AP-42 Section 9.2.3
Reference 6
Report Sect.
Reference

county of ventura

Air Pollution Control District
James B. Lehr
Director

May 26, 1972

Dennis Ackerson
Assistant Sanitary Engineer
Environmental Protection Agency
Applied Technology Division
National Source Inventory Section
411 W. Chapel Hill Street
Durham, North Carolina 27701

Dear Dennis:

In response to your request, I am enclosing some literature which have data on orchard heater emissions and some illustrations of heaters. I meant to go out to the orchard to take photos of various kinds of heaters, but never got around to it, so to avoid further delay, I am sending you what we have collected so far.

If you need further information, data, or illustrations, etc., let me know. I'll see what we can do.

Have a nice, long memorial weekend.

Sincerely,

ENVIRONMENTAL HEALTH DEPARTMENT
JAMES B. LEHR, DIRECTOR

T Wakai

Ted Wakai
Air Pollution Control District

TW:pas

Enclosures

TREE-HEET

MOBIL TREE-HEET (SOLID FUEL)
2 Blocks Inside
RANCHO SESPE

BRICKETT HEATERS
MARSHALL ORCUTT

MASCO HEATER 12/70
Peter Deale lighting match
Calibration - Aliso Canyon

OLD ORCHARD HEATERS - LIMCO

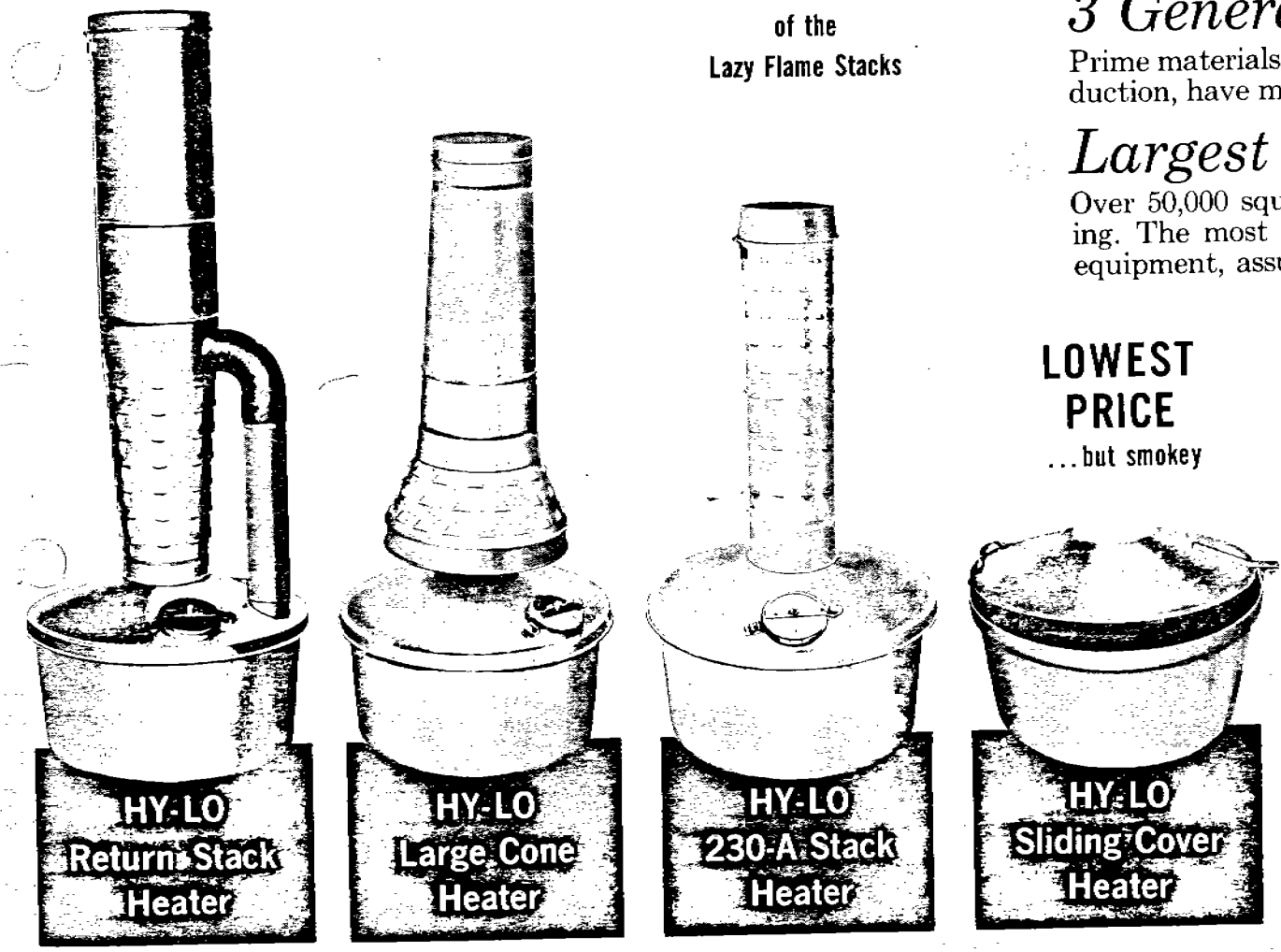
Standard o
the Industr

BEST COMBUSTION
Less Soot... No Sludge

HIGHLY RADIANT

CLEANEST BURNING
of the
Lazy Flame Stacks

LOWEST PRICE
...but smokey



50 Years of Heater Design and Development Know-How

Since 1911 leader in design and development... continuing resea brings you constant improvement.

Continuous Management— 3 Generations

Prime materials, highest manufacturing standards, and volume p duction, have made HY-LO Heaters the Standard of the Indust

Largest Manufacturer

Over 50,000 square feet devoted to manufacturing and wareho ing. The most complete manufacturing facilities, plus specializ equipment, assures highest quality at lowest cost.

Basic Manufacturer

This gives complete control of producti and quality—*assures easy assembly a satisfactory fit of all parts.* HY-LO He ers out-perform... out-sell all other typ

REPLACEMENT PARTS

We carry a complete stock of moder Replacement Parts. Price list show detail of parts.

HEATER ACCESSORIES

- LIGHTING TORCHES
- CARRIERS
- FILLING BUCKETS
- HEATER WICKS
- CLEANING BRUSHES
- THERMOMETER

Take Your Choice... but BUY ONLY HY-LO HEATERS

MASCO RADIANT HEATER

MASCO RADIANT HEATERS are designed and engineered to provide maximum radiant heat output while discharging a minimum of air pollutants. They easily comply with all air pollution control regulations.

Comparative tests conducted at independent laboratories and universities show conclusively that MASCO HEATERS produce more radiant heat at lower operating pressures than any other system available. And since the system is centrally fueled and controlled, heat may be increased or decreased as the situation demands resulting in maximum continuous radiant heat with minimum use of fuel.

Heavier gauge metal in the stack and highest quality materials in all components assure a much longer service life for your MASCO RADIANT HEATERS. Easily and quickly installed, MASCO RADIANT HEATERS are a performance proved frost protection system that will provide years of economical, labor-saving service.

SPECIFICATIONS

Stack Height: 47"
Stack Diameter: 9"
Metal Thickness: 24 Gauge Galvanized
Weight: 12 Pounds

PERFORMANCE

Surface Temperature: High 1197° F., Low 757° F.
Emerging Gas Temperature: 1209° F.
Temperature of Nozzle @ Inlet: 120° F.
Operating Pressure: 75-150 PSI

NUMBER 2 DIESEL OIL

Operating Pressure Lbs.	Fuel Rate Gal./Hr. Per Heater	Gram Per Minute	BTU/Hr. Input	Radiant Fraction %
50	0.500	.045	66,840	40.8%
75	0.625	.033	70,065	41.4%
100	0.687		93,291	42.0%
125	0.795	.057	102,499	42.4%

Performance: Surface Temperature: High 1197° Low 757°

STATEWIDE AIR POLLUTION
RESEARCH CENTER
UNIVERSITY OF CALIFORNIA,
RIVERSIDE
RESULTS OF TESTS WITH MASCO
RADIANT ORCHARD HEATER
IN BURNING TOWER AT
RIVERSIDE, JUNE 19,1970

MASCO JUNIOR HEATER

MASCO JUNIOR ORCHARD HEATERS are designed and engineered to provide maximum efficiency while complying with all air pollution regulations.

MASCO JUNIOR has been proven the most economical heater on the market today. Costs per heating hour have been greatly reduced, compared to other centralized oil systems. However it is possible when necessary to deliver 145,000 BTU (British Thermal Units) of heat per heater.

Most important to growers is initial cost, cost per heating hour, performance and reliability.

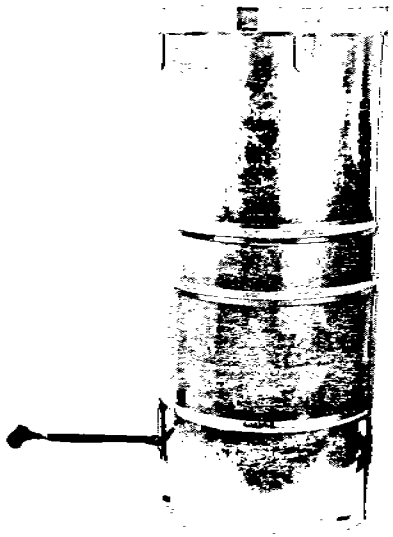
Check all these proven features and find MASCO JUNIOR is the money saver for the grower when it comes to orchard heating.

