feed.

At such future time that the Rurals are sending a clean marketable grain, the Central cleaner may be eliminated. This will allow installing a truck front-end hoist to quickly dump the bulk grain. The hoist would be overhead-rail mounted just outside the building for easy adjustment to variable truck lengths.

From the cleaner, grain will be moved into the dump. At San Pedro Sula, the dump will use a belt conveyor for bulk rice. Although Figure 6 shows a rice drier at both Central facilities, further study of rice areas may reveal that a rice drier is only necessary at San Pedro Sula.

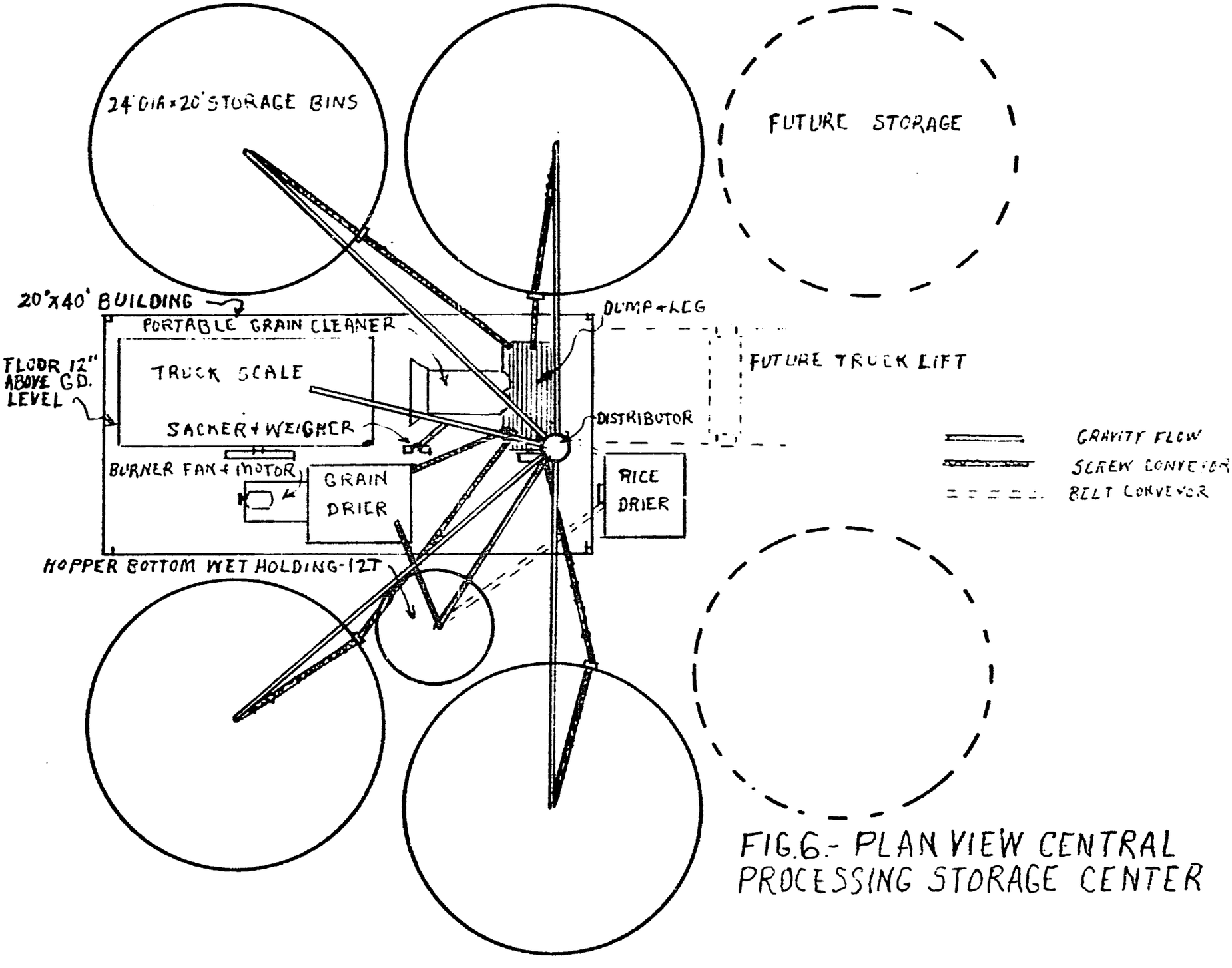


FIG.6.- PLAN VIEW CENTRAL PROCESSING STORAGE CENTER

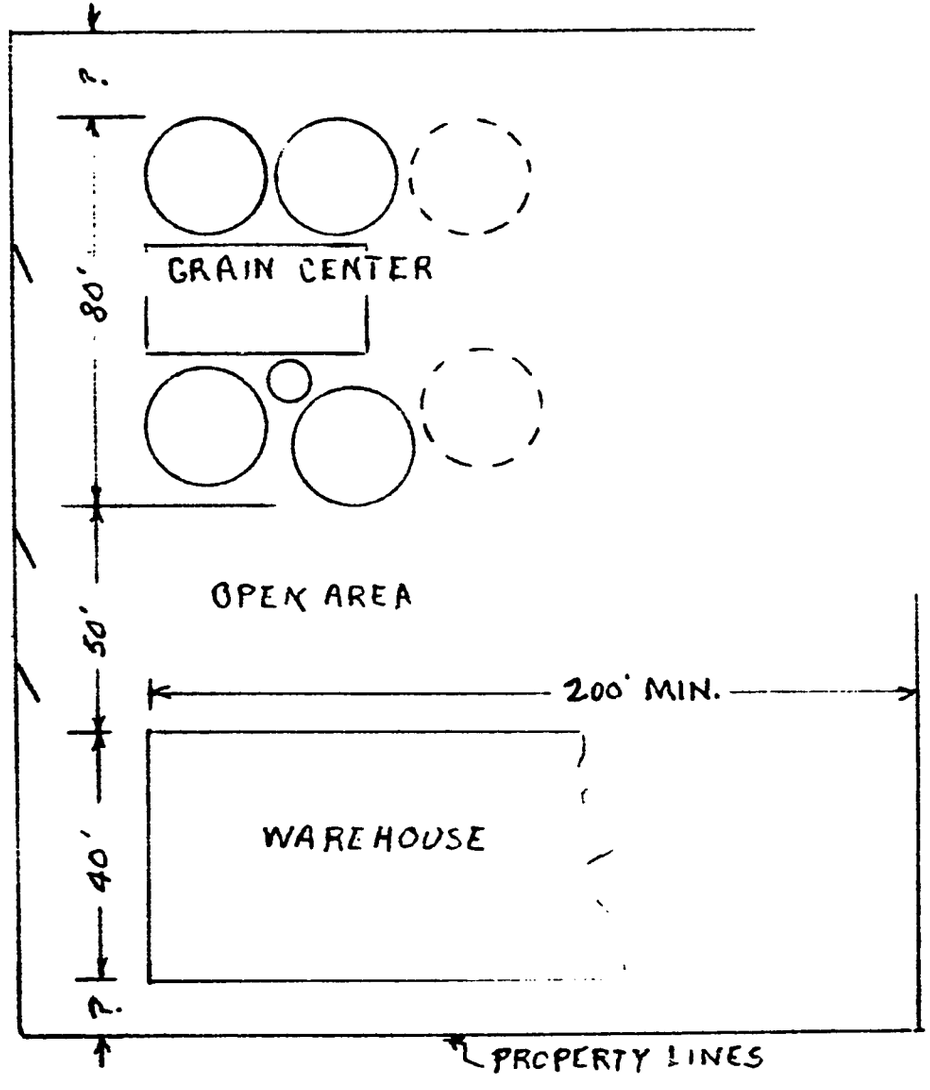


FIG7-SKETCH OF CENTRAL PROPERTY NEEDS

At Tegucigalpa, the dump can use an auger conveyor. The leg elevator shall be the same as at Rurals, differing only in lift height (68 feet above ground level) and horsepower needed to operate. It shall be capable of 600 bu/hr., operate at low speed, and allow additional cups to increase future output. A distributor with a minimum of 8 spouts will be used, thus allowing two extra spouts for future expansion.

