PILOT FRUIT DRIER FOR LOS AZUFRES GEOTHERMAL FIELD MICHOACAN, MEXICO

DOE/ID/13040--19

DE93 008560

FEBRUARY 1993

DISCLAIMER

Work Performed Under Grant No. DE-FG07-90ID13040

For
U. S. Department of Energy
Office of Industrial Technologies
Washington, D.C.

By
Geo-Heat Center
Oregon Institute of Technology
Klamath Falls, OR 97601

DOE/ID/13040-19

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for
Los Azufres Geothermal Field
Michoacan, Mexico

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For

Los Azufres Geothermal Field
Michoacan, Mexico

Prepared For:

Gerencia de Proyectos Geothermoelectrios
Comision Federal de Electricidad
Morelia, Michoacan, Mexico

Prepared By:

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Klamath Falls, OR 97601

DISCLAIMER STATEMENT

This report was prepared with the support of the U.S. Department of Energy (DOE Grant No. DE-FG07-90ID 13040). However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the view of DOE.

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Introduction

Comision Federal de Electricidad (CFE) has a Division in charge of the exploration of a geothermal reservoir located in Los Azufres, State of Michoacan. At present, CFE is only using the steam of the wells and rejecting the hot water that comes off associated with the steam.

CFE is interested in promoting the use of the hot water in industries with high consumption of heat. So far, they have installed a chamber for drying lumber (wood) with very good results. Several local industries are interested in constructing facilities at Los Azufres and to buy the heat from CFE. They have constructed a greenhouse to grow flowers in winter and produce gladiolus bulbs.

Since the region of Los Azufres is mainly a fruit producer (peaches, pears, apples, guava, etc.), they propose to install a small "fruit drier" for demonstration purpose. They are confident that if they succeed in showing the feasibility of drying fruit with geothermal water, they will have a demand for larger drying installations.

Based on a trip to the Los Azufres geothermal field in December of 1992, a design for a pilot geothermal fruit drier was undertaken for CFE. The details of the geothermal field and the local fruit production are detailed in an attached report prepared by Engineer Miguel Rangel.

Fruit Drying

The fruit in the area is mainly pears. Thus, the drier was designed for this purpose; however, other fruits can also be dried in the same drier.

The processing and preparation of the fruit is based on a 1946 report prepared by the California Agricultural Experiment Station (Bulletin 698). No new publications are available; however, the information is still valid according to Dr. James Thompson of the Agricultural Engineering Station at U.C. Davis. A copy of Bulletin 698 is available in the Geo-Heat Center library.

Drying Tray Design

Two trucks will be used; each 100 cm x 100 cm by 182 cm high when loaded with trays. The truck will have a base with four casters (pivot wheels) and a detachable handle that can be attached at either end. This will allow the trucks to be reversed when halfway through the drying process time. The base will be of plywood approximately 2 cm thick. The trucks will each carry 30 trays.

The trays will be constructed of 1 cm thick plywood and have a 5 cm high by 2 cm wide wood strip attached to either edge. The plywood will have 1 cm diameter holes drilled in them for drainage.

The trays are each designed to carry approximately 13.5 kg of moist fruit, or approximately 800 kg total for the 60 trays on two trucks. These weights will vary, depending on the type of fruit and placement on the trays.

Building Design

The drier building will be about 400 cm long, 135 cm wide and 320 cm high. The actual dimensions will depend upon the size of local building materials.

The walls will be constructed of concrete block, the ceiling and roof of timber and the floor of placed concrete. The floor will have a slight depression down the middle and slope towards the front doors for ease of cleaning. The fan motor will be housed on the roof away from the hot air stream.

The trucks and walls will be designed so that there is about 2 to 2 1/2 cm of clearance on either side and at the top.

Louvered doors will be provided for entering, recirculation and leaving air. The louvers will be manually set, but could be set automatically as controlled by temperature sensors.

Heat Exchanger

The required air flow for fruit drying is about 152 m/min (500 ft/min). Assuming the trays and fruit block 70% of the tunnel, then the cross section for air flow will be 1 m x 2 m x 0.30 = 0.6 m^2. Thus, a capacity of 90 m^3/min (2700 ft^3/min) will be needed. Converting this requirement to 3000 m (10,000 ft) elevation, a capacity of 120 m^3/min (4500 ft^3/min) will be necessary at Los Azufres.

A minimum 0°C (32°F) outside entering air temperature and a 71°C (160°F) drying temperature was assumed. The geothermal resource was assumed to enter at 121°C (250°F) and exit at 99°C (210°F). Based on these assumptions, the required heat exchanger will need two rows of 8 tubes at 91 x 91 cm (36 x 36 in) cross sections.

The geothermal flow rate can be adjusted by a valve to compensate for changing outside air temperature. A three-way valve with a temperature sensor could be used for automatic control.

The coil model number from Pace is: 82HW-36.0 x 36.0 - A-6/8. The estimated price is $800; however, it can probably be purchased for less.

Fan Unit

The tube axial fan was designed for 120 m^3/min (4500 ft^3/min) and 2 cm (3/4 inch) of water pressure loss (air flow friction loss). This will require 1.05 BHP or a 1.5 hp motor. The fan will be 45 cm (18 inches) in diameter and have 5 blades with a 10.5° blade tip pitch. Due to the high temperature of the air flow, the fan motor will have to be located on top of the building outside of the air stream. Details of the fan and housing are on the attached diagram.

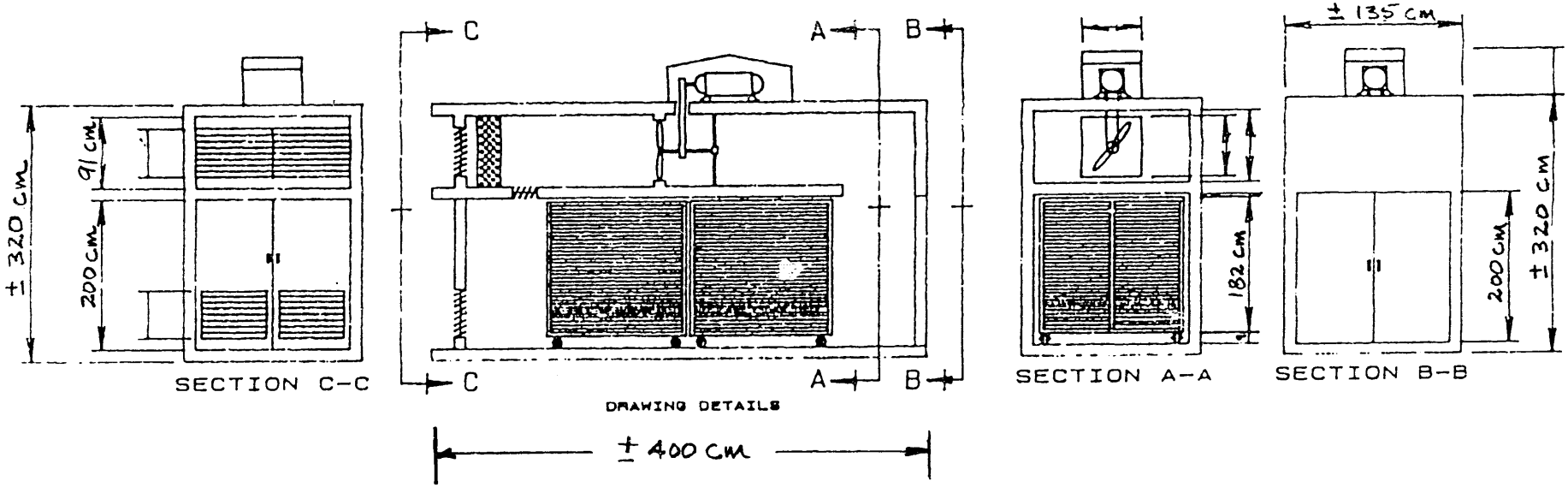
The estimated cost is $1650, but this again is probably high. The fan specification from Pace is: 18D-6H-5R11-10.5T.

Construction and Operation

It is estimated that this unit will be constructed with local materials during the Spring of 1993. Operation will begin for the Summer/Fall 1993 harvest season.