SPECIFICATIONS

Stack Height: 20"
Stack Diameter: 9"
Metal Thickness: 24 Gauge Galvanized
Weight: 6¼ Pounds

PERFORMANCE

Surface Temperature: 825° F.
Emerging Gas Temperature: 1400° F.
Temperature of Nozzle @ Inlet: 120° F.
Operating Pressure: 80-200 PSI



Atmospheric Emission Evaluation
Prepared by:
Valentine - Tomlinson & Fisher
Consulting Engineers
Seattle, Washington

SUMMARY OF RESULTS
Sampling Time: 60 Minutes
Particulate Matter: .131 gm/minutes

GAS ANALYSIS
Carbon Dioxide % by Volume: 0.3
Carbon Monoxide % by Volume: 20.7
Nitrogen Dry-basis: 79
Molecular Weight of Stack Gases (dry): 28.87

RADIANT OMNI-HEATER

For Economical Frost Protection
of Orchards, Groves and Field Crops

PROPANE CARBURETION SERVICE

PRO-FLAME

1740 LIRIO STREET
SATICOY, CALIFORNIA 93003
ROY L. COPE
MANAGER
P. O. BOX 4745
PH. 485-6405

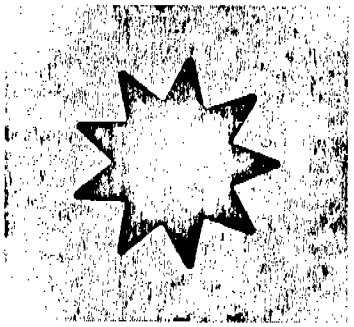
New Draulics Inc. • P. O. Box 1525 • Salt Lake City, Utah 84110

RADIANT OMNI-HEATER

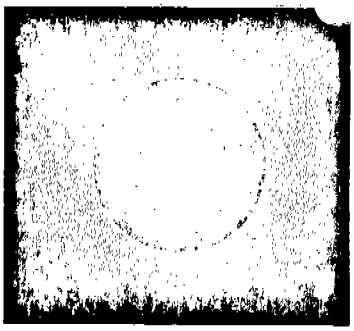
The most effective frost-fighter ever developed

RADIANT HEATING PROVEN BEST

No other heating system gives you the total protection, ease of operation or economy like radiant heating with New Draulics OMNI-HEATERS. This has been proven on thousands of acres in all parts of the country. OMNI-HEATERS are designed with a special scalloped outside surface (see diagram at right) providing more square feet of radiation surface than conventional heaters. This unique chamber design also provides more efficient internal combustion so more fuel energy is converted into useable protective heat at less cost. To assure continued operation at high temperatures and to retard oxidation, both the radiation chamber and deflector lid are made of aluminized steel.



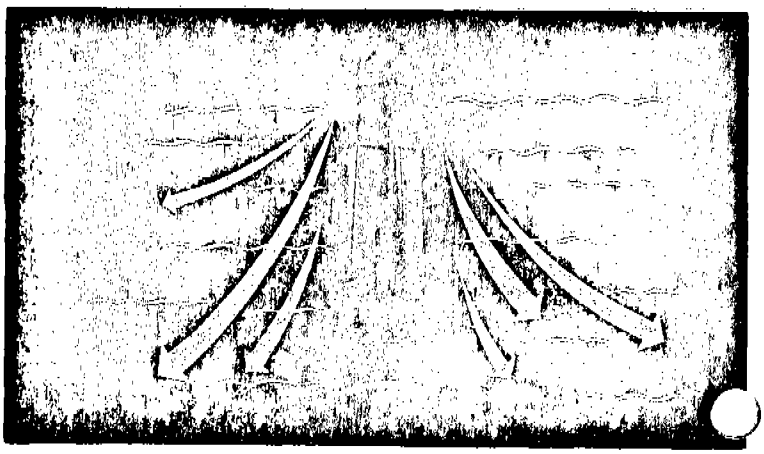
Radiant Omni-Heater



Conventional Heater

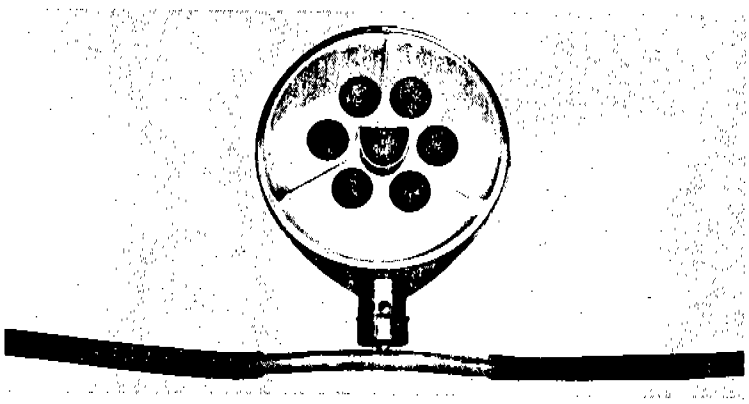
DESIGN KEEPS HEAT LOW

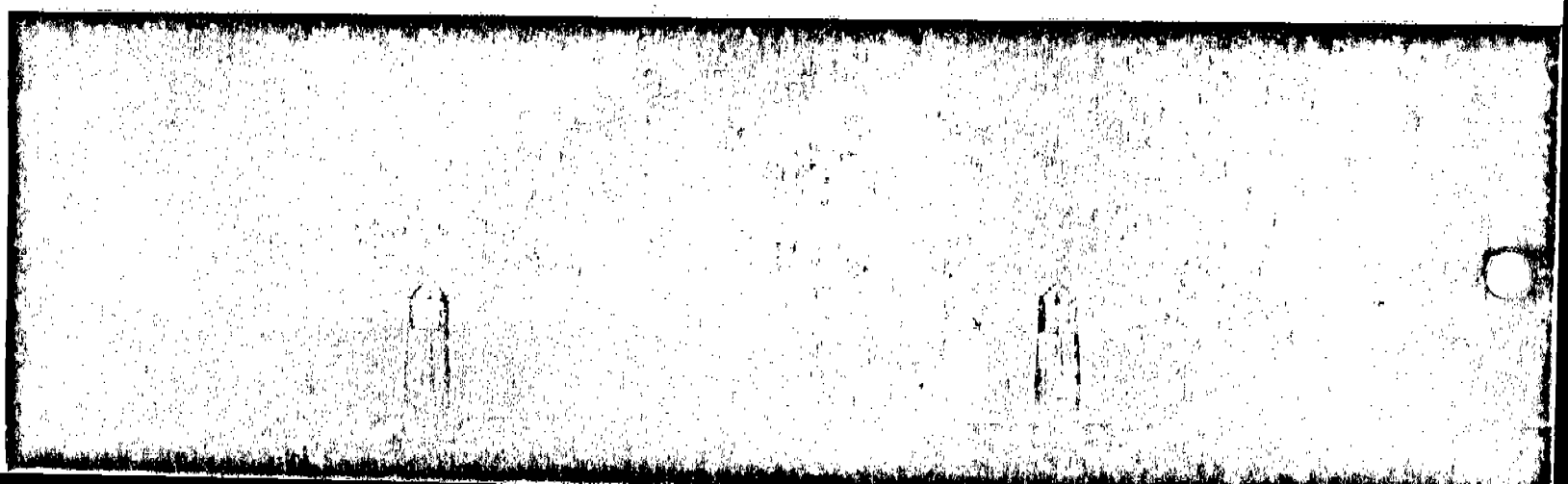
The exclusive design keeps convected heat low where it needs to be for tree protection. There is minimum vertical heat loss as with many other heaters. While convected heat drifts from the ground level upward through the trees, radiated heat travels directly from the OMNI-HEATER to the trees providing total, positive protection. The new AFTER-BURNER screen, which is part of the OMNI-HEATER lid, converts convected heat into additional radiated heat as the gasses pass through the screen. The AFTER-BURNER cap fits tightly over the radiation chamber so it cannot be blown off.



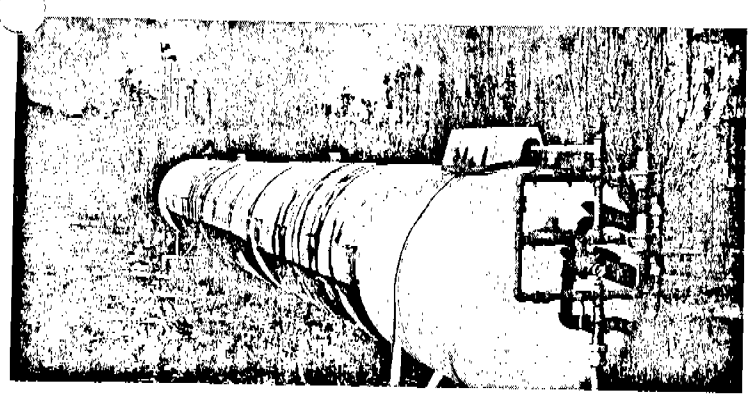
NEW BURNER MORE EFFICIENT

The OMNI-HEATER burner and combustion tube mixes oxygen and gas more efficiently, and the pilot operates on less than 0.07 gallons of fuel per hour per heater. That's less than one cent per heater per hour in most areas. Unlike other heaters, the OMNI-HEATER radiation efficiency **increases** as the BTU's increase. There is good fuel drainage so lighting is easier and quicker with very little "pop." The burner tube connects easily to the gas distribution system with no tools required. The burner works equally well on natural or propane gas, and since combustion is total, there is **no smoke or smudge** when you protect with Radiant OMNI-HEATERS.