If specific data becomes available indicating that Central handling estimates are low, the leg elevator output must be increased accordingly, specifying one that output can be increased by adding cups and increasing horsepower.

From the elevator, grain can move into a wet grain-holding bin or directly to storage bin if dry. The wet grain bin will have a capacity for two 6-ton truckloads. Grain can move from this bin to the appropriate drier. An auger can handle corn and an approved conveyor should be used for rice.

From the drier, grain moves back into the dump, to the leg and into storage bins. Each storage bin will hold at least 3,250 qq., being 24 feet in diameter and 20 feet in effective storage height.

All bins shall have a perforated floor capable of holding 20 feet of grain. Each shall have an aeration fan capable of delivering 700 cfm (approximately 1/10 cfm. per bu.). Each bin shall have a peak loading door ventilator to allow air and moisture to escape. With this size bin, an escape hatch and ladder shall be part of the project. The bins shall be caulked at all joints with floor, plenum, and wall watertight as shown in Figure 5.

The aeration fan shall run continuously when relative humidity is below 65%. Consideration should be given to putting this on automatic

control. (Such a control is available from Honeywell, Inc., 2753 Fourth Ave. South, Minneapolis, Minnesota, 55408). Each bin must be random probed twice weekly or more often if continuous high humidity occurs. When grain temperature is 15° F or greater than atmospheric air with aeration fan running, a random moisture sample should be taken. At 14% grain moisture and excess heating, the grain should be redried.

At the center of each perforated floor in each bin, a draw-off opening will be used which is adaptable to a self-unloading auger. The self unloader shall not be purchased as a part of the initial Central plan. One under-floor auger and motor shall be part of the project. It will unload the bin down to the angle of incline of the bin and workers will then finish unloading manually. One auger and motor shall unload all bins. Permanent equipment shall not block the auger bin opening to allow auger insertion. The bin auger and conveyor to the dump shall have approximately the same capacity as the leg. Two conveyors will be needed with proper lengths to reach the dump from any bin. Design must be such that all augers operate at full capacity to minimize grain breakage and wear.

At Tegucigalpa the dump will use an auger properly protected to control overloading. (See drawing on page 28 and 30 of MWPS booklet 13). The concrete pit shall be watertight. A small hand sump pump will be needed to empty the pit of water from blowing rain. At San Pedro Sula, the dump conveyor shall be belt type to handle rice.

A downspout shall go to the center of each bin; one shall go to the scales for loading out trucks; one shall go to a two-way automatic sacker with overflow into the dump.

The driers shall be of the fuel-oil type and driven by an electric motor.

The grain center building will be 20 feet wide and 16 feet high at the eaves, with open sides and a concrete floor 12 inches above ground level. It shall be constructed of approved pilasters with clear-span steel trusses and steel purlings with cement-asbestos roof.

Wiring and controls for all motors and lights shall meet specifications of the National Electric Code. Control switches shall be convenient to operators.

A mechanical spreader shall be considered for uniform loading on each bin in future additions. In the meantime, the bins shall be leveled manually after being filled to allow uniform air distribution.

Under no circumstances shall a bin be loaded from the escape hatch near the edge because bins of this height can be toppled by loading only one side.

When fumigation is necessary, phostoxin or its equivalent shall be used in the manner and amount recommended by the supplier (available from C. H. Eyl, Apartado 271, Tegucigalpa).

Training of FECOAGROH Operations Personnel

It is recommended that an experienced elevator operator spend the first season at both the Rural and Central facilities and subsequent training be given to new personnel as other units are installed.

One possible way of getting this help is to have ACDI contact cooperatives in the United States for some retiring elevator operator that might be interested in spending some time in Honduras.