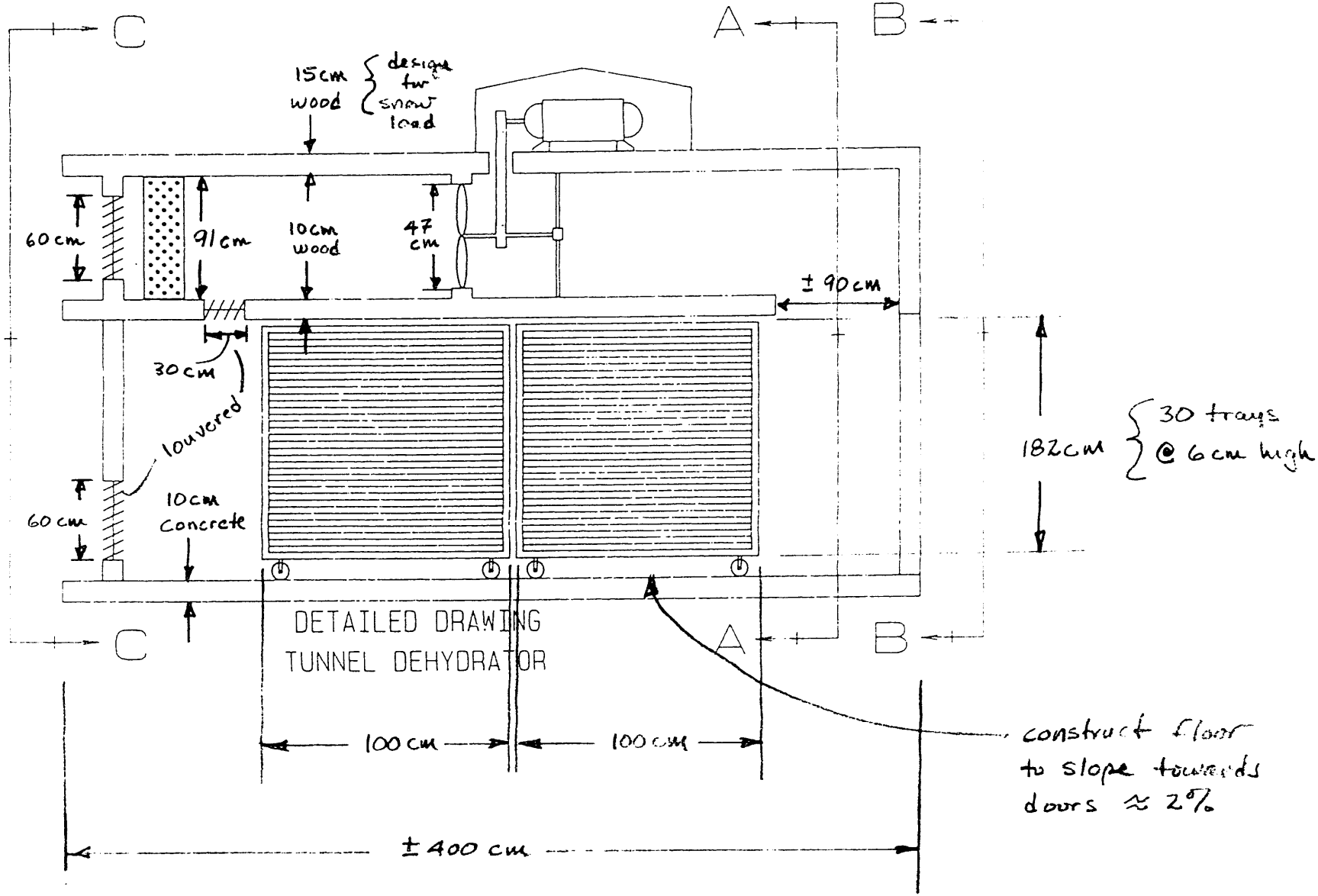
The actual temperature and air flow rates will have to be adjusted by trial-and-error to achieve the proper final product in terms of moisture and color.