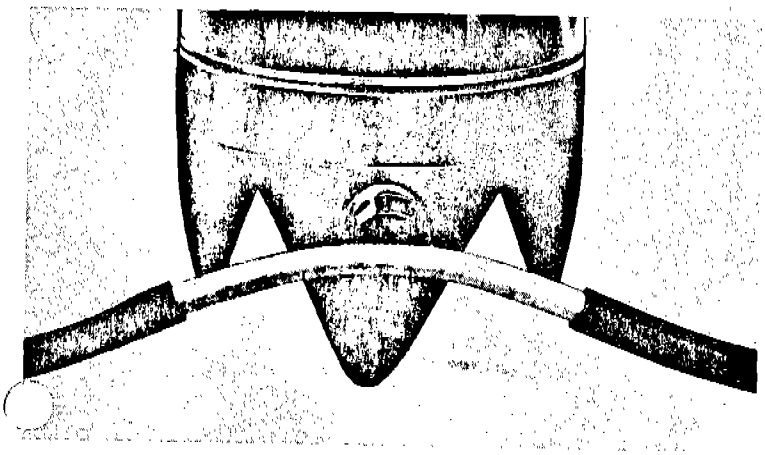


Easy to set up • Trouble free • Low cost operation



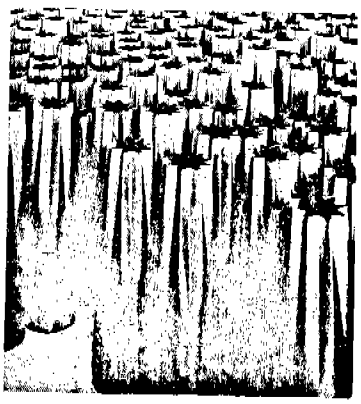
ONE-MAN OPERATION

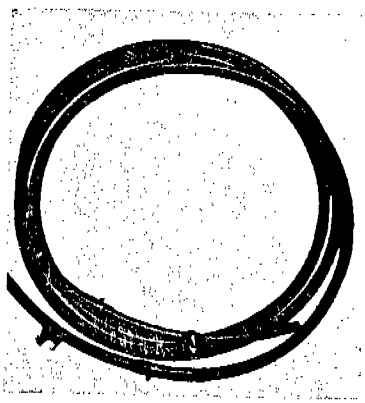
The Radiant OMNI-HEATER gas distribution system is designed for one-man operation from one central valve. Gone forever is the long and tiresome task of filling heaters throughout your orchard or grove. The entire system or any portion can be lighted early in the evening and left on low-cost pilot operation until full heating is required. Then, one man can regulate and control the entire system from one central point, keeping it fully operational for as long as needed. With a New Draulics OMNI-HEATER system, you are always ready for that killing frost.



HEATERS SET FIRMLY

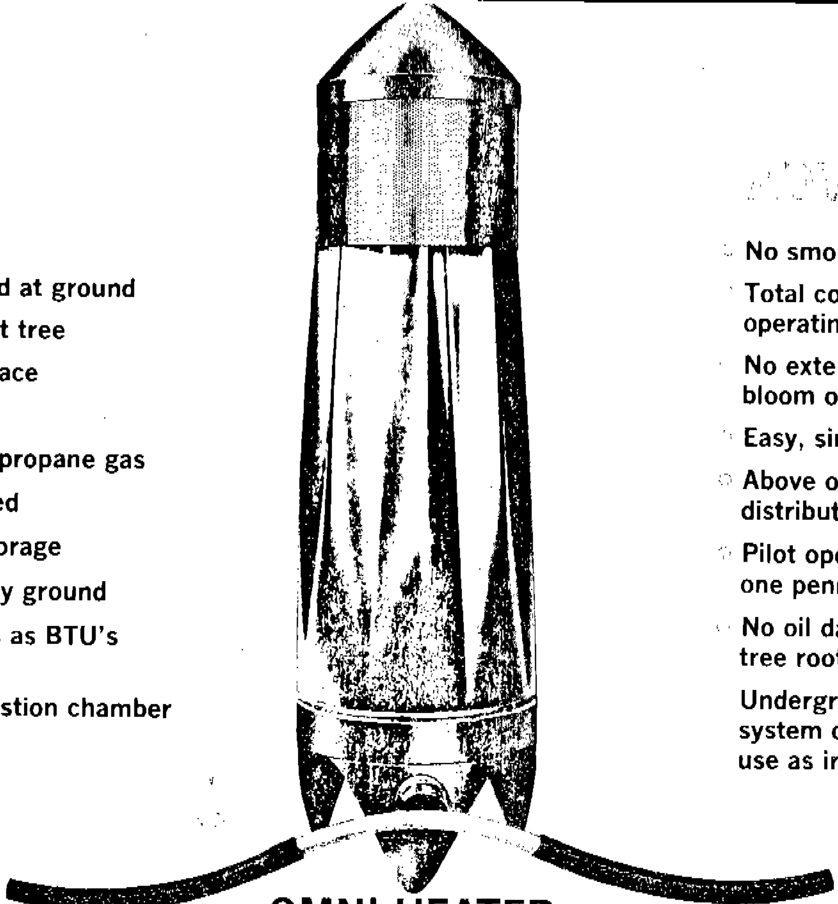
On hillsides or flat ground, on hard or soft soil, the new OMNI-HEATER base stays put where you set it. Wind will not topple the heater. The base is made of heavy-gauge galvanized steel and fits precisely and snugly into the combustion chamber. In fact, each part of the OMNI-HEATER is manufactured carefully to fit together easily yet hold firmly. This will save hours of set-up time and assures year after year of trouble free, maintenance free operation. There is no finer heater on the market today.





EASY, COMPACT STORAGE

Radiant OMNI-HEATER units stack conveniently and easily one upon the other. There is no need to take up valuable storage space during off-seasons. The combustion chambers, after-burner lids, and bases all nestle compactly and require very little storage space. And, as an added convenience, fuel adapters have been designed with a curve allowing fuel hose and adapters to be rolled up quickly together. This not only saves space, but also saves time during the set up and tear down of the system.



OMNI-HEATER

FEATURES

- One-Man operation
- Convected heat directed at ground
- Radiant heat directed at tree
- Optimum radiation surface
- Quick, positive lighting
- Operates on natural or propane gas
- No maintenance required
- Units nestle for easy storage
- Base holds firmly on any ground
- Radiated heat increases as BTU's increase
- Aluminized steel combustion chamber
- Weighs only 8 pounds

ADVANTAGES

- No smoke or smudge
- Total combustion on all operating pressures
- No external fire to damage bloom or burn trees
- Easy, simple installation
- Above or below ground gas distribution system
- Pilot operates for less than one penny per heater per hour
- No oil damage to ground or tree roots
- Underground gas distribution system can be designed for use as irrigation system

APPROXIMATE OPERATION SPECIFICATIONS PER HEATER

	GAS PSI SETTING	GAL/HR.	BTU/HR.
Piloting	3 ounces	0.02	2,000
Normal Operating Range	1 PSI	0.07	7,000
	5 PSI	0.33	31,000
	10 PSI	0.65	62,000
	15 PSI	0.80	76,000
	20 PSI	1.00	95,000
	25 PSI	1.13	107,000
Extreme Cold Operation	30 PSI	1.25	119,000
	35 PSI	1.40	133,000
	40 PSI	1.56	150,000

PROPANE GAS #57 ORIFICE • MODEL ROH-150-LP

LAYOUT DATA FOR GAS DISTRIBUTION SYSTEM

Main Distribution Line
2" minimum diameter
1600 ft. maximum length
40 lateral lines maximum
Buried underground

Lateral Lines
¾" minimum diameter
600 ft. maximum length
30 heaters per lateral
Buried or above ground
Valve each lateral

Minimum gas storage to supply 1 gallon per hour per heater for as long as needed to burn between deliveries. Suggested, 10 Hrs. min.

Minimum Recommended Heaters Per Acre

ACRES	SQUARE PLOT	RECTANGLE PLOT
1-5	50	50
5-10	45	50
10-up	40	45

FOR MAXIMUM EFFICIENCY, DOUBLE THE NUMBER OF HEATERS AROUND PERIMETER OR ORCHARD.

[illegible]
P.O. Box 1525, Salt Lake City, Utah 84110
Telephone (801) 484-8751
Subsidiary of Sealcraft Corporation

Manufacturers of:
Radiant Orchard Heating Systems • Air and Hydraulic Pruning Equipment
Orchard Lift Equipment • Wire Cutting & Crimping Tools
Sprinkler Irrigation Systems • Automatic Filtering & Fertilizing Systems

PRO-FLAME GAS CO.
P. O. BOX 4745
1740 LIRIO STREET
SATICOY, CALIFORNIA 93003
(805) 485-6405

$8.00 ea. F.O.B. Salt Lake City.
Roy

1692M

TURN ON SPOT HEATERS . . .
TURN OFF THE "FROST DRAIN"!

We've spent years developing the best FROST PROTECTION package--It works. You can install the SPOT HEATER system yourself . . . You can rely on a nation-wide manufacturer.