Another means of training FECOAGROH personnel in proper grain storage methods is to send them to the Grain Storage and Marketing Short Course held annually at Kansas State University. This Short Course is conducted in conjunction with Kansas State University's Contract AID/csd-1588

specifically for participants under USAID sponsorship. The next Short Course will be held in June-July of 1972 and will be five weeks long. A general outline of material covered in the Short Course is as follows:

I. Introduction to Course

- A. Importance of Proper Grain Storage and Marketing
  1. Prevent Loss of Food and Feed Grains
  2. Provide Stable Prices for Food and Feed Grains
- B. Purpose and Scope of the Course
  1. Provide Basic Fundamentals of Grain Drying, Storage, Handling, Marketing, and Transportation
  2. Provide Practical Knowledge and Techniques Needed in Grain Storage and Marketing

II. Review of Grain Production and Utilization (in Participant's Country)

- A. Production
  1. Grains Produced
  2. Production Areas
  3. Quantities Produced
- B. Utilization
  1. Consumption - Food and Feed
  2. Export
  3. Import
- C. Basic Information
  1. Population
  2. Climate and Topography
  3. Transportation

III. Fundamentals of Grain in Storage

- A. Structure of Cereal Grain Kernels
- B. Moisture and Its Measurement
- C. Chemical, Physical and Nutritive Changes in Grain During Storage

IV. Grain Inspection

- A. Grain Standards
- B. Grain Sampling
- C. Grain Grading
  1. Grading Factors
  2. Methods

V. Grain Handling

- A. Movement of Grain
  1. Hand Methods
  2. Mechanical Methods

B. Methods and Facilities for Conditioning Grain
   1. Cleaning Equipment
   2. Temperature Monitoring Systems
C. Aeration
   1. Air Properties
   2. Air-Grain Temperature Relationships
D. Grain Drying
   1. Principles of Grain Drying
      a. Temperature-Moisture Relationships
      b. Effect of Drying on Quality
   2. Types of Drying
      a. Natural Drying
      b. Unheated Air Drying (Aeration)
      c. Heated Air Drying
   3. Types of Driers
      a. Bagged Grain
      b. Batch System
      c. Continuous Flow
   4. Drier Operation
      a. Heat Source
      b. Air Flow Rates
      c. Air-Grain Temperature Relationships
      d. Weight Loss in Moisture Removal
E. Equipment Maintenance

VI. Storage

A. Type of Structures
   1. Farm Storage
   2. Warehouse Storage
   3. Elevators
B. Structural Maintenance
C. Storage Methods and Procedures
   1. Warehousing
   2. Elevators
      a. Binning
      b. Blending

VII. Sanitation Program

A. Housekeeping
   1. Warehouse and Elevator Perimeters
   2. Warehouse and Elevator Interior
   3. Warehouse and Elevator Equipment
B. Insect Control
   1. Biology and Identification of Insects and Their Importance
      a. Biology of Major Pest Insects
      b. Identification of Stored Grain Insects
      c. Insects in Relation to:
         (1) Grain Temperature and Moisture Content
         (2) Fumigants
         (3) Grain Condition

2. Control Methods
    a. Housekeeping
    b. Residual Sprays
    c. Protectants
        (1) Bags
        (2) Grain
    d. Fumigation
        (1) Warehouse
        (2) Elevator
    e. Inspection
3. Pesticide Safety

C. Rodent and Bird Control
1. Biology and Identification
    a. Rodents
    b. Birds
2. Importance of Rodents and Birds in Relation to Grain
3. Control Methods
    a. Structural Condition
    b. Traps
    c. Baits and Poisons

D. Microbial Control
1. Importance of Micro-organisms in Grain
    a. Development of Micro-organisms on Damp Grain
        (1) Molds (Fungi)
        (2) Yeasts
        (3) Bacteria
    b. Mycotoxins
        (1) Production
        (2) Effect on Man and Animals
2. Control Methods
    a. Drying
    b. Cooling
    c. Proper Management