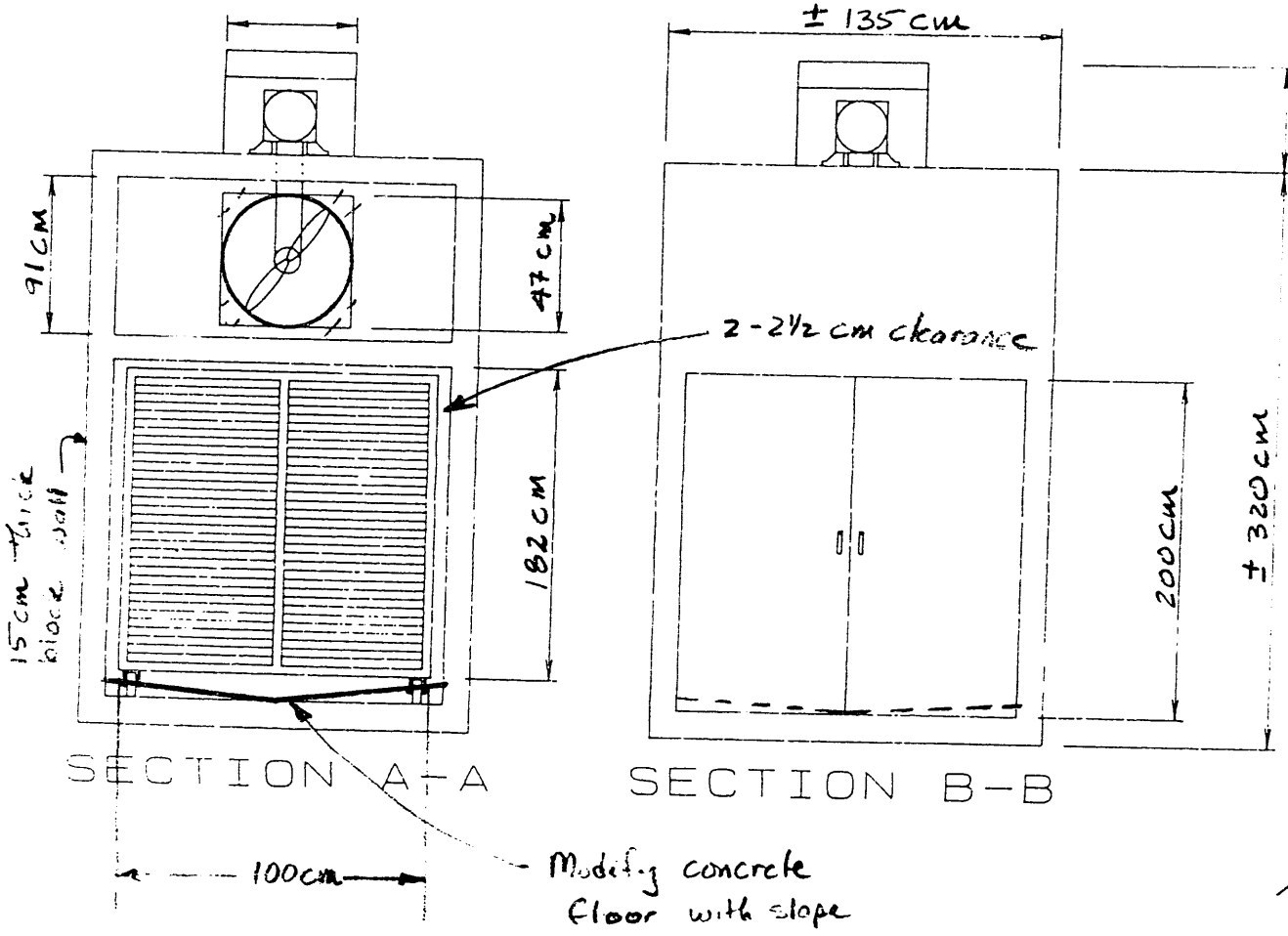
APPENDIX



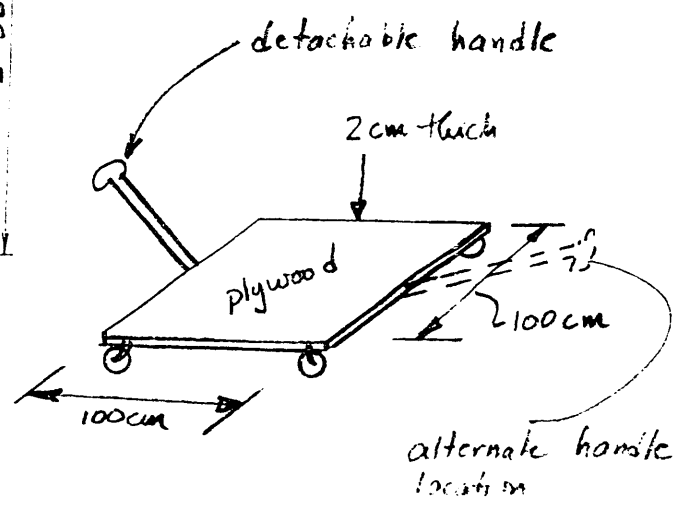
TUNNEL DRYER

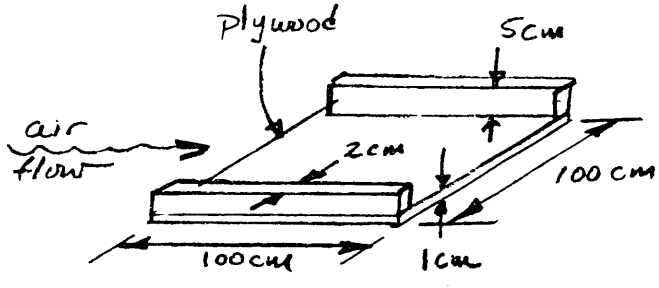
Tunnel Dryer,
Design Details


C
A
B
15cm wood
design for snow load
60 cm
91 cm
10cm wood
47 cm
± 90 cm
30 cm
louvered
182cm
30 trays @ 6cm high
60 cm
10cm concrete
DETAILED DRAWING
TUNNEL DEHYDRATOR
100 cm
100 cm
construct floor to slope towards doors ≈ 2%
± 400 cm

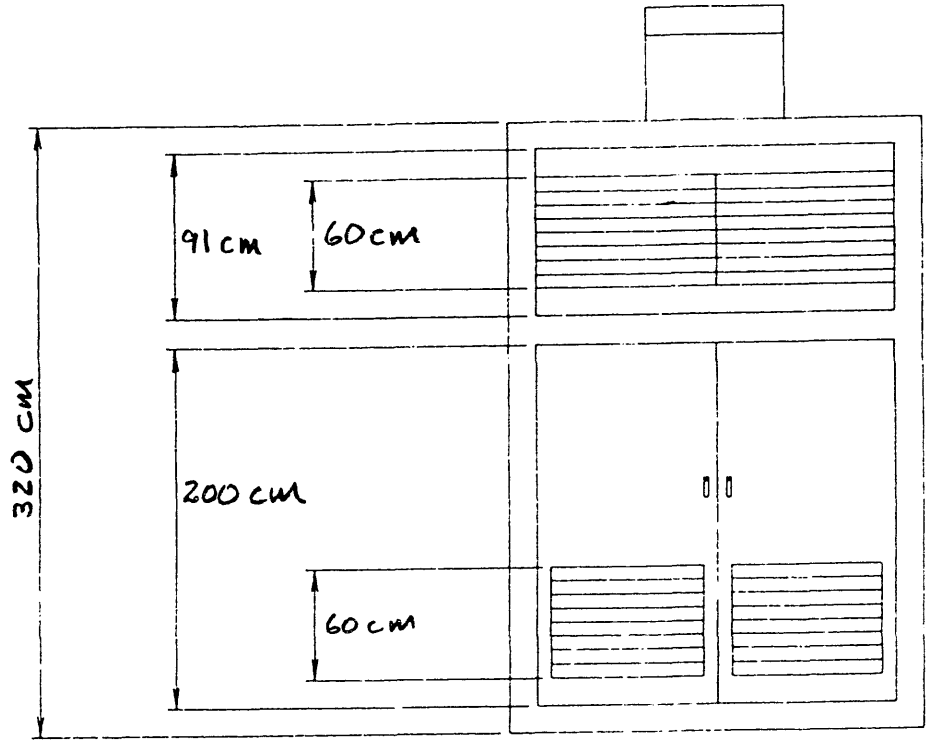


TRUCK BASE DESIGN

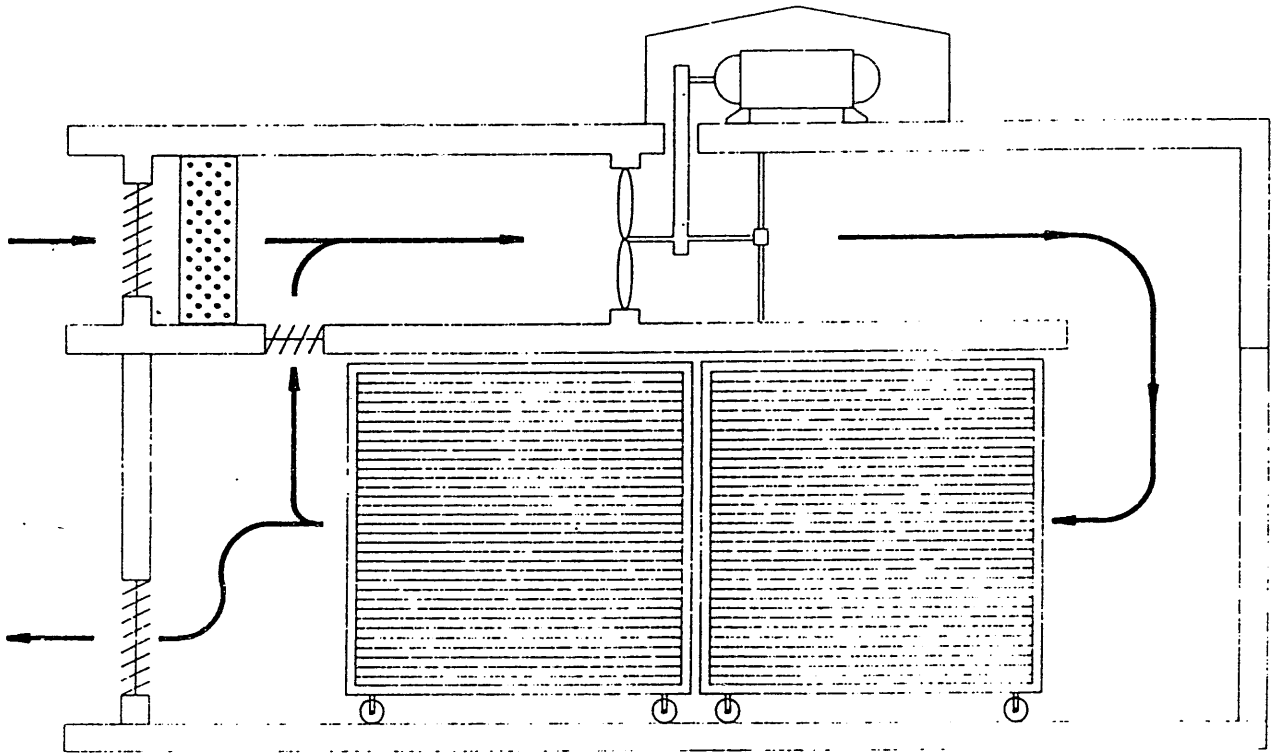




TRAY DESIGN
(30 per truck)



SECTION C-C



AIR FLOW PATTERN

PACE
ENGINEERED SALES
Quality HVAC Products Since 1948

PACE Engineered Sales
9460 S.E. Lawnfield
Clackamas, Oregon 97015
Phone (503) 652-7177
Fax (503) 652-7196

Budget Pricing

To: John Lund

Re. Fan Selection/pricing, Coil pricing

Please see fan curve attached, budget price for one 18D-oH-3R11-10.5T Tube Axial PACE Fan, $1450

Budget price for one 82 HW 36 x 36 A 6/8 Hot Water Coil, 5795.

Please give me a call if you have any questions.