WE HAVE CONVERSION UNITS for STACK HEATERS and AUTOMATIC IGNITION SYSTEMS

Contact the dealer in your area He'll answer your questions:

BILL BOATMAN
P. O. Box 126
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Dinuba, Calif. 93618
Ph. (209) 591-2861

CAPICO INC.
P. O. Box 638
556 South Mirage
Lindsay, Calif. 93247
Ph. (209) 562-4944

ART PAR CO.
P. O. Box 275
36146 Avenue 9
Madera, Calif. 93637
Ph. (209) 264-7980

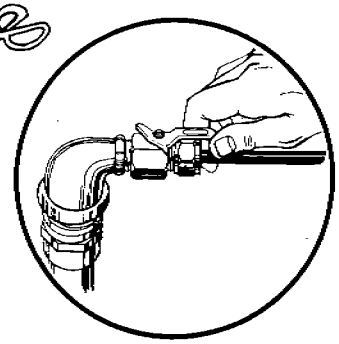
NELSON MACHINERY CO.
611 West Florida
Hemet, Calif. 92343
Ph. (714) 658-3215

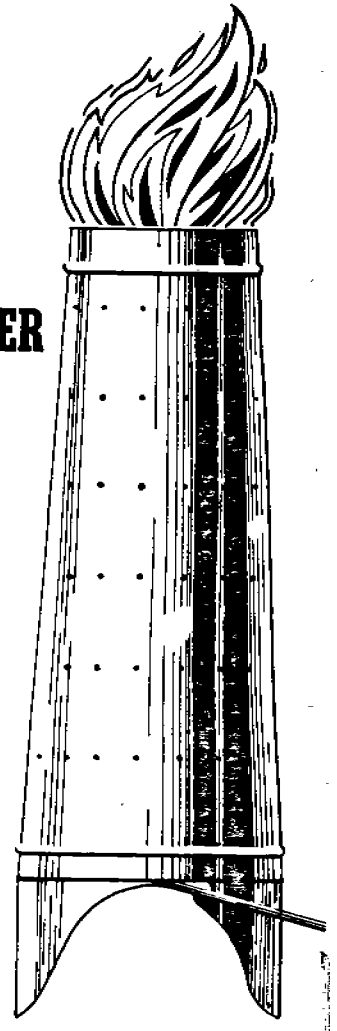
Venco Growers Supply Co.
Rose Rd. & Hiway 101
Oxnard, Calif. 91401
Ph. (805) 485-1131

Hykil Sales Corp.
P. O. Box 188
10427 Avenue 416
Sultana, Calif. 93666
Ph. (209) 591-5263

Hykil Sales Corp.
P. O. Box 869
1021 Fruit Street
Santa Ana, Calif. 92702
Ph. (714) 542-3985

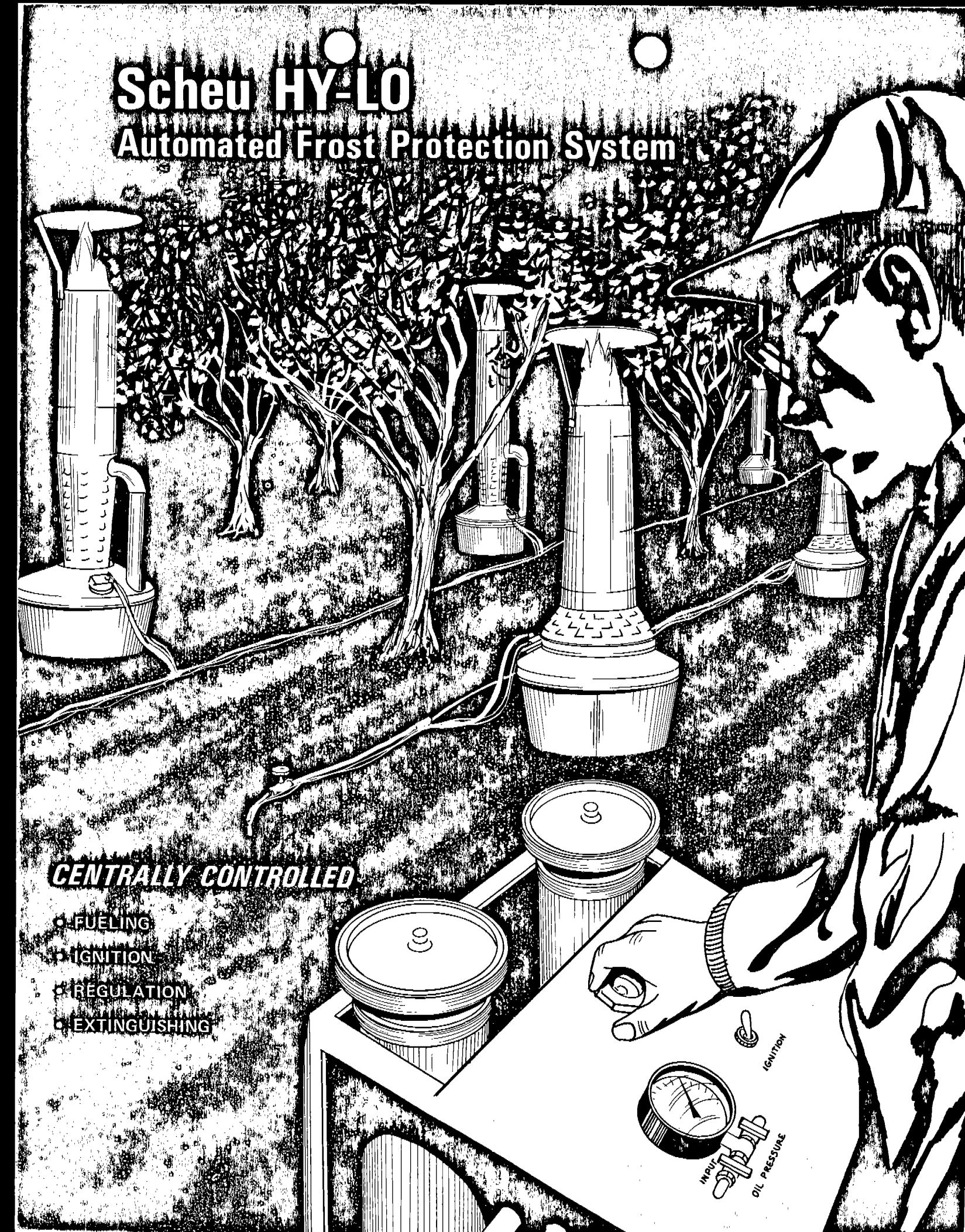
CLIP COUPON





Scheu HY-LO

Automated Frost Protection System



CENTRALLY CONTROLLED

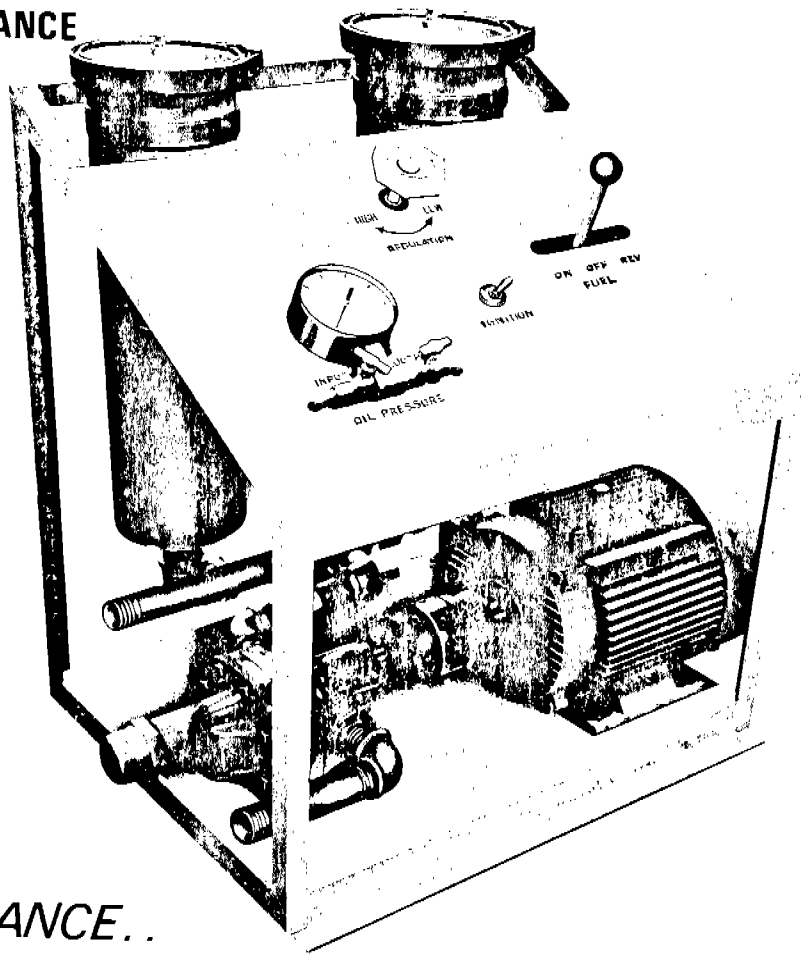
- FUELING
- IGNITION
- REGULATION
- EXTINGUISHING

THE NEW AUTOMATED FROST PROTECTION SYSTEM ELIMINATES ALL OPERATING LABOR AND PRO
ON TO PROVIDE MAXIMUM FROST PROTECTION. YEARS OF EXPERIENCE HAVE PROVEN THAT BOTH

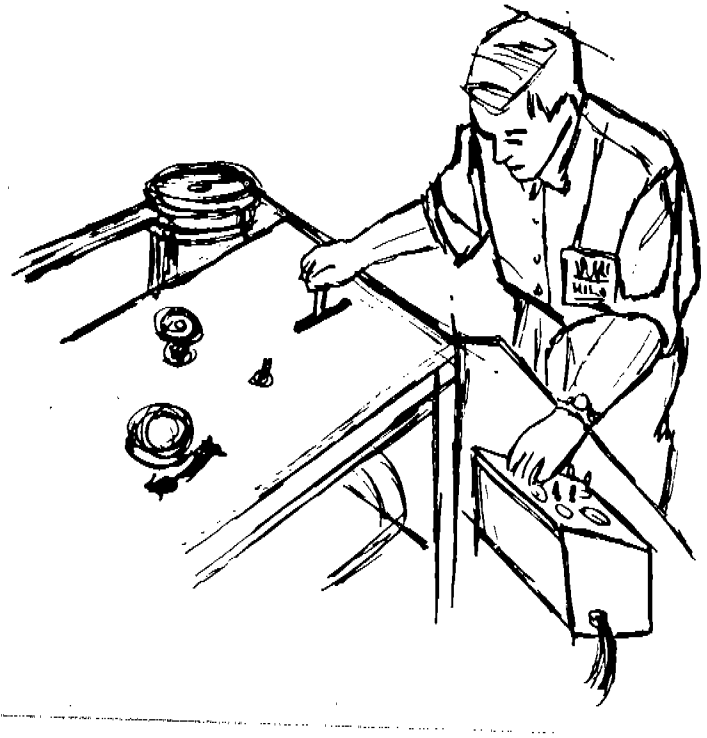
NOW, A FULLY AUTOMATED SYSTEM WITH FROST PROTECTION PERFORMANCE

Automated Central Control Station....