VIII. Economics of Marketing Management and Operations

A. Principles of Management
1. Organization within Firm
    a. Assignment of Responsibility
    b. Training of Personnel
2. Organization to Provide Customer Service
    a. Importance of Consumer
    b. Educational Services

B. Principles of Operation
1. Exchange
    a. Buying
    b. Selling
2. Economics of Physical Handling
    a. Storage
        (1) Cost of Alternatives
        (2) Location
        (3) Type

b. Transportation
(1) Local
(2) National
(3) Export
c. Processing
3. Facilitating Operations
a. Financing and Risk Taking
b. Information
(1) Price and Demand
(2) Crop Production
(3) Supplier
(4) Procedures for Informing Public
c. Standardization
(1) Establishing Grades
(2) Licensing Procedures
(3) Arbitration
4. Bookkeeping, Accounting, Inventory Control
C. Government and Grain Marketing
1. Commercial Regulations
2. Legal Environment
3. Action Programs
a. Farm
b. Non-farm
4. International Programs and Policies
D. Form of Business Organization
1. Individual Proprietor
2. Partnership
3. Corporation
4. Cooperative
5. Government

IX. Tours of Local Facilities to Point Out and Demonstrate Course Material

X. Laboratories to Complement Lectures

A. Grain Inspection Methods
B. Tours, in Part, to Observe Handling Equipment
C. Models of Driers and/or Demonstration of Effects of Improper Drying
D. Inventory Control for Warehouses and Elevators - Bookkeeping, Etc.
E. Insect Identification
F. Demonstration of Pest Control Methods
G. Business Procedures and Market Analysis Methods

APPENDIX A

EQUIPMENT MANUFACTURERS AND SUPPLIERS

The following is a selected list of companies which can supply the various pieces of equipment referred to in the body of this report. This list does not include all companies handling the various pieces of equipment. Those listed are generally considered to be reliable.

Column-type, Oil-fired Grain Driers:

Aeroglide Corp.
P. O. Box 1839 --uses baffle
Raleigh, North Carolina 27602

American Drying Systems Incorp.
1135 N. W. 159th Drive
Miami, Florida 33169

Campbell Industries Inc.
Dean Avenue
Des Moine, Iowa 50317

Column-type Grain Driers (May or may not be oil-fired):

Behlen Mfg. Co.
P. O. Box 569
Columbus, Nebraska 68601

Butler Mfg. Co.
General Officers --round column
Kansas City, Missouri 64126

M. &. W. Farm Power Products
Sango S. de R. L.
Apartado 67"
Tegucigalpa

Super B Grain Driers
Beard Industries, Inc.
Frankfort, Indiana

York Mfg. Co.
Box 188
Henderson, Nebraska 68371

Farm Fans, Inc.
5900 Elmwood Ave.
Indianapolis, Indiana 46203

Hart-Carter Co.
1209 W. Pioneer Parkway
Peoria, Illinois 61614

NOTE: Selected grain drier capable of removing 5 points of moisture at the rate of 80 to 100 qq. per hour.

Rice Driers:

Aeroglide Corp. *

American Drying Systems, Inc. *

A. T. Ferrell & Co.
Saginaw, Michigan 48602

NOTE: Select rice drier capable of removing not over 3 points moisture at rate of 80 to 100 qq. per hour. Allow 8 to 12 hours between drying. Grain temperature prefer not to exceed 100° F, absolute not above 110° F.

Galvanized Grain Bins with Perforated Floors:

Behlen Mfg. Co. *

Butler Mfg. Co. *

Columbian Steel Tank Co.
1509 W. 12th Street
Kansas City, Missouri 64101

Duplex Mill and Mfg. Co.
415 Sigler P. O. Box 1266
Springfield, Ohio 45501

Clayton and Lambert Mfg. Co.
Farm Producers Div.
Buckner, Kentucky 40010

Eaton Metal Products Mfg. Co.
1301 Willis Avenue
Omaha, Nebraska

Sioux Steel Co.
196½ East 6th Street
Sioux Falls, South Dakota 57101

Superior Atlanta Mfg. Co.
Box 106
Tucker, Georgia

York Mfg. Co. *

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* See earlier listing for complete address.