Cheers,

1/ 5/93 @ 17:01

B-R-O-D & Mc-C-L-U-N-G P-A-C-E C-O

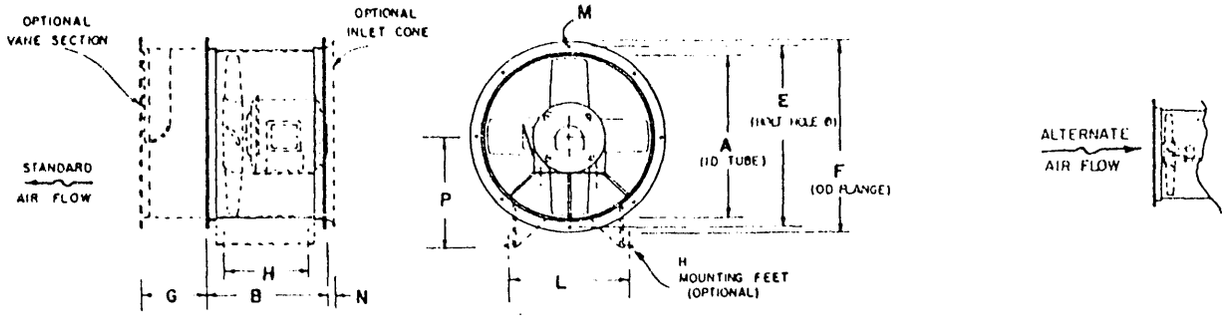
C-O-I-L S-E-L-E-C-T-I-O-N P-R-O-G-R-A-M
W-A-T-E-R H-E-A-T-I-N-G & S-E-N-S-I-B-L-E C-O-O-L-I-N-G
****

-PACE Coil Model Number-

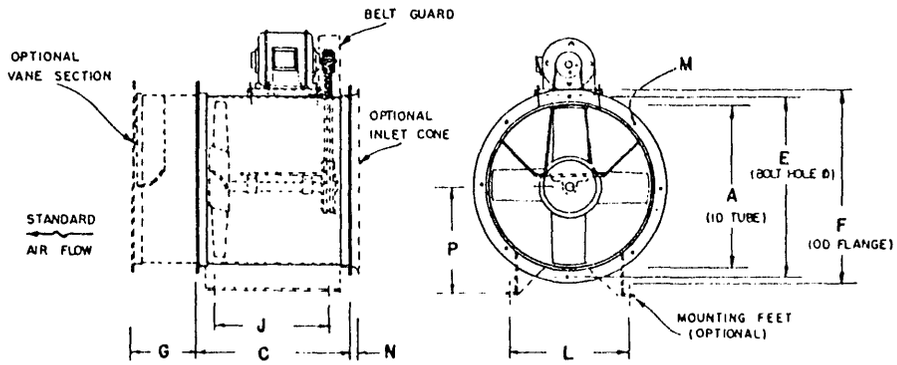
8 2 HW - 36.0 X 36.0 -_A- 6/ 8

Item Number Identifier	Fruit Dryer
Standard Air Flow Rate (CFM)	2666.
Actual Air Flow Rate (CFM)	4500.
Elevation (Ft)	10000.
Density Ratio	.592
This selection is for DRAW-Thru Configuration	
Entering Air Dry Bulb Temperature (F)	32.0
Leaving Air Dry Bulb Temperature (F)	159.5
Entering Water Temperature (F)	250.0
Leaving Water Temperature (F)	210.0
Total BTU/HR for Each Coil	370616.
Gallons per Minute Each Coil	18.53
Gallons per Minute per Feed	3.09
Coil Face Area (Sq. Ft.)	9.00
Standard Face Velocity (FPM)	296.2
Actual Face Velocity (FPM)	500.0
Rows Required for 8 -FPI	2.00
Rows Required for 10-FPI	1.66
Rows Required for 12-FPI	1.43
Air Pressure Drop @ 8-FPI (In WG)	.10
Number of Tubes Fed (circuits)	6
Number of Passes	8
Water pressure Drop (Ft. of H20)	2.82
Connection Size (In)	1.50

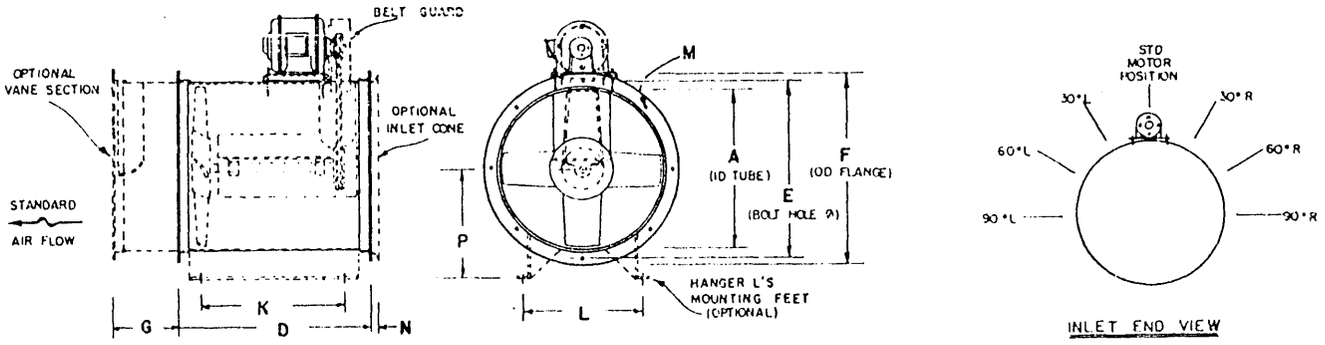
TUBE AXIAL FANS "TA"



DIRECT DRIVE



BELT DRIVEN MOTOR EXTERNAL OPEN DRIVE (M.E.O.D.)



INLET END VIEW

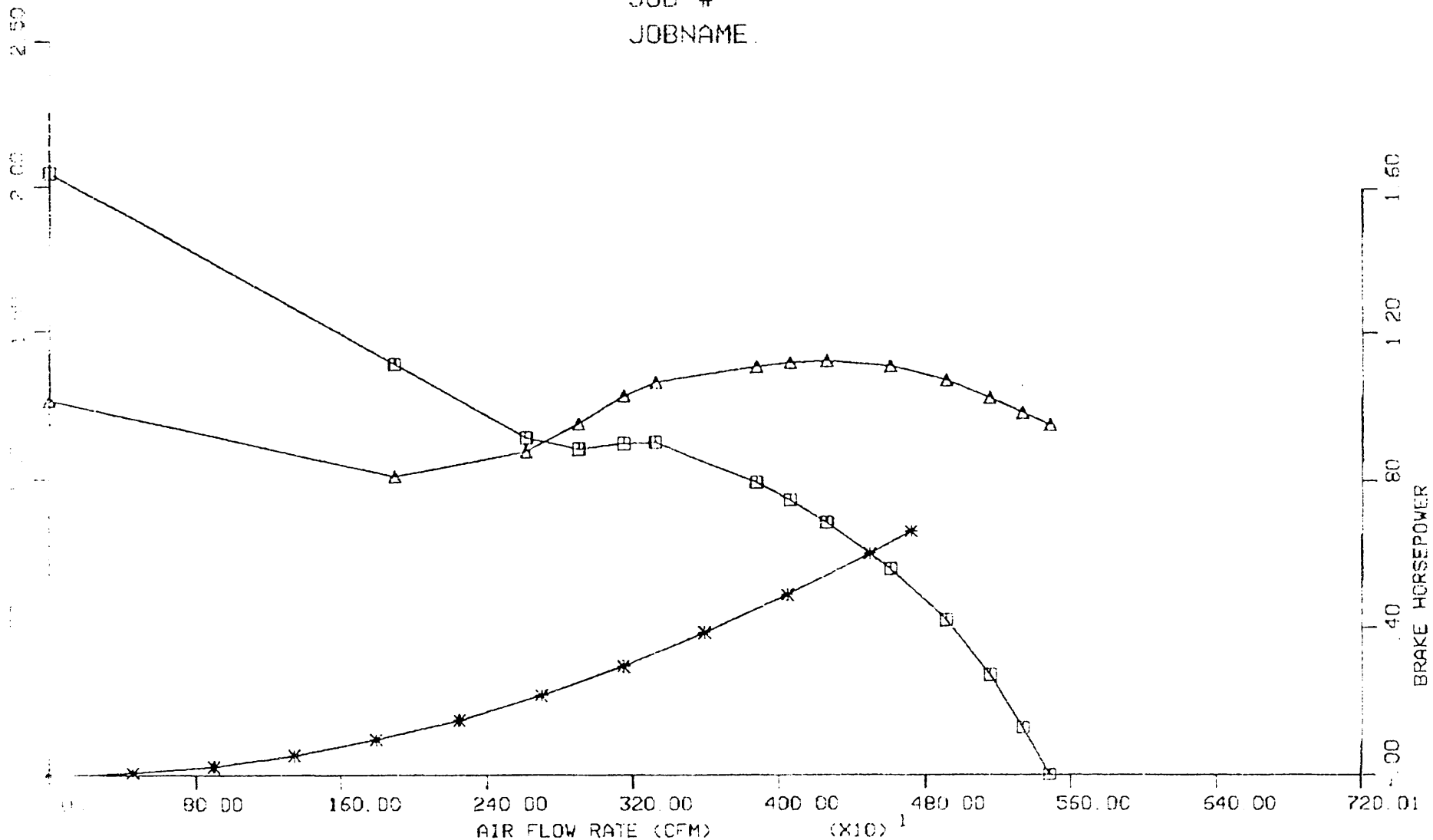
BELT DRIVEN MOTOR EXTERNAL ENCLOSED DRIVE (M.E.E.D.)