Instant operation from control station – full instrumentation – allows instant control of all heaters through a network of small oil and electrical lines.



ENGINEERED FOR PERFORMANCE..



BUILT FOR RELIABILITY

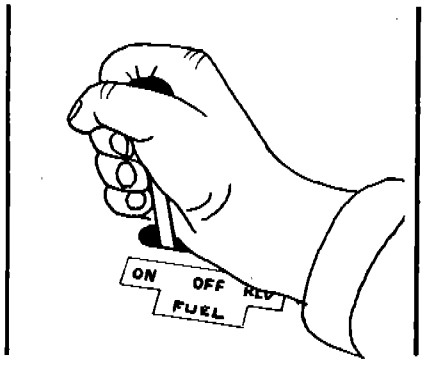
Years of research and development plus Scheu Know-how have gone into the design and selection of components to insure a fully engineered system which offers maximum frost protection performance, economical operation and built-in reliability.

PERFORMANCE – The merit of any heating system is based on its performance in combating frost. Scheu HY-LO Heaters have no equal when it comes to performance. The Return Stack and Large Cone Heaters speak for themselves with years of proven effectiveness in all major fruit growing districts. Authorities recognize them as having no equal where maximum frost protection is required.

ES SUBSTANTIAL FUEL SAVINGS WITH INSTANT CENTRAL CONTROL OF HEATERS THAT CAN BE RELIED
E RETURN STACK AND LARGE CONE HEATERS ARE UNEQUALLED IN THEIR ABILITY TO FIGHT FROST.

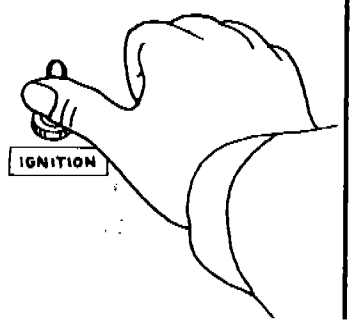
. . . INSTANT

FUELING



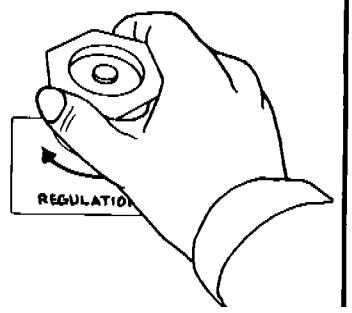
By turning on the fuel switch, oil is continuously fed through oil lines to the heaters where it is burned at the atomizing nozzle.

IGNITION



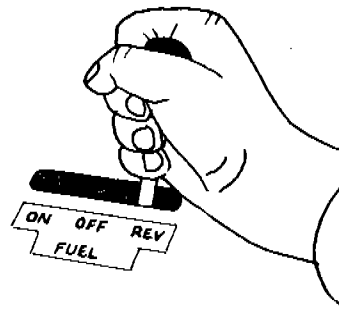
Depressing the ignition switch for a 30 second cycle activates an ignition unit, igniting the heaters. Without optional electrical ignition, the system can be readily lit with conventional lighting devices.

REGULATION



By adjusting the regulator, the heaters can be instantly set at the desired burning rate. A very wide burning range is offered from less than 70,000 BTU's (½ gal.) to over 140,000 BTU's (1 gal.) per heater hour.

EXTINGUISHING



By turning off the fuel switch, prompt extinguishing follows as fuel is discontinued to the heaters. By turning the fuel switch to reverse, the majority of the oil remaining in the lines is returned to the oil reservoir.

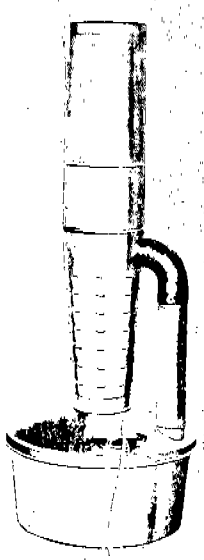
AFTER SEASONAL INSTALLATION — Heaters are Always Ready for INSTANT Use — No Caps to Remove, Regulators to Adjust or Oil to Handle.

PROVEN PERFORMERS

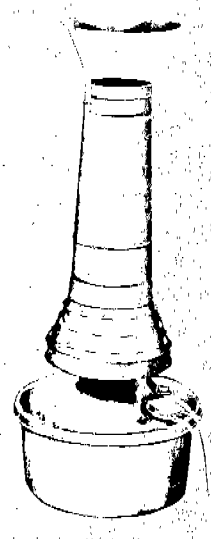
ECONOMY — After all costs are considered, the Scheu HY-LO Automated Frost Protection System provides the most protection per dollar spent. In the final analysis, this is what really counts. Over half a century of Scheu Know-how insures built-in economy with low operating costs.

RELIABILITY — Years of field experience indicates reliability to be a very important part of any frost protection system — the Scheu HY-LO Automated System insures this reliability.

Return Stack



Large Cone



temperature. In seven minutes the temperature of the bud dropped 2.5° F. At that point, the rate of water application was increased to .14 inches per hour. In 12 minutes the temperature of the bud was restored to its previous level. It was repeatedly shown in other tests that tissues respond very quickly to application of water or to changes in rate of application.

Temperature readings taken at 5-minute intervals fluctuated widely, showing a maximum drop of 3 degrees and a maximum rise of 4 degrees at these intervals. This was probably caused by poor distribution of water and by the thermometer bulb being missed on several consecutive passes of the sprinkler. As there is a continued rapid loss of heat by radiation, the temperature dropped quickly when water was not applied. These temperature drops show that the ice coating itself is of little, if any, benefit in maintaining temperature. The rapid drops in temperature, while undesirable, probably were of such short duration that no damage resulted.

Table 1. Results of Sprinkling for Frost Control in Close-Planted, Severely Pruned 10-Year-Old Pear Seedlings, Using "Overtree" Sprinklers (February 21-22, 1965)

Time	Nonsprinkled area		Sprinkled area				Remarks
	Sheltered alcohol thermometer	Exposed alcohol thermometer*	Sheltered alcohol thermometer	Thermister inserted in exposed bud	Exposed mercury thermometer	Exposed alcohol thermometer*	
	°F	°F	°F	°F	°F	°F	
7:45PM	35.0	33.0	35.2	34.0	33.5	33.0	Clear
9:30	32.5	30.0	33.5	33.0	34.0	33.0	Clear, gusty breeze
9:40	33.5	31.0	34.0	34.0	34.0	33.5	Clear, gusty breeze
11:40	29.0	28.0	29.0	29.3	29.3	28.2	Clear, calm
Average	32.5	30.5	32.9	32.6	32.7	31.9	
11:45	Water on .06 inches per hour						
11:50	29.1	27.2	29.0	29.7	29.0	29.0	Clear, calm
11:55	29.2	27.1	29.0	29.7	31.0	30.3	" "
12:00	29.0	26.9	28.9	29.0	28.0	30.0	" "
12:05AM	28.9	26.9	28.8	30.0	29.8	30.2	" "
12:15	29.2	26.8	29.2	30.0	30.2	30.0	" "
12:30	28.5	26.8	29.0	29.3	28.3	29.0	" "
12:35	28.0	26.4	28.8	29.8	30.8	29.0	" "
12:40	28.0	26.3	28.2	30.2	30.0	30.4	" "
Average	28.7	26.8	28.9	29.7	29.6	29.7	

Table 1 (Continued)

Time	Nonsprinkled area		Sprinkled area				Remarks
	Sheltered alcohol thermometer	Exposed alcohol thermometer*	Sheltered alcohol thermometer	Thermister inserted in exposed bud	Exposed mercury thermometer	Exposed alcohol thermometer*	
	°F	°F	°F	°F	°F	°F	
12:45AM	27.8	26.3	28.5	29.0	30.5	30.0	Clear, calm
12:55	27.1	26.2	28.0	31.0	27.7	28.0	" "
1:00	27.5	26.1	28.0	29.0	27.8	28.0	" "
1:10	27.0	25.8	27.5	30.0	28.2	30.0	" "
1:15	26.8	25.8	27.5	30.0	28.3	30.0	" "
1:25	27.2	26.0	26.6	27.0	27.0	27.5	" "
1:30	27.2	26.0	26.8	28.3	31.0	29.5	" "
1:35	27.0	26.4	27.8	29.0	30.0	30.0	" "
1:40	27.0	25.0	28.0	29.0	29.5	30.0	" "
1:45	27.0	26.1	28.2	30.5	29.5	30.2	" "
1:50	27.0	26.3	28.2	28.9	28.5	30.0	" "
2:00	26.5	25.0	27.0	28.9	28.0	28.0	" "
Average	27.1	25.9	27.7	29.2	28.8	29.3	
2:03	Water increased to .08 inches per hour						
2:05	26.5	24.9	27.0	29.5	27.8	28.5	Clear, calm
2:10	26.2	24.9	27.0	29.8	29.0	28.3	" "
2:15	26.2	25.0	26.8	27.9	27.0	27.9	" "
2:20	26.0	25.0	26.5	28.0	28.0	29.0	" "
2:25	26.0	25.5	26.5	28.0	28.0	29.0	" "
2:30	26.8	24.7	26.5	29.0	27.0	29.0	" "
2:35	25.7	24.8	26.2	28.5	28.5	28.5	" "
Average	26.2	25.0	26.6	28.7	27.9	28.6	
2:38	Water increased to .10 inches per hour						
2:40	26.0	25.0	26.2	28.0	29.2	30.0	Clear, calm
2:45	25.6	24.4	26.6	29.2	29.5	29.5	" "
2:50	26.0	24.5	26.8	29.8	29.0	29.5	" "
3:00	27.6	27.0	28.0	30.0	30.5	30.5	Clear,increase wind drift from North
3:10	27.5	26.0	28.0	30.0	30.2	30.5	Clear,increase wind drift from North
3:15	27.5	26.5	28.5	30.6	31.2	30.8	Clear,increase wind drift from North
3:30	26.5	24.0	27.5	29.2	30.0	30.0	Clear, calm
3:35	26.3	24.0	27.3	29.0	29.2	29.5	" "
3:40	26.0	24.0	26.8	27.8	28.0	29.0	" "

