PROJECT REPORT

ON PILOT SCALE TREATMENT

BY HSVE METHOD

PREPARED FOR

STA-RITE INDUSTRIES

DELAVAN, WISCONSIN

BY

JAY JATKAR, INC.

NAPERVILLE, ILLINOIS

JAN. 1997

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EXECUTIVE SUMMARY

Heated Soil Vapor Extraction (HSVE) (Patent Pending) is a method developed by Jay Jatkar to quickly remediate soil contaminated by organic compounds. By using present SVE method normally it takes many years to remediate the soil and is very expensive. Costs are very unpredictable and time of remediation is not known. Many consulting companies wrongly predict the time of remediation and generally spend more than twice the time and twice the money for remediating a project. By using HSVE method time of remediation is cut down from a few days to a few weeks and the cost is known up front. As in the case of this project the cost is given in the proposal and the estimated time of remediation is between 3 days to 3 weeks depending on the use of temperatures used for remediation.

In this method a hot oil circulating heater/boiler (approximately 1 million BTU per hour capacity) will be used to circulate oil in a one inch pipe line. This pipe line is insulated outside, above ground. A six inch pipe, which is welded at the bottom and capped at the top will be installed to a depth of approximately sixteen feet in the ground. This six inch pipe will serve to prevent any leakaga of oil to the ground in case of leak from the one inch circulating pipe line. Before heater/boiler is fired up, the one inch pipe line is pressure tested to make sure that it will not leak during the operation. Since oil is circulated within one inch pipe it will serve as lubricant, and prevent any corrosion of the pipe. This one inch pipe line will be installed within the six inch diameter line and the six inch line will be filled up with fine sand or pee gravel as a heat transfer media,

Heat transferred from oil to the ground is a function of the temperature. The higher the temperature difference (ΔT) between the ground and temperature of oil, the higher the rate of transfer to the ground. This is given by Fouriers Law of heat flow of conduction, which is for a unit surface given by

$$q/A = - K (dT/dX)$$

where q/A = Heat Transfer Per Unit Area
K = Thermal Conductivity
dT = Temperature Difference
dX = Thickness

This equation can be solved by use of boundary conditions to calculate the heat transferred to the soil. Once the heat is transferred to the soil and the

temperature of the soil is increased, vapor pressure of the organic contaminants and water, which is present in the soil is increased. With high vapor pressure of organic and evaporation of small quantity of moisture (less than half percent), which enhances the removal of organic (steam distillation).

HSVE is predominantly dominated by evaporation and distillation of organic depending on the temperature and not by diffusion as in the case of SVE. In this case the temperature of the system will be controlled in such a way that the exhaust temperature of the vapors will remain below 145 degrees F, so that the PVC pipe of the SVE will not melt.

Since this system (heating with oil) is a close system and pressure tested before start up, there is no possibility of leakage to the ground. Since this is a close system, as per dicussion with Tom Wentland of DNR SE district - "No ROD" action to the pilot scale operation is given by DNR.

INTRODUCTION

Heated soil vapor extraction system or HSVE (patent pending) has been designed and invented by Jay Jatkar to improve the present method of extracting vapors or contaminants from soil. Present method of SVE takes at least 3 to 5 years to clean-up a site and is very costly. HSVE takes a very short time, generally 3 to 6 weeks, depending on the type and concentration of the contaminants. In many cases a temperature of 200 F is enough to remove contaminants quickly, as in the case of STA-RITE INDUSTRIES, but temperature as high as 600 F can be achieved in extreme cases, where diesel or oil contamination is present. All the VOC's can be reduced to non-detect level even by reaching a temperature up to 200 F.

A temperature distribution chart, i.e., temperatures at various locations in soil has been calculated and included.

LABORATORY TEST

Laboratory tests conducted with soil contaminated with Acetone, Benzene and tri-chloroethylene showed remarkable results. A 1kg. sample of soil contaminated with approximately 5% of VOC (above solvents) each of the above material was treated at 200 F for 24 hours. Tests on the treated material showed non-detect levels of Acetone, Benzene and tri-chloroethylene on each of the samples.

A Table shows a vapor pressure of a few solvents at low temperature and at Boiling point.

Name	20mm	60mm	100mm	200mm	400mm	760mm	Comments
Acetone	--------	-2.0	7.7	22.7	39.5	56.5	C
Benzene	--------	15.4	26.1	42.2	60.6	80.1	C
Ethyl Benzene	38.6	61.8	74.1	92.7	113.8	136.2	C
Toluene	18.4	40.3	51.9	69.5	89.5	110.6	C
2-xylene	45.1	68.8	81.3	100.2	14.7	144.4	C
Water	22.1	41.5	51.6	66.5	83.0	100.0	C

Therefore, at higher temperature it is possible to remove solvents very quickly from soil. For example, by boiling water in a container it can be vaporized very quickly in a few minutes where as by letting it stand at room temperature, it will take several days to vaporize the same quantity of water.

The same principle applies here for HSVE, where a solvent can quickly evaporate from the soil, condensed in a heat exchanger, collected in a receiver, and a small amount can be let out in the air.