SIZE	A	B	C	D	E	F	G	H	J	K	L	M	N	P	SHAFT
15	15-3/8	15	25-1/2	32	16-9/16	17-9/16	8	11	21-1/2	28	12-1/2	8 - 3/8" Ø	3	11-3/4	1-7/16
18	18-3/8	16	26	32	19-9/16	20-9/16	8-1/2	12	22	28	14-1/2	8 - 3/8" Ø	3	13-1/4	1-7/16
21	21-3/8	19	27-1/2	32	23-1/16	24-9/16	9	14	22-1/2	27	16-3/4	8 - 1/2" Ø	3	14-3/4	1-7/16
24	24-3/8	19	28	32	26-1/8	27-5/8	9-1/2	14	23	27	19	8 - 1/2" Ø	3	16-9/16	1-7/16
27	27-3/8	20	28-1/2	32	29-1/8	30-5/8	10	15	23-1/2	27	21	8 - 1/2" Ø	3	17-13/16	1-7/16
30	30-3/8	23	29	32	32-1/8	33-5/8	10-1/2	18	24	27	23-1/2	8 - 1/2" Ø	4	20-5/16	1-7/16
32	32-3/8	23	29-1/2	32	34-1/8	35-5/8	10-1/2	18	24-1/2	27	24-1/2	8 - 1/2" Ø	4	21-5/16	1-7/16
34	34-3/8	23	30-1/2	41	36-1/8	37-5/8	11	18	25-1/2	36	26	8 - 1/2" Ø	4	22-5/16	1-11/16
36	36-3/8	27	32	41	38-3/4	39-3/4	11-1/2	22	27	36	27-1/2	16 - 1/2" Ø	4	23-3/8	1-11/16
40	40-3/8	27	34	51	42-3/4	44-3/4	12	21	28	45	30-3/8	16 - 1/2" Ø	4	25-3/8	1-15/16
44	44-3/8	29	34-1/2	51	46-3/4	48-3/4	12-1/2	23	28-1/2	45	33-1/8	16 - 1/2" Ø	5	28-3/8	1-15/16
48	48-1/2	29	35	51	50-7/8	52-7/8	13	23	29	45	36	16 - 1/2" Ø	5	30-3/8	1-15/16
54	54-1/2	31	37	58	57-3/8	59-7/8	14	24	30	51	40-3/8	16 - 1/2" Ø	5	33-3/16	1-15/16
60	60-1/2	33	38	64	63-3/8	65-7/8	15	26	31	57	44-1/2	16 - 1/2" Ø	5	36-3/4	2-3/16
66	66-1/2		39	64	69-3/8	71-7/8	16		32	57	51	16 - 1/2" Ø	5	39-1/2	2-3/16
72	72-1/2		40	64	75-3/8	77-7/8	17		33	57	57-3/4	16 - 1/2" Ø	5	42-1/2	2-3/16
84	84-1/2		44-1/2	88	87-3/8	89-7/8	18-1/2		37-1/2	81	67-3/4	24 - 1/2" Ø	6	49-1/4	2-7/16

Seal Cover

□ = STATIC PRESSURE
△ = BRAKE HORSEPOWER
■ = SYSTEM CURVE

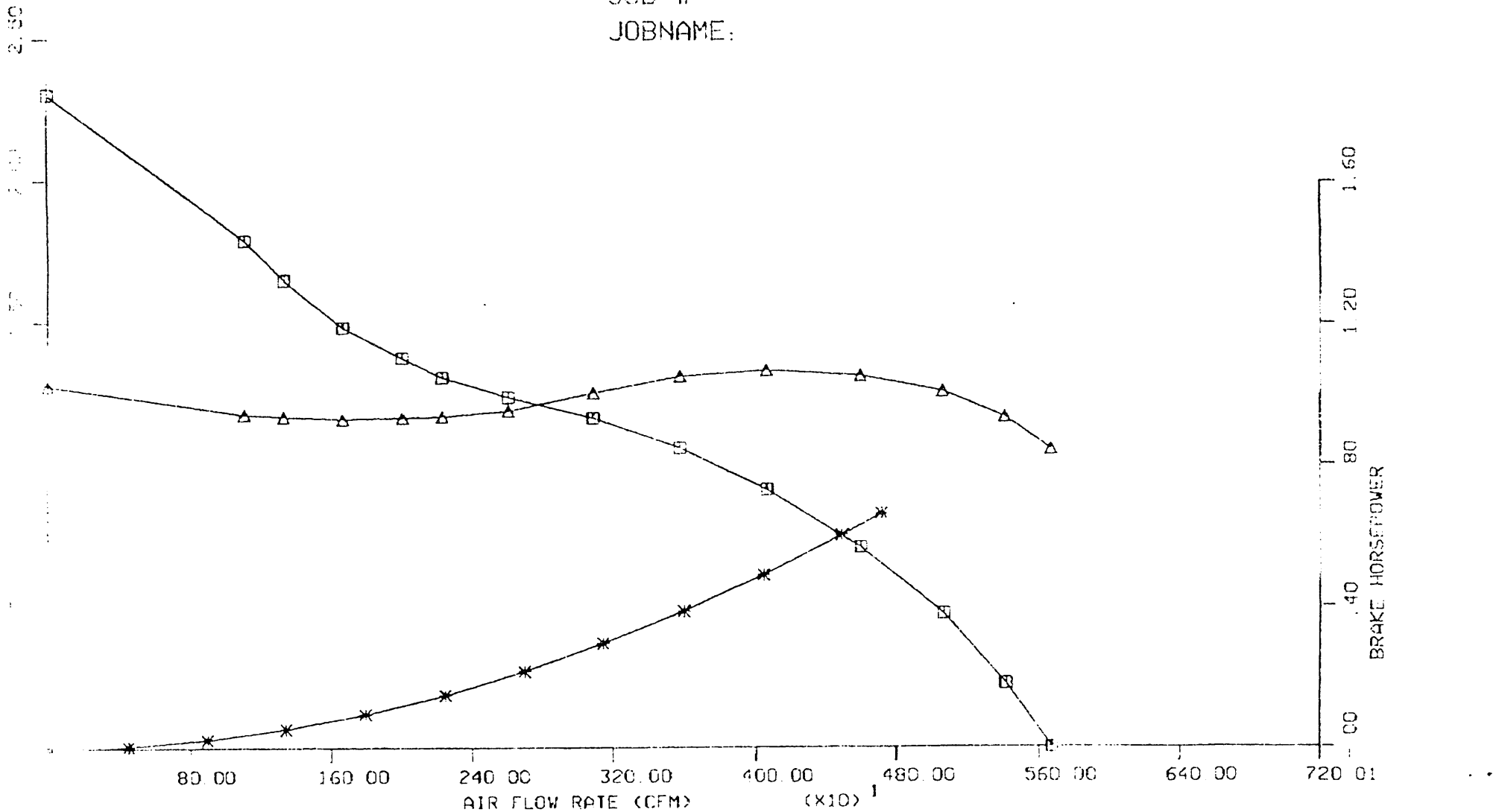
BROD & McCLUNG - PACE Co. PORTLAND, OR
SIZE 18D-6H-5R11-17.5T
2287 RPM 0750 #/CF INLET AIR DENSITY
INLET VOLUME = 4500 CFM BHP = 1 11
DISCHARGE STATIC PRES. = 0 750 IN. W. G.
JOB #
JOBNAME.