NOTE: Other companies make good bins. Watch for specified amount of zinc coating and accept nothing less than 1½ ounce per sq. ft. Keep bins clean of grain rotting. When first signs of rust appear, paint the area with zinc-base paint containing at least 70% zinc dust.

Paint Suppliers:

Porter Paint Co.
Unico-Alliance, Ohio
Farmland Industries, Kansas City, Missouri

Bucket Elevators:

Burrows Equipment Co.
1316 Sherman Avenue
Evanston, Illinois 60204

Aeroglide Corp. *

American Drying Systems, Inc. *

Behlen Mfg. Co. *

Farm Fans, Inc. *

A. T. Ferrell and Co. *

Duplex Mill and Mfg. Co. *

Hutchinson Div.-Royal Industries
Clay Center, Kansas 67432

York Mfg. Co. *

NOTE: Watch for leg that can increase volume by adding buckets and increasing H. P.

Augers (Other than Listed under Bins):

Wyatt Mfg. Co., Inc.
P. O. Box 1227
Salina, Kansas 67401

Burrows Equipment Co. *

NOTE: Always select slow-speed augers (400-500 RPM to minimize grain damage)

Belt Conveyors:

American Drying Systems, Inc. *

Aeroglide Corp. *

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* See earlier listing for complete address.

Burrows Equipment Co. *

Behlen Mfg. Co. *

Clay Equipment Corp.
Cedar Falls, Iowa 50613

Duplex Mill and Mfg. Co. *

Flow Meters:

Burrows Equipment Co. *

Duplex Mill and Mfg. Co. *

Clay Equipment Corp. *

Fairbanks Morse, Weighing Systems Div.
Colt Industries
711 East St. Johnsbury Road
St. Johnsbury, Vermont 05819

Mix Mill Inc.
P. O. Box 328
Buffton, Indiana 46714

Scales:

Burrows Equipment Co. *

Fairbanks Morse, Weighing Systems, Div., Colt Industries *

Howe Richardson Scale Co.
Van Houten Avenue
Clinton, New Jersey 07015

Duplex Mill and Mfg. Co. *

National Controls Inc.
P. O. Box 1501 Pines Road
Rosa, California 95403

Toledo Scale Co., Division of Reliance Electric Co.
5225 Telegraph Road
Toledo, Ohio

Round Grain Cleaners:

Portable Elevator Mfg. Co.
A Corporate Division of Dynamics Corp.
Bloomington, Illinois

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* See earlier listing for complete address.

Hutchinson Div.-Royal Industries *

Farm Fans Inc. *

Burrows Equipment Co. *

Wyatt Mfg. Co. Inc. *

Fan and Heater Units:

NOTE: Fan and heat units for sack drying available from nearly all companies making column driers listed above.

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* See earlier listing for complete address.

APPENDIX B

TESTING EQUIPMENT NEEDED AT RURAL UNITS

1. Battery-powered moisture tester that measures electrical resistance or capacitance of grain. Simple to use with charts and thermometer. In slack grain receiving period, it can be brought in to the Centrals and calibrated against oven or Brown Duvel.

   Moisture Tester Suppliers:

   Burrows Equipment Co., Evanston, Illinois
   Butler Manufacturing Co., Kansas City, Missouri
   Motomco Inc., Clark, New Jersey
   Radson Engineering Co., Macon, Illinois
   Seedburrow Equipment Co., Chicago, Illinois
   Stormer, Fremont, Nebraska (Not sure of batter unit)

2. Sample scales

3. Sample containers

4. Temperature probes for bins - 6 feet, Dial type for sacks 8-inch stem.

5. Trier approximately 60 inches long for probing grain

6. Set of dockage sieves

7. Inexpensive relative humidity indicator.

For Items 2 through 7, Burrows has good reputation as supplier.

