PN-ABD-827
ISN 63732

R E P O R T

September 4, 1989

FACILITY DESIGN CONCEPT

GREENHOUSE FACILITIES

NEW DELHI: September, 1989

Consultant Report by

David Mears

Agricultural Research Project (386-0470)

Implementation Order No. 33

Contract No. 386-00000-C-00-5039-00

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FACILITY DESIGN CONCEPT

GREENHOUSE FACILITIES

NATIONAL BUREAU OF PLANT GENETIC RESOURCES

QUARANTINE DIVISION

Prepared by

David Mears

September 4, 1989

Drafts reviewed by:
- NBPGR staff
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September 4, 1989

To: Dr. Rana, NBPGR
Dr. B.P. Srivastava, USAID
Dr. Colin McClung, Winrock

From: David R. Mears

Re: Design concept for greenhouse facilities for
The Plant Quarantine Division of NBPGR

Enclosed is a report containing recommendations for the design concept for the greenhouse facilities required by the Plant Quarantine Division for the locations specified at New Delhi, Bhowali, Hyderabad and the Andaman Islands.

These plans and recommendations have been developed after a number of discussions and consultations with members of your staffs and with several representatives of greenhouse manufacturers operating in India. Also, before coming to India plans and specifications for several USDA quarantine facilities were obtained and reviewed.

Based on these discussions and having visited two of the proposed sites on this trip and one during an earlier assignment in India as well as a site visit to a commercial facility utilizing state of the art greenhouse technology in Bangalore it is my belief that facilities meeting the functional requirements requested by NBPGR can be constructed on a turn key basis. As indicated in the document, certain critical components including the cooling systems, controls and glazing must meet rigid performance specifications and as these items are not yet available in India it is recommended they be imported. The functions of the quarantine facilities must be maintained.

The construction of these facilities will give NBPGR the capacity to carry out the tasks indicated in the scope of work. It should be emphasized that continued successful performance of the facilities over time will require careful attention to the details of facility operation and maintenance. The possibility of utilizing the facilities of local greenhouse operators where state of the art environmental control and structural units are in operation for the training of personnel should be considered.

It has been a rewarding experience working on this project and hopefully the project can be implemented in a timely fashion. I want to express my sincere appreciation to all those who have helped with the logistical support and with providing information and insight.

b'

GREENHOUSE DESIGN FOR QUARANTINE DIVISION OF NBPGR

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DESIGN SPECIFICATIONS DRAFT OF SEPTEMBER 3, 1989

INTRODUCTION

The recommendations contained in this report are in response to a request to provide such information for technical assistance and guidance in the design of greenhouses for the quarantine division of NBPGR. The scope of work is contained in an appendix.

In initial discussions with NBPGR and USAID it has been made clear that it is their desire that plans for the required facilities be developed in such a way that a single turn key contract can be let, preferably to an Indian firm which has an established track record of successful greenhouse erection and operation in India and has access to appropriate sources in the US for that equipment which must be imported.

During the course of the discussions with a number of parties concerned with the final implementation of the project a number of ideas have been developed regarding the plans for these facilities. These discussions have been extremely useful in focusing attention on the key functional requirements for the various tasks to be performed, namely: plant propagation, virus indexing, plant quarantine and screened growing. There have been several iterations in this planning process and a number of initial planning concepts have been discarded in favor of developing improvements.

It is to be noted that the placement of the first three functions in a single structure appears to be a unique solution to the problem of locating all types of facility at a single station. The construction and operating costs are going to be significantly less than if separate structures were erected and the functional requirement of isolation of the material under test from the local environment is maintained to the same degree as would be the case in individual units. The most significant improvement in planning concept is the switch from what had been considered to be screen houses for the growing out of clean plant material in an insect free environment to a more effective and efficient low cost greenhouse structure suitably screened against local insects as required.

The design concepts laid out in this report will meet the functional requirements as specified by NBPGR. These requirements as ascertained in a series of intense discussions are spelled out in the section on responses to requests for data. The structures proposed are based on state of the art commercial greenhouse technology modified to provide the specified level of security against ingress and egress of insects. It should be noted that these facilities provide the environment in which recommended phytosanitary practices can be carried out. It is essential that in the operation and maintenance of these facilities these practices be followed.

The request that a design be developed which can be implemented as a turn key project by an Indian firm has been honored. A key element in the design concept is keeping the design components in the range of commercial greenhouse technology wherever possible. In this regard it must be noted that the provision that some or all of the plant quarantine compartments be equipped as bacteriological containment facilities represents the [illegible] departure from this concept.

STRUCTURE FOR PLANT PROPAGATION, QUARANTINE AND VIRUS INDEXING

Layouts and sizes:

A variety of arrangements and floor plan layouts to achieve the objectives of NBPGR for greenhouse facilities for the quarantine division have been considered. Initial consideration was given to separate structures for each of the four functional activities: plant propagation, plant quarantine, virus indexing and screened growing areas. It is clear that significant advantages can be obtained by joining the first three units in a single building at each location.

As these functions all require that materials transported to and from them be isolated from the outdoor environment the enclosed corridors needed will be minimized if the units are as close together as possible. Also, putting the units together in one structure reduces the number of exterior walls conserving both construction costs and operating costs for energy as well as land area. The interior walls separating the functional areas need to be sealed against movement of insects as do all exterior walls. As 60 mesh screening is mandated by NBPGR it is essential that all structural elements be sealed completely so there are no openings larger than that of a 60 mesh screen, ie less than 0.01 inch.

In order to put the plant propagation, quarantine and virus indexing areas in a single structure, the number of quarantine compartments becomes the major determining factor in the total building size. In most cases this results in providing somewhat more area for propagation and virus indexing than originally requested. It should be noted that due to the shape and dimensions of the building these increases come at the expense of adding interior wall and roof sections without any change in the building ends which bear most of the structure and equipment cost. Note the original requested dimensions of 40' width for propagation and 20' total width for virus indexing are maintained and changes proposed are only in the length.

At New Delhi the plan shown in the sketches calls for 10 quarantine compartments with 5 located on each end of the building resulting in a building 50' long. Note that 10' modular post spacings and 20' modular widths are common standard commercial units. Allowing a 5' corridor the compartments are the 10'x15' requested, except the end compartment can utilize the extra 5' for a total length of 20'. The proposed propagation unit is then 40'x50' which is 20' longer than the original request. The virus indexing area at 20'x50' is similarly 20' longer than requested. Note that fixing the internal partitions under the gutters of a multispan building will allow thorough sealing far more securely than would be the case if the partitions where elsewhere and had to run to the roof up through the trusses.

The building proposed for the Andamans is identical to the unit in New Delhi and in that case the increased size of the propagation area does not quite come up to the total area requested. The original request for 2 units each 30'x40' would result in a total of 2400 square feet. The 2000 square feet proposed in one space will be more efficient vis a vis the relationship between walkways and bench space as only one central aisle is required, saving about 150 square feet of bench. Also note the virus indexing area is 400 square feet larger than requested so the total for virus indexing and quarantine are the same as proposed. As the environmental requirements in virus indexing areas are at least those

requested for the propagation area there is the option to consider using some of the extra virus indexing area provided for propagation if no requirements for isolation are violated.

The building proposed for Bhowali would have the 4 quarantine compartments along one side resulting in a building 40' long. This results in both the propagation area and the virus indexing area being 10' longer than requested. At Bhowali the availability of a plot suitable for a unit this size was established on a site visit.

The building for Hyderabad will have 3 quarantine compartments on each side resulting in a building 30' long. Thus the propagation and virus indexing areas are as requested originally. This arrangement results in a building which has unusually short pad to fan distance. A layout with all 6 quarantine compartments along one side would give a building 60' long. The virus indexing and propagation could then each be in a section 20' wide by 60' long giving the same area requested for propagation but double that requested for virus indexing. The first arrangement is the one for which the heating and ventilation requirements have been computed and tabulated.

Framing:

As noted above, the basic structure proposed to contain the propagation, quarantine and virus indexing facilities is based on modular dimensions which are fairly standard. There are a variety of acceptable approaches to designing the main frame of the building. The frame should be designed to withstand 20 pound per square foot loading's (80 miles per hour wind). It is recommended that the frame be high strength galvanized steel tubing, preferably of square cross section for ease of fastening accessories. There are commercial greenhouse units of these modular dimensions which meet the needed strength and corrosion protection requirements.

Glazing:

While there are a number of potentially viable glazing options for this project it is recommended that major consideration be given to Fiberglas and glass. NBPGR leadership has indicated a preference for Fiberglas and this is a good choice. In selecting the Fiberglas to be used it is essential that it be a high quality material such as Filon Solar Plate/20 which is guaranteed to transmit at least 80% of available light for 10 years and to be free from surface fiber exposure and to be structurally sound for 20 years. Properly installed on the above framing Fiberglas meeting these standards will withstand the windloads expected at all 4 locations and anticipated hail as per reports from those interviewed regarding hail potential at the sites.

Large sheet glazing with greenhouse quality glass having parallel surfaces will also be a satisfactory choice. Spare glass should be stocked to enable the prompt replacement of any broken panes. The use of double walled extruded plastic glazing such as polycarbonate or acrylic sheets are not recommended for this application. Their large volume to weight ratio will make shipping costs very high. A major advantage of double walled rigid glazing over single is the savings in heating energy costs, which is not a major factor at any of the proposed locations. Double layer polyethylene is not recommended for these units where containment is

required as inadvertent damage can compromise the isolation from the environment and the cover does need to be changed periodically which would provide more of an opportunity for phytosanitary security to be breached.

NBPGR has specified that in all three of these units all ventilation inlets and outlets be screened against insects ingress or egress with nominal 60 mesh screening which provides for inlets no larger than 0.01 inch. Therefore it is essential that all seams between individual Fiberglas glazing panels and all edges, ends and corners be thoroughly sealed with closure strips and sealants to prevent any cracks. It must also be recognized that maintenance of the required integrity of the glazing sealing will require regular inspection and maintenance by NBPGR staff. Sunlight will deteriorate the sealing materials, especially under Indian conditions of intense solar radiation and prolonged high temperatures, (except at Bhowali).

Enclosed walkways:

It is mandated that at New Delhi a closed and insect proof walkway be provided between the quarantine section of the new building and the greenhouses. This enclosed walkway is to lead into both the greenhouse complex and to a headhouse where soil for planting is prepared and pots and other support materials are kept. The proposed layout for the corridor is shown in the sketch, and the length of walkway to the main building is to be determined. The materials to be used for the construction of the walls and roof of the corridor need to be selected to prevent any ingress or egress of insects and must have the same standard of sealing as the greenhouses. It is suggested that Fiberglas be considered for both headhouse and corridors providing a consistent construction method for all. Light transmission at high levels is not needed and in order to keep the temperature down opaque panels should be used for the most part. Insertion of some transparent panels at intervals in the wall can provide some natural light. To keep the corridor reasonably cool it is suggested that an exhaust fan be placed at one end and an evaporative pad system at the other end nearest to the main building. Both inlet and exhaust must be screened with 60 mesh screen as with the greenhouses.

Floors and drains:

All floors in the propagation, quarantine and virus indexing areas shall be paved with concrete. Drains will be installed directing all drainage water to a sump where it can be treated to insure against any release of dangerous pests to the environment. Chemical or steam sanitation of the discharge according to accepted phytosanitary standards will be required.

Benching layouts:

A fixed peninsula bench system is recommended for each of the units in plant propagation, quarantine and virus indexing. Peninsula systems give the most usable bench area in a greenhouse of all fixed layouts. Fixed benches will be generally more economical and easier to sanitize than movable bench systems which do provide more space utilization. Concrete benches are common in Indian research greenhouses and will be suitable for this facility. Particular care should be taken that the surfaces are well sealed and smooth to facilitate sanitation.

The layout for the small quarantine chambers as shown indicates a central aisle with 3.5' benches along either side wall and at the pad end. The layout for the virus indexing units indicate a 3' main path down one side wall with 2' alleys between each bench. Recommended bench width is 6' with a 3.5' bench area at the end of each alley. The 50' long units proposed for New Delhi and Andamans are shown in the sketch. A similar arrangement can be utilized in the propagation house with the alleys and benches being 20' longer than in the virus indexing area.

STRUCTURES FOR SCREENED GROWING

Initial consideration was given to screenhouses for growing out crops in the normal soil for the purpose of multiplying clean and disease free plant material. In discussions it was noted that it has been observed that when screening fine enough to exclude insects is used for the roof light is reduced below the point that is acceptable. Also it was noted that the functional requirement is to provide an environment essentially the same as the external environment but protected against any ingress of insects. The internal area can be laid out for various crops but need not be compartmentalized as the interior is all to be insect free and only clean material is being grown.

In light of these requirements it is recommended that standard ground to ground quonset greenhouses be constructed with screened inlets at one end and screened fans at the other. By providing about 1 air change per minute of ventilation interior temperatures will not exceed ambient temperatures by more than a few degrees. If cooler than ambient temperatures are required an evaporative pad system can be added. The standard houses should be 30'x96' in size which is somewhat larger than originally requested. In light of the cost of screening it should be noted that this type of house will be substantially cheaper than an all screen house. NBPGR has requested that this type of house also be covered with Fiberglas of the same standard as the other units. This is a reasonable request. An alternative would be double covered polyethylene of good quality. Poly film such as Armin Tufflite III or CT Films (formerly Monsanto) 703 would be suitable. An advantage of polyethylene over Fiberglas in addition to cost is the ease of sealing the entire roof. As the cover is one piece and the long edges can be buried the only concern regarding sealing against insect ingress is the screened ends. A major concern regarding the use of polyethylene glazing is the potential problem of acquisition of replacement film as suitable material is not yet available in India.

In New Delhi it is recommended by NBPGR that the 4 units described above be located at some appreciable distance from the other units as casual laborers are to be employed with an increase in probability of accidental damage to the structure. There are 2 units required at Andamans and 1 each at Bhowali and Hyderabad.

ENVIRONMENTAL CONTROL - HEATING

Design assumptions:

The design inside temperatures for the propagation, quarantine and virus indexing houses is 15 C. The coldest reported outdoor temperatures are 5 C at New Delhi, -2 C at Bhowali, 12 C at Hyderabad and 21 C at Andamans. No heat is required at Andamans.

Capacities:

The heating design calculation results for the various units are shown in the attached table. Note that these calculations should be carefully checked by the contractor as this work is being done quickly without double checking of most calculations.

Equipment:

The suggested heating equipment capacities are set out in the attached table. It is suggested that gas fired unit heaters be used for the plant propagation and virus indexing units in New Delhi and Bhowali where the peak load requirements are the highest. Unit electric heaters are suggested for the quarantine chambers as independent control is needed for each unit and unit capacities are from 1 to 4 KW. Similarly, the requirements for propagation and virus indexing at Hyderabad can be met by unit electric heaters. Note that degree day data on which annual heating energy requirements can be computed are not available but it is indicated that the design minimum temperatures rarely occur and that heating energy costs are not considered a major concern.

Controls:

The controls for the electric heating units in the quarantine chambers should be single stage thermostats, one for each chamber and unit heater. There are a total of 21 such units, 10 at New Delhi, 4 at Bhowali, 6 at Hyderabad and 1 for the heat treatment compartment at Andamans.

The controls for the heating systems in the plant propagation and virus indexing units at the three locations requiring heat should be single stage controls which are teamed up with the cooling system 4 stage control. There are a total of 6 such units required. There is no indication from NBPGR that separate day/night control is required and single settings for heating and cooling for the full day are acceptable.

ENVIRONMENTAL CONTROL - COOLING

Basis for airflow estimates:

The ventilation design calculation results are presented in the attached table. The method of calculating the design airflow follows that in the ACME Greenhouse Climate Control Handbook. Note that in all these calculations, except for the screened growing areas, the short pad to fan distance dictates a relatively high airflow capacity. The base airflow rate of 8 cfm per square foot of floor is multiplied by the appropriate pad to fan factor from the design table. These factors are:

1.83 for pad to fan distance of 30 ft
1.58 for pad to fan distance of 40 ft
1.41 for pad to fan distance of 50 ft

Note that for the screened growing houses this factor can be taken as 1.0. As with the heating calculations above, the contractor should carefully check all these figures.

Airflow requirements:

The airflow requirements for the various units are shown in the attached table along with the floor areas on which they are based. As the airflow requirement for the individual quarantine chambers is so low it is proposed that the fans be arranged so that one set of fans operating in three stages can ventilate an entire row of 3, 4, or 5 chambers. This can be done by having the air inlet for each chamber through a screen and wet pad on the outer wall and the discharge to the center corridor through screening in the door or corridor wall. The air then is drawn up through a screen over the corridor by the exhaust fans mounted in the gable end over the corridor ceiling. The end compartment discharges directly through an extension of the screened corridor ceiling rather than through the door to the corridor. Alternatively, the end chamber could also have a screened door with the extension of the corridor ceiling over that chamber completely sealed.

When the system has been constructed the ventilation system should be run and the airflow checked to see that comparable amounts are flowing in each chamber. If necessary, the screened opening from chamber to corridor may have to be partially masked in some units to balance airflow.

Note that for biological security it is preferable that the air be moving out of the corridor whenever any external doors are open in the quarantine units. With the layout proposed it is possible to insure this by having the first stage of ventilation in these units controlled by a switch in the lock in the access door so that whenever workers are present and entry is possible the door will be unlocked and the first stage ventilation activated. Early in the morning in winter there may be times when entry should be delayed until cold conditions very early in the morning ameliorate. It is not anticipated that this method of control of insects by having a minimum exhaust airflow when workers are present will cause problems with overventilation under cold conditions as it is not expected that workers will be in the quarantine units during cold nights.

Exhaust fan requirements:

The exhaust fans have been selected from a design table from the ACME catalog and a copy of the table is attached. Note that the column for a static pressure drop of 0.150" water pressure is utilized for equipment selection to allow for the approximately 10% derating of the fan for 50 rather than 60 cycle operation. Note that all fan motors should be wired for 50 cycle current at 220 volts. In each unit fans have been selected to allow for three stages of ventilation. The exhaust fans selected for this project should have a performance capability of delivering the required airflow against a static pressure of 0.10 inches water pressure and with the motor horsepower not greater than that of the units indicated in the table.

Evaporative pad requirements:

The requirements for evaporative pad systems are laid out in the attached table on ventilation design calculation results. Note that due to the relatively short pad to fan distances the face velocities through the pad are much lower than the 250 fpm normally used. The selection of the pad areas required is based upon the performance characteristics of ACME KOOL-CEL pad systems 4 inches thick. These systems have an evaporative pad cooling efficiency of 0.88 at 100 feet per minute face velocity and 0.83 at 200 fpm. The respective air flow resistances at these velocities are 0.01 to 0.02 inches of water pressure. The pad system for any of the 30'x96' screened growing area houses are an option as the requested requirement is for environmental temperatures within a few degrees of seasonal ambient which can be met by ventilation alone.

Shading:

In order to reduce plant stress and improve the effectiveness of the ventilation and cooling systems a movable shade system is recommended for the propagation, quarantine and virus indexing areas. The material recommended for this application is the LS material consisting of combinations of strips of reflective aluminum and strips of clear polyester giving variable amounts of shading. This material has been developed by Ludwig Swensen in Europe and is highly recommended for its effectiveness in greenhouse cooling applications as well as for heat conservation. It is suggested that double systems be installed at all locations except Bhowali where temperatures are not as extreme as in the others. At Bhowali a single system utilizing LS 13 material is suggested. At the other locations the first system can be the same LS 13 and the second system can be LS 15. With this selection shading of nominal 30% or 50% or both can be selected. While consideration should be given to using a mechanical shading drive system in the larger plant propagation areas simple hand operation should suffice in the other areas. As the peninsula bench system is being utilized hand operation of the systems in the larger plant propagation area should be feasible if the materials are pulled across the house allowing the workers to pull from the cross alleys.

Fog:

The use of fog to relieve plant stress is coming into widescale commercial practice in many areas and does allow practical commercial production of some cool weather crops in summer conditions. It is suggested that a fog system be installed in at least one location, preferably New Delhi. A single filter/pump system can be installed with fog nozzles on lines with individual shutoffs to each compartment in plant quarantine and to the plant propagation and virus indexing units. Note that the analysis of the agmet data provided to date indicates that there will be times in New Delhi when the wet bulb temperature exceeds 25 C and that target temperature will therefore be exceeded. How much time this will occur is not certain. Fog has demonstrated capabilities for reducing plant stress at higher than normal growing temperatures. It is possible that relieving plant stress may enable virus expression at higher than normal growing temperatures. As mechanical air conditioning of the virus indexing greenhouse area would require about 30 tons of capacity it is suggested that evaporative cooling with shading and fog be considered.

Controls:

Fans have been selected so as to provide for 3 stages of cooling in plant propagation, quarantine and virus indexing units. The pump for the evaporative cooling system should be the fourth cooling stage. Windows should be located outside the cooling pads and opened by an external rack and pinion with the opening in 3 stages with the number of fans operating. The first stage cooling window opening should allow for an inlet velocity through the window of about 800 fpm to insure uniform air delivery along the length of the window. Note that plant quarantine chambers having the capability to operate as bacteriological containment or heat treatment chambers need to be set up so that the window on those chambers can be manually disconnected from the rack and pinion and kept closed while those window sections on quarantine chambers operate normally.

The thermostat for controlling the ventilation and evaporative cooling in the quarantine units should be located in the center chamber and that should be the last chamber utilized on that side for bacteriological containment. If all chambers are so utilized only first stage ventilation should be used to move some air through the corridor when the doors are opened to the outside. The thermostats/temperature sensors in plant propagation and virus indexing sections should be located near the center. All thermostats should be shielded from direct sunlight and fan aspiration of the sensing element is recommended.

ENVIRONMENTAL CONTROL - LIGHTING

Capability of lighting for continuous 24 hour photosynthetic lighting to increase the likelihood of virus expression is requested. It is suggested that this capability be installed in a single quarantine chamber or in a limited area in the virus indexing unit. Based on other lighting research it is suggested that PL-830 light fixtures from PL-Lightsystems be installed. At a mounting height of 1.05 m these light an area of 4.75x1.95 m at an intensity of 4000 foot candles. These lights utilize high pressure sodium lamps which do have a spectral distribution of the light energy which has been found effective for photosynthesis for a wide variety of crops. A critical requirement for horticultural lighting fixtures is the uniformity of light intensity at the crop level produced by a fixture mounted at a convenient height above the crop. These fixtures have the required uniform distribution pattern needed for this purpose.

ENVIRONMENTAL CONTROL - SCREENING

Functional requirements:

As indicated, NBPGR mandates that screening against ingress or egress of insects be provided for all air inlets and exhausts and that such screen be of nominal 60 mesh. In order to insure proper air flow it is essential to provide sufficient screen area that velocities will be low enough so as not to cause unacceptable back pressure on the fans. The quarantine chamber air will flow through 3 layers of screen and all other units will have airflow through 2 screens. As the total static pressure contributed by the screening should be no more than 0.05 to 0.06 inches water pressure screen pressure drops should be under 0.02 inches.

Areas required based on current assumptions:

Some tests have been conducted on screens to discover airflow/pressure drop relationships and based on some information in hand the area of screening proposed in the attached table are at 50% more than the pad open area. At this rate the 2' high pads used on all plant quarantine chambers will have a 3' high screen. This gives 30 square feet of inlet screen for each inlet. The drawing of the section of the chamber indicates an option for a 6'x3' door with additional screen on the corridor wall. It could be an option to put all the required screen in the wall rather than the door. Note that if future tests indicate pressure drops are less severe less screen area may be acceptable. The 3' screen in the ceiling matches the area on the inlet. The screen inside the inlet pads needs to be at least 4" away from the wet pad.