10,000 ft

⊡ = STATIC PRESSURE
△ = BRAKE HORSEPOWER
✱ = SYSTEM CURVE

BROD & McCLUNG - PACE Co. PORTLAND, OR
SIZE 18D-6H-5R11-10.5T
3158 RPM .0451 #/CF INLET AIR DENSITY
INLET VOLUME = 4500 CFM BHP = 1.05
DISCHARGE STATIC PRES. = 0.750 IN W.G
JOB #
JOBNAME:



DRYING FRUIT AT THE LOS AZUFRES GEOTHERMAL FIELD

1.- SCOPE OF THE PROJECT

Comision Federal de Electricidad (CFE) has a Division in charge of the exploration of a geothermal reservoir located in Los Azufres, State of Michoacan.

At present CFE is only using the steam of the wells and rejecting the hot water that comes off associated with the steam.

CFE is interested in promoting the use of the hot water in industries with high consumption of heat. So far we have installed a chamber for drying lumber (wood) with very good results. Several local industrials are interested in constructing their own in Los Azufres and to buy the heat from CFE. We also construted a green house to grow flowers in winter and produce gladiolous bulbs.

Since the region of Los Azufres is mainly a fruit producer (peaches, pears, apple, guava, etc...) we have plans to instal a small "Fruit dryier" for demosfration purpose. We are confident that if we succed in showing the feasibility to dry fruit with geothermal steam, we will have a big demand of heat for big drying factories.

In this report we present the basic information of the field, the heat and the fruits, expecting to receive a proposal with the minimun size of a drying plant, for demostration purpose, having in mind that CFE will promote this industry for wide application in Michoacan State.

2.- GEOGRAPHICAL

The Los Azufres geothermal field is located in the Michoacan State at the southwest of the Mexican Republic (Fig. 1). The most important city of Michoacan is Morelia, which is located approximately 80 Km away from Los Azufres (Fig. 2). The city population is around 1,000,000 inhabitants.

The distance between Morelia and Mexico City is approximately 300 Km. Comunication between this two cities is wide, there are three daily flights and the road conditions are excelent. Going by car it takes approximately 4 hours.

3.- ATMOSPHERIC CONDITIONS

Average conditions from 1983 to 1990.

Atmospheric pressure	**0.73**	**bar**
Maximum temperature	**31**	**°C**
Minimum temperature	**-4**	**°C**
Mean anual temperature	**12**	**°C**
Anual precipitacion	**1,171**	**mm**
Relative Humidity (anual mean)	**63**	**%**
Mean wind speed	**2.2**	**m/s**

Figs. 4 and 5 show the dry bulb temperature and the relative humidity evolution along the year.

4.- STEAM AND BRINE PRODUCTION

The field has 63 geothermal wells at an average depth of 2,100 m (Fig. 3). The total steam production is 1,550 t/h with a noncondensible gases content of 3 % by weight, which are composed of 97 % Co_2 and 3 % H_2S. The field brine production is 1,600 t/h at a separation temperature of 170 ^oC.

The brine production by well is approximately 50 t/h.

BRINE CHEMICAL COMPOSITION (pmm)

PH	7.2
EC	12,500.0
Cl	4,399.0
B	365.4
HCO_3	83.2
SiO_2	1,050.4
So_4	22.8
Na	2,321.4
K	628.0
Li	31.8
Rb	5.4
Cs	4.1
Ca	16.4
As	28.2
Mg	0.03

5.- FRUIT TO DRY

At present, the anual fruit production of the area are the following:

	Kg/year
- Pear	15,000,000
- Peach	1,350,000
- Guava	900,000
- Apple	140,000
- Prune	5,000,000

According with recent studies, drying necesities in some cases are estimated in 40 % of the anual production.

TIEMPOS DE RECORRIDO

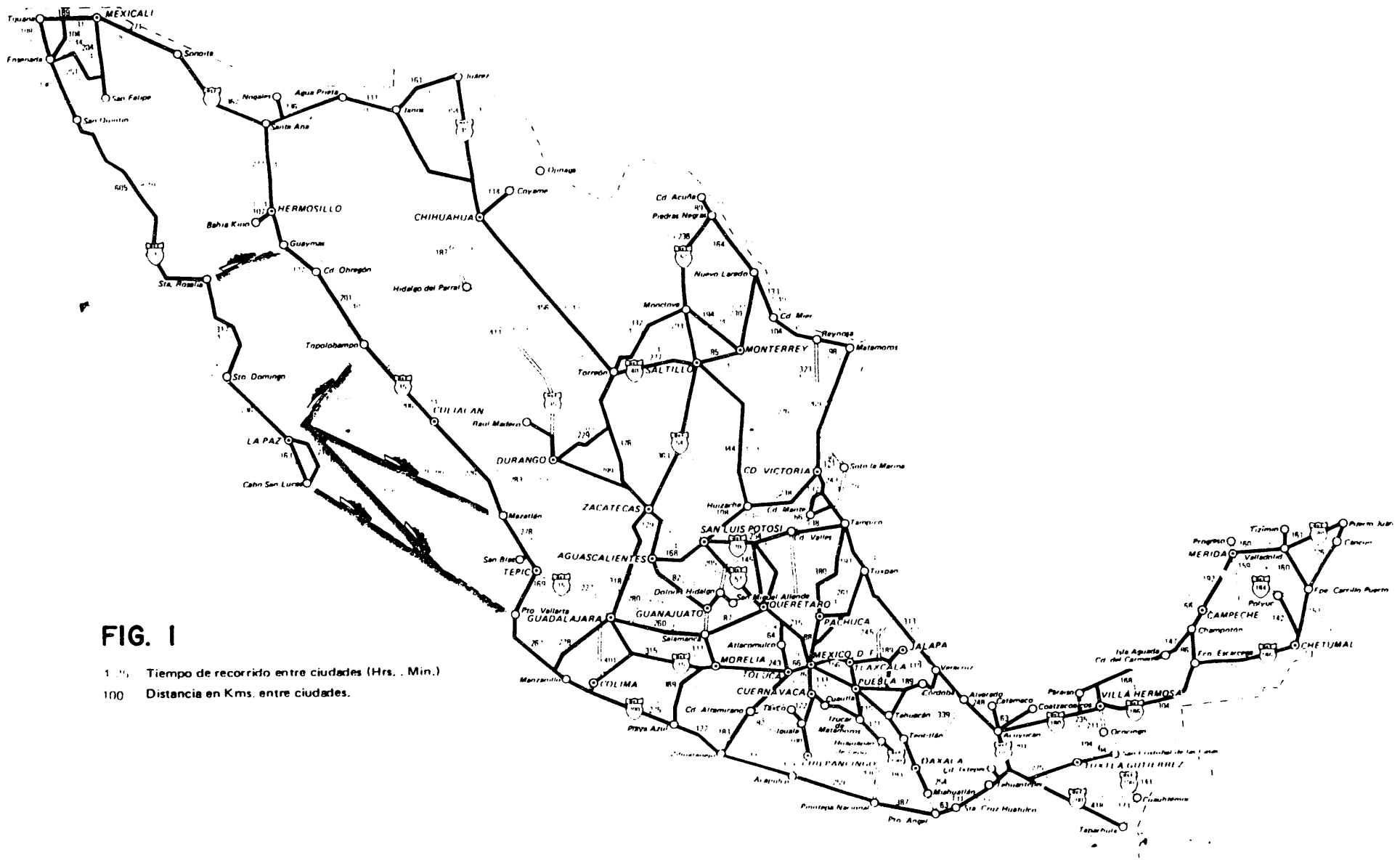


FIG. I

1 :) Tiempo de recorrido entre ciudades (Hrs. . Min.)

100 Distancia en Kms. entre ciudades.

FIG. 2. LOCALIZACION DEL CAMPO GEOTERMICO DE LOS AZUFRES, MICH.