APPENDIX C

TESTING EQUIPMENT NEEDED AT CENTRAL FACILITIES

1. Brown-Duvel or oven moisture tester and electric or battery-powered tester as at Rural facilities

2. Sample scales

3. Sample containers

4. Temperature probe capable of up to 12 feet - Supply of dial probes for sacks

5. Approximately 3-foot trier for bulk trucks

6. Approximately 6-foot trier for bins

7. Quality relative humidity indicator

8. Grain dockage sieves

9. Specialized equipment may be needed after personnel fully understand grain grades, a grading system is established in the country and volume justifies.

Burrows is a respectable source for all of this equipment.

APPENDIX D

REQUEST FOR TECHNICAL PROPOSALS ON THE STAGE II FACILITIES OF THE RURAL UNIT AND THE CENTRAL FACILITIES IN FECOAGROH'S PROJECT

The following draft for technical proposal requests on Stage II-Rural and Stage II-Central facilities was prepared by Mr. David Handly based on recommendations and assistance from Mr. Elwyn S. Holmes.

I. Brief Description of Project

A. Stage II Installation of Rural Unit

A model plan is desired for a small drying and bulk storage facility. This plan will be used for construction of the Stage II installation at each of the various Rural coops of the FECOAGROH. The model plan will be adjusted to the needs of each coop by FECOAGROH and submitted to local contractors for construction. The plan for the Stage II should allow for expansion without disrupting operations in the original facility. Particular care must be taken in the design to obtain an installation which is extremely simple to operate and manage and which is consistent with economic construction.

The Stage II installation will basically consist of four corrugated galvanized round bins (each with a 60-ton capacity) and a grain center building with the necessary grain handling and drying equipment.

Each bin will be 18 feet in diameter and have an effective storage height of 11 feet. All bins will have perforated floors and aeration fans. A draw-off will be used in the center of the floor of each bin which will allow the addition of a self-unloader in the future. One portable underfloor auger will be used to unload all bins. Two conveyors will be needed to move grain to the dump from any bin. The length of these two conveyors will be determined by the maximum and minimum distance of bins to dump.

Grain is expected to be received in sacks, wet and very dirty, at a rate of approximately 20 tons per day.

A bucket elevator with a minimum capacity of 600 bushels per hour will be used. It shall be the slow-speed gravity discharge type with loading on the "up" leg.

The grain dryer shall be a continuous flow, column-type dryer with a capacity of 80-100 quintales per hour. It shall be oil-fired and use indirect heating. It will have a holding hopper to hold one-hour's capacity. A diesel engine will be used to drive the dryer.

A 12-ton hopper bottom bin, 9 feet in diameter and approximately 17 feet high, will be used in the system as a wet storage bin.

The elevator dump pit will be constructed of watertight concrete. A horizontal screw conveyor with lift-doors or other flow-control devices to prevent overloading will be used.

Other items to be included in the installation are a two-way bag filler and a flow meter for loading out bulk grain. The elevator, all conveyors, and any small equipment will be powered by small electric motors. A generator will be needed to supply electricity to these motors and lighting.

In those cases where rice is to be processed in bulk, a belt conveyor will be installed in the dump and belt conveyors will be used to unload rice from bin to dump. Also, a separate rice dryer will need to be added to the installation.

The grain center building will be 20 feet wide, approximately 30 feet long, and 12 feet high at the eaves. It will be an open-side building with a concrete floor 12 inches above ground level. It will have steel clear-span trusses with cement-asbestos roofing.

B. Central Installations

Central installations consisting of (1) a warehouse building and (2) a small drying and bulk storage facility are to be constructed in San Pedro Sula and Tegucigalpa. Because the two Central installations will be almost identical, only one plan will be needed, with site adaption for each location. Also, because rice will be handled in bulk in the San Pedro Sula installation and not in Tegucigalpa, there will be some differences in equipment needed at each Central installation. In all cases, plans should allow for expansion without disrupting operations in the original facility.