The screened inlets for the propagation and virus indexing areas are indicated in the attached tables and drawings as 6' high to correspond to the 4' high pads. This gives a screen area of 120 square feet for the virus indexing and 240 square feet for the propagation areas. Similar screened areas need to be provided over the inlets to the exhaust fans. These internal screens need to be 6" away from the pads and 3' away from the inlets to the exhaust fans.

On the inlet to the screened growing houses of 30'x96' the inlet screens are 9'x30' and equivalent screens need to be located inside the exhaust louvers. These screens need to be 1 ft off the end walls. The screens inside the inlet end can be within 6" of the wet pads if pads are used but should be at least 2 ft off the end wall if there is only a window and no pads.

Materials options:

NBPGR is using a locally available 60 mesh stainless steel wire which is reported to have a wire diameter of .15 mm, a 38% open area and .01" opening. It comes in 3' and 4' widths and currently costs Rs 35 per square foot. In initial discussions it was indicated that the use of plastic materials was not desired due to anticipated short life due to weather and ultra violet exposure. As all screens are envisioned as being installed inside Fiberglas greenhouses and therefore protected from both weather and ultra violet rays this option of plastic screening could be considered. Note all internal screens need to be installed in panels which can be removed for maintenance and cleaning.

Proposed testing and assumption confirmation/correction:

As indicated above, a critical consideration in determining the screen area required is the resistance to airflow. One US university laboratory has a wind tunnel set up to enable such tests to be conducted and the sectional area of the test unit is 4'x4'. If a sample of the local screen can be obtained and tested the screen area requirements noted above can be reconsidered and modified as necessary. As the amount of screening is quite large and the unit cost is high there is a potential for significant savings if the resistance to airflow is less than the assumption currently being used. If the resistance is higher performance of the ventilation system will be compromised so this testing should be done.

MISTING CHAMBERS

NBPGR requests that at each location one plant quarantine chamber be set up as a misting chamber. It is proposed that one of the end chambers with the extra growing area be utilized for this purpose. A misting system and controller can be installed in the chamber.

HEAT TREATMENT CHAMBERS

NBPGR requests that at each location one plant quarantine chamber be set up as a heat treatment chamber to treat materials infested with virus at elevated temperatures of 38 - 40 C for extended periods of time. To do that it is necessary to decouple the chamber from the normal ventilation system by disconnecting the window for that section from the rack and pinion opener. A supplemental heater on its own thermostat can be used to boost the temperature above that being maintained in the other chambers during either ventilation or heating. The most direct solution is to increase the capacity of the heater in the chamber to be used for heat treatment to provide the needed total capacity. The required extra heating capacity is 9 KW each at New Delhi, Bhowali and Hyderabad and 7 KW at Andamans. The thermostats on the heat treatment chambers can be set up to the desired temperature when being used for that purpose and at the lower setting of 15 C when used for normal quarantine. The increased capacities of the heat treatment chambers, also indicated on the heater unit table, are: 13 KW at New Delhi, 15 KW at Bhowali, 10 KW at Hyderabad and 7 KW at Andamans.

In order to provide ventilation when solar input would raise the temperature above the desired level a separate fan is required. An ACME FCP1284 fan mounted in the gable end wall and screened with 12 square feet of 60 mesh screening will provide sufficient airflow to keep temperatures no higher than several degrees above outside temperatures. A matching shutter inlet can be mounted in the end wall over the regular window and behind the main inlet screen. This airflow will not be through the wet pad system.

BACTERIOLOGICAL CONTAINMENT

NBPGR requests that all plant quarantine chambers also be equipped for operation as bacteriological containment facilities with closed operation under mechanical air conditioning. Under this mode of operation it is recommended that the chambers be kept under negative pressure with the air being exhausted from the chamber through a HEPA filter system. At this writing the airflow requirements for the chambers to provide satisfactory negative pressure to satisfy U.S. Federal Standard 209B for Class 100 Conditions. However, NBPGR does have one indoor room equipped with such a filter, (ULTRAKLENZ), provided by a local firm which could presumably size and install units as needed. This exhaust unit and the air conditioning unit could be installed in the external side wall of each chamber. This is assuming unit air conditioners are used. Consideration should be given to using central compressor units with evaporators and air handling units in each chamber to reduce costs of installation, operation and maintenance. There is the possibility of tying into the central air conditioning system in the main building in New Delhi and using just evaporator/air handling units in each chamber. The heat load estimates for bacteriological containment units are calculated on an attached sheet and are 10 tons for corner units and 8 tons for interior chambers.

PRIORITIES

As of this writing there has been no comprehensive effort to compute costs of the total project as conceived in the above discussion. If the quotations received should exceed what can be afforded and some adjustments must be made consideration could be given to some of the following ideas for saving total costs:

Presumably the cost of providing bacteriological containment will be very high. Therefore reducing the number of such facilities required could be considered without seriously compromising most aspects of the program. Note that 6 such chambers are currently being constructed in New Delhi. It is clear that the environmental control systems in these units will not be adequate for the purpose intended but advice on how to improve their design is to be given independently and use of those facilities may help to relieve the load on the quarantine units designed here. Also some consideration should be given to setting up indoor growth chambers for this purpose where cooling requirements are much less as there is no solar load. This question may best be considered by quarantine experts knowledgeable in biological containment at high levels of security.

It is anticipated that the cost of the enclosed corridors could be fairly high if their length is very great. As the layout and location of the facilities is to be determined by NBPGR consideration should be given to minimizing this aspect. Consideration of having open exterior access through double doored entryways as planned for the Bhowali site may be given consideration at other sites if necessary. As it is anticipated that the greenhouse in New Delhi will be constructed before the main building is completed it is suggested that the connecting corridor not be a part of the greenhouse construction contract but left to others for a later date. This issue needs to be considered at Hyderabad and Andamans also.

As the environmental conditions in both propagation and virus indexing areas are identical and both are required to be kept free of local insects consideration could be given to eliminating the partition between them and thereby simplifying the heating and ventilation systems and their controls. Ventilation would presumably be set at the lower level of 25 C desired for virus indexing and certainly acceptable for propagation of almost all plants.

Consideration could be given of reopening the question of utilizing polyethylene film rather than the more expensive Fiberglas for the 30'x96' screened growing houses. As there is concern regarding the ease with which recovering plastic material could be obtained in the future, stocking reserve material could be considered. Note that both Fiberglas and polyethylene will have to be imported as there is no indication that acceptable materials are available within India.

RESPONSES TO REQUESTS FOR DATA FROM NBPGR THROUGH AUGUST 27

Facility needs at each geographic location.

New Delhi

Weather, heating based on 5 C, cooling based on 45 C as per scope of work. Note wet bulb temperature exceeds 28 C about 5% of the time as per ASHRAE.

Plant Propagation - for routine plant raising

One glass greenhouse screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen of a nominal floor size of 30 ft by 40 ft. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 15 C night temperature and target of no more than 30 C day temperature. Partial shading by internal curtain system desired.

Plant Quarantine

One glass greenhouse screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen. There should be 10 compartments off a central corridor with single entry doors to the corridor. Each compartment should be a nominal floor size of 10 ft by 15 ft. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry to the central corridor required. Double zones for environmental control with provision for no less than 15 C night temperature and target of no more than 30 C day temperature. Partial shading by internal curtain system desired. Option to use one of the compartments for heat treatment of virus with ability to maintain setpoint temperature of about 40 C day and night desirable. See heat treatment below. Additional option to use one compartment for a mist chamber as described below. Note quarantine cabinets also need to be used at some times for bacteriological containment necessitating sealing the compartment, putting it under negative pressure with a fan exhausting through a HEPA filter and cooling by air conditioning. The compartments can be separated into two areas.

Virus Indexing

Two glass greenhouses screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen. There should be a nominal floor size of 10 ft by 30 ft. There can be a single house of at least equivalent area. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 20 C night temperature and target of no more than 25 C day temperature. Partial shading by internal curtain system essential, possibly a double system one at 30% and the other at 45% for 3 possible levels depending upon conditions. High pressure fog should be considered for maximal cooling without resorting to use of a sealed facility with mechanical refrigeration. ASHRAE data indicates wet bulb temperatures in Delhi exceed 28 C about 5% of the time. Ag met data on wet bulb temperatures may indicate the desirability of having air conditioning for the virus indexing section.

Screenhouses

Four screenhouses of nominal size of 25 ft by 75 ft. The walls should be nominal 60 mesh screen and the roof glass. The entrance should be through a double door. The interior area should be laid out in 3 zones. No heating is required. Provision to introduce evaporatively cooled air would be desirable. Alternatively, a fog cooling system could be considered. Interior partitions do not need to be insect proof. Inside temperatures should be near outside temperatures. One large area meeting insect proof requirements would be acceptable. There is concern in this unit regarding inadvertent damage to structure due to utilization of casual hire employees. This structure can be away from the others and need not be connected via an insect proof corridor.

Mist Chamber

A mist chamber can be created at Delhi by utilizing one compartment of the quarantine house by providing that compartment with an independently controlled misting or fogging system. The chamber can be used as a quarantine compartment by shutting off the extra mist or fog system and setting the ventilation control as required for quarantine.

Heat Treatment

Heat treatment of up to 40 C can be maintained in one compartment of the quarantine house by providing that compartment with the following options:

An independent control for ventilation

An auxiliary heating system with independent control

The compartment can be used for quarantine when not being used for heat treatment by setting these controls at appropriate levels and the extra heating capacity will not be utilized during those periods.

Bhowali

Weather, heating based on -2 C, based on site data and cooling based on 45 C as per scope of work. Note 4 months mean maximum temperature is about 28 C based on site data.

Plant Propagation - for routine plant raising

One glass greenhouse screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen of a nominal floor size of 30 ft by 40 ft. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 15 C night temperature and target of no more than 30 C day temperature. Partial shading by internal curtain system desired.

Plant Quarantine

One glass greenhouse screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen. There should be 4 compartments off a corridor with single entry doors to the corridor. Each compartment should be a nominal floor size of 10 ft by 15 ft. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry to the central corridor required. Double zones for environmental control with provision for no less than 15 C night

temperature and target of no more than 30 C day temperature. Partial shading by internal curtain system desired. Option to use one of the compartments for heat treatment of virus with ability to maintain setpoint temperature of about 40 C day and night desirable. See heat treatment below. Also have option for misting in one compartment as described below.

Indexing

Two glass greenhouses screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen. There should be a nominal floor size of 10 ft by 30 ft. There can be a single house of at least equivalent area. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 20 C night temperature and target of no more than 25 C day temperature. Partial shading by internal curtain system essential, possibly a double system one at 30% and the other at 45% for 3 possible levels depending upon conditions. High pressure fog should be considered for maximal cooling without resorting to use of a sealed facility with mechanical refrigeration.

Screenhouses

One screenhouse of nominal size of 25 ft by 75 ft. The walls should be nominal 60 mesh screen and the roof glass. The entrance should be through a double door. The interior area should be laid out in 3 zones. No heating is required. Provision to introduce evaporatively cooled air would be desirable. Alternatively, a fog cooling system could be considered. Interior partitions do not need to be insect proof. Inside temperatures should be near outside temperatures. There is concern in this unit regarding inadvertent damage to structure due to utilization of casual hire employees. This structure can be away from the others and need not be connected via an insect proof corridor.

Mist Chamber

A mist chamber for propagating cuttings can be created at Bhowali by utilizing one compartment of the quarantine house by providing that compartment with an independently controlled misting or fogging system. The chamber can be used as a quarantine compartment by shutting off the extra mist or fog system and setting the ventilation control as required for quarantine.

Heat Treatment

Heat treatment of up to 40 C can be maintained in one compartment of the quarantine house by providing that compartment with the following options:

An independent control for ventilation

An auxiliary heating system with independent control

The compartment can be used for quarantine when not being used for heat treatment by setting these controls at appropriate levels and the extra heating capacity will not be utilized during those periods.

Hyderabad

Weather, heating based on 12 C, and cooling on 43 C as per scope of work.

Plant Propagation - for routine plant raising

One glass greenhouse screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen of a nominal floor size of 30 ft by 40 ft. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 15 C night temperature and target of no more than 30 C day temperature. Partial shading by internal curtain system desired.

Plant Quarantine

ne glass greenhouse screened against ingress/egress of insects with ominal recommendation for a 60 mesh screen. There should be 6 ompartments off a central corridor with single entry doors to the orridor. Each compartment should be a nominal floor size of 10 ft by 15 t. Plants to be grown on benches in containers. Floor paved with drain o collect run-off for treatment. Double door entry to the central orridor required. Double zones for environmental control with provision or no less than 15 C night temperature and target of no more than 30 C day emperature. Partial shading by internal curtain system desired. Option o use one of the compartments for heat treatment of virus with ability to aintain setpoint temperature of about 40 C day and night desirable. See eat treatment below. Additional option to use one compartment for a mist hamber as described below. Note quarantine cabinets also need to be used t some times for bacteriological containment necessitating sealing the ompartment, putting it under negative pressure with a fan exhausting hrough a HEPA filter and cooling by air conditioning. The compartments can be separated into two areas.

Virus Indexing

Two glass greenhouses screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen. There should be a nominal floor size of 10 ft by 30 ft. There can be a single house of at least equivalent area. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 20 C night temperature and target of no more than 25 C day temperature. Partial shading by internal curtain system essential, possibly a double system one at 30% and the other at 45% for 3 possible levels depending upon conditions. High pressure fog should be considered for maximal cooling without resorting to use of a sealed facility with mechanical refrigeration. Ag met data may indicate air conditioning is required.

Screenhouses

One screenhouse of nominal size of 25 ft by 75 ft. The walls should be nominal 60 mesh screen and the roof glass. The entrance should be through a double door. The interior area should be laid out in 3 zones. No heating is required. Provision to introduce evaporatively cooled air would be desirable. Alternatively, a fog cooling system could be considered. Interior partitions do not need to be insect proof. Inside temperatures should be near outside temperatures. There is concern in this unit regarding inadvertent damage to structure due to utilization of casual hire employees. This structure can be away from the others and need not be connected via an insect proof corridor.

Mist Chamber

A mist chamber can be created at Hyderabad by utilizing one compartment of the quarantine house by providing that compartment an independently controlled misting or fogging system The chamber can be used as a quarantine compartment by shutting off the extra mist or fog system and setting the ventilation control as required for quarantine.

Heat Treatment

Heat treatment of up to 40 C can be maintained in one compartment of the quarantine house by providing that compartment with the following options:

An independent control for ventilation

An auxiliary heating system with independent control

The compartment can be used for quarantine when not being used for heat treatment by setting these controls at appropriate levels and the extra heating capacity will not be utilized during those periods.

Andaman Islands

Weather, heating based on 21 C, and cooling on 33 C as per scope of work and NBPGR data.

Plant Propagation - for routine plant raising

Two glass greenhouses screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen of a nominal floor size of 30 ft by 40 ft. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 15 C night temperature and target of no more than 30 C day temperature. Partial shading by internal curtain system desired.

Plant Quarantine

One glass greenhouse screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen. There should be 10 compartments off a central corridor with single entry doors to the corridor. Each compartment should be a nominal floor size of 10 ft by 15 ft. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry to the central corridor required. Double zones for environmental control with provision for no less than 15 C night temperature and target of no more than 30 C day temperature. Partial shading by internal curtain system desired. Option to use one of the compartments for heat treatment of virus with ability to maintain setpoint temperature of about 40 C day and night desirable. See heat treatment below. Additional option to use one compartment for a mist chamber as described below. Note quarantine cabinets also need to be used at some times for bacteriological containment necessitating sealing the compartment, putting it under negative pressure with a fan exhausting through a HEPA filter and cooling by air conditioning. The compartments can be separated into two areas.

Virus Indexing

Two glass greenhouses screened against ingress/egress of insects with nominal recommendation for a 60 mesh screen. There should be a nominal floor size of 10 ft by 30 ft. There can be a single house of at least equivalent area. Plants to be grown on benches in containers. Floor paved with drain to collect run-off for treatment. Double door entry required. Single zone for environmental control with provision for no less than 20 C night temperature and target of no more than 25 C day temperature. Partial shading by internal curtain system essential, possibly a double system one at 30% and the other at 45% for 3 possible levels depending upon conditions. High pressure fog should be considered for maximal cooling without resorting to use of a sealed facility with mechanical refrigeration.

Screenhouses

Two screenhouses of nominal size of 25 ft by 75 ft. The walls should be nominal 60 mesh screen and the roof glass. The entrance should be through a double door. The interior area should be laid out in 3 zones. No heating is required. Provision to introduce evaporatively cooled air would be desirable. Alternatively, a fog cooling system could be considered. Interior partitions do not need to be insect proof. Inside temperatures should be near outside temperatures. One large area meeting insect proof requirements would be acceptable. There is concern in this unit regarding inadvertent damage to structure due to utilization of casual hire employees. This structure can be away from the others and need not be connected via an insect proof corridor.

Mist Chamber

A mist chamber can be created at Andamans by utilizing one compartment of the quarantine house by providing that compartment with an independently controlled misting or fogging system. The chamber can be used as a quarantine compartment by shutting off the extra mist or fog system and setting the ventilation control as required for quarantine.

Heat Treatment

Heat treatment of up to 40 C can be maintained in one compartment of the quarantine house by providing that compartment with the following options:

An independent control for ventilation

An auxiliary heating system with independent control

The compartment can be used for quarantine when not being used for heat treatment by setting these controls at appropriate levels and the extra heating capacity will not be utilized during those periods.

Cropping plans at each facility over time

New Delhi

Plant Propagation - for routine plant raising

A wide range of indicator plants (temperate, tropical and subtropical), will be raised in the propagation unit throughout the year for virus indexing. The growing of tobacco plants for hypersensitivity reactions for bacteria will be carried out.

Plant Quarantine

Crops to be grown in the Rabi (October/November to March/April) season include:

I. Chick Pea - Pea - Lentil - French Bean - Faba Bean - Lathyrus Medicago - Trifolium

II. Barley - Winter Vegetables including: Tomato - Carrot - Lettuce Onion - Turnip - Beet - Cauliflower - Squash

Crops to be grown in the Kharif season include:

Soybean - Cowpea - Moth Bean - Mung Bean - Winged Bean - Lima Bean - Rice Bean - Ord Bean - Guar - Brinjal - Cucurbits

Virus Indexing

Germplasm material from the various agri-horticultural crops described under the plant quarantine section above will be screened against seed borne (true seed or vegetative propogules) viruses by artificially inoculating indicator plants to establish virus infection.

Screenhouses

Screenhouses are to be used for direct sowing of seed in soil of International trial material and germplasm where healthy progeny of material is to be released. The crops are the same as those listed under the quarantine section.

Mist Chamber

A mist chamber should be provided as an option in one of the plant quarantine chambers.

Heat Treatment

A heat treatment chamber to treat plant materials infected with virus is needed in one quarantine chamber. As this facility is not needed at all times the controls should be set up so the chamber can also be used for normal quarantine.

Bhowali

Plant Propagation - for routine plant raising

A wide range of indicator plants (temperate, tropical and subtropical), will be raised in the propagation unit throughout the year for virus indexing. The growing of tobacco plants for hypersensitivity reactions for bacteria will be carried out.

Plant Quarantine

Plants to be grown for plant quarantine are the temperate and sub-tropical fruits such as:

Apple - Prune - Pear - Apricot - Peach - Cherries - Raspberry Strawberry - Blackberry

These plants will be grown throughout the year in isolation for specific periods prior to their release to indenting institutions/scientists.

Virus Indexing

Germplasm material from the various agri-horticultural crops described under the plant quarantine section above will be screened against seed borne (true seed or vegetative propogules) viruses by artificially inoculating indicator plants to establish virus infection.

Screenhouses

Screenhouses are to be used for direct sowing of seed in soil of International trial material and germplasm where healthy progeny of material is to be released. The crops are the same as those listed under the quarantine section.

Mist Chamber

A mist chamber should be provided as an option in one of the plant quarantine chambers.

Heat Treatment

A heat treatment chamber to treat plant materials infected with virus is needed in one quarantine chamber. As this facility is not needed at all times the controls should be set up so the chamber can also be used for normal quarantine.

Hyderabad

Plant Propagation - for routine plant raising

A wide range of indicator plants (temperate, tropical and subtropical), will be raised in the propagation unit throughout the year for virus indexing. The growing of tobacco plants for hypersensitivity reactions for bacteria will be carried out.

Plant Quarantine.

Plants grown will be mainly meant for isolation growing for quarantine responses for the ICRISAT mandatory crops:

Sorghum - Pigeon Pea - Chickpea - Peanut - Pearl Millet

At the second stage germplasm material and trials raised at Delhi center will also be grown at Hyderabad for the South Indian States.

Virus Indexing

Germplasm material from the various agri-horticultural crops described under the plant quarantine section above will be screened against seed borne (true seed or vegetative propogules) viruses by artificially inoculating indicator plants to establish virus infection.

Screenhouses

Screenhouses are to be used for direct sowing of seed in soil of International trial material and germplasm where healthy progeny of material is to be released. The crops are the same as those listed under the quarantine section.

Mist Chamber

A mist chamber should be provided as an option in one of the plant quarantine chambers.

Heat Treatment

A heat treatment chamber to treat plant materials infected with virus is needed in one quarantine chamber. As this facility is not needed at all times the controls should be set up so the chamber can also be used for normal quarantine.

Andaman Islands

Plant Propagation - for routine plant raising

A wide range of indicator plants (temperate, tropical and subtropical), will be raised in the propagation unit throughout the year for virus indexing. The growing of tobacco plants for hypersensitivity reactions for bacteria will be carried out.

Plant Quarantine

Plants grown will include tropical and sub-tropical crops as a source for third country quarantine.

Virus Indexing

Germplasm material from the various agri-horticultural crops described under the plant quarantine section above will be screened against seed borne (true seed or vegetative propogules) viruses by artificially inoculating indicator plants to establish virus infection.

Screenhouses

Screenhouses are to be used for direct sowing of seed in soil of International trial material and germplasm where healthy progeny of material is to be released. The crops are the same as those listed under the quarantine section.

Mist Chamber

A mist chamber should be provided as an option in one of the plant quarantine chambers.

Heat Treatment

A heat treatment chamber to treat plant materials infected with virus is needed in one quarantine chamber. As this facility is not needed at all times the controls should be set up so the chamber can also be used for normal quarantine.

Functional requirements for each facility over time.

New Delhi

Plant Propagation - for routine plant raising

The plant propagation facility shall have at least 1200 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired.

Plant Quarantine

There shall be 10 compartments each of nominal size 10' x 15' or about 150 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired. All compartments will have doors to an access corridor such that two doors must be passed by any insect moving from one compartment to another. In order to enable quarantine to be carried out under bacteriological containment for some materials, provision must be made to seal off all screened inlets and outlets and ventilate the compartment by exhausting air through a filter meeting U.S. Federal Standard 209B (article 50.1). This exhaust system will keep the compartment under negative pressure and will exhaust through an outside wall. Cooling of the compartment during operation requiring bacteriological containment will require an internal recirculating air conditioning system. It is desired that all quarantine compartments be so equipped.

Virus Indexing

The virus indexing facility shall have at least 600 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 25 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired.