Table 1 (Continued)

Time	Nonsprinkled area		Sprinkled area				Remarks
	Sheltered alcohol thermometer	Exposed alcohol thermometer*	Sheltered alcohol thermometer	Thermister inserted in exposed bud	Exposed mercury thermometer	Exposed alcohol thermometer*	
	°F	°F	°F	°F	°F	°F	
3:45AM	26.5	24.5	27.0	30.0	29.0	28.9	Clear, calm
3:50	26.5	24.4	27.0	28.5	29.0	29.0	" "
3:55	26.5	24.7	26.9	28.5	28.3	28.5	" "
4:00	26.0	24.2	26.9	29.1	29.0	29.1	" "
Average	26.5	24.9	27.2	29.3	29.4	29.6	" "
4:03	Water increased to .12 inches per hour						
4:05	26.0	24.0	26.9	29.0	29.5	29.5	Clear, calm
4:10	25.4	23.5	26.5	29.5	30.5	30.0	" "
4:15	25.3	23.7	26.3	29.0	29.3	29.5	" "
4:20	25.2	23.5	26.0	29.5	29.0	29.0	" "
4:25	25.2	24.5	26.0	28.8	30.2	29.5	" "
4:30	25.0	23.8	25.8	29.0	27.5	28.0	" "
4:35	24.8	22.6	25.6	29.8	29.0	28.8	" "
4:40	24.7	22.3	25.5	30.0	28.9	29.5	" "
4:45	24.7	22.9	25.5	30.0	29.0	29.5	" "
Average	25.1	23.4	26.0	29.4	29.2	29.3	
4:48	Water reduced to .06 inches per hour						
4:50	24.7	22.6	25.6	28.5	28.0	28.5	Clear, calm
4:55	24.6	22.8	25.2	27.0	26.5	27.5	" "
Average	24.7	22.7	25.4	27.8	27.3	28.0	" "
4:58	Water increased to .14 inches per hour						
5:00	24.5	22.7	25.0	27.0	26.2	27.0	Clear, calm
5:05	24.5	22.7	25.0	29.0	27.5	28.0	" "
5:10	24.7	23.0	25.2	30.2	29.0	28.5	" "
5:15	25.0	24.0	25.4	29.2	28.5	28.5	" "
5:25	25.5	23.7	26.0	29.0	27.5	28.3	" "
5:30	25.5	24.0	26.0	29.5	27.5	28.3	" "
5:35	25.5	23.5	26.0	29.0	28.3	29.0	" "
5:40	25.0	23.2	26.0	29.0	28.0	28.5	" "
5:45	25.6	23.4	26.0	29.0	29.5	29.2	" "
5:55	25.0	24.0	26.2	30.2	30.2	30.0	" "
6:00	25.0	23.5	26.0	30.0	31.0	30.5	" "
6:05	24.5	23.5	25.6	30.2	30.5	30.0	" "
6:10	24.0	23.0	25.0	28.0	31.0	30.2	" "
6:15	23.8	22.4	25.0	28.5	31.0	30.5	" "
6:20	24.0	22.4	25.0	27.6	31.0	31.0	" "
6:25	23.7	21.9	25.0	30.0	30.2	30.7	" "
6:30	23.4	21.9	24.8	29.2	30.5	31.0	" "

Table 1 (Continued)

Time	Nonsprinkled area		Sprinkled area				Remarks
	Sheltered alcohol thermometer	Exposed alcohol thermometer*	Sheltered alcohol thermometer	Thermister inserted in exposed bud	Exposed mercury thermometer	Exposed alcohol thermometer*	
	°F	°F	°F	°F	°F	°F	
6:35AM	23.4	22.7	25.0	29.0	31.0	31.2	Clear, calm
6:40	23.2	23.2	25.2	29.7	31.5	31.5	" "
6:45	23.4	22.8	25.0	29.3	31.5	31.5	" "
6:50	23.5	22.6	24.8	28.3	31.0	31.0	" "
6:55	23.5	22.8	24.6	28.6	30.8	30.8	" "
7:00	23.3	22.3	24.3	29.2	30.0	30.2	" "
7:05	23.4	21.8	24.3	29.3	28.5	29.7	" "
7:10	23.5	22.7	24.3	29.5	28.5	28.5	Sun barely up
7:15	23.8	22.3	24.6	30.0	28.5	29.0	Sun up
7:18	23.9	22.2	25.0	30.3	29.5	29.8	
Average	24.2	22.9	25.2	29.2	29.6	29.7	

*Metal frame removed from exposed alcohol thermometers.

Tissue temperatures increased as more water was applied (Table 2). Water applied at the higher pressure was broken into a finer spray, but this did not seem to increase its efficiency. At an application rate of .14 inches per hour, the temperature of the bud was raised 5° F. This is as much protection as can be obtained from 35 heaters per acre under good heating conditions and more than can be obtained under adverse conditions of air drift or very high ceiling. It is interesting to note that freezing .14 acre-inch of water per hour releases the same amount of heat as burning 32.5 gallons of oil per acre per hour. This indicates that the heat liberated by freezing the water from overhead sprinklers is about as efficient for frost protection as the heat from burning oil.

Table 2. Temperature Increase of Thermometers in "Overtree" Sprinkled Area Over That of Sheltered Thermometer in Nonsprinkled Area (February 21-22, 1965)

Inches per hour	Sheltered thermometer	Thermister in bud	Exposed mercury thermometer	Exposed alcohol thermometer	Avg. of exposed thermometers and thermister
	°F	°F	°F	°F	°F
.06	.6	2.1	1.7	2.2	2.0
.08	.4	2.5	1.7	2.4	2.2
.10	.7	2.8	2.9	3.1	2.9
.12	.9	4.3	4.1	4.2	4.2
.14	1.0	5.0	5.4	5.5	5.3

The temperature of the air in the sprinkled area was raised a maximum of 1° F above the air temperature of nonsprinkled areas. However, as only one sprinkler was operated, air movement into and out of such a small area would have a great effect. This was demonstrated later in the 18-acre orchard.

Test No. 2 - Undertree Sprinklers

In test No. 1 the tree parts were protected by applying water directly to them and by warming them with heat liberated by the freezing water. To do this, it was necessary to apply the water over the tops of the trees. It would be more convenient and less hazardous to apply water under the trees if the same amount of heating could be obtained.

This was tested by placing three rainbird sprinklers with 3/32-inch nozzles so that their sprinkler patterns had a good overlap. Sheltered and exposed thermometers were set up outside the sprinkled area and above the sprinkled area at the 10-foot level, which was high enough so they would not be wet. This additional height placed them in somewhat warmer air. Eight readings at 5-minute intervals before the sprinklers were turned on showed that the sheltered thermometers above the area to be sprinkled averaged 0.7° F warmer than the outside sheltered thermometer (Table 3).

Table 3. Results of Sprinkling for Frost Control in Close-Planted, Severely Pruned 10-Year-Old Pear Seedlings, Using "Undertree" Sprinklers (February 28-March 1,1965)

Time	Nonsprinkled area		Sprinkled area			Remarks
	Sheltered alcohol thermometer	Exposed alcohol thermometer	Thermister inserted in exposed bud	Sheltered alcohol thermometer	Exposed alcohol thermometer	
	°F	°F	°F	°F	°F	
4:45 AM	30.5	28.0	30.5	31.0	30.3	Clear, calm
4:50	30.0	28.2	30.1	31.2	29.3	" "
4:55	29.9	27.6	30.0	31.0	28.6	" "
5:00	29.7	27.5	29.9	30.2	28.0	" "
5:05	29.5	27.6	29.8	30.0	27.8	" "
5:10	29.5	28.0	29.5	29.9	27.0	" "
5:15	29.4	26.9	29.5	30.0	28.8	" "
5:20	29.0	27.2	29.3	29.7	28.5	
Average	29.7	27.6	29.8	30.4	28.5	
5:25	Water on under trees					
5:30	28.6	27.0	29.0	29.5	28.5	Clear, calm
5:35	28.6	27.5	29.0	29.6	27.8	" "
5:40	28.5	27.0	29.0	29.6	27.0	" "
5:45	28.5	27.5	28.8	29.0	27.0	
Average	28.6	27.3	29.0	29.4	27.6	

Table 3. (Continued)