THE OPERATING (HEATING) SYSTEM

SVE is described in many literatures as well as by Simon Hydro-Search in their report, so emphasis is placed here on HSVE i.e. heating system.

The heating system consists of oil heater which is heated by diesel or light diesel oil. Thermic fluid capable of reaching temperature up to 450 degree F will be used as a heating media. Heat will be transferred to the thermic fluid by burning diesel or LDO in the boiler. Efficiency of these heating units is generally above 95%. A circulation pump will circulate the oil through one inch pipe line. Heat will be transferred to the soil by conduction. Heater unit will have many controls as well as automatic shut off system. This unit will be mounted in a trailer. In case of emergency the system will shut down by it-self. As an example, if oil leaks within the six inch pipe line, the system will shut down because of low oil level and prevent any spill. It is possible to heat the oil to almost 450 degrees F by using oil such as MobilTherm or ExxonTherm that are available in the market.

After completion of the work oil will be drained from the pipeline. Sand or Pee-gravel will be vacuumed, and one inch pipe line will be dismantled. Six inch piping which is installed during drilling operation will be removed and void space will be filled, and impacted with cleaner soil or clay.

TIME SCHEDULE

Jan 13 - Jan 15	Submission of Report
Jan 13 - Jan 17	Approval of Report
Jan 17 - Jan 25	Ordering of Equipment
Jan 25 - Feb 15	Equipment Arrival & Installation
Feb 15 - Feb 21	Installation & Testing
Feb 22 - Feb 28	Trial Runs
Mar 1 - Mar 21	System Run - Project Completion
Mar 21 - Mar 31	Testing of Soil etc.

HEAT REQUIREMENTS

For this pilot plant operation, consider contamination of size

30 ft long X 30 ft wide X 20 ft deep = 18,000 cubic ft of soil

= 666.6 cubic yds of soil

= 1.8 million lbs of soil

Amount of heat required to heat soil from 35 degrees F to 200 degrees F = $mC_p\Delta T$

= 1,800,000 lbs X 0.75 btu per lb X (200-35)

= 222,750,000 btu

1 gallon of fuel has calorific value of approximately 1,000,000 btu

Therefore fuel requirement = approximately 225 gallons to heat the soil

Losses through SVE system = 225 X 1.5 gallons = 337.5 gallons

So Fuel requirement = 562.5 gallons

Heat requirement to maintain temperature of the soil, (Fuel requirement)

= 350 gallons

Total fuel requirement = 912 gallons

MONITORING PROGRAM PLAN

All the analysis of the gases out of SVE system on a regular basis as required as well as soil analysis will be conducted by STA-RITE.

HEALTH AND SAFETY PLAN

Safety equipment available at the site will be used for emergencies such as first-aid kit, fire extinguishers, eye-wash stations and spill clean up supplies etc.

GENERAL SAFTY RULES:

1. All personnel shall have appropriate training in performing their specific duties related to HSVE/SVE system.

2. Wear safty glasses all time on site.

3. Treatment facility will be designated non-smoking area.

4. All incidents will be reported to STARITE representative.

5. If any hazardous material is used, then MSDS will be maintained on the site.

HSVE - Patent Pending

Heated Soil Vapor Extraction Method

Patent Pending

Inventor

Jay Jatkar

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- HSVE - Technology
- Applicatons - Soil & Bio-Remediation
- IN-SITU Application Overview
- HSVE - Overview, Equipment
- HSVE - Achievable & Recommended Temperatures
- HSVE - Advantages
- Comparision - SVE Vs HSVE

HSVE - Patent Pending

HSVE - TECHNOLOGY

- To Replace Present Method - SVC
- Dramatically Reduces Clean-Up Time From Many Years to 2 to 12 Weeks
- Concentration Of Contaminant - Any Concentration - No Problem
- Temperature's - Upto 600 degree Centi - Max
- Low Boiling Contaminants - Reduced to Non-Detect Level

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- Diesel - Below 10 PPM - In 3 Weeks
- Below 1 PPM - In 6-10 Weeks
- Can Remove *PARA-NECLUEAR-AROMOTICS*
- Can Clean-Up Any Oils - Will Take Longer Time

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HSVE -APPLICATIONS

a. IN-SITU Soil Remediation

- Soil Cleaning - Containing Gasoline, Diesel, Organics, Olis,.....
- Will Clean-Up PNA's
- Will Remove Diesel To 100%
- Or Less Than 1 PPM

b. Bio-Remediation

- Will Maintain Temperature Of Soil At Prescribed Temperature Through the Year

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- Can Work Without Removing Tanks
- Can Clean-Up Gasoline Tanks Without Disturbing Operation
- Clean-Up Halogenated Solvents To Non-Detect Levels Within Three Months, Any Concentration, Any Size Contamination
- Sizeof Contamination - No Problem - Will Design Equipment Accordingly

HSVE - Patent Pending

HSVE - IN- SITU OVERVIEW (Cont.)