Screenhouses, Mist Chamber and Heat Treatment

The functional requirements for: Screenhouses, Mist Chamber and Heat Treatment facilities are indicated under facility needs above.

Bhowali

Plant Propagation - for routine plant raising

The plant propagation facility shall have at least 1200 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be

no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. A shading system providing 30% shading to relieve heat stress is desired.

Plant Quarantine

There shall be 4 compartments each of nominal size 10' x 15' or about 150 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. A shading system providing 30% shading to relieve heat stress is desired. All compartments will have doors to an access corridor such that two doors must be passed by any insect moving from one compartment to another.

Virus Indexing

The virus indexing facility shall have at least 600 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 25 C to the extent possible. A shading system providing 30% shading to relieve heat stress is desired.

Screenhouses, Mist Chamber and Heat Treatment

The functional requirements for: Screenhouses, Mist Chamber and Heat Treatment facilities are indicated under facility needs above.

Hyderabad

Plant Propagation - for routine plant raising

The plant propagation facility shall have at least 1200 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired.

Plant Quarantine

There shall be 6 compartments each of nominal size 10' x 15' or about 150 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired. All compartments will have doors to an access corridor such that two doors must be passed by any insect moving from one compartment to another. In order to enable quarantine to be carried out under bacteriological containment for some materials, provision must be made to seal off all screened inlets and outlets and ventilate the compartment by exhausting air through a filter meeting U.S. Federal Standard 209B (article 50.1). This exhaust system will keep the compartment under negative pressure and will exhaust through an outside

wall. Cooling of the compartment during operation requiring bacteriological containment will require an internal recirculating air conditioning system. It is desired that all quarantine compartments be so equipped.

Virus Indexing

The virus indexing facility shall have at least 600 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 25 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired.

Screenhouses, Mist Chamber and Heat Treatment

The functional requirements for: Screenhouses, Mist Chamber and Heat Treatment facilities are indicated under facility needs above.

Andaman Islands

Plant Propagation - for routine plant raising

The plant propagation facility shall have at least 2400 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired.

Plant Quarantine

There shall be 10 compartments each of nominal size 10' x 15' or about 150 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 30 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired. All compartments will have doors to an access corridor such that two doors must be passed by any insect moving from one compartment to another. In order to enable quarantine to be carried out under bacteriological containment for some materials, provision must be made to seal off all screened inlets and outlets and ventilate the compartment by exhausting air through a filter meeting U.S. Federal Standard 2098 (article 50.1). This exhaust system will keep the compartment under negative pressure and will exhaust through an outside wall. Cooling of the compartment during operation requiring bacteriological containment will require an internal recirculating air conditioning system. It is desired that all quarantine compartments be so equipped.

Virus Indexing

The virus indexing facility shall have at least 600 sq ft gross floor area with permanent benches of masonry construction with smooth tops to enable sanitation to be easily carried out. Minimum temperatures should be no less than 15 C and maximum temperatures should be held to no more than 25 C to the extent possible. Shading systems providing 30% and 45% shading which can be used independently or in tandem to relieve heat stress are desired.

Screenhouses, Mist Chamber and Heat Treatment

The functional requirements for: Screenhouses, Mist Chamber and Heat Treatment facilities are indicated under facility needs above.

Sanitary requirements for each facility..

There should be arrangements for disposing of foliage materials and used pots in accordance with strict quarantine procedures. The floors in the quarantine, virus indexing and plant propagation houses should be concrete with run-off water collected and drained to a sump where steam sterilization or chemical treatment can be provided before discharging the effluent.

Meteorological conditions at each site

Design high and low temperature conditions at each site are noted at the head of the facility needs section. Further specific meteorological data provided is listed out below:

New Delhi

Bhowali

Elevation 1660 meters above sea level
Rainfall 1363 mm per year

Hyderabad

Andaman Islands

Maximum temperature range 28.7 C in August to 32.4 C in April
Minimum temperature range 20.7 C in February to 23.2 C in July
May to November is rainy season with 3180 mm per year

Relative humidity:	8:30 am	86% max August to October
		65 to 70% min January to March
	5:30 pm	84 to 87% max September to October
		65 to 70% min January to March

Topographical and area requirements at each site

New Delhi

One plot 100' x 110' near the new building for the combined headhouse and plant propagation/virus indexing/quarantine greenhouses.
One plot 110' x 160' for four 30' x 96' screened houses.

Bhowali

Two plots as described below.

Hyderabad

One plot 80' x 110' for the combined headhouse and plant propagation/virus indexing/quarantine greenhouses.

One plot 110' x 40' for the 30' x 96' screened house.

Andaman Islands

One plot 100' x 110' for the combined headhouse and plant propagation/virus indexing/quarantine greenhouses.

One plot 110' x 80' for the two 30' x 96' screened houses.

Special constraints at each site

New Delhi

As provision must be made for fire apparatus to move just inside the boundary wall, neither headhouse nor any greenhouse or walkway structure can be closer to the boundary wall than 5 m.

As there is a drive from the front of the main building to the side entrance to the plant quarantine area the walkway from the treatment area in the main building to the headhouse and greenhouse complex must be long enough to clear the planned drive.

To insure the above conditions are met the length of corridor to the complex must be ascertained in consultation with the planners of the main building and this information provided to the bidder.

There may be an opportunity in New Delhi to tap into the central air conditioning system of the main building to provide cooling for the quarantine chambers when they must operate under bacteriological containment procedures. If this can be done it should simplify the operation and maintenance of the quarantine units and should reduce the cost of the air conditioning equipment. This concept needs to be checked with the main building design engineers.

NBPGR has indicated that it is desirable to locate the recommended complex of 4 - 30' x 96' ground to ground greenhouses substantially away from the other units as casual labor will need to be utilized in those units. Note that there is no need for a covered walkway to these units.

Bhowali

Due to the topography there are limited areas on site where the greenhouses can be placed. Based on a site visit it is recommended that the complex including plant propagation, virus indexing and quarantine areas be located on C block. As this block slopes most steeply at the northern end it is suggested the southwest corner of the greenhouse be placed as close to the large rock outcropping near the center of C block as possible to minimize

land clearing. Space must be left for the entrances between the greenhouse and the terrace to the east of C block. The free standing headhouse for this greenhouse complex can be located adjacent to the rock outcropping to its east. Due to the limited width of the site it will not be practical to provide a closed corridor between the headhouse and the greenhouses.

The 30' x 96' ground to ground greenhouse being recommended for the growing out of virus free plant material can be placed on either of two levels of the F block. The upper terrace of the two is recommended for this purpose as the soil is better for the in ground growing of plants and there is more room for possible future additions than the lower portion.

Hyderabad

There was no visit to the Hyderabad site. Assuming there are no significant site restrictions it is suggested that the ridges of all the greenhouses be oriented north south. This orientation provides for slightly more uniform light levels across the greenhouse during the course of the day than does an east west orientation. This is not a major factor at this latitude and therefore other site considerations may indicate some other orientation to be preferable.

Andaman Islands

There was no visit to the Andamans site. Assuming there are no significant site restrictions it is suggested that the ridges of all the greenhouses be oriented north south. This orientation provides for slightly more uniform light levels across the greenhouse during the course of the day than does an east west orientation. This is not a major factor at this latitude and therefore other site considerations may indicate some other orientation to be preferable.

HEATING DESIGN CALCULATION RESULTS

LOCATION AND DESIGN TEMPERATURE	ITEM UNITS	PLANT PROP.	QUARANTINE CHAMBERS	VIRUS INDEXIN
NEW DELHI	EXPOS. AREA SQUARE FEET	3,120	4 @ 556 6 @ 316	1,560
5 C	HEAT REQ'D BTUh	68,000	3 @ 12,000 6 @ 7,000 1 @ 42,000	34,000
OR				
	HEAT REQ'D KW	20	3 @ 4 6 @ 2 1 @ 13	10
BHOWALI	EXPOS. AREA SQUARE FEET	3,088	2 @ 556 2 @ 316	1,344
-2 C	HEAT REQ'D BTUh	115,000	1 @ 21,000 2 @ 12,000 1 @ 52,000	50,000
OR				
	HEAT REQ'D KW	34	1 @ 6 2 @ 4 1 @ 15	15
HYDERABAD	EXPOS. AREA SQUARE FEET	2,256	4 @ 556 2 @ 316	1,128
12 C	HEAT REQ'D BTUh	15,000	3 @ 3,600 2 @ 2,000 1 @ 33,600	7,000
OR				
	HEAT REQ'D KW	4	3 @ 1 2 @ 1 1 @ 10	2
ANDAMANS	EXPOS. AREA SQUARE FEET	3,120	4 @ 556 6 @ 316	1,560
21 C	HEAT REQ'D BTUh	NIL NIL	1 @ 24,000 9 @ NIL	NIL
OR				
	HEAT REQ'D KW	NIL NIL	1 @ 7 9 @ NIL	NIL NIL

HEATER REQUIREMENTS

GAS FIRED HEATERS, MODINE MODEL NUMBERS UTILIZED

LOCATION	PLANT PROPAGATION	QUARANTINE CHAMBERS	VIRUS INDEXING	SCREENED GROWING
NEW DELHI	PA105		PA50	
BHOWALI	PA200		PA105	

TOTAL GAS FIRED HEATERS NEEDED

1 @ PA50
2 @ PA105
1 @ PA200

ELECTRIC HEATER CAPACITY IN KILOWATTS

LOCATION	PLANT PROPAGATION	QUARANTINE CHAMBERS	VIRUS INDEXING	SCREENED GROWING
NEW DELHI		3 @ 4 KW 6 @ 2 KW 1 @ 13 KW (FOR HEAT TREATMENT)		
BHOWALI		1 @ 6 KW 2 @ 4 KW 1 @ 15 KW (FOR HEAT TREATMENT)		
HYDERABAD	1 @ 4 KW	5 @ 1 KW 1 @ 10 KW (FOR HEAT TREATMENT)	1 @ 2 KW	
ANDAMANS		1 @ 7 KW (FOR HEAT TREATMENT)		

TOTAL ELECTRIC HEATERS

5 @ 1 KW
7 @ 2 KW
6 @ 4 KW
1 @ 6 KW
1 @ 7 KW
3 @ 9 KW
1 @ 10 KW
1 @ 13 KW
1 @ 15 KW

ALSO 26 THERMOSTATS FOR ELECTRIC HEATERS

VENTILATION DESIGN CALCULATION RESULTS

LOCATION AND DESIGN TEMPERATURE	ITEM UNITS	PLANT PROP.	QUARANTINE CHAMBERS	VIRUS INDEXING	SCREENED GROWING
NEW DELHI	FLOOR AREA SQUARE FEET	2,000	2@1,000= 2,000	1,000	4@3,000= 12,000
5 C	VENTILATION CFM	22,400	2@11,200= 22,4000	11,200	4 EACH @ 33,600
	PAD AREA SQUARE FEET	4X40=160	2@2X50= 200	4X20=80	4@6X30= 720
	SCREEN AREA SQUARE FEET	6X40=240	2@3X50= 300	6X20=120	4@9X30= 1080
BHOWALI	FLOOR AREA SQUARE FEET	1,600	800	800	3,000
-2 C	VENTILATION CFM	20,200	10,100	10,100	33,600
	PAD AREA SQUARE FEET	4X40=160	2X40=80	4X20=80	6X30=180
	SCREEN AREA SQUARE FEET	6X40=240	3X40=120	6X20=120	9X30=270
HYDERABAD	FLOOR AREA SQUARE FEET	1,200	2@600= 1,200	600	3,000
12 C	VENTILATION CFM	17,600	2@8,800= 17,600	8,800	33,600
	PAD AREA SQUARE FEET	4X40=160	2@2X30= 120	4X20=80	6X30=180
	SCREEN AREA SQUARE FEET	6X40=240	2@3X30= 180	6X20=120	9X30=270
ANDAMANS	FLOOR AREA SQUARE FEET	2,000	2@1,000= 2,000	1,000	2@3,000= 6,000
21 C	VENTILATION CFM	22,400	2@11,200= 22,4000	11,200	2 EACH @ 33,600
	PAD AREA SQUARE FEET	4X40=160	2@2X50= 200	4X20=80	2@6X30= 360
	SCREEN AREA SQUARE FEET	6X40=240	2@3X50= 300	6X20=120	2@9X30= 540

GREENHOUSE EXHAUST FAN REQUIREMENTS

LOCATION	PLANT PROPAGATION		QUARANTINE CHAMBERS		VIRUS INDEXING		SCREENED GROWING	
	NO.	MODEL	NO.	MODEL	NO.	MODEL	NO.	MODEL
NEW DELHI	1	DC24E 2S	2	DC24E 2S	1	DC24E 2S	8	DC48H
	2	DC36G	2	DC36F	1	DC36F		
			1	FCP1284				
BHOWALI	1	DC24E	1	DC24E 2S	1	DC24E 2S	2	DC48H
	2	DC30G	1	DC30F	1	DC30F		
			1	FCP1284				
HYDERABAD	1	DC24E	2	DC24E 2S	1	DC24E 2S	2	DC48H
	2	DC36F	2	DC24F	1	DC24F		
			1	FCP1284				
ANDAMANS	1	DC24E	2	DC24E 2S	1	DC24E 2S	4	DC28H
	2	DC36G	2	DC36F	1	DC36F		
			1	FCP1284				

CORRIDORS AT DELHI, HYDERABAD AND ANDAMANS 3 DC36F

TOTAL FANS NEEDED BY TYPE

DC24E 2S	11
DC24E	4
DC24F	3
DC30F	2
DC30G	2
DC36F	11
DC36G	4
DC48H	16
FCP1284	4

NOTE THE DC24E 2S IS A 2 SPEED FAN. ALL OTHERS ARE 1 SPEED.

THE ABOVE MODEL NUMBERS REFER TO ACME FANS AS PER CATALOG C7R 585.

HEAT LOAD CALCULATIONS FOR BACTERIOLOGICAL CONTAINMENT

It is desired that certain quarantine compartments be equipped with air conditioning and HEPA filters on an exhaust air system so that they can be essentially sealed and kept under negative pressure for containment of bacteria and fungi. In order to do this the AC system must be capable of removing all of the solar load and sensible heat gain from the hotter outside surroundings. Also it is essential to note that the AC system must be capable of meeting the design cooling requirement when the outside air temperature is at the design maximum which is 45 C in New Delhi.

Calculations of heat load on corner and interior compartments were made based upon both ASHRAE guides and the simplified method of Jordan and Priester utilizing tables 10.10 and 10.11. (Text courtesy of Dr. P Chandra.) The calculations over a number of hours of the day indicate that the maximum solar load on interior compartments occurs near solar noon whether the outside wall faces north or south. The maximum solar load on corner compartments occurs near 1:00 pm solar time.

The calculation for the corner compartment is based on 200 square feet of horizontal roof, 240 square feet of outside end wall and 100 square feet of outside side wall.

$$(267+25)\times 200 + (49+22)\times 240 + (19+22)\times 100 = 80{,}000 \text{ BTUh}$$

Allowing 50% for sensible gain through interior walls and infiltration caused by the evacuation system and duty factor the corner cabins need 120,000 BTUh capacity or 10 tons at operating temperatures of 25 C inside and 45 C outside.

The calculation for the center compartments is based on the 200 square feet of horizontal roof and 100 square feet of outside side wall.

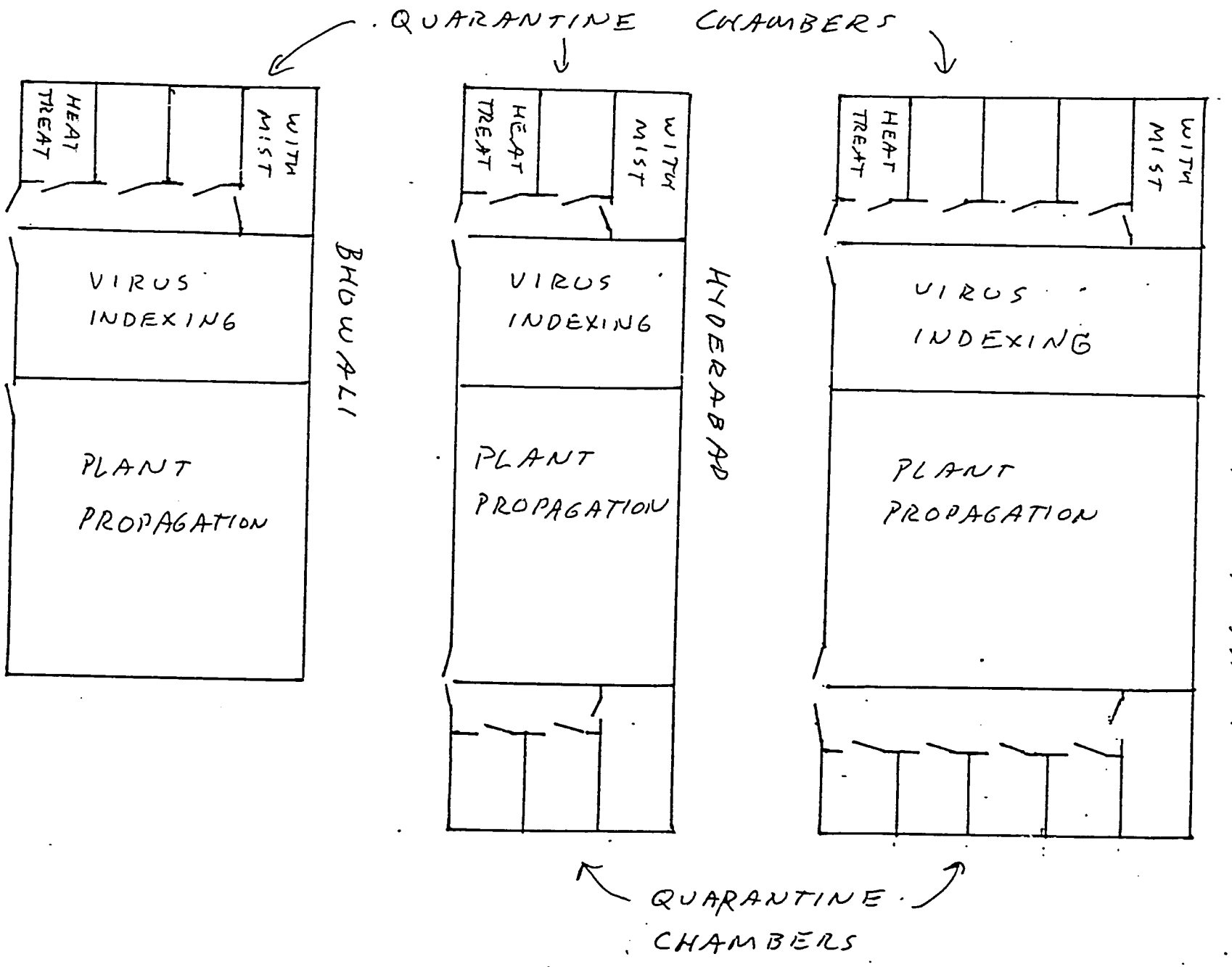
$$(276+21)\times 200 + (45+19)\times 100 = 66{,}000 \text{ BTUh}$$

Again allowing 50%, the corner cabins need 99,000 BTUh capacity or 8 tons at operating temperatures of 25 C inside and 45 C outside.

It is recommended that each corner cabinet that must be capable of being sealed against egress of bacteria be equipped with a capacity for airconditioning of 10 tons and each interior compartment should have an 8 ton capacity. Each compartment so utilized must have the exterior window closed and sealed and the screen from the compartment to the central corridor and exhaust fan also sealed. The compartment should then be evacuated through a HEPA filter meeting the U.S. Federal standard 209B for class 100 conditions.

It is suggested that in prioritizing the quarantine chambers used for this purpose the interior units be utilized first, then those corner units not equipped for misting, and the corner unit equipped for heat treatment should be the last utilized as it has an extra fan and air inlet to be sealed. Note that for any compartment to be used for this purpose it is necessary that the outside window over the pad system be separate from the adjoining window sections so that it can be manually disconnected from the rack and pinion opening system and kept shut while other windows are venting.