Time	Nonsprinkled area		Sprinkled area			Remarks
	Sheltered alcohol thermometer	Exposed alcohol thermometer	Thermister inserted in exposed bud	Sheltered alcohol thermometer	Exposed alcohol thermometer	
	°F	°F	°F	°F	°F	
6:30AM	27.5	26.0	27.0	28.0	25.5	Clear, calm
6:35	27.4	26.0	27.0	28.2	26.0	" "
6:40	27.0	25.8	27.0	28.0	27.0	" "
6:45	27.0	25.2	27.2	28.0	26.5	
Average	27.2	25.8	27.1	28.1	26.3	
	Undertree sprinklers turned off					
	Overtree sprinkler turned on .12 inches per hour					
6:48						
6:51	27.0	25.8	27.0	28.2	31.0	Clear, calm
6:55	27.1	26.0	27.2	28.2	31.0	" "
7:00	27.5	26.8	27.2	28.5	30.5	" "
7:02	1/4 sun peeping over horizon					
7:05	27.8	26.5	27.6	28.6	30.5	" "
7:15	28.0	27.0	28.0	29.5	32.0	
Average	27.5	26.4	27.4	28.6	31.0	

The undertree sprinklers were turned on at 5:25 a.m., March 1, shortly after the outside air temperature reached 29° F. Four readings made at 5-minute intervals showed the air temperature above the sprinklers had not changed in relation to the nonsprinkled air temperature (30.4 - 29.7 = .7), (29.4 - 28.6 = .8). No readings were taken for the next 45 minutes, giving the sprinklers an opportunity to warm the air. Four more readings were then taken at 5-minute intervals. These again showed that the air temperature above the sprinklers had not changed significantly in relation to the outside air temperature (28.1 - 27.2 = .9). Relative humidity readings taken during the test period with a sling psychrometer showed no difference between the two areas, both showing 92% to 95% relative humidity. Under the conditions of this test, bearing in mind its limited area, undertree sprinkling had no appreciable effect on either the temperature or relative humidity of the air above the sprinkled area.

At this point, the undertree sprinklers were turned off and overtree sprinkler turned on to deliver .12 inches per hour. An average of five readings at 5-minute intervals showed the exposed alcohol thermometer in the sprinkled area to be 31° F. This was 3.5° F above the air temperature in the nonsprinkled area. The air temperature under the sprinklers raised .4° F more than the outside air temperature (30.4 - 28.6 = 1.8), (29.7 - 27.5 = 2.2).

The temperature relationships in the test are summarized in Table 4.

Table 4. Temperature Readings of Thermometers in Sprinkled Area Compared to the Sheltered Thermometer Readings in the Nonsprinkled Area (February 28-March 1, 1965)

	Sheltered thermometer	Exposed thermometer
	°F	°F
Before sprinkling occurred	+ .7	- 1.2
With sprinkling under trees		
(First 20 minutes)	+ .8	- 1.0
(60 to 80 minutes)	+ .9	- .9
With sprinkling above trees	+ 1.1	+ 3.5

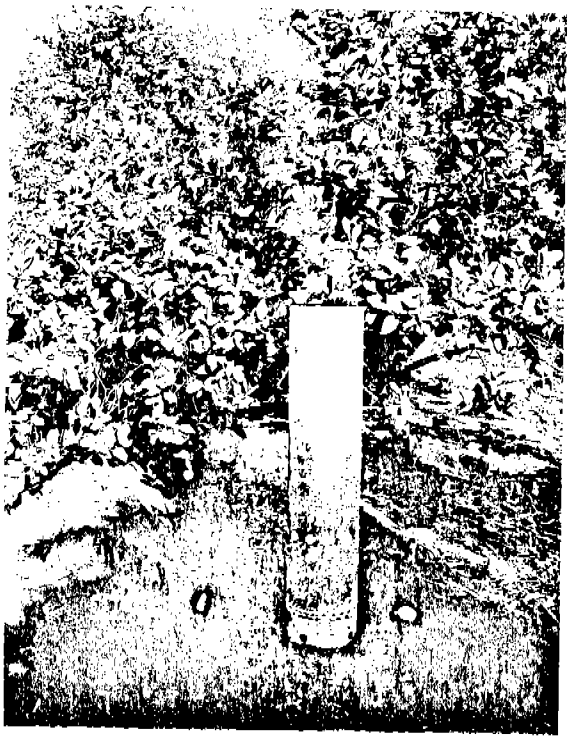
Test No. 3 - Undertree Sprinklers

Another attempt to warm the air by undertree sprinklers was made on the night of March 12. Four "Perm-a-rain" sprinklers with No. 3 nozzles were placed on the corners of a 25-foot square. These sprinklers whirled rapidly and produced a fine spray. The pattern overlapped at the center. Air temperatures above the sprinkled area at the 10-foot level and outside the sprinkled area were taken. The sprinklers were turned on at 6:05 a.m., March 13, when average outside air temperature at the 5-foot level was 29.2° F. The sprinklers were run for 30 minutes, then read five times at 5-minute intervals. The average air temperature above the sprinkled area actually dropped slightly in relation to the outside air temperature. Again, undertree sprinkling of a limited area failed to warm the air above the sprinkled area.

It seemed reasonable to assume that if undertree sprinkling was to be effective under conditions of high relative humidity, the water droplets would have to freeze in the air and impart their heat of freezing directly to the air. It was observed that the relatively fine droplets produced by these sprinklers did not freeze in the air but did freeze on the surface of the soil. The heat of freezing in this case would be imparted to the soil and quickly lost by radiation, thus relatively ineffective in raising air temperature.

Test No. 4 - Mist Sprinkler

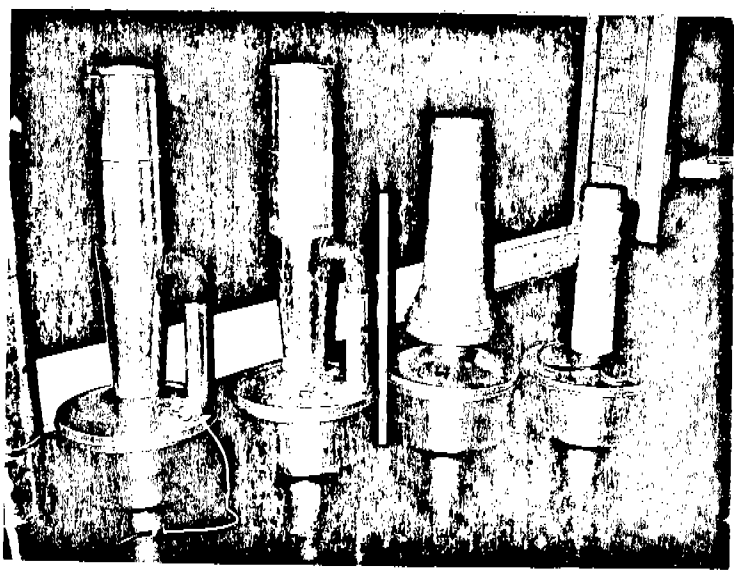
To test this further, four sprinklers producing a very fine mist were set up on a 25-foot square. These sprinklers were similar to a spray nozzle with approximately a 1/32-inch opening in the disc and a whirl plate below the disc. The very fine mist was discharged as a plume atop a 7-foot riser. The plume was 4 feet wide and 5 feet high, and the minute droplets settled gently to the ground. They did not appear to freeze in the air, but settled and froze on contact with the ground. These mist sprinklers were tested on the night of March 13. Before the sprinklers



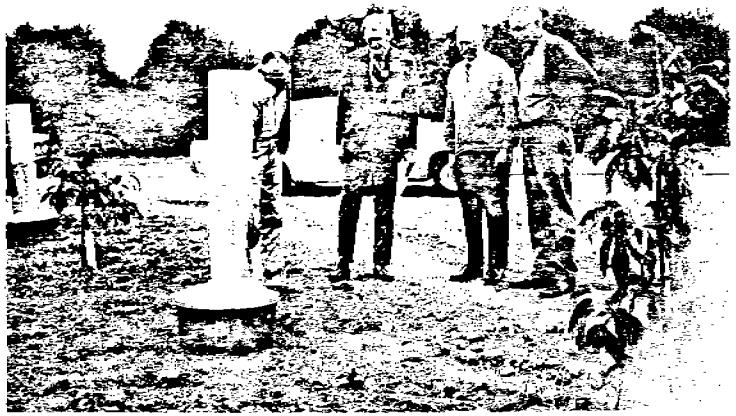
12-15-70 10:10 a.m.
Masco pipeline in operation - Galbraith Ranch, Aliso Canyon Rd.

APPROVED ORCHARD HEATERS

12-14-70: left to right - Spot Heater, Masco Jr. Masco, Universal or Return Stack (pipeline) Universal or Return Stack, Tree Heat (foreground)



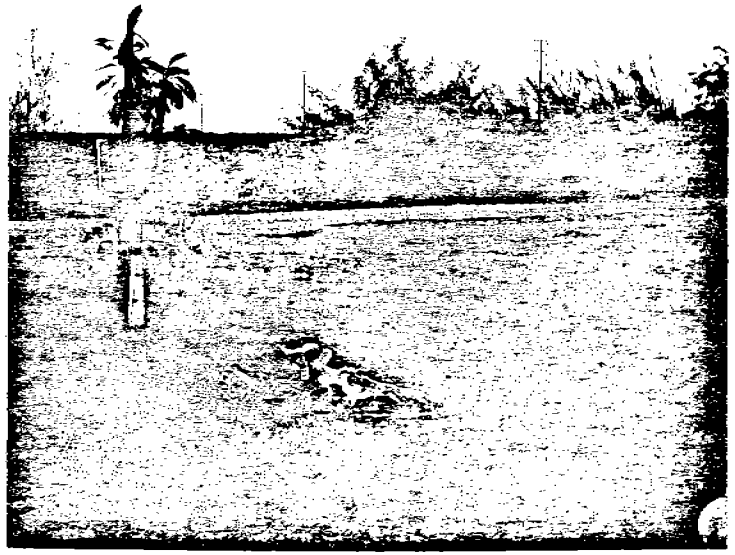
12-14-70: left to right - Universal or Return Stack (pipeline), Universal or Return Stack, Large Cone or Jumbo Cone, Lazy Flame



10-5-70 Lighting of Return Stack Heater (Universal)
Bob Burns, Jim Lehr, Al Tiffany Ed Curran

10-5-70 Lighting of Return stack Heater (Universal
Bob Burns, Ed Curran, Jim Lehr, Al Tiffany

10-5-70 Mobil Oil Co. "Tree Heat". White area in
center is where tree heat is burning.