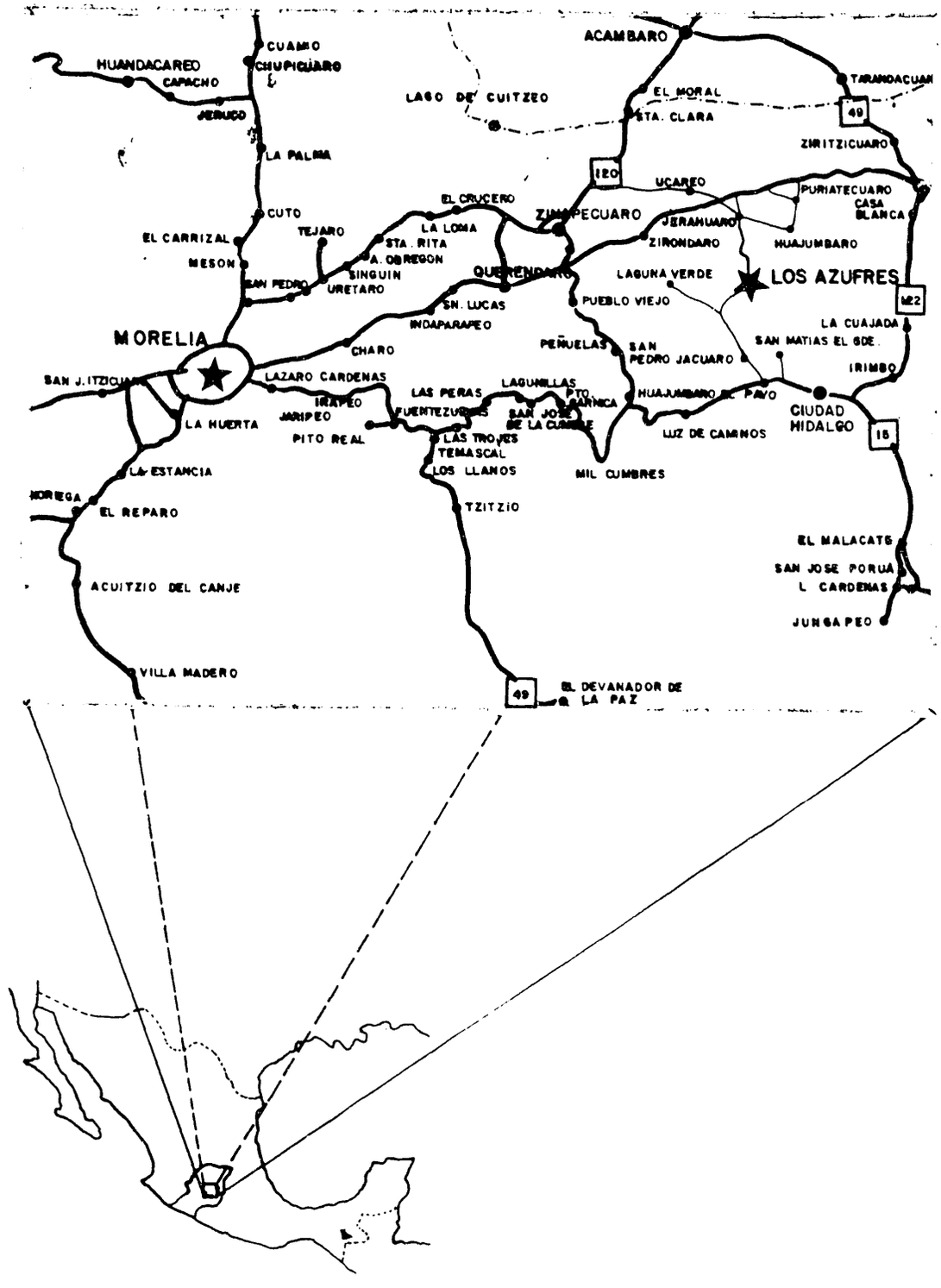


FIG. 3. LOCALIZACION DE POZOS EN EL CAMPO GEOTERMICO LOS AZUFRES, MICH.