PLAN LAYOUTS SCALE 1" = 20'



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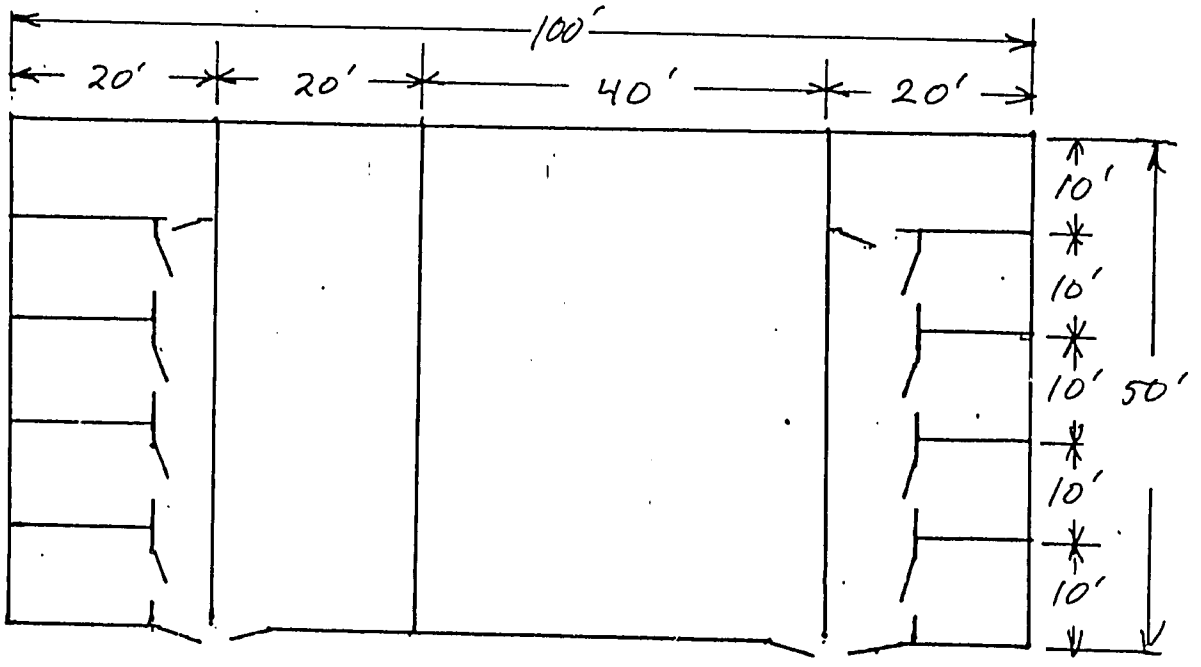
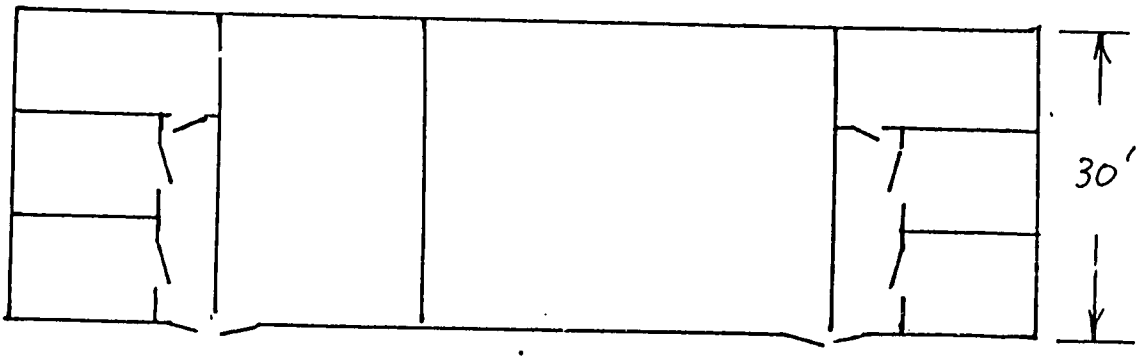
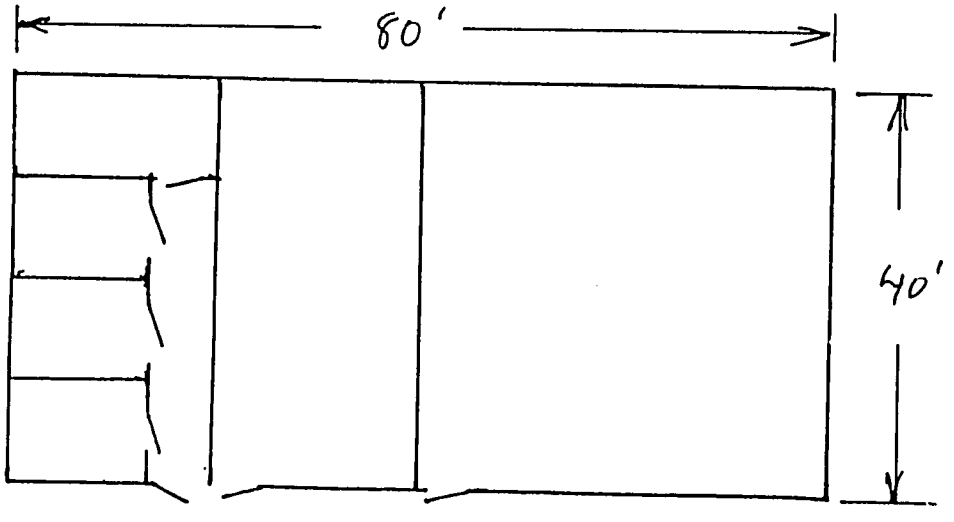
NOMINAL DIMENSIONS @ 1" = 20'







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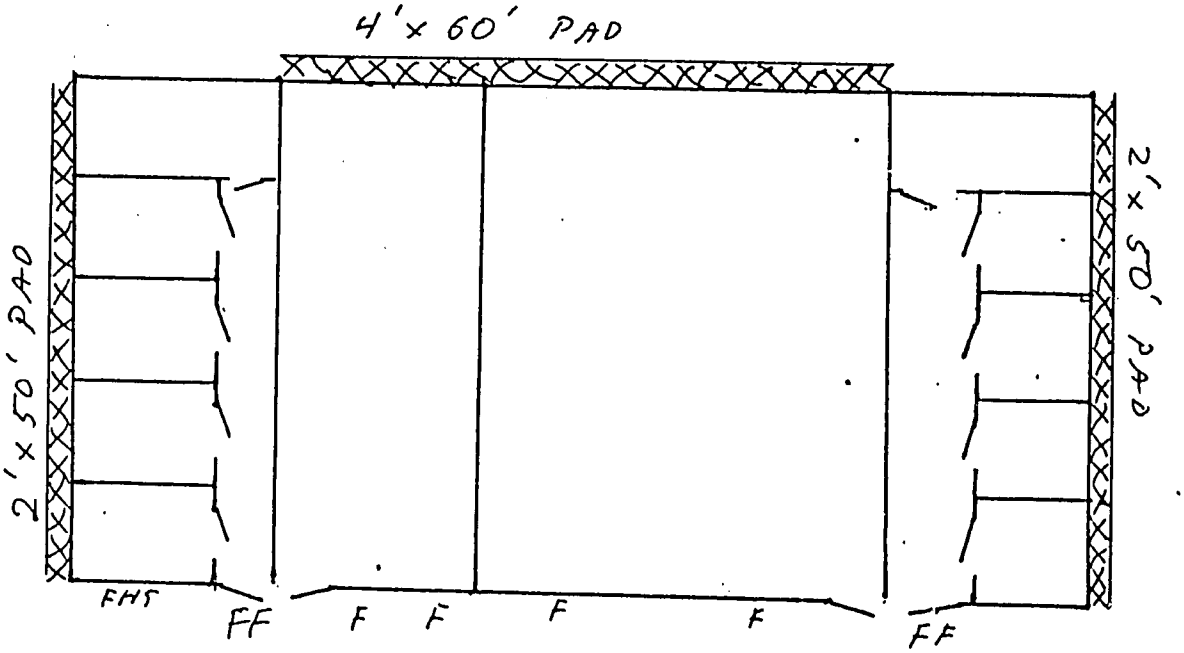
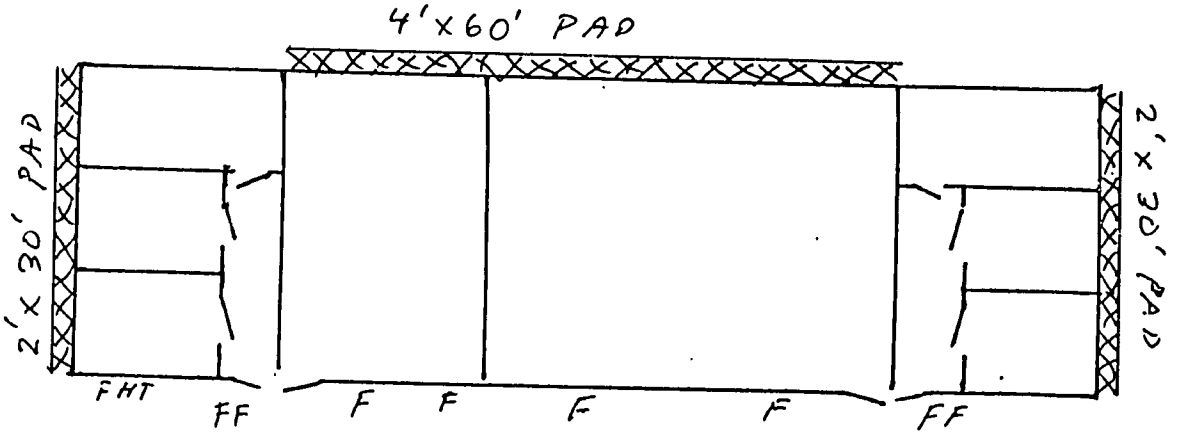
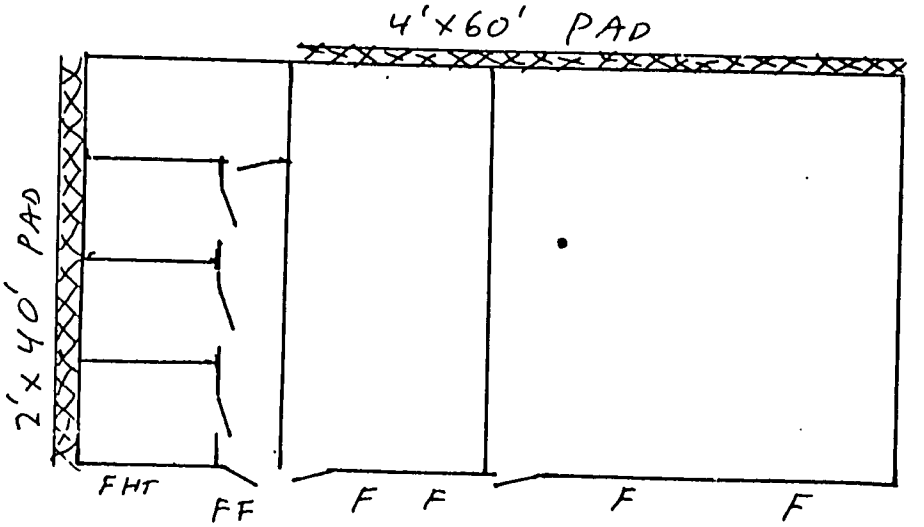
PAD AND FAN. LOCATIONS 1" = 20'







FHT IS SMALL FAN THROUGH SIDEWALL OF HEAT TREAT CHAMBER

FANS EXHAUSTING PLANT QUARANTIN CHAMBERS ARE IN GABLE OVER ENTRY DOOR

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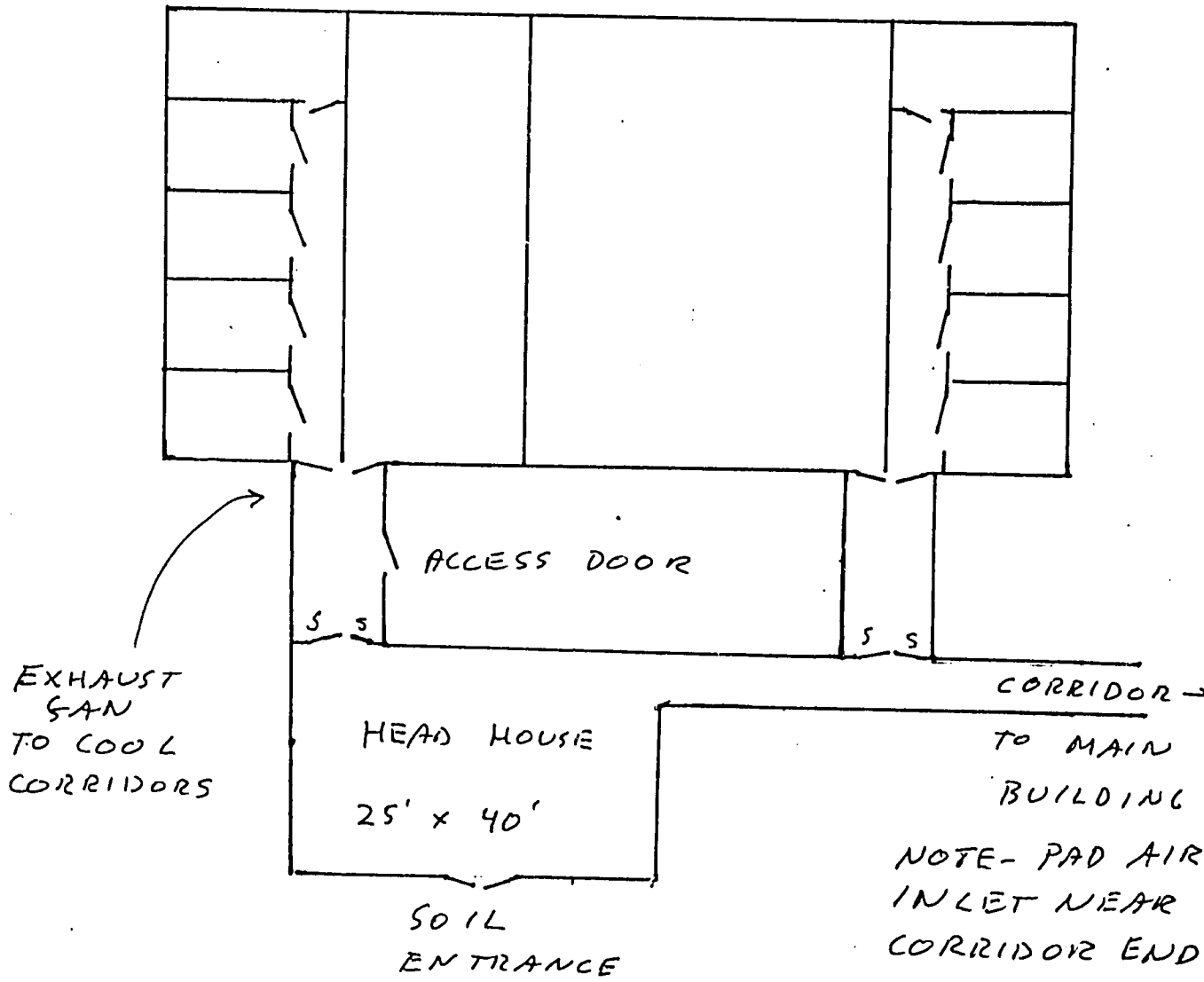
NEW DELHI 1" = 20'

CORRIDOR & HEAD HOUSE LAYOUT



S = SCREEN DOORS

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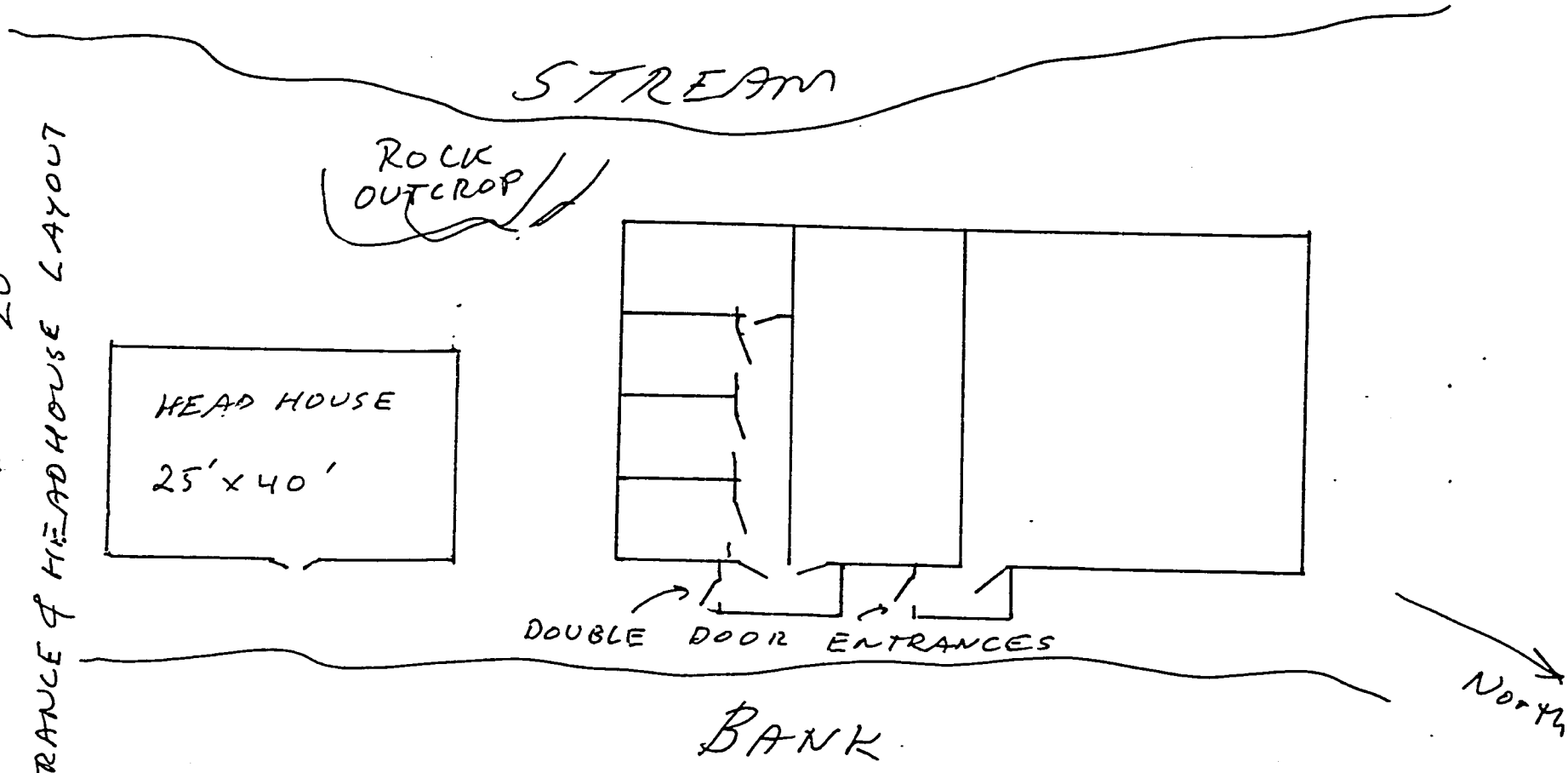
BHOWALI 1" = 20'
ENTRANCE & HEADHOUSE LAYOUT



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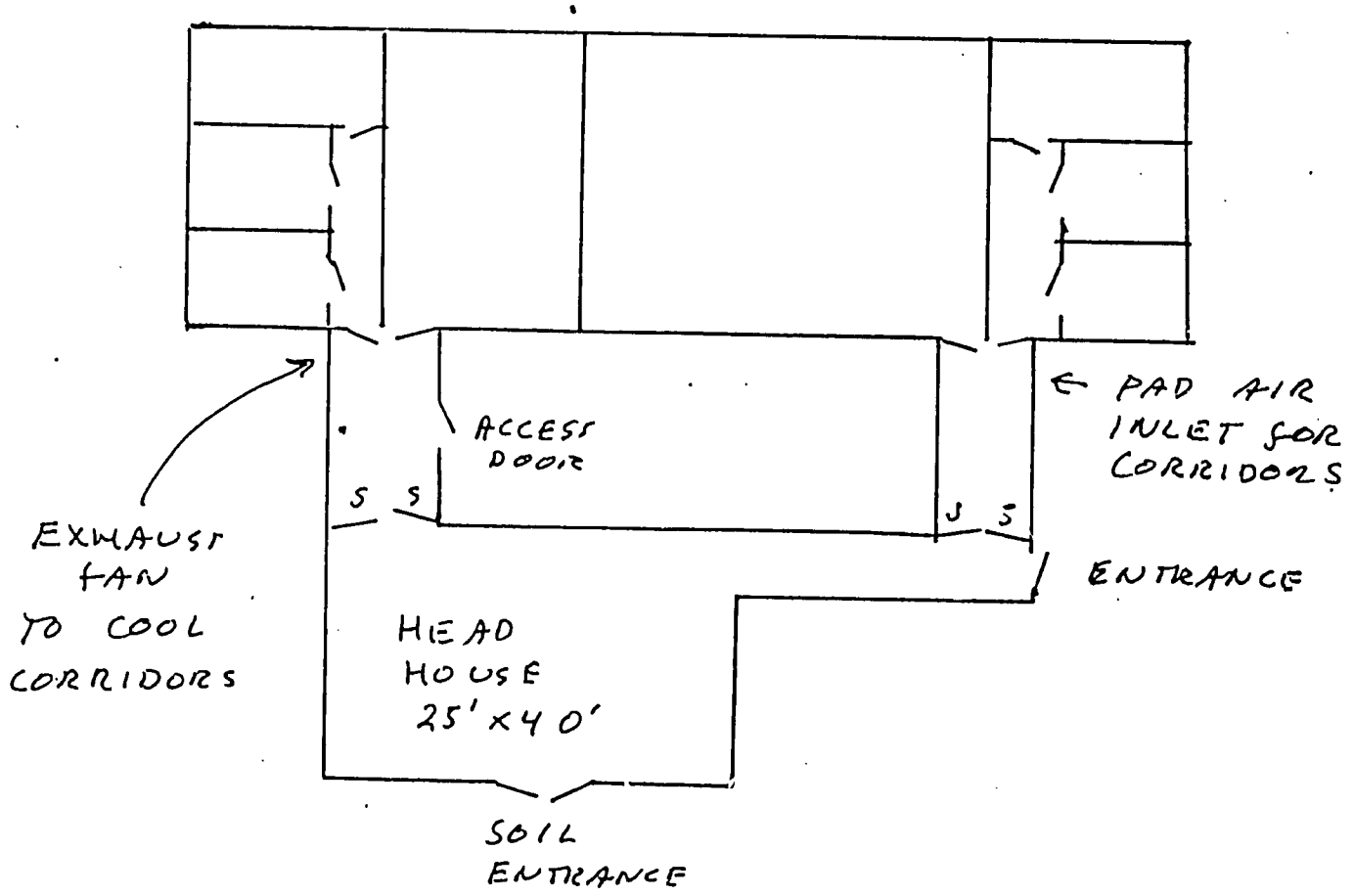
HYDERABAD 1" = 20'

CORRIDOR & HEADHOUSE LAYOUT

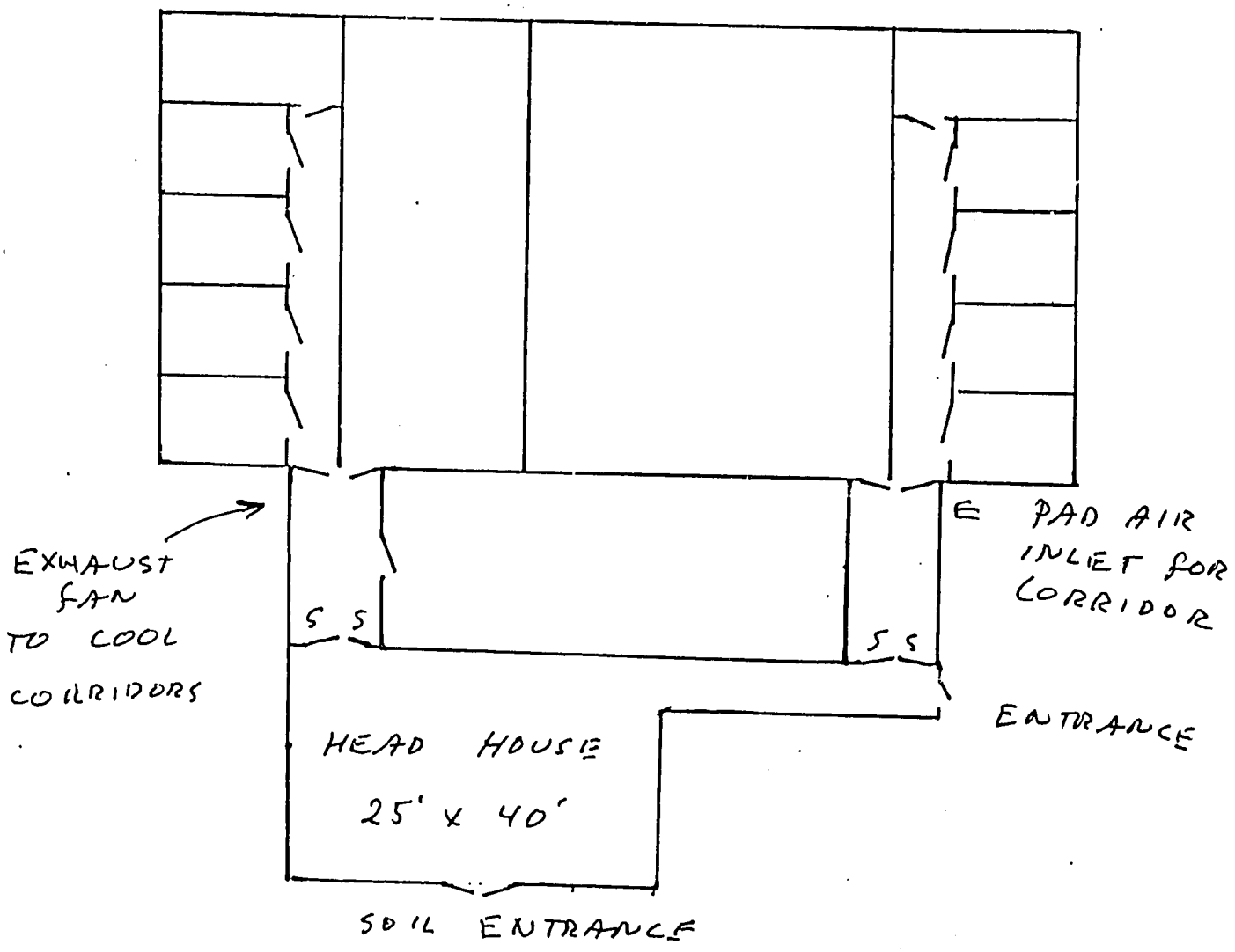


S = SCREEN DOORS

AUG 28 '94

ANDAMANS 1" = 20'