10-5-70 Mobil Oil Co. "Tree Heat Block & Flame.

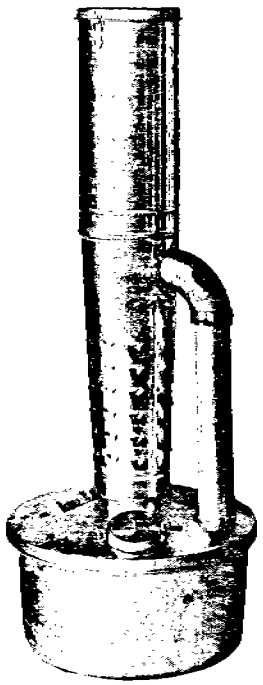
National-Riverside

IMPROVED ORCHARD HEATERS

MANUFACTURERS OF QUALITY HEATERS FOR OVER 50 YEAR

CLASS "A" HEATERS--APPROVED BY ALL AIR POLLUTION CONTROL ORDINANCES--

The Riverside tall Stack heaters pass ALL anti-smudge and smog control tests with a wide margin. Carbon emission is considerably less than the allowable ½ gram per minute.



UNIVERSAL

University of California, College of Agriculture stated after testing the improved UNIVERSAL: "Tests run by us during the past month on your current model Return Stack orchard heater indicate that its design is near the optimum for this type of heater. Its minimum burning rate with full bowl of fuel is a little less than one-half gallon per hour; and its combustion is virtually smokeless up to one gallon per hour. It showed no appreciable loss in performance after nearly 100 hours of operation without cleaning."

Orchard heating costs are actually reduced with the UNIVERSAL because of its efficient, clean burning, trouble-free operation. We have delivered thousands of these heaters to growers who have had a chance to compare and have found our UNIVERSAL to have the most ideal burning and heating characteristics of any return stack heater produced.

SPECIFICATIONS
Height . . . . . 52"
Weight . . . . . 24.5 lbs.
Bowl Capacity . . . 10 gal.
Fuel . . . . . No. 2 Diesel
Fuel Consumption . . . ½ to 1½ gal. per hr.

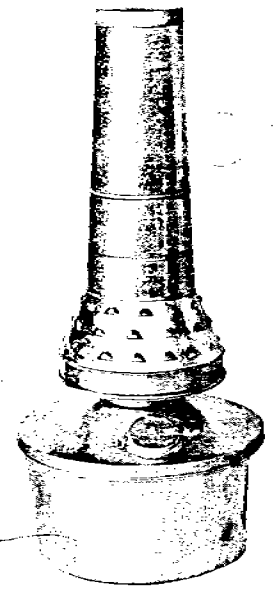
HEAT RANGE 70,000-210,000 B.T.U.'s PER HOUR

CLASS "A" HEATERS - Orchard heaters so designed or equipped that they can be effectively operated so as not to discharge unconsumed solid carbonaceous matter at a rate in excess of one half (½) gram per minute.

Improved with Automatic Regulator - insures a constant burning rate - the same rate as originally regulated without additional manual adjustment as the fuel in the bowl is consumed. Recent official Laboratory Tests point out OUTSTANDING ADVANTAGES of the Riverside JUMBO.

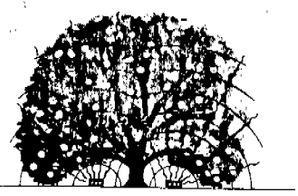
GREATEST FROST PROTECTION ASSURED: The Jumbo Cone Heater was developed to provide the maximum amount of frost protection per gallon of fuel consumed. The high percentage of radiant heat produced by the Jumbo Cone Heater can often provide the margin of safety to bring the crop through a frost or freeze. Actual tests prove the JUMBO produces far more radiant heat, while consuming less oil. This is the heater for those really cold areas.

SPECIFICATIONS:
Height . . . . . 45"
Weight. . . . . 19.5 lbs.
Bowl Capacity. . . . 10 gal.
Fuel . . . . . No. 2 Diesel
Fuel Consumption. . . ½ to 1½ gal. per hr.



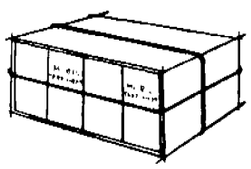
JUMBO

Mobil® Tree-Heet

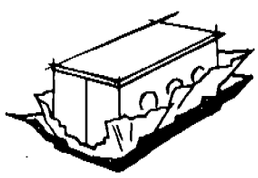


CITRUS USE BULLETIN

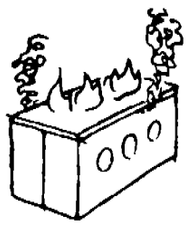
GENERAL INFORMATION



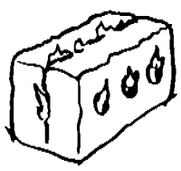
TREE-HEET package, comes in wire strapped bundles of 12 x 4-lb or 8 x 6-lb pkgs.



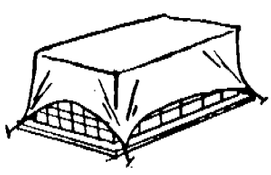
Plastic bag holds two or three bricks, igniter cap, wax paper wrap



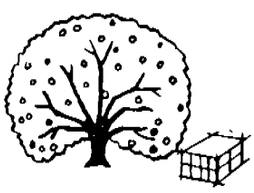
First half-hour burning: 6-8" flame from igniter, gives some grey smoke



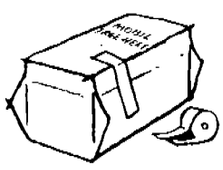
Then burns 5-6 hours — with low intense flame, smokeless radiant glow



After cold season, store off ground, under tarp, ready for next year



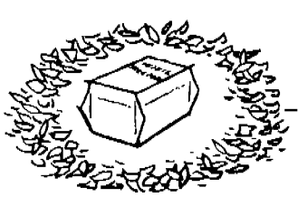
Keep field reserve ready in bundles — for several nights or severe cold



Avoid puncturing bag, mend with plastic tape, moisture in bag slows burning

Remove packages from the orchard prior flood irrigation or cultivation

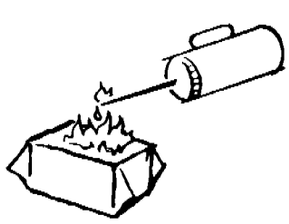
PLACING AND LIGHTING



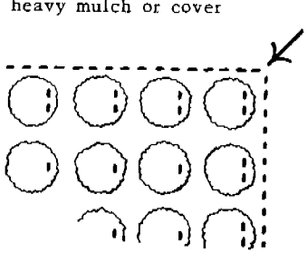
Put on level ground with printed side up. Remove heavy mulch or cover

Most efficient heating — under arch of scaffold branches, 3 feet apart

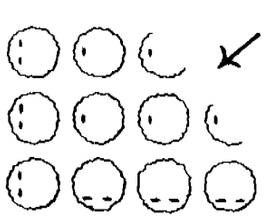
For faster lighting between trees, near or at drip line. Nearly as effective



With pot lighter pour burning 60/40 gas-diesel on top — 100 pkgs./gal.

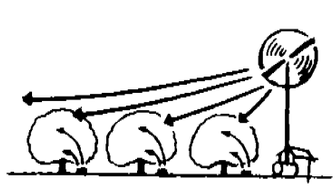


Warm wind or air drift with line of packages on border. Light ¼-½ first



Double quantity on all borders to warm cold air drawn in by mass air rise

Use with oil heaters on nights with high ceiling, severe cold & on borders



Use with wind machines — with high ceiling, severe cold, borders, corners

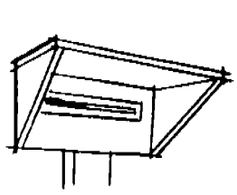
REMINDERS

Contract for labor early — explain duties, equipment, safety precautions, plan.

Seek advice from Weather Bureau, farm advisers, read... university bulletins.

FRUIT	– 27°-30.5°
BLOOM	– 27°-30°
LEAVES	– 23°-28°
SMALL WOOD	– 21°-25°
MAJOR WOOD	– 19°-21°
(AVERAGE RANGE)	

Know the critical temperature for all tree parts. Consider condition, etc.



Calibrate and place thermometers to know °F all areas. They signal *light.*

TEMPERATURE RISE DATA calm - clear nights

Quantity (Packages/Acre)	Square Foot Per Package	Spacing	Expected Temperature Rise — 5' Level In Trees	
			Burned Under Tree	Burned in Rows — Near Tree
100 x 4 lb. 67 x 6 lb.	435 650	20' x 22' or 15' x 29' 25' x 26' or 20' x 32'	2½ - 3°F	2 - 2½°F
200 x 4 lb. 133 x 6 lb.	218 325	20' x 11' or 15' x 15' 20' x 16' or 25' x 13'	5 - 6°F	4 - 5°F
300 x 4 lb. 200 x 6 lb.	145 218	20' x 7' or 15' x 10' 20' x 11' or 15' x 15'	7½ - 9°F	6 - 7½°F

READ WITH SALES BROCHURE