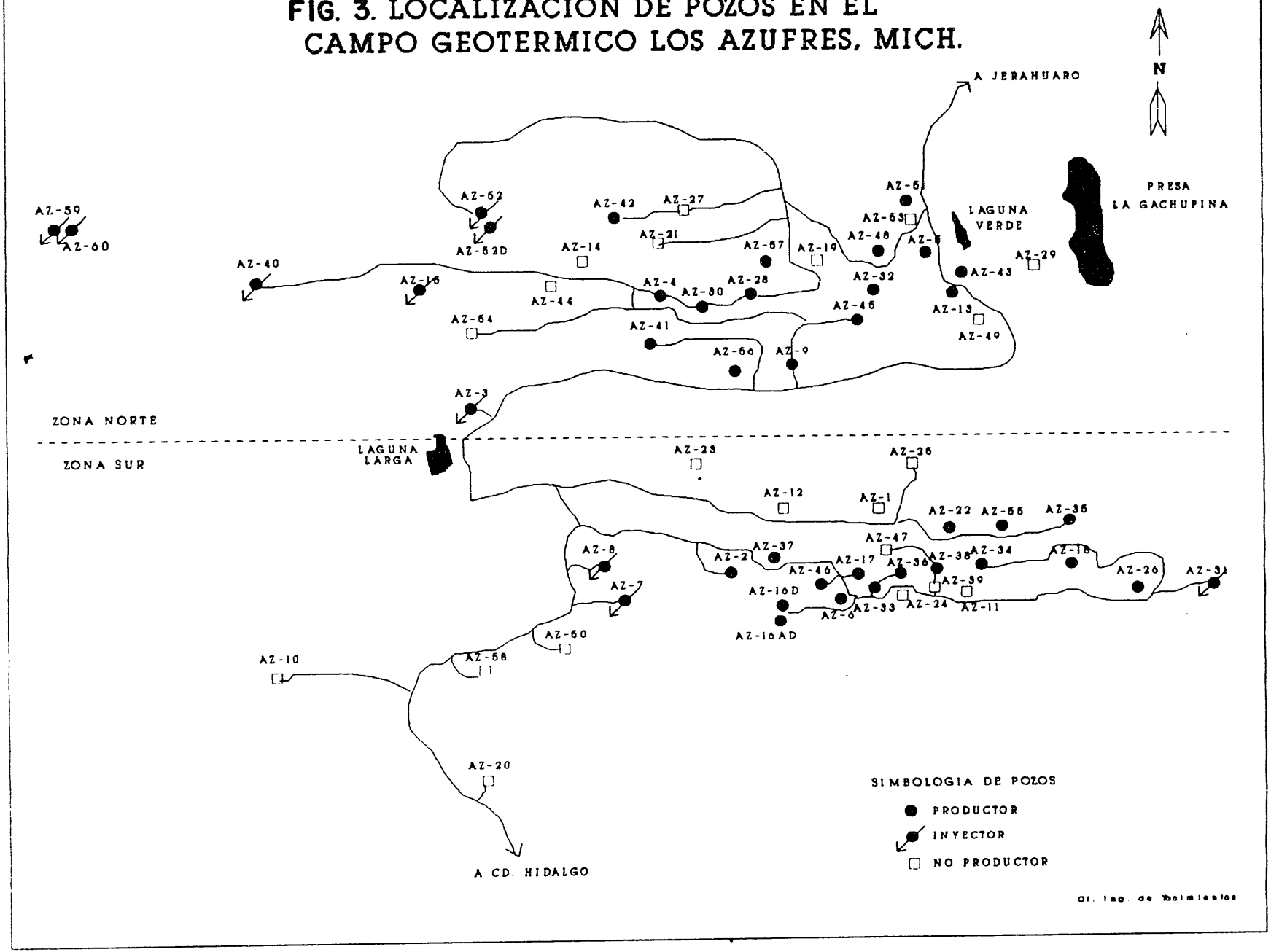


FIG. 4 TEMPERATURA DE BULBO SECO ESTACION TEJAMANILES

PERIODO 1982 - 1986

T.B.S MEDIA ANUAL = 7.8 °C

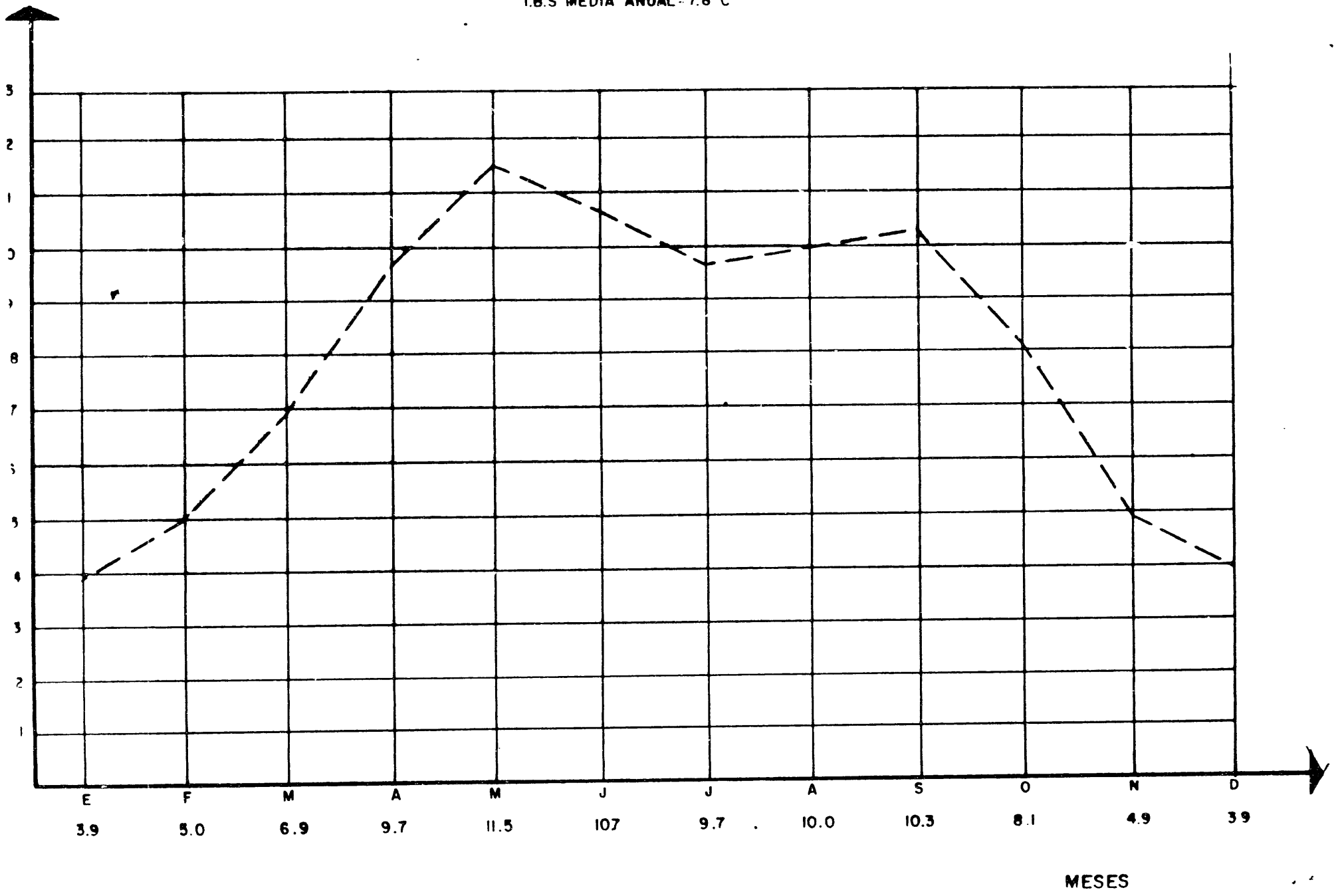
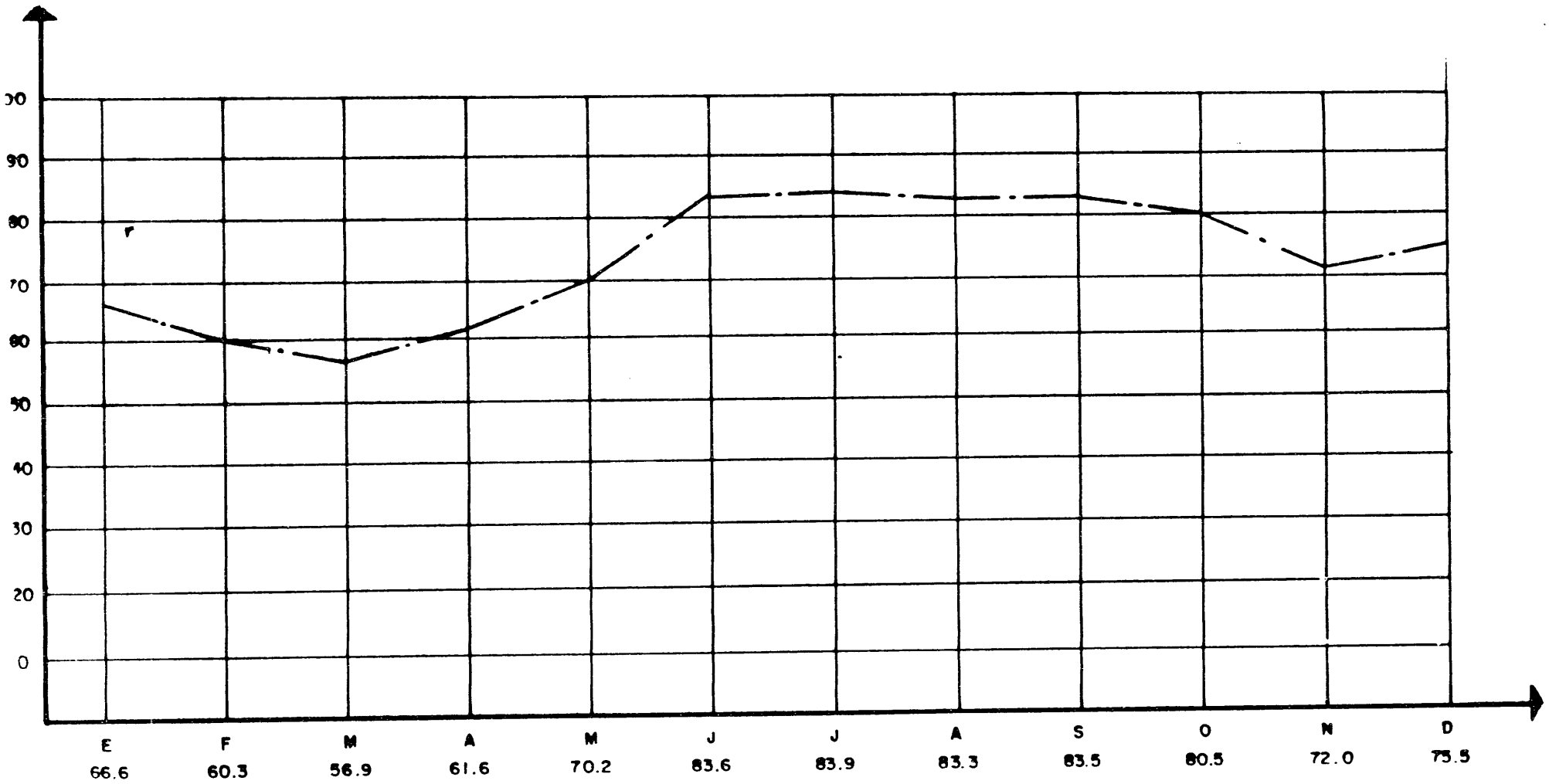


FIG. 5 **HUMEDAD RELATIVA ESTACION TEJAMANILES**

PERIODO 1982 - 1986

H.R. MEDIA ANUAL= 73.1 %



AP-TJ-0189

COOPERATIVE EXTENSION
UNIVERSITY OF CALIFORNIA

Agricultural Engineering Ext.
Davis, CA 95616
Phone: (916) 752-6167
Fax No. (916) 752-2640

Date: 14 Jan

TO: John Lund
Geo Heat Center
Oregon Inst. of Tech
Klamath Falls, OR 97601

Enclosed is a good reference on fruit drying (out of print)

"Fruit Dehydration"

1. "Principles and Equipment" by R. L. Perry, E. M. Mrak, H. J. Phaff, G. L. Marsh, and C. D. Fisher, California Agriculture Experiment Station, Bulletin 698, December 1946.*

James F. Thompson, P. E.
Extension Agricultural Engineer

University of California and the United States Department of Agriculture Cooperating

* Available in the Geo-Heat Center library.

END

DATE
FILMED
5/24/93