1. Central Warehouse Building. The warehouse building will be of the same design as FECOAGROH's Stage I building, except that it shall be 180 feet long and will have a height to the eaves of 16 feet. The front 30 feet of the warehouse will be designed to house the Central offices of FECOAGROH on two floor levels. Also, a truck dock will be needed along one long side of the building with several large loading doors opening on to the dock.

2. Central Drying and Bulk Storage Facility. This facility will be almost identical to the Stage II-Rural unit installation except that it will have a larger bulk storage capacity. The Central installation will basically consist of four corrugated galvanized round bins (24 feet in diameter and 20 feet effective storage height) and a grain center building with necessary grain handling and drying equipment.

All bins will have perforated floors capable of holding 20 feet of grain and adequate aeration fans.

The methods of grain handling will be the same as that used in the Stage II-Rurals unit.

Dryers will be the same type used in the Stage II-Rural unit except they will be powered by electric motors.

The leg elevator shall be the same as at the Stage II-Rural, differing only in lift and horsepower needed to operate it.

A truck scale shall be installed in the grain center building.

The grain center building will be 20 feet wide, approximately 40 feet long, and 16 feet high at the eaves. It will be an open-side building with a concrete floor 12 inches above the ground level. It will have steel clear-span trusses with cement-asbestos roofing.

The San Pedro Sula installation will be used to handle rice in bulk. Therefore, a separate rice dryer or suitable multi-grain dryer shall be specified for this installation, with belt conveyors being specified in appropriate places.

II. Scope of Work

The consultant shall perform and assume full responsibility for the following services:

A. Stage II Rural Unit

1. Prepare architectural plans, equipment specifications, and construction cost estimates of the Stage II Rural unit for the approval of FECOAGROH and AID.

2. Prepare final detailed standard design with complete specifications of all equipment of the Stage II-Rural unit, excluding only site adaption.

3. Prepare all necessary standard contract documents, in Spanish and English, in accordance with the laws of Honduras and AID regulations for construction contracts.

4. Assist in awarding construction contracts, make necessary site adaptions, and supervise construction of the first Stage II-Rural unit built by FECOAGROH.

B. Central Installations

1. Make necessary modifications in FECOAGROH's Stage I-Rural unit building to obtain final construction plans, specifications, and cost estimates for the Central warehouse, including site adaption, for the two locations.

2. Prepare architectural plans, equipment specifications, and construction cost estimates of the Central drying and bulk storage facility for the approval of FECOAGROH and AID.

3. Prepare final detailed designs of the Central drying and bulk storage facility with complete specifications of all equipment at each site, including site adaption for both installations.

4. Prepare all necessary standard contract documents, in English and Spanish, in accordance with the laws of Honduras and AID regulations for construction contracts and assist in awarding the construction contracts.

5. Supervise construction of the Central warehouse and Central drying and bulk storage facility at the two locations.

III. Time Limits on Project. The time required by the consultant to perform these services will be an important consideration in awarding the contract.

IV. Type of Contract Contemplated. A fixed-price (lump-sum) contract is contemplated for this job.

V. Restrictions and Qualifications. Prequalified firms wishing to submit proposals will be required to be familiar with the country before submitting proposals.

VI. Currencies Paid. The consultant will be paid in Lempiras.

VII. Information to be Included in Technical Proposals.

A. Estimated schedule of work of architectural-engineering services for the project.

B. Personnel to be assigned to the project and approximate man-months of service each will be expected to perform.

C. Documents showing the firm's recognition and approval to work in Honduras.

D. Rough sketches demonstrating understanding and ability to handle project by the Colegio de Ingenieros Civiles de Honduras (if not previously presented).

VIII. Deadline for Submission of Technical Proposals. Technical proposals will be accepted until Monday, September 6, 1971, 12:00 noon, Honduras time, at the office of FECOAGROH, Avenida La Paz No. 412, Apartado Postal No. 120-C, Tegucigalpa, D. C., Honduras, C. A.