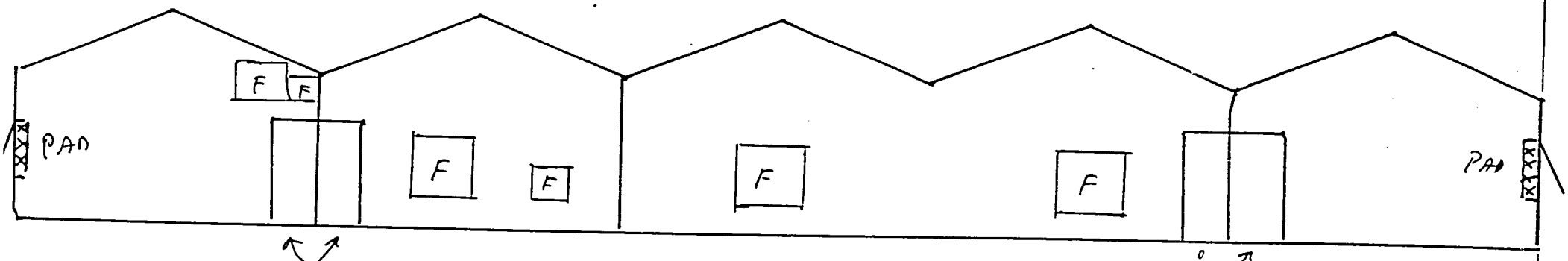
CORRIDOR & HEADHOUSE LAYOUT



S = SCREEN DOORS

AUG 28 '89

SCALE 1" = 10'

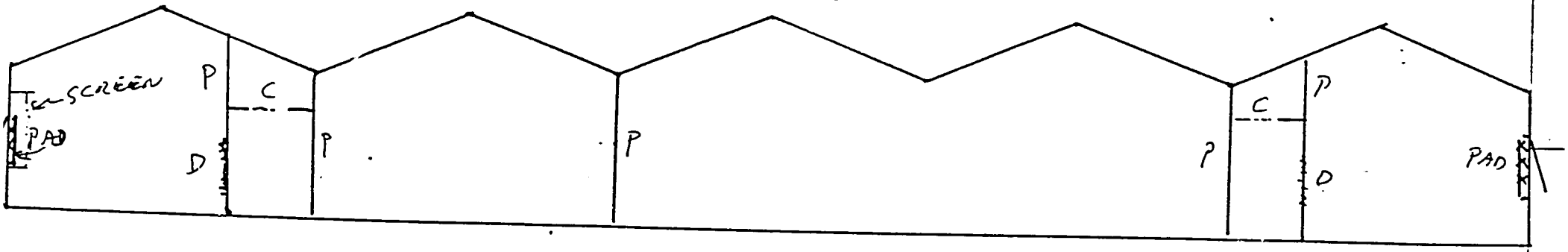


3'x6' DOORS

FAN END WALL

3'x6' DOORS

F = EXHAUST FANS
P = TRANSPARANT PARTITION FLOOR TO ROOF
C = SCREENED CEILING OVER PASSAGE END TO END OF QUARANTINE
D = SCREENED DOOR TO EACH COMPARTMENT



SECTION

SECTION THROUGH QUARANTINE/VIRUS INDEXING/ PROPAGATION FOR NEW DELHI, HYDERABAD AND ANDAMANS

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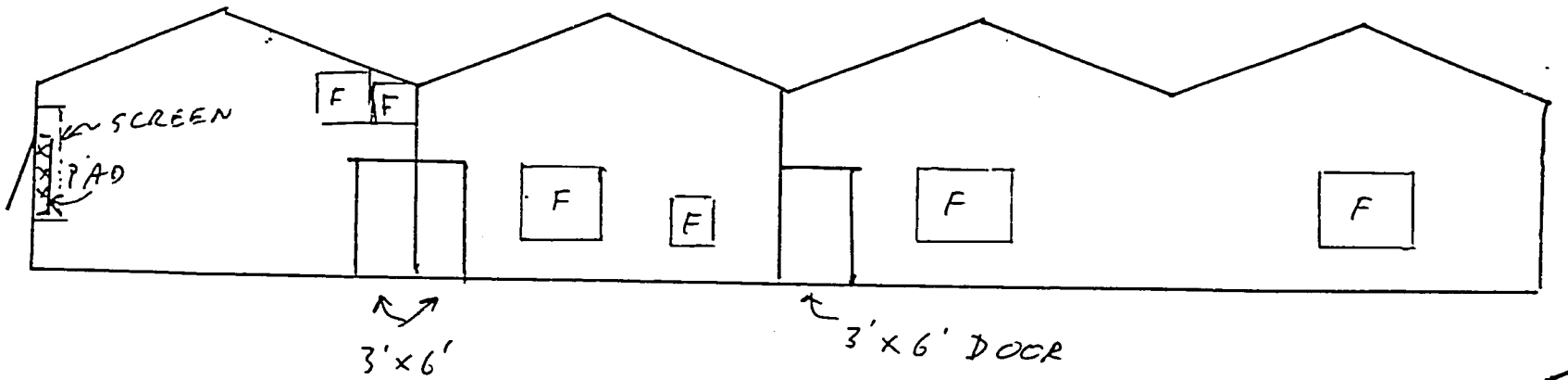
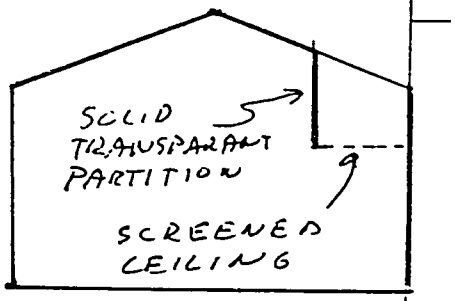
DEC 20 '09

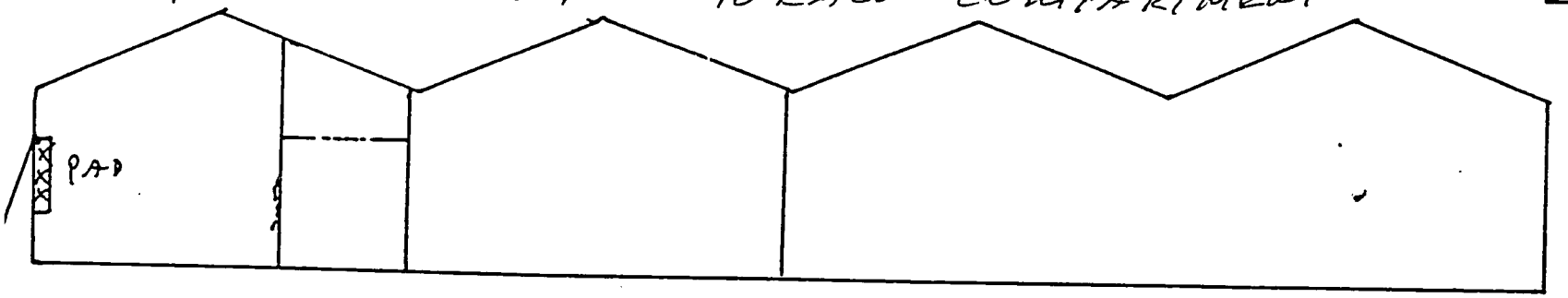


FAN END WALL

F = EXHAUST FANS
P = TRANSPARANT PARTITION FLOOR TO ROOF
C = SCREENED CEILING 40' LONG
D = SCREENED DOOR TO EACH COMPARTMENT



SECTION THROUGH MIST COMPARTMENT



SECTION

SECTION THROUGH QUARANTINE/VIRUS INDEXING/PROPAGATION

BHOWALI

D41

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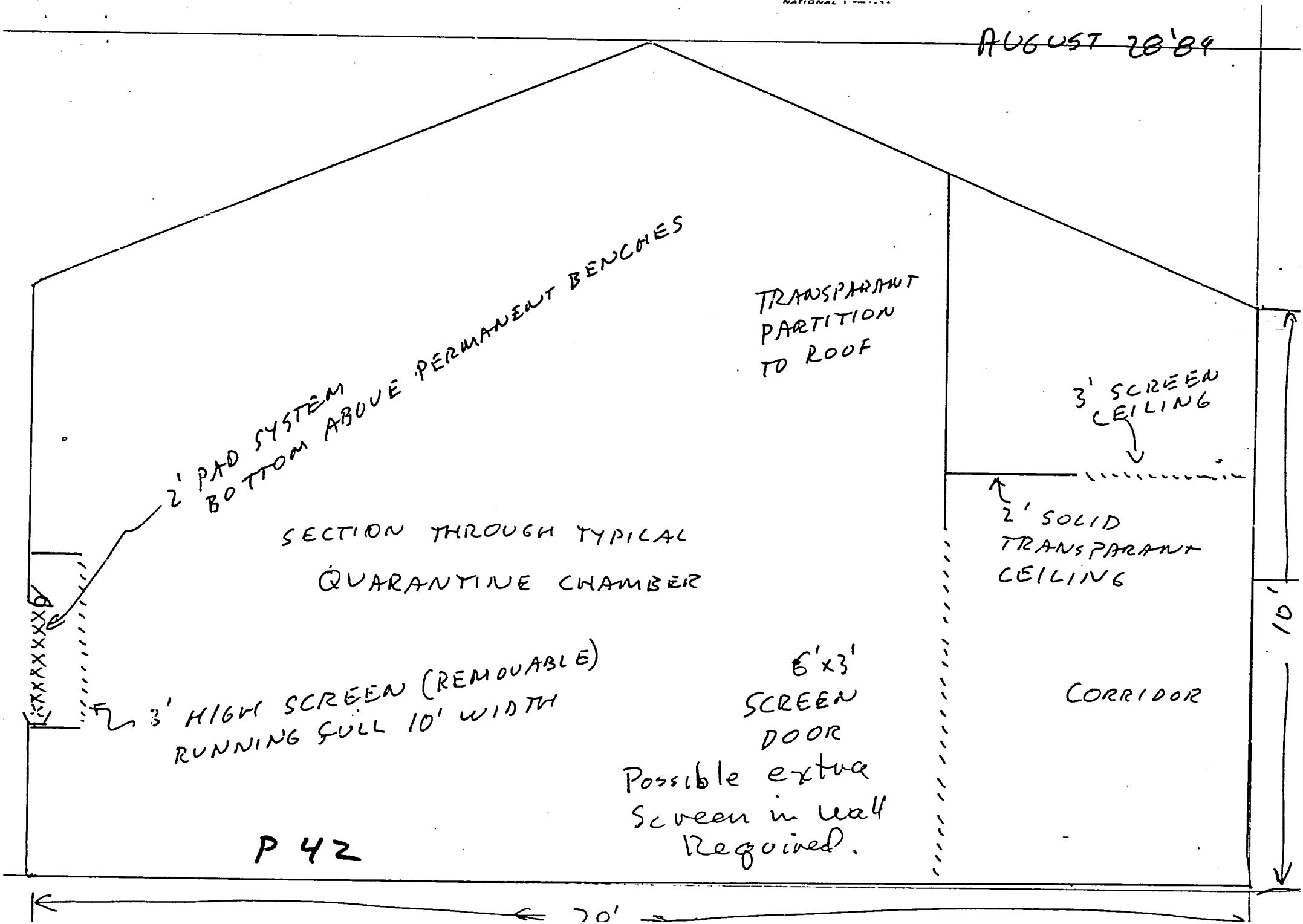
AUGUST 28'89



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NATIONAL 42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE

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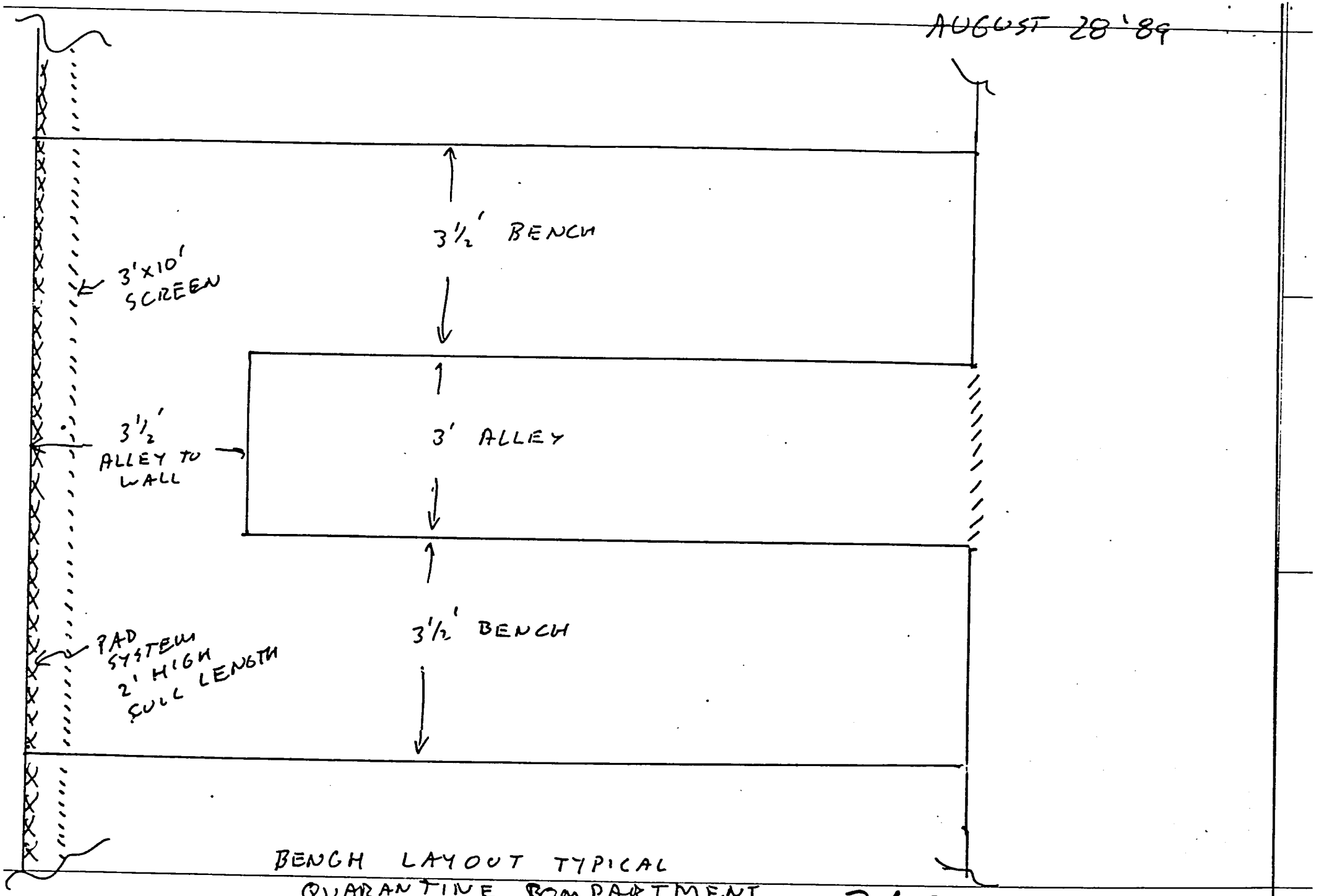
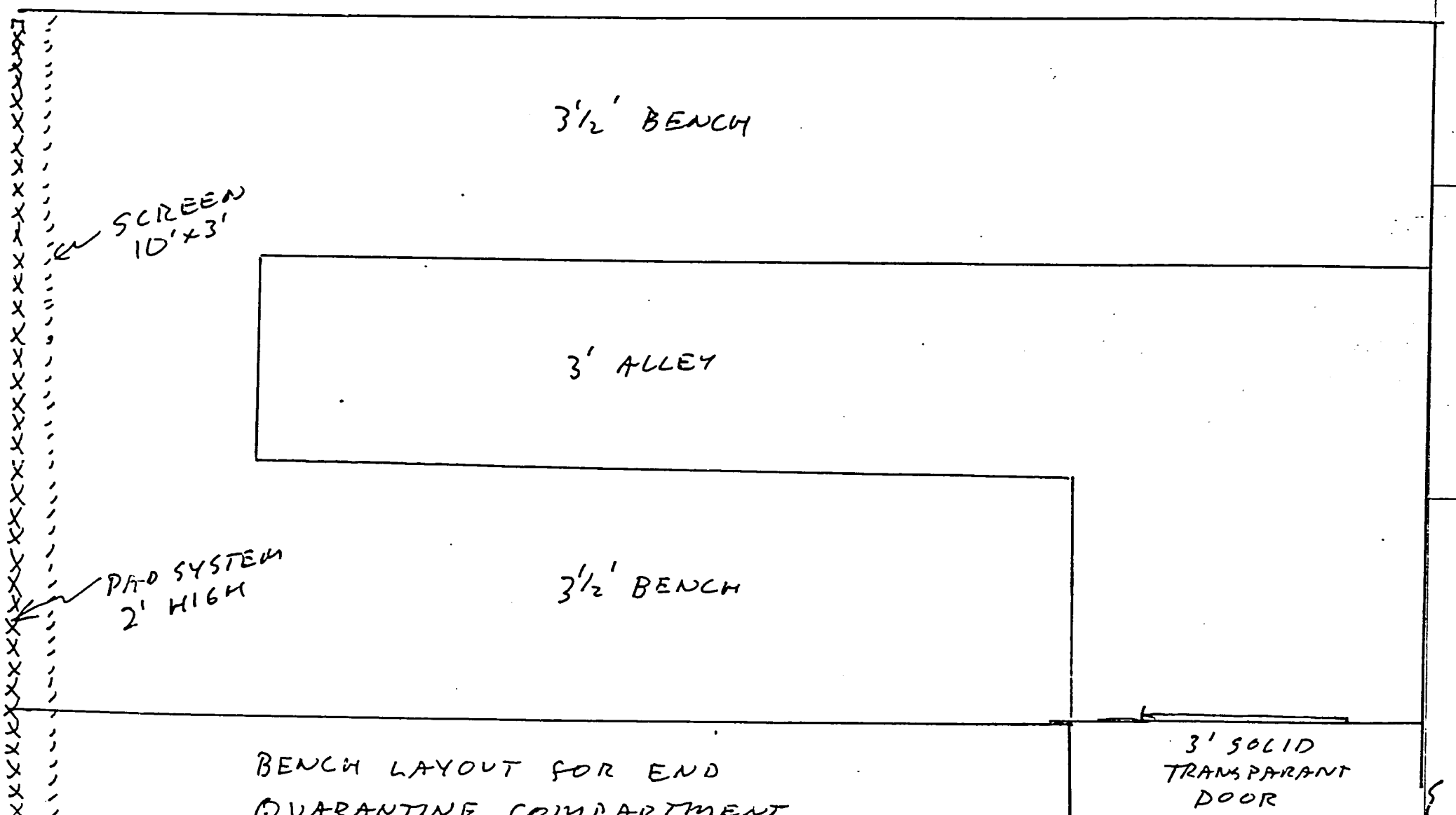


BENCH LAYOUT TYPICAL
QUARANTINE COMPARTMENT

D 43

NATIONAL 42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE

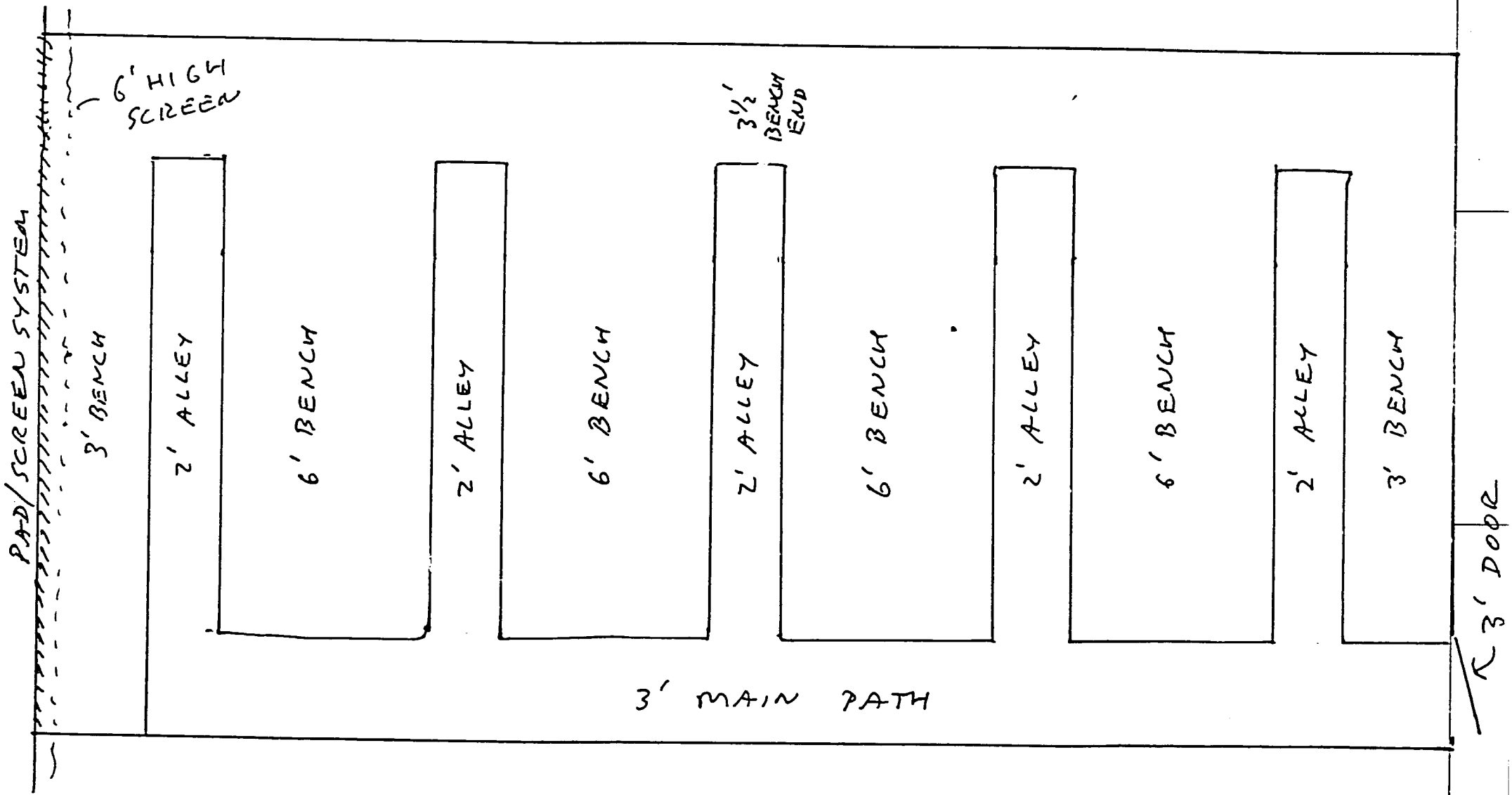
AUGUST 28 '89



BENCH LAYOUT FOR END
QUARANTINE COMPARTMENT

DWW

PENINSULA BENCH LAYOUT IN VIRUS INDEXING (20'x40') HOUSE AT BHOWALI ★ PLANT PROPAGATION HOUSE SIMILAR, 10' LONGER BENCH



40' LONG SCALE 1" = 4'

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AUGUST 28 '89

SCOPE OF WORK

BACKGROUND

Under the PGR Project budget there is a provision of $700,000 for construction of Greenhouses and Screenhouses at NBPGR Head Quarters, New Delhi and at some of its stations. Appropriate expertise is not available in India for construction/fabrication of Greenhouses/ Screenhouses to suit the varied agro-climatic conditions of various sites at which they have to be provided. Services of an expert are, therefore, required by NBPGR for technical assistance and guidance on the subject.