- Cost Of Equipment Can Be Reduced By Alternate Heating Method
- Estimated Savings Between 20 - 40% of SVE Costs

HSVE - Patent Pending

HSVE - COMPARISION

	SVE	HSVE
1.	Long Time 1-10 Years	Short Time 2-12 Weeks Depending On Soil & Temp. Used
2.	High Cost	Low Cost
3.	Mobil Unit	Mobil Unit - Will Dismental & Remove
4.	Low Efficiency	High Efficiency
5.	Operates At Room Temp	Temp Can Be Controlled

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HSVE -OVERVIEW

- Closed System
- Heat Transfer By Conduction
- Same Efficiency Throughout Year
- No Leakage To Soil
- All Pipes Are Welded & Tested Periodically
- Cost Of Operation Very Low

HSVE - Patent Pending

HSVE - EQUIPMENT

- Trailer
- Boiler/heater
- Heat Exchanger
- Receiver
- Piping
- Carbon Cells
- Installation

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HSVE - TEMPERATURES

- Achievable Temperatures Upto 400 degrees C
- Recommended Temperatures Upto 200 degrees C For Low Boiling Solvents

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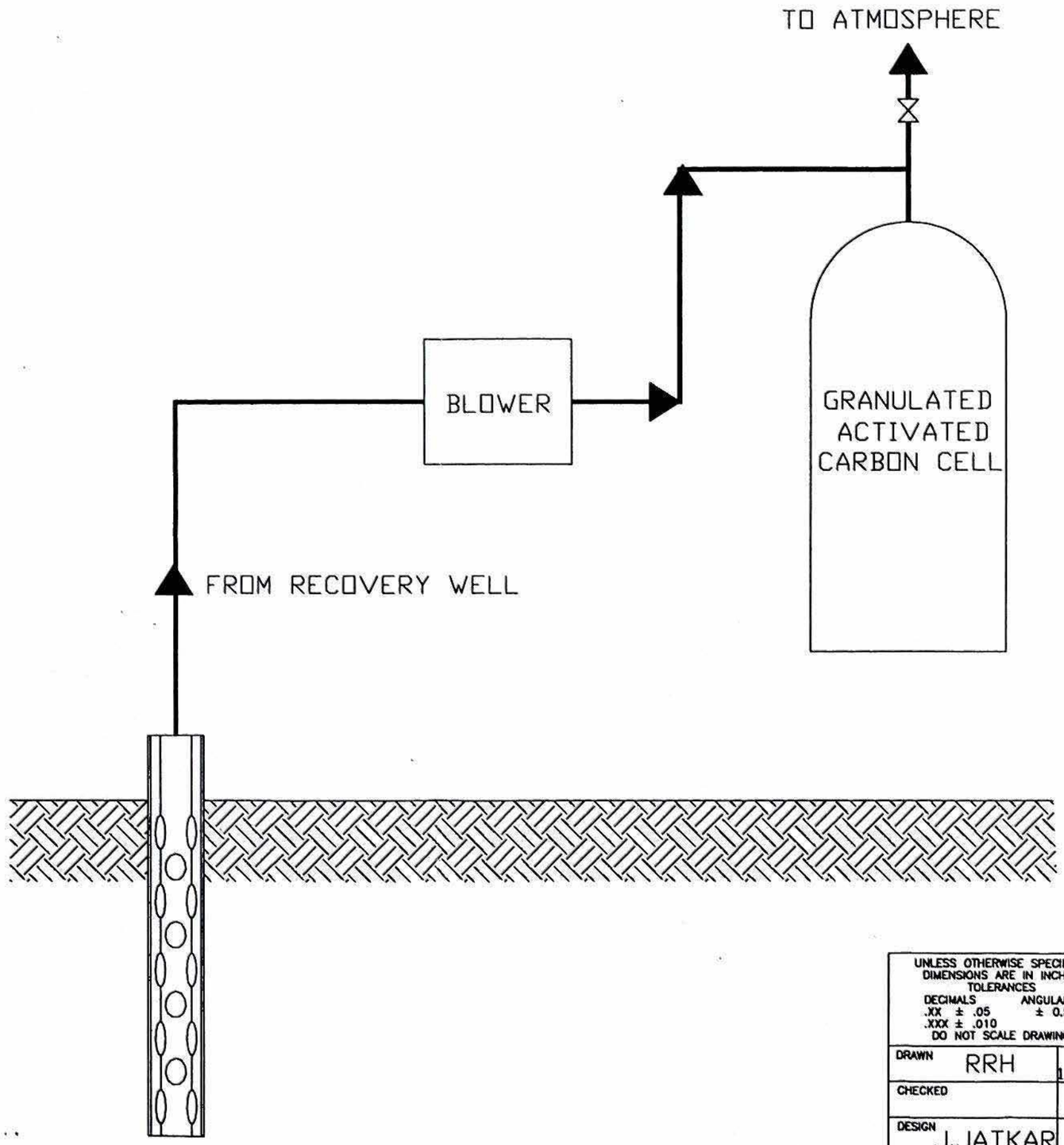
HSVE - ADVANTAGES

- Cost Of Operation Known Up-front
- Know The Time Up-front
- No Continuous Analysis Required
- Good For PR
- Indefiniteness W.R.T. Time & Cost With SVE Method
- HSVE Will Be The BEST Technology In The World
- Cost & Inflation Not Affected



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