SCOPE OF WORK

It is proposed to make Greenhouses and Screenhouses at the following locations.

Location	Climate	Temperature Range
Hyderabad	Semi-arid Tropical	12°C (Dec) to 43°C (May/June)
Port Blair	Humid Tropical	21°C (Feb) to 33°C (April)
Bhowali	Temperate & Humid	2°C (Jan) to 30°C (May)
Delhi	Subtropical	5°C (Jan) to 45°C (May/June)

Technical assistance/guidance from the expert is required for the Greenhouses and Screenhouses on the following points:

1. Advise on appropriate citing and directions after visiting the locations, if required.

2. Size of each unit keeping in view the agro-climatic conditions, fabrication components and equipment.

3. Guidance for the development of design of each unit including the arrangement of bench spaces and all other activities routinely undertaken for plant raising in Greenhouses and Screenhouses having automatic temperature, humidity and light control systems. Vagaries of nature like strong winds, hailstorms etc. should be kept in view while developing the design.

4. Guide in the development of design of Greenhouses/Screenhouses to meet quarantine requirements.

5. In consultation with NBPGR, recommend appropriate fabrication materials.

6. Provide lists and detailed specifications of imported and indigenous components for fabrication materials and equipment required for automatic or semi-automatic control of temperature, humidity and light keeping in view the maximum possible energy conservation.

7. Finalize the training plan of NBPGR staff on plant raising under protected environment.

8. Submit a written report at the end of the period.

AGRE:BPS:rs:05090:6/22/89

DAILY ACTIVITIES LOG OUTLINE AUGUST 8 TO SEPTEMBER 6, 1989

8/8 Travel
8/9 Travel

8/10 Arrive Delhi @ 12:50 am. Hotel Vasant Continental @ 3:00 am
9:00 arrive Winrock Office and start introductory discussions. Discussions with Winrock, (A. Colin McClung and M.A. Nair), on work plan, available support facilities and tentative travel schedules. Later in morning shift to USAID offices.

Discussions with B.P. Srivastava on USAID expectations regarding consultancy and status of PGR project.

Contact Indo American Hybrid Seed Co.

Fix appointment with NBPGR for Friday morning.

Discuss status of PGR project with Dr. Andrea Blumberg. Greenhouse construction is budgeted at $600 k for imported items and $100 k Rs equivalent in dollars for a $700 k total.

8/11 9:30 leave for meeting with Dr. Rana at PGR and other NBPGR staff. After introductory discussions with Dr. Rana tour facilities to review changes since my last visit and re-establish contacts. Note that Dr. Chandel's new facilities and equipment are coming together rapidly and look good. These first discussions take about 4 1/2 hours and indicate general directions to be taken. Question of travel to Bhowali and Andaman's is opened and Dr. Rana will consider.

3:00 pm, review progress with USAID. Later call from Dr. Attavar in Bangalore. Indo American willing to do PGR project on turnkey basis.

8/12 9:00 am, meet with Mr. Ramnath who is head of Quarantine Division and three of his key scientists:

Dr. P.C. Agarwal	Bacteriologist
Mr. D.B. Parakh	Virologist
Dr. C. Amantha Kumar	Virologist

During about 5 hours of discussions regarding the functional requirements for the four basic types of facilities at each of the four geographic locations a great deal of information was obtained, some optional approaches to design concept discussed and some general concepts preliminarily agreed upon. The outline of the information requested and the major topics covered and data obtained are covered in separate notes.

8/13 Sunday: Continue analysis in hotel, then shift to Winrock office to utilize WANG computer and initiate preliminary design work.

8/14 Monday: 8:00 am Winrock office to copy the initial request for data, the responses filled in to date and the layout sketches for the plant propagation 30 by 40 greenhouse. Send these items to Ramnath via Alex. From 9:00 am to 1:30 pm meet with Surjan & BP at AID office.

4:00 pm Meet with Ramnath at NBPGR to review documents sent earlier and discuss possible travel to Bhowali (17,18) and Bangalore (24,25).

5:00 pm Meet with Dr. Pitam Chandra. Discuss the possibility of his involvement in some aspects of the PGR greenhouse effort which he is willing and anxious to do. He will get some data on stainless steel screening available and look for needed weather data for cooling and heating calculations. Prepare initial heating and cooling calculations for NBPGR review.

8/16 Wednesday Set up Bhowali and Bangalore trips with design work in between. Noon review progress with AID, early pm continue design work, finish (hopefully) scheduling problems. 3:30 - 6:00 pm @ NBPGR. Dr. Rana agrees with travel schedule, leaving Andaman travel an open question. Give Dr. Rana Rod Sharp's information and he will discuss with Dr. Paroda as policy issues are in the ICAR for decision.

Ramnath and staff will work with Pitam to get more specific agmet data for the sites. Staff have worked up a number of answers to earlier inquiries and have several questions to iron out which are done. They have discussed the issue of mist chambers and like the idea of having one quarantine chamber at each location equipped for that. There is considerable discussion on the need for mechanical AC instead of evaporative cooling only and it is agreed calculations based on real agmet data should be done before settling this issue.

8/17 Thursday At Winrock working on designs and specifications. Phone conversations with Dr. Agarwal of NBPGR re agromet data and layouts. The agromet data being worked on and looking for Pitam to find what he has. As per layout, it is intended that covered and insect secure walkways will join the lab with all greenhouses and screenhouses. Note the issue of ventilation of these must be addressed. Late afternoon meet with BP on the issue of how contracts are to be handled and depending upon that what sort of form is required and what information is needed in my report.

8/18 Friday At Winrock drafting up layouts for NBPGR to consider. First layout concept will follow their requests for buildings as per numbers and dimensions and allow for some future expansion and attempt to minimize the length of covered path needed while allowing sufficient space between buildings for air intakes/exhausts as needed and maintenance. Noon return Winrock via USAID finish up and arrange design info completed to date. 2:30 go to Pitam and again encourage his help on the agmet data and evaporative cooling potential for Delhi. Shift to NBPGR and go over progress to date. Discover that I misunderstood part of the requirement, namely that the quarantine chambers must be sealed and kept under a negative pressure via discharge through a HEPA filter to avoid any possible egress of fungi or bacteria! (I missed this point earlier having thought discussion of screening for these chambers and need to fix up such chambers built already but non-functional covered that.) After long discussions it is clear high levels of containment at all sites except Bhowali are sought.

8/19 6:00 am leave for Bhowali with Ramnath and Alex driving. Arrive there about 2:30. Extensive discussions along the way in which we evolve the concept that we can switch from individual units to bays within one unit for plant propagation, virus indexing and quarantine and the individual quarantine compartments each have independent HEPA filter evacuation. As these units must be air conditioned these sizings must be specified, noting operating temperat res at which specs must be met. At Delhi there is the possibility of utilizing the central air conditioning systems so only heat exchangers, controls and air handlers may be needed. At Bhowali no bio filter is required. At Hyderabad and Andamans AC must be provided. It is desired to be able to also use these cabins as originally designed with evaporative cooling and 60 mesh screen so they can be run without AC when biocontainment is not needed to save operating costs. By putting up a single building for these 3 units we will have to alter the total areas for each somewhat but that appears to be no problem, especially in view of potential savings. In our discussions of what have been labeled as screenhouses should be regular glass houses with forced

ventilation from end to end with possible consideration of evaporative cooling and perhaps some heating at Bhowali. The purpose is to grow plants under normal seasonal conditions in the soil but protected from insects by 60 mesh screening. This screen will not allow enough light if used for a roof so glass must be on the roof. Therefore ventilation is required to remove heat build up as natural ventilation through sidewalls will not suffice. Building one multi span unit will be more practical than separated units. Temporary internal screened partitions can be used as needed.

At Bhowali review overall scope of project and discuss the types of greenhouse technology being contemplated with Mr. K.J. Pant, head and P.J. Joshi and K.S. Negi. Found the design temp. should be -2 C and not + 2 C! After agreeing in general on the sizes of the units we review possible sites. The preferred site from the staff standpoint is C block a nominal 15 m wide fairly flat strip with a slope to the NW. There is a large rock outcrop about 40 m from the north edge so there is room for a 40' x 60' structure for pp, vi and quarantine. As this block is on poor soil, close to the offices and away from most other tillable blocks it is the best spot for these activities. Further up there are two F blocks which could be suitable for the screened houses where growing is to be in the ground (which is judged to be good soil for this purpose). The lower F block is just over 40' wide by 95 ' long and the screened house could be fit in there. The upper block is about 80' by 90' and is therefore better suited to a 60' by 60' screened house which is about the total area required. On that block there could be future expansion of another 20' section.

8/20 6:00 am to 2:30 pm travel to Delhi and calculate heating and ventilation requirements for the new layouts conceived of during the Friday meetings and this trip.

8/21 Monday At Winrock office doing layouts on new designs based on recent discussions. Make copies and discuss with USAID. Set meetings for NCPA with USAID and Mr. Kumar for Wed. am. West building errands then return to Winrock to complete preliminary layouts for design. Mid pm to NBPGR and Pitam at ag engineering. In this meeting substantial objections are raised with regard to the "screenhouse" facilities in support of a desire to return to the screen walls glass roof concept. It is pointed out that these units need to be shifted away from the other 3 types and that there is not a need for access to them to be through a covered walk as I had earlier thought. The issue is related to the labor utilized in the different facilities. Workers in the "screen" houses will be casual employees limited to 80 days employment and therefore it is expected that there could be inadvertent vandalism which could damage glass walls. This will not be an issue in the other 3 types of facilities.

There follows an extensive discussion of how to solve the problem of having a screened facility subject to currently understood constraints. Wire reinforced glass for walls is also not acceptable as it is glass. As far as the functional requirements of these facilities are concerned a very practical solution would be double poly on 30' quonset with forced ventilation, possibly evap cooled and screened. It is felt poly is not acceptable. There is a preference for Fiberglas. I note there can be a concern regarding sealing all the irregular edges to a level of containment consistent with 60 mesh screening. It is stated that Fiberglas roof and screened walls will be acceptable.

With regard to the number of quarantine chambers that must actually be prepared for bacteriological containment it is indicated that as the quarantine division does not control the workload of clearing materials it

is possible that large numbers of samples requiring maximum containment can required to be processed at one time and it is necessary to be prepared to handle any peak load. Discussion of the earlier request that we suggest modifications to enable the 6 newly constructed double glass wall chambers to be utilized as air conditioned chambers with HEPA filtered air exhaust leads to the point that it is felt that when the new building comes up this work should be conducted in the new facilities.

7:30 pm meet with Dr. Attavar of Indo American Hybrid Seed Co. to discuss his progress in establishing greenhouses, the potentials for involvement in the PC project and to introduce the concepts and progress of designing NBPGR facilities. Set meeting for 8/22 @ 3:00 in Winrock.

8/22 Tuesday 8:00 am to Winrock to start refiguring new plans based on yesterdays discussions. 9:30 to USAID with BP then go to Mr. Kumar in West building for inputs on process and technical issues. It is possible to go to a local Indian company for a turn key contract. It is potentially feasible to utilize the central air conditioning system in the main building in New Delhi for refrigerant for the greenhouse complex. 12:30 return to Winrock to continue calculations. Locate meteorological date in ASHRAE that indicates wet bulb temperatures in Delhi exceeds about 28 C at least 5% of the time.

Working on sizing AC units for quarantine chambers and virus indexing chambers. Comparable results obtained using ASHRAE method and simpler method in Pitam's Jordan and Priester text. The AC requirements in Delhi with an allowance of 20 - 25% over calculations are:

8 tons for each interior 10' x 20' quarantine chamber
10 tons for each corner 10' x 20' quarantine chamber

Note that the calculations are based on peak load without allowance for saving due to internal screening system. Thus the total requirement for the 10 compartments in Delhi is about 88 tons. Similarly, the 20' x 50' virus indexing section has a 40 ton requirement. Note that the major requirement is for the solar gain through the roof near solar noon which works out very close to 300 BTUh per sq ft. Heat gains through interior walls are assumed covered by the 20% allowance.

3:30 meet with BP Srivastava and Dr. Manmohan Attavar of Indo American Hybrid Seed Co. Focus of discussions is on business and contracting possibilities. Indo American is interested in bidding on a complete project. Finish preliminary AC analysis.

8/23 Wednesday 1:30 - 5:30 meet with Ramnath and Dr. Agrawal on current state of planning. Still looking for cost and width of screen, agmet data and needs for lighting. On the issue of need for bacteriologicaly secure chambers it is felt all 10 must be so equipped as the workload cannot be controlled.

8/24 Thursday At Winrock organizing materials produced so far for trip to Bangalore. 10:00 to airport, arrive Bangalore 3:00 pm Indo American 3:30.

Tour new facilities at 3 farms constructed since my last visit. Two large ranges and one good 30' x 96' double poly quonset are up. The large gutter connected range is local design frame, bent sheet metal gutters as at Kube Pak, high strength plated tubing for structure and fiberglas cover. One section is local fiberglas which is already suffering surface erosion and discoloration after less than one year. Also not large tissue culture lab up and in operation and large office/research laboratory block coming up. Review general project objectives and requirements with Indo American staff and Don Sharp.

PM working dinner and evening at hotel with Don. After general

overview of all technical requirements and our views on layouts and approaches and history as to how we arrived at these points note the following items for further thought and checking:

- For heating consider electric in small chambers and bottled gas for gas fired heaters where capacity is higher? (check on degree days and fuel costs).
- Consider fiberglas rather than glass for roof and exterior walls and note that Indo American and Don Sharp strongly prefer fiberglas over glass based on their experience and feel that sealing between sheets and at ends can be done. Note sealing cracks at edges of glass is also critical.
- Increase side wall from 8' to 10' and go for one peak per 20' rather than the two peaks indicated in Venlo style units. Both good ideas.
- Agree with concept of putting screening inside pad system and inside house rather than outside. Suggest possibility of using velcro fastening on screen sections. Also consider possibility of using plastic netting rather than stainless steel as screen will be protected from weather and especially UV degradation inside the house.
- Note that in the chamber used for heat treatment a separate fan to the side wall is indicated for ventilating to 40 C as main circulation system is to be disabled. Air for this chamber will be drawn from the walkway through that side panel screen normally running air the other way.

8/25 Friday Working breakfast and morning in hotel continuing design detail discussions. Later shift to Indo American. (Note Ramnath reading the article in March Grower Talks on control of Thrips with screens notes that perhaps 40 mesh rather than 60 mesh screen will be acceptable.)

Regarding shading levels it is agreed that the LS system is to be preferred and that having two independent systems is desirable at most locations except one will suffice at Bhowali due to less maximum heat stress at that location. Indo American's experience is that no vegetable being grown for production should have more than 50% shade. The suggestion is that 30% be used at Bhowali and if double systems are used at the other locations one be 30% and the other 45%. Manual drives should be used in the quarantine chambers and probably in the virus indexing units. Possibly a mechanical drive would make sense in the larger plant propagation areas.

There is agreement that the first stage of ventilation should be on at all times in the quarantine sections when workers are at the facility.

It is agreed that for the screen houses requested the best way to achieve the functional requirement that plants be grown in the natural soil under temperature conditions as close as possible to ambient with complete protection against local insects the most practical solution is ground to ground double poly houses with forced ventilation. There is the option to add evaporative cooling if slightly better than ambient conditions are desired. It is noted that such structures could also serve as examples of potentially practical commercial growing structures.

8/26 AM misc. personal errands. 2:00 pm pick up BP and go to NBPGR to meet with Dr. Rana and Ramnath to review progress to date. Discussions of business aspects and also details of design work so far. Information needed for report is discussed but conclusion note completely clear so it is agreed early draft needs to be prepared for review. Emphasis should be on documenting need for NIRC for most components and for suitability of selected contractor. Dr. Rana expects USAID to manage a turnkey contract directly. While the desirability of utilizing their facilities as a state of the art demonstration for potential commercial growing is a high priority it is also stipulated that double poly cannot be used due to high winds in dust storms in Delhi and the difficulty in getting replacement

poly in future years. Therefore all houses must be imported Fiberglas. The concept of tapping into the buildings AC system can be looked into but the idea is that the greenhouses should be independent and far off. (The requirement for insect proof passageway from lab to greenhouses presents a problem.)

8/27 Sunday 8:00 am to 9:30 pm. Writing up notes and specifications. Finish first draft of report on requirements for facility and data gathered from NBPGR. Note the supplementary agmet data, data on cost, width availability and actual mesh count and open area of local screen not yet available. Also to be resolved the lighting requirements and the actual requirement for bacteriologicaly secure compartments.

8/28 Monday 8:00 am working on layouts of the various greenhouse groupings and preparing rough site plans. Sketches of floor plans, bench layouts, elevations, air circulation layouts, elevation views and corridor arrangements. Midday review progress with USAID and pick up drive for WANG laptop. 8:00 pm to 10:30 meet with BP, Don Sharp and Manmohan Attavar at Hyatt to review designs as envisioned to date. Deliver draft of sketches and RESPONSES TO REQUESTS FOR DATA FROM NBPGR THROUGH AUGUST 27 to BP for USAID review with suggestion that will be essentially in the final report pending inputs or corrections from USAID or NBPGR.

8/29 Tuesday 8:00 am through 10:00 pm working on recalculating the fan and heating system requirements for the 16 component systems and developing tables of requirements and suggested equipment to use. Complete fan and heater calculations and enumeration. Meet over noon hour with USAID.

8/30 Wednesday
Most of day typing up substantive draft of technical recommendations which is essentially done less introduction and summary but there can be more work on tables and etc of more and more details. Need to find out more definitively what is needed.

8/31 Thursday AM work on getting draft report copied and prepared for circulation. Leave draft with Winrock, USAID and NBPGR for review with the request that input be received by Friday noon if possible. Set meetings to review with USAID on Fri and then go to NBPGR. Review progress with Ramnath, and check with Pitam Chandra on his results. His technician measured the screen and found it to be 60 mesh with .15 mm diameter wire. The 38% open area is based on this.

Go over the problem of cooling the two containment units under construction and give my recommendations to Ramnath and Pitam on how to proceed to mitigate the problem. A 50% reflective curtain would help reduce the loading on the AC unit. The AC requirement is estimated at about 8 tons under peak conditions. The HEPA filtered exhaust systems are needed and it appears many of the glass panes are not yet fully sealed and that needs to be done. It is suggested that a trial could be conducted in one far end chamber by adding the existing AC units one at a time to verify the actual cooling capacity needed under local conditions. This is a simple step involving installing the units that are there one at a time.

9/1 Friday 8:00 am Winrock writing things up. 9:00 am review NBPGR report with USAID and Winrock. Basically the draft report which has been circulated is acceptable to all. Several points are noted where explanations as to why recommendations are made should be expanded upon for clarity. Most comments focus on the need to emphasize the absolute

necessity for imported items where these are needed. Note that it is my position that in some cases where I am not sure about local availability of materials it may be appropriate to shop around first and then make the decision as to importing or purchasing local. The conclusion is that with the editorial comments suggested the report can be a final draft.

9/2 Saturday Meet essentially all day at ICRI offices with a large group of those active in greenhouse development in India regarding potential future activity.

9/3 Sunday through Tuesday prepare written report and discuss final concepts with Winrock, USAID and NBPGR.

SUPER WINDMASTER PERFORMANCE

PERFORMANCE TABLE FOR MODEL DC (STEEL)

FAN SIZE	FAN MODEL	HP	RPM	Certified CFM vs. Static Pressure 0"	.05"	.10"	.125"	.150"	CERT. MAX. BHP*	SHIP. WT.
24"	DC24E	¼	622	5300	4900	4500	4200	3900	255	80
	DC24F	⅓	735	6200	6000	5700	5500	5300	419	86
	DC24G	½	820	7000	6700	6500	6300	6100	578	88
	DC24H	¾	949	8100	7800	7600	7500	7400	889	93
30"	DC30F	⅓	529	8500	8000	7400	7000	6600	415	96
	DC30G	½	607	9700	9300	8800	8600	8300	626	100
	DC30H	¾	686	11000	10600	10200	10000	9800	899	105
36"	DC36F	⅓	431	10300	9600	8800	8300	7700	386	106
	DC36G	½	495	11800	11200	10600	10200	9800	574	110
	DC36H	¾	575	13700	13200	12700	12400	12100	882	115
	DC36J	1	634	15000	14600	14200	14000	13700	1 169	125
42"	DC42G	½	385	14000	13600	12500	11800	11100	591	157
	DC42H	¾	442	16600	15900	15000	14500	14000	876	162
	DC42J	1	485	18200	17500	16800	16300	16000	1 145	165
48"	DC48G	½	308	17500	16200	14700	13700	12200	608	205
	DC48H	¾	354	20100	19000	17800	17100	16200	891	210
	DC48J	1	382	21700	20700	19600	19000	18300	1 110	220
54"	DC54J	1	311	25100	24000	22900	22000	20900	1 143	247
	DC54K	1½	334	27700	26800	25800	25200	24400	1 541	255

Performances shown are for units without ducts *BHP does not include drive losses
Certified Sound Ratings for DC Models shown in Catalog S2C

PERFORMANCE TABLE FOR MODEL DCA (ALUMINUM)

FAN SIZE	FAN MODEL	HP	RPM	Certified CFM vs. Static Pressure 0"	.05"	.10"	.125"	CERT. MAX. BHP*	SHIP. WT.
24"	DCA24E	¼	622	4900	4600	4200	3900	29	78
	DCA24F	⅓	735	5800	5550	5250	5050	48	83
	DCA24G	½	820	6500	6300	6100	5950	67	88
	DCA24H	¾	949	7400	7200	7000	6900	99	94
30"	DCA30F	⅓	529	8200	7700	7200	6900	37	92
	DCA30G	½	607	9400	9000	8600	8300	71	97
	DCA30H	¾	686	10600	10300	9900	9800	1 04	102
36"	DCA36F	⅓	431	10000	9300	8600	8000	39	106
	DCA36G	½	495	11600	11100	10500	10100	60	111
	DCA36H	¾	575	13300	12800	12200	11900	88	117
	DCA36J	1	634	14600	14200	13800	13600	1 17	123
42"	DCA42G	½	385	14700	13600	12500	11800	67	122
	DCA42H	¾	442	16700	15900	15200	14700	95	127
	DCA42J	1	485	18300	17600	17000	16600	1 22	134
48"	DCA48G	½	308	17500	16200	14500	13400	62	158
	DCA48H	¾	354	19800	18800	17600	16800	91	163
	DCA48J	1	382	21400	20500	19500	18900	1 12	169

Performances shown are for units without ducts *BHP does not include drive losses

MOTOR NOTES:

1. All single speed single phase motors are dual voltage (115/230) except ¼ horsepower.
2. All ¼ horsepower single phase motors are single voltage (115 or 230).
3. Two speed motors are single voltage (115 or 230) and not available in 1 horsepower and 1½ horsepower.
4. Maximum capacity of two speed ½ and ¾ HP models is approximately ten percent less than shown on tables.
5. Low speed capacity of two speed fans is approximately one half of maximum.
6. All three phase motors are triple voltage (200/230/460)

These fans are listed by the Canadian Standards Association Testing Laboratories as approved

CERTIFIED RATINGS FOR AIR AND SOUND

Acme Engineering and Manufacturing Corporation certifies that the Super Windmaster Models DC and DCA Skymaster Model EC, Master-Ex Model DDA, Dynamaster Models FQ and FN and Centrimaster Model PW shown herein are licensed to bear the AMCA seal on Air Performance Models DC, EC, DDA, FQ, FN and PW are also licensed to bear the AMCA seal on Sound Performance The ratings shown are based on tests made in accordance with AMCA Standard 210 and 300 and comply with the requirements of the AMCA Certified Ratings Program

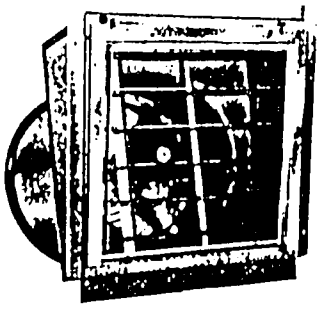
Sound ratings were obtained in accordance with AMCA Standard 300 test setup No 4 Loudness values in sones at a distance of 5 feet were calculated in accordance with AMCA Standard 301 Sound ratings on models above are shown in the following catalogs Model DC in catalog S2C, Model EC in catalog S3B Models FQ/FN in catalog S4B and Model PW in catalog S13C Model DDA sound ratings shown in performance chart on page 7 of this catalog.

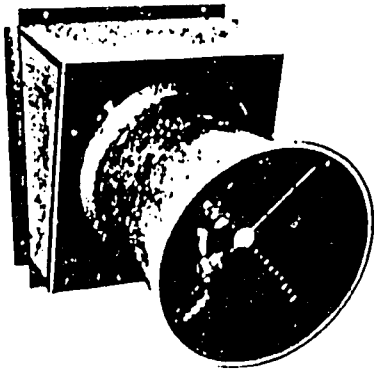
Master-Ex

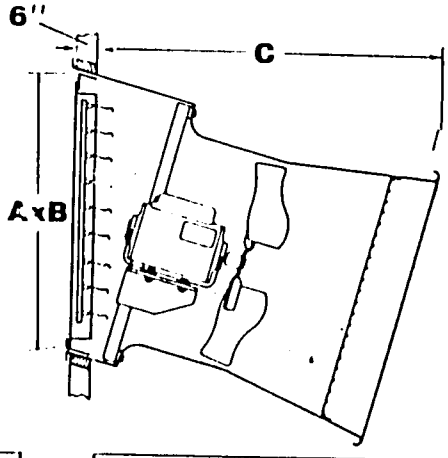
Master-Ex

Each Master-Ex is a complete unit, including unique high performance discharge housing, guards, high efficiency motor, quiet blade and optional shutter. All components are shipped as a package ready for quick and easy installation. Optional shutter must be ordered separately.

The energy efficient design, relatively trouble-free direct drive style and ease of installation make MASTER-EX ideal for the modern horticultural industry.







MASTER-EX...AIR AND SOUND PERFORMANCE
STAINLESS STEEL

FAN MODEL	HP	Nominal RPM	BLADE DIA	VOLT	000" S P CFM CFM/Watt	000" S P BHP SONES	050" S P CFM CFM/Watt	050" S P BHP SONES	100" S P CFM CFM/Watt	100" S P BHP SONES	125" S P CFM CFM/Watt	125" S P BHP SONES	VARIABLE SPEED 000" S P MIN CFM	SHIPPING WEIGHT
DDS12I1	1/10	1580	12"	115	1270 6 7	190* 10	1200 6 2	192* 11	1120 5 7	195* 11	1080 5 5	195* 11	80	21
DDS18E4	1/4	1700	18"	115 or 230	4140 10 0	28 23	4000 9 6	29 22	3850 9 2	30 21	3780 8 8	31 21	1370	89
DDS24F6	1/3	1080	24"	115 or 230	7100 16 6	36 26	6780 15 4	37 25	6450 14 0	39 24	6300 13 6	39 24	2040	119

Data listed is as run performance -- RPM shown is nominal and performance is based on actual speed of tests *WATTS

- Ratings are based on tests with shutter housing and guards in place
- At minimum speed the variable speed fan creates very little static pressure in the building, therefore the low speed performance is listed at 000" S P

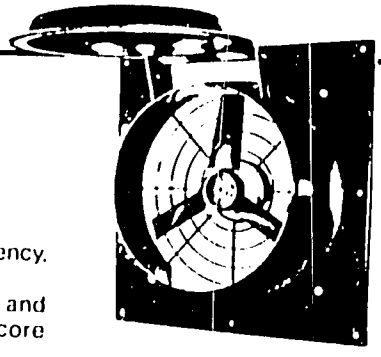
AMCA Seal does not apply to CFM/Watt ratings
Performances shown are for units without ducts

INSTALLATION DIMENSIONS

FAN SIZE	A WIDTH	B HEIGHT	C DEPTH
12"	19⅛"	20⅞"	21"
18"	27⅛"	28⅞"	34"
24"	33⅞"	35⅞"	34"

DynaMasterEX®

The corrosion resistant plastic fan



A BLADE ASSEMBLY BUILT TO LAST...

Dynamaster EX blades are made of polypropylene for added resiliency, durable strength and a consistent shape and angle

The glass-reinforced nylon hub is factory-slotted for the best and most efficient blade orientation and features an aluminum hub core attached firmly to the shaft

. AND AN ENERGY-EFFICIENT MOTOR

The rugged Dynamaster EX split capacitor motor adds the advantage of direct-drive design to the reliability of sealed and permanently lubricated ball bearings Motors operate well at low temperatures and are equipped with thermal overload for low line voltage protection and automatic restart after cooling

A DOUBLE-DUTY INLET GUARD

The Dynamaster EX inlet guard does two jobs at once its PVC-coated metal construction resists corrosion, and its 8-point connection design serves as a sturdy motor mount and speeds field installation So simple, yet so functional to maintain motor position, guard the impeller and lock in an efficient blade/orifice ratio The design even allows four-screw mounting on inside walls, without removing guard or motor

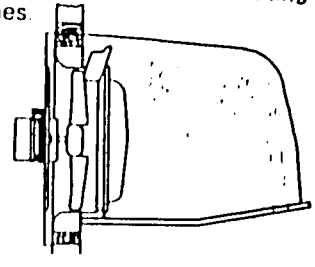
A STURDY, ONE PIECE FAN DAMPER

The ABS plastic fan damper resists drafts and fights corrosion: it's attached by nylon hinges and bolts, and an optional outlet guard is available for easy slide-in installation

The ABS plastic housing works with the door...it resists cracking and splintering in temperature extremes.

WEATHER HOOD

High density polyethylene weather hood with UV inhibitors has out-turned flanges for easy mounting to outside wall Hood should be used where high winds could interfere with damper operation

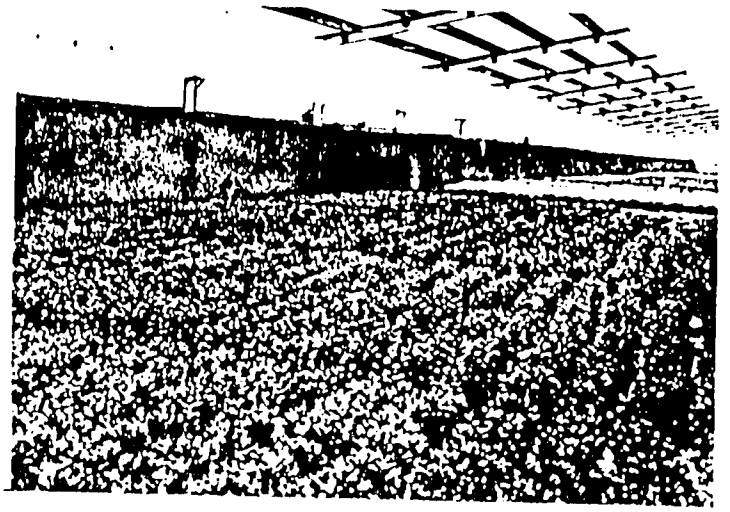


FAN MODEL	HP	NOMINAL RPM	PROP. DIA	VOLT	PERFORMANCE VS. SP (IN WG) 00" CFM	00" BHP	05" CFM	05" BHP	.10 CFM	.10 BHP	.125 CFM	.125 BHP
FCP8B2	1/10	3000	8 25	230	915	163w	885	166w	855	170w	835	172w
FCP12B4	1/10	1625	12 25	230	1430	067	1330	071	1225	066	1160	062
FCP18B4	1/10	1625	18 25	230	2660	089	2445	096	2210	099	2080	100
FCP18F4	1/4	1625	18 25	230	4385	383	4190	382	3980	379	3875	377
FCP24G4	1/2	1625	24 5	230	6885	555	6495	555	6105	555	5910	555

56

kool-cel® ACME'S KOOL-CEL EVAPORATIVE COOLING PAD SYSTEM—

An Idea Yesterday...A Proven Performer Today!



Kool-Cel on Greenhouse

Kool-Cel Pads

Kool-Cel pads are cellulose cooling cells 4" and 6" deep, 12" wide and available in 12" increments from 24" to 72" tall with two pieces of 4" combined to make 84" and 96" tall pads. The cooling cells are made from a specially formulated cellulose paper impregnated with insoluble antirot salts. It is designed with an exclusive cross-fluted configuration which induces highly turbulent mixing inside the pad between the water and the air, and contributes to the evaporative efficiency. The cross-fluted design makes Kool-Cel a strong self-supporting pad with high evaporative efficiency and low pressure drop (resistance to air flow).

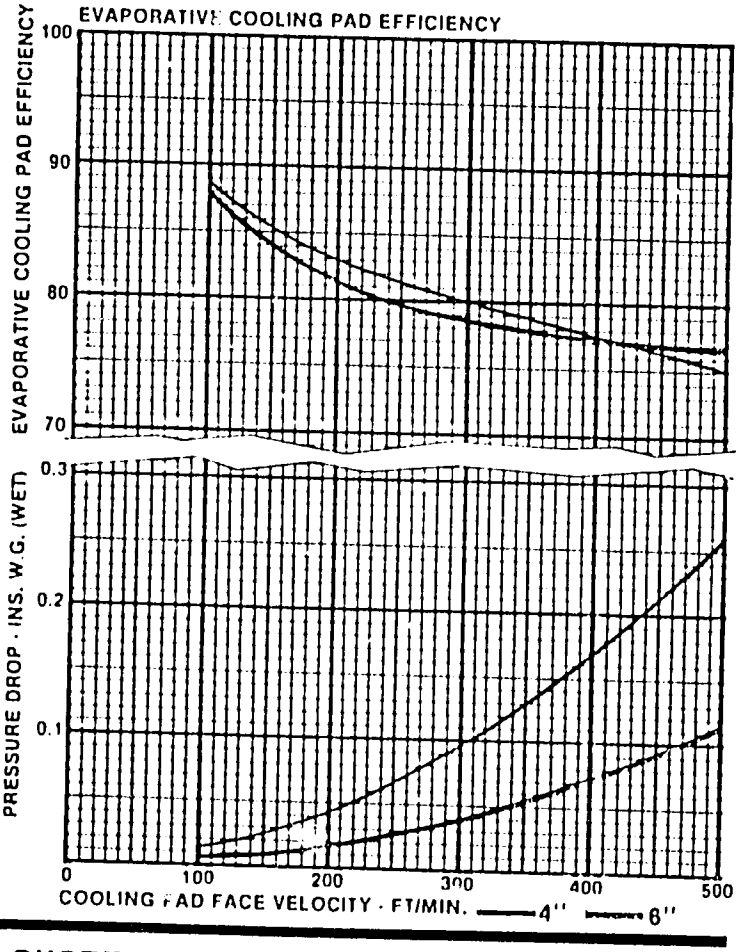
A face velocity of 250 feet per minute for 4" and 400 feet per minute for 6" is recommended for the most economical cost and operation of the Kool-Cel system.

Sizing Kool-Cel Pad

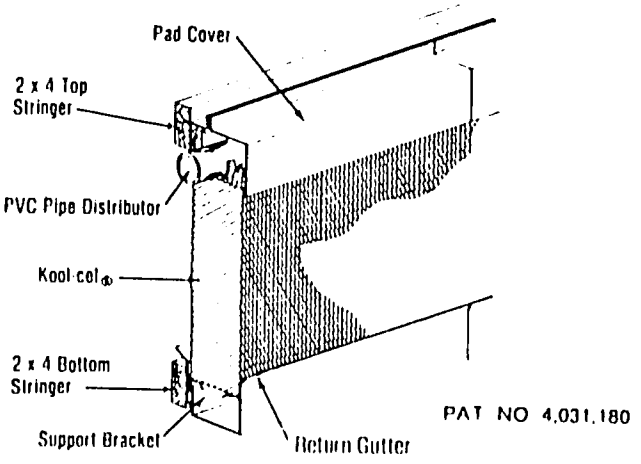
Determine Total Summer Cooling Required in CFM, then divide by velocity to obtain pad area in square feet. The pad area divided by the length will determine the pad height in feet.

$$\text{Total pad area, sq. ft.} = \frac{\text{Total Summer Cooling Required (CFM)}}{\text{Velocity (250-4" 400-6")}}$$

DESIGN



KOOL-CEL® SYSTEM



- HIGH EFFICIENCY COOLING - Exclusive flute configuration achieves higher evaporative efficiency.
- LOW AIR FLOW RESISTANCE - Lower static pressure for higher fan performance.
- ECONOMICAL - 4" deep with 6" performance.
- LONG LASTING - Years of use with proper care.
- STAINLESS STEEL or ALUMINUM water distribution and return systems
- COMPLETELY FABRICATED - Ready for installation and assembly
- COMPLETE SYSTEM - All components including plumbing available — just add sump tank, cover and tank fittings.

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Kool-Cel Distribution & Return System

The system comes complete with a water distributor and cover, return gutter, strainer, pump, and miscellaneous fittings and fasteners to complete the assembly.

The cells are supported at their base by the special support built into the gutter. The water distributor is composed of rigid PVC pipe with metered outlet holes and a removable cover. Flush-out plugs and connection tees are provided to facilitate cleanout and water connection. All hardware and fittings are provided to ease the installation.

The return gutter supports the cells that when wet weighs 2¾ lbs. 4" (4 lbs. - 6") per square foot and, therefore, should be adequately reinforced and supported.

Aluminum System 4"

The aluminum system utilizes quick snap together components for easy installation using a minimum of hardware. The heavy extruded gutter and support are designed to support the pads and carry the water back to a sump with capacities for an 8' x 100' system. The aluminum top cover is made in two pieces to facilitate cleaning the PVC pipe if clogged.

Stainless Steel System 4" and 6"

For those regions where water is highly corrosive, a completely stainless steel system is available. Using a quality stainless steel, a formed gutter and top assembly offers a highly corrosive resistant system while providing strength and ease of installation. All components and hardware are stainless steel or PVC.

Pad Care

Kool-Cel pads are very durable and long lasting. To maximize the life of your pads and keep the efficiency of the original installation, correct any conditions that may be detrimental to the pad.

A. Ph of recirculating water (from sump) must be maintained between 6 and 9 (7 is pure water). If these limits are exceeded, the stiffening agents in the pad will leach out and destroy the pad.

B. Hard water resulting in Calcium Carbonate deposits on the pad is not harmful, but should be kept within limits.

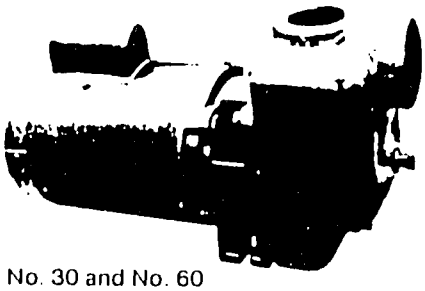
C. Sodium Chloride (salt water) concentrate above 50,000 ppm (approx.) will deposit salt on the pad and reduce air flow. Keep salt concentrates below 50,000 ppm in recirculating water and below 40,000 ppm in make-up water.

D. Algae will grow on any surface that is wet and exposed to sunlight. To help prevent algae build up, follow these tips:
1. Do not draw make-up water from an open pond. Use well water or chlorinated water from city systems.
2. Cover the sump to avoid exposure to sunlight and air-borne particles, and to keep animals from drinking it.
3. Keep the fans running after the pump is shut off to dry the pads, thus killing the algae spores left on the pad.
4. Isolate the water make-up system from any other system.
5. Pads should be shaded from direct sunlight.

E. Air-borne dust and bugs do not seem to clog the air flow passages of Kool-Cel. When the system is running this clogging washes away.

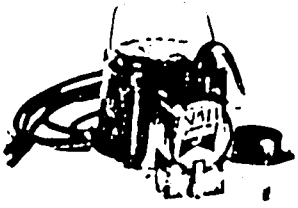
F. When Kool-Cel is installed within reach of poultry or livestock, it should be guarded.

G. Bleed-Off - Since the water is continuously evaporating and being replaced by fresh water, the salts and minerals are left behind in the re-circulating water. To reduce the build-up of deposits and scale a bleed off for the recirculating water is provided.



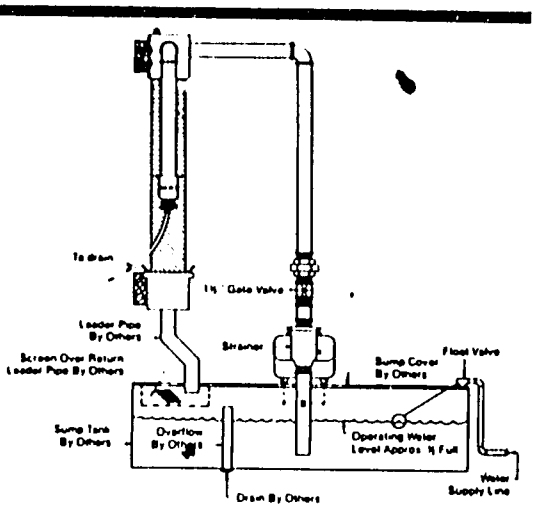
No. 30 and No. 60

These pumps are heavy duty centrifugal, self-priming type featuring high volume and low head pressure performance.



No 15S, No 30S, No 60S

These pumps are submersible type with cast iron housing, polypropylene base and polycarbonate cover. They include a lifetime oil supply and non-clog pumping head and impeller.



The plumbing package is designed for use with all the pumps for the Kool-Cel systems and includes the necessary plumbing fittings and valve to complete the installation from the sump to the distributor and, also, contains the water strainer and float valve.

The sump tank, cover and tank fittings are furnished by others and should be sized to provide ¾ gallon per square foot of 4" pad area and 1 gallon per square foot of 6" pad area.

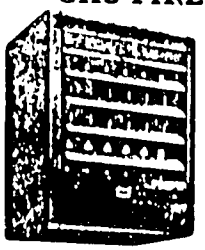
MODEL	TYPE	H.P.	VOLTAGE	CAPACITY AT 10' HEAD	SYSTEM LENGTH 4"	SYSTEM LENGTH 6"
#30	Centrifugal	⅓	115/230/1	42 GPM	70'	55'
#60	Centrifugal	½	115/230/1	55 GPM	100'	80'
#15S	Submersible	¼	115/1	29 GPM	40'	35'
#30S	Submersible	⅓	115/1	42 GPM	70'	55'
#60S	Submersible	½	115/1	63 GPM	100'	80'

The pumps should be sized to provide ½ gallon per minute for 4" and ¾ gallon per minute for 6" of flow per linear foot of pad to insure adequate wetting

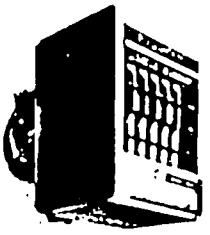
MODINE

GREENHOUSE HEATING/VENTILATING UNITS

GAS-FIRED UNIT HEATERS



PROPELLER MODEL PA



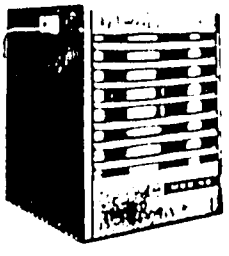
BLOWER MODEL BA

Gas-fired unit heaters are available for greenhouse heating with natural or propane gas Both propeller types (Models PA) and blower types (Models BA) have A G A (American Gas Association) and C G A (Canadian Gas Association) design certification Propeller models are for installation within the area to be heated and cannot be used to distribute air through polytubes or ductwork Blower models can be attached to polytube or ductwork and will operate efficiently against static resistances as high as 0 4" w c Accessory polytube transitions for blower models are available from Modine (Modine catalogs 6-150 and 10-204)

PA, BA* Model No.	BTU/HR Input	CFM @ 70° F PA	CFM @ 70° F BA*	Temp. Rise °F PA	Temp. Rise °F BA*	Ship. Wt. Lbs. PA	Ship. Wt. Lbs. BA
30	30 000	400	–	60	–	50	–
50	50 000	675	617	55	60	72	119
75	75 000	855	925	65	60	97	142
105	105 000	1400	1300	60	60	116	156
130	130 000	1725	1600	60	60	156	218
150	150 000	1900	1850	53	60	156	218
175	175 000	2540	2160	60	60	167	222
200	200 000	2900	2470	53	60	222	300
225	225 000	2900	2800	60	60	222	303
250	250 000	4275	3086	46	60	239	307
300	300 000	4275	3700	53	60	260	328
350	350 000	4400	4320	60	60	352	451
400	400 000	5300	4910	60	60	433	524

*Based on 0 0 external static pressure without blower enclosure

OIL-FIRED UNIT HEATERS



Modine oil-fired unit heaters have a direct-driven propeller fan to provide effective heat throw with automatic operation They cannot be installed and operated with directly connected polytube or ductwork All models are pre-wired, fire-tested and U L listed for fuel oil grades No 1 or 2 (Modine catalog 4-110)

Model	Output BTU/HR	Input GPH	CFM @ 70° F	Temp Rise °F	Max* MTG/HT	Heat Throw	Ship Wt. Lb.
POH100	100 000	0 85	1890	49	12	39	345
POH145	145 000	1 25	2400	56	13 5	50	354
POH185	185 000	1 65	3200	54	12	51	410

*From floor to bottom of unit and deflector blade pitched 45°

STEAM/HOT WATER UNIT HEATERS

HORIZONTAL MODEL HS

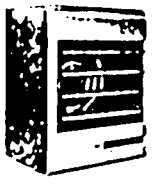
VERTICAL MODEL V

Where a steam plant is available for soil sterilization, steam/hot water unit heaters will be the most economical choice for greenhouse heating Horizontal and vertical air delivery types are offered to suit all applications Cannot be connected to ductwork or polytubes (Modine Catalog 1-150)

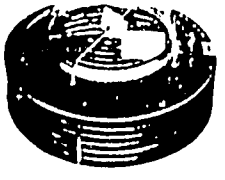
HS Models	CFM @ 60° F	BTU/HR*	Ship. Wt. Lbs.	V Models	CFM @ 60° F	BTU/HR*	Ship. Wt. Lbs.
HS 18	340	18 000	19	V 42	950	42 000	43
HS 24	370	24 000	22	V 59	1 155	59 000	47
HS 33	630	33 000	36	V 78	1 590	78 000	52
HS 47	730	47 000	42	V 95	1 665	95 000	55
HS 63	1 120	63 000	53	V 139	2 660	139 000	78
HS 86	1 340	86 000	55	V 161	2 945	161 000	87
HS 108	2 010	108 000	80	V 193	3 500	193 000	100
HS 121	1 775	121 000	82	V 212	3 610	212 000	112
HS 165	3 240	165 000	104	V 247	4 820	247 000	117
HS 193	2 900	193 000	110	V 279	5 460	279 000	127
HS 258	4 560	258 000	173	V 333	5 980	333 000	185
HS 290	4 590	290 000	183	V 385	7 680	385 000	189
HS 340	5 120	340 000	210	V 500	10 390	500 000	236
				V 610	11,750	610 000	371

*2 PSI Steam and 60° F entering air

ELECTRIC UNIT HEATERS



Cannot be connected to ductwork or polytubes.



HORIZONTAL MODEL HE

VERTICAL MODEL VE

HE, VE Model No.*	KW	BTU/HR†	CFM @ 70° F HE	CFM @ 70° F VE	Temp. Rise °F HE	Temp. Rise °F VE	Ship. Wt. Lbs. HE	Ship. Wt. Lbs. VE
50	5 0	17 065	530	800	29	18	52	39
75	7 5	25 597	530	800	43	25	52	39
100	10 0	34 130	830	940	41	36	66	43
125	12 5	42 660	830		50		66	
150	15 0	51 195	830	1340	60	39	66	43
200	20 0	68 260	1300	1600	52	42	109	43
250	25 0	85 325	1300	1600	65	54	109	69
300	30 0	102 390		2575		34		122
400	40 0	136 520		2575		45		122
500	50 0	170 650		2575		56		122

*A 11 7 H - for 277 480 and 600 volt HE models
†A 11 12 H - for 480 and 600 volt VE models (Modine catalog 2-115)

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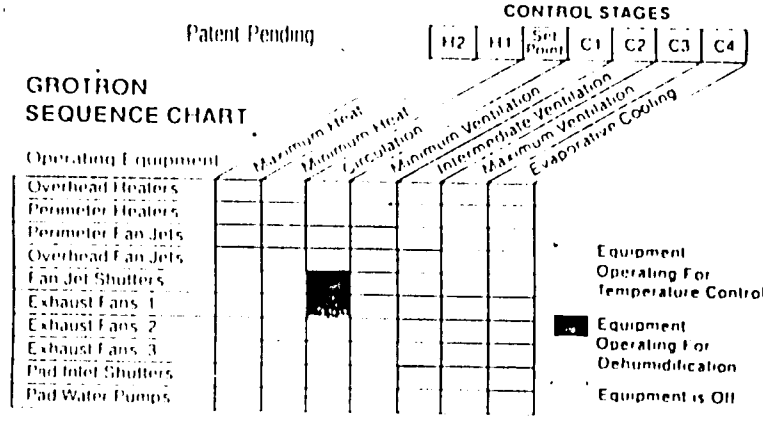
Equipment Controls:

ACME'S Grotron AUTOMATICALLY PROVIDES CONTROL OF GREENHOUSE TEMPERATURE, HUMIDITY AND CIRCULATION DURING EVERY SEASON OF THE YEAR USING MINIMUM ENERGY

NOW FIELD PROGRAMMABLE!!

Patent Pending



REMOTE SENSOR — allows the Grotron to be installed in an office or a secure work area for easy monitoring and less tampering.

SOLID STATE — printed circuits eliminate internal wires that can loosen and cause shorts.

24 VOLT CONTROL - safe, low cost wiring.

12 TERMINALS — 12 separate equipment functions.

8 STAGES — 2 heat, 4 cool, 1 circulation and dehumidification. Equipment activity follows the gradual rise and fall in temperature and humidity in the greenhouse.

STAGE ADJUSTMENTS — each stage adjustable to 15°F from set point for flexibility.

BUILT-IN HYSTERISIS — 1° F differential between on and off switching prevents cycling of equipment.

INDICATOR LIGHTS — Identify stage activity.

SEPARATE HEAT/COOL DIALS — set point range is flexible and determined by the grower in the spread between the heat and cool dials.

SEPARATE DAY/NIGHT HEAT DIALS — photocell automatically switches heat control between day and night settings when photosynthesis starts and stops. Cooling control is not affected and, therefore, there is no need for night cooling lockout.

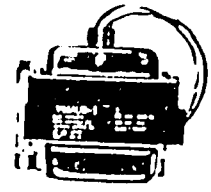
NIGHT MODE — a light indicates when the control is changed to the night setting.

ERROR LIGHT — indicates that the heat dials are set above the cool dial setting or the cool dial is set below the heat setting.

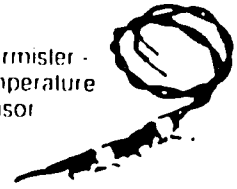
See Cat. C46 for additional information.

STANDARD EQUIPMENT FURNISHED WITH Grotron®

Humidistat
0-90% R.H.



Transformer — 100 VA class 2, 115 VAC — Primary, 25 Vac — secondary



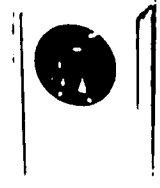
Thermister - Temperature Sensor

Photocell Day/Night Control

ACCESSORIES:

GROTRON SECURITY ENCLOSURE

Protects your settings against tampering by unauthorized personnel. Includes overcenter latch and padlock. A must when installed in a greenhouse.



ASPIRATED THERMISTER

24 Vac - use when no air circulation is provided by Fan-Jet or other means.

VAPOR CAPSULE

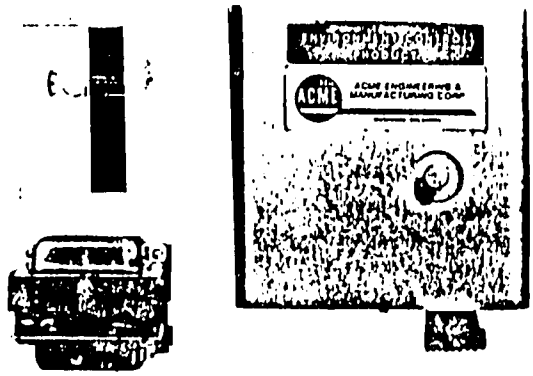
Emits protective vapor continuously for one year. A must when Grotron is installed in the greenhouse.

SENSOR WIRE

Special 18/2 twisted pair with jacket. (Do not use regular 18/2 wire for sensor.)

Team I*

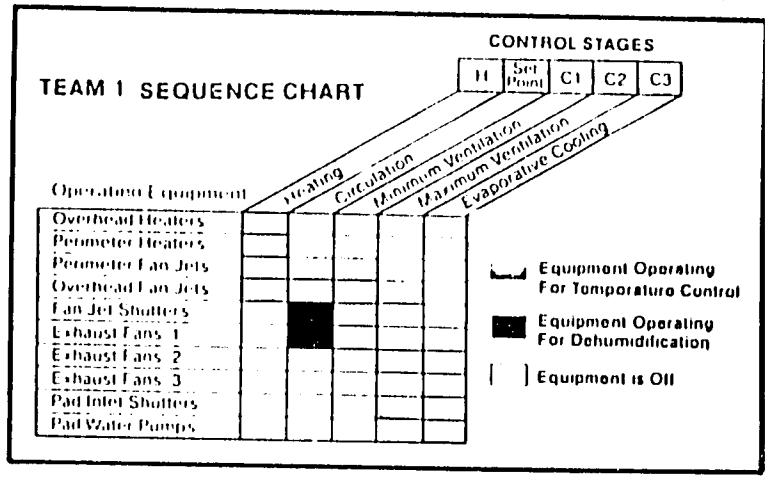
A MECHANICAL CONTROLLER WHICH AUTOMATICALLY TURNS ALL NECESSARY EQUIPMENT ON OR OFF AT THE PROPER TIME AND IN THE PROPER SEQUENCE



*Total Environment Air Manager

- One Heat Stage
- One Circulation Stage
- Three Ventilation and Evaporative Cooling Stages
- Humidity Control
- 24 Volt Control Circuit
- Installs In Greenhouse
- Approximately 3°F Between Stages

The TEAM I is a mechanical sequencer, not adjustable, having a single temperature dial. TEAM I cannot be remotely located from the greenhouse.



FIXED BULB THERMOSTATS

Range 30° - 100°F • Capacity - 1½ HP
- 115/230/1/60 single stage - SPDT
- Two stage - utilizes 2-SPDT switches - 3° differential.

TWO-SPEED SWITCH

115/230/1 – 1½ HP • SPDT with high, off, low position.

HUMIDISTAT

Range 10-90% R.H. – SPDT – 3 wire
125 V.A. 120/240 V.A.C. Pilot duty only

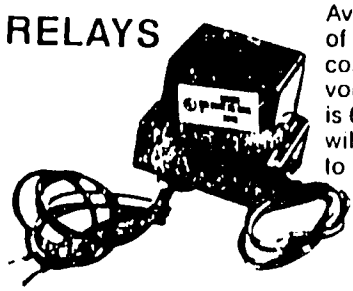
TIMER

For dehumidifying by time
- 115V or 230V • Capacity 1½ HP SPST.
- 10 minute cycle repeating

DISCONNECT SWITCH

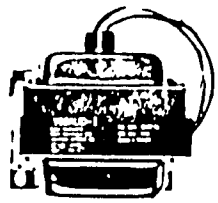
115/230/1 - 1½ HP • DPDT with on-off auto position.

RELAYS



Available in coil voltages of 24, 115 and 230 and contact ratings up to 230 volt. (24 volt coil load is 6.0 va). Contacts will handle up to 1½ HP.

24 volt relays required with Grotron and Team 1



TRANSFORMER

115 V primary, 24V secondary
- 100VA; class 2 (included in Grotron and Team 1 controllers.)

230V primary also available.

SPEED CONTROLS

- Variable speed control – 115V or 230V For use with Master-Ex, Dynamaster, and CentriMaster 100 and 110 only
- Two speed switch for manual control of two speed fans

It goes without saying that it is impossible that the total flux output of the fitting is completely used for the crops. A part is lost by obstacles like columns, pipes, etc.
That part of the light flux that really reaches the working plane is called the utilization factor. Under normal conditions utilization factors of 76% are easily obtained by PL-830 fittings.

4.3.9. Conversion set PL-830

The typical construction of the PL-830 fitting permits the use of the reflector with built-in socket to be used as an independent unit.
Obsolete fittings, of any make, of which the control gear is still in good working order, can be made up to date with the conversion set.
A much higher light output, better uniformity and reduced mounting height will be obtained.

4.3.10. Application PL-830

The fitting PL-830 is used in those situation where only reduced mounting height is available, as is the case in multilayer culture systems. The lay-out of the fitting has to be chosen carefully. A number of often encountered situations is given in the table below.

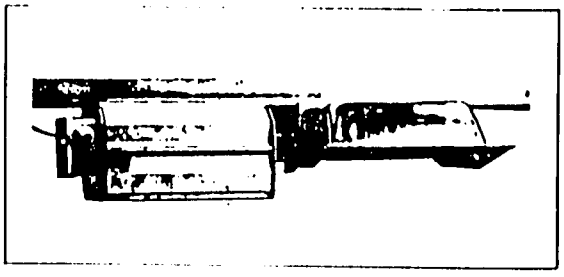
Application table PL-830/N 400, with a net output of 37.000 lumen per fitting

light level in lux	square m per fitting	support rail distance in m.	fitting distance in m	mounting height in m
2000	18,5	6,70	2,76	1,52
2500	14,8	6,00	2,45	1,36
3000	12,4	5,50	2,25	1,25
3500	10,6	5,00	2,10	1,15
4000	9,25	4,75	1,95	1,05

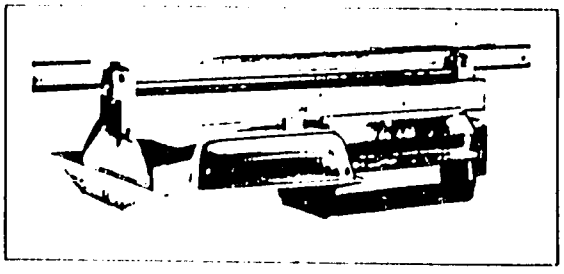
Of course other and quite different solutions are possible
In order to make a reasonably accurate estimation of the fitting lay-out, following "rule of the thumb" may be used
As long as the distance between the support rails lies between 3,6 and 4,4 times the mounting height and the distance between the fittings on the support rail is not over 1,6 times the mounting height, a uniformity of over 80% is assured.
Because the configuration of the PL-830 fittings has to be exactly determined, it is necessary to contact Poot Lichtenergie or your local dealer. The solutions rendered will always be based upon the principle of maximum uniformity at minimum cost.

4.3.11. PL-830 systems at work

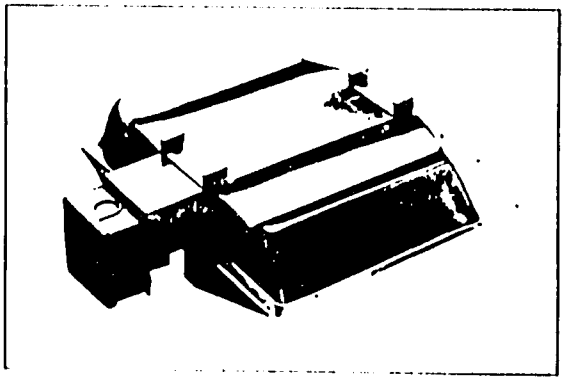
The PL-830 fitting is suitable for mounting in line as well as for individual mounting
In the first case the support rails are installed and the pre-prepared cables laid in the cable groove of the rails
The reflectors and the ballast-units are "clicked" onto the rails with a single movement
Connection of the cables is done in the connectionboxes, so the fitting itself does not have to be opened
In the case of individual mounting, a piece of support rail with a length of



Side view of fitting PL-830.



Movable version of fitting PL-830.



Conversion set PL-830.

LS SHADE AND HEAT RETENTION FABRICS

All growers face three control problems:

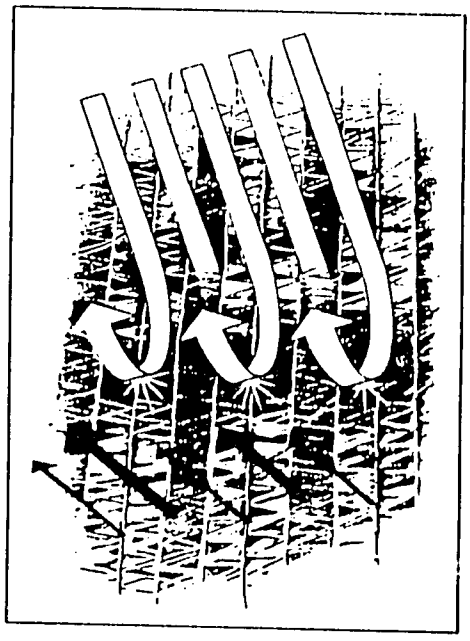
1. Light
2. Temperature
3. Humidity

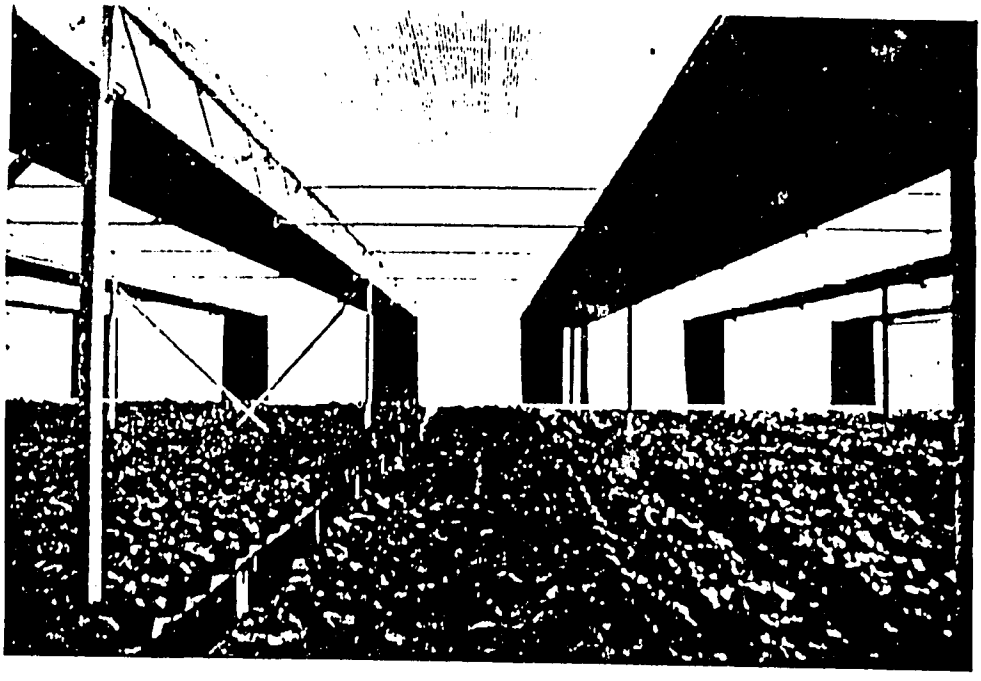
With LS fabrics and a Sharp's shade and heat retention system you can solve all three.

SOLUTION NO. 1: Special LS screens allow the degree of shading to be varied from 20% to 99.9%.

SOLUTION NO. 2: LS screens are composed of polyester and aluminum woven in strips. When placed on the roof and housefront these screens virtually eliminate temperature stratification in the greenhouse and result in increased productivity through the maintenance of constant temperature levels.

SOLUTION NO. 3: LS fabrics are slightly permeable so when they are closed water vapour can escape. Yet by closing the curtains some water vapor will be trapped and the screens can be used to boost humidity during warm frost-free periods. All LS fabrics are completely non-drip under normal circumstances.





This investment can pay for itself in as little as one year:

- Very high energy savings
- Lower water consumption
- Reduced risk of boiler stoppages
- Less use of pesticides
- Earlier crop production
- Improved product quality
- Long service life
- Minimum need for white wash
- Greenhouse enlargement does not automatically require increased boiler capacity.

Screen composition can range from 100% clear polyester to 100% pure aluminum. A sample of LS 16 for example will have one strip of clear polyester and two strips of pure aluminum. This configuration in a closed position will provide 65% shading and about 60% energy savings.

Their high degree of reflection, great flexibility, and low mass create very little shading in the open position.

FABRIC	SHADE	ENERGY SAVING	NOTES
LS10	80%	45%	All crops day & night
LS11	95%	70%	All crops day & night
LS11+1	99.9%	75%	Mums, Points, etc.
LS11+7	95%	75%	Mums, etc.
LS13	30%	50%	Hybiscus, Carnations
LS 14	40%	50%	Carnation, Roses
LS 15	50%	55%	Gerbera, Cyclamen
LS 16	65%	60%	Fresia, Tomato
LS 17	75%	65%	Foliage plants
LS 18	85%	70%	Foliage plants

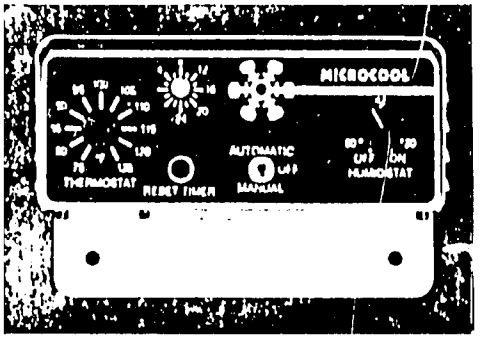
A NEW GENERATION OF SHADE/HEAT RETENTION FABRICS

GREENHOUSE FOGGING SYSTEM

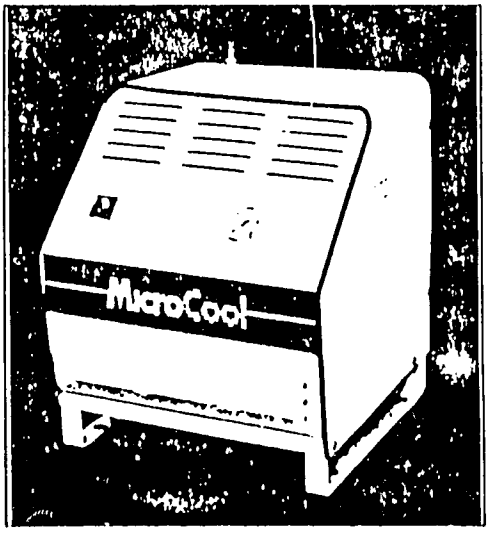
The MicroCool system produces an even distribution of atomized micron size water particles (fog), which evaporate in the air to provide uniform cooling and humidifying throughout both natural and fan ventilated houses. In contrast to Pad cooling, minimal fan usage is required (saving energy) and temperature gradients are eliminated.

Pump Module: A special feature of MicroCool is its space saving pump module. The base of the MicroCool 100 measures 15"x20". High quality Baldor motors and Hydrocell pumps are used to ensure reliable, trouble - free operation. The pump is a quiet, pulsation free, diaphram type with no cups, packings, sleeves or greasing. It is unaffected by change in water pressure and can even run dry.

Water Filtration and Treatment: The water supply first passes through a 10 micron filter and then through a second filter housing containing special water conditioners to prevent nozzle scaling. Finally the water is filtered for a third time through an even finer 5 micron filter before entering the pump.



Automatic Controls: The MicroCool electronic control box operates on a 24 volt circuit and is wired to the pump module controls. It can be positioned at any convenient location in the greenhouse. Time, temperature, and humidity can all be set. The greenhouse operator can adjust the controls to create the exact climate required for maximum growth and propagation.



- Cost Effective
- Even distribution
- Uniform Cooling
- Minimal Fan Use
- Compact
- Reliable
- No temperature gradients
- Minimal maintenance
- Proven Durability

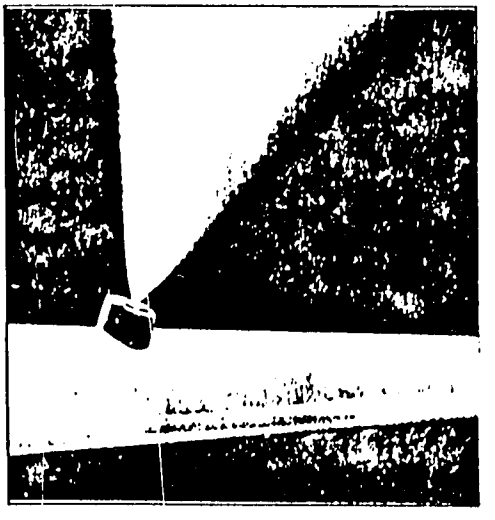
PORTABLE FLEXI FOGGER

An affordable do-it-yourself fogging system for the small grower (up to 7,000 sq. ft.). Essential for propagation, germination and plug operations. Includes humidistat and sensor for reliable climate control. Operates up to 100 nozzles. Can also be used as pressure washer.

Tubing: MicroCool 1/2" tubing is custom extruded, schedule 80 ultra violet resistant PVC specially reinforced to withstand high temperatures and is rated to 1200 PSI. The tubing is connected with threaded brass couplings and sealed with a high pressure pipe joint compound.

Nozzles: MicroCool nozzles are inserted directly into the tubing. At 600 PSI they provide 10 micron atomized water particles which flash evaporate while floating through the air. The unique design of the nozzles ensures that there is no dripping or condensation.

Drainage: The system will automatically drain when turned off, ensuring that no damage occurs to the nozzles from stagnant water.



Warranty

MicroCool systems have a 1 year factory warranty on all parts.

Technical Specification

System Size	Voltage	HP	Operational GPM	Nozzles In System
MC 100	110	1½	2	100
MC 200	220	2	4	200
MC 300	220	3	6	300
MC 400	220	5	8	400

Note: Electric motors are single phase. MC 300 and 400 systems are available in 3 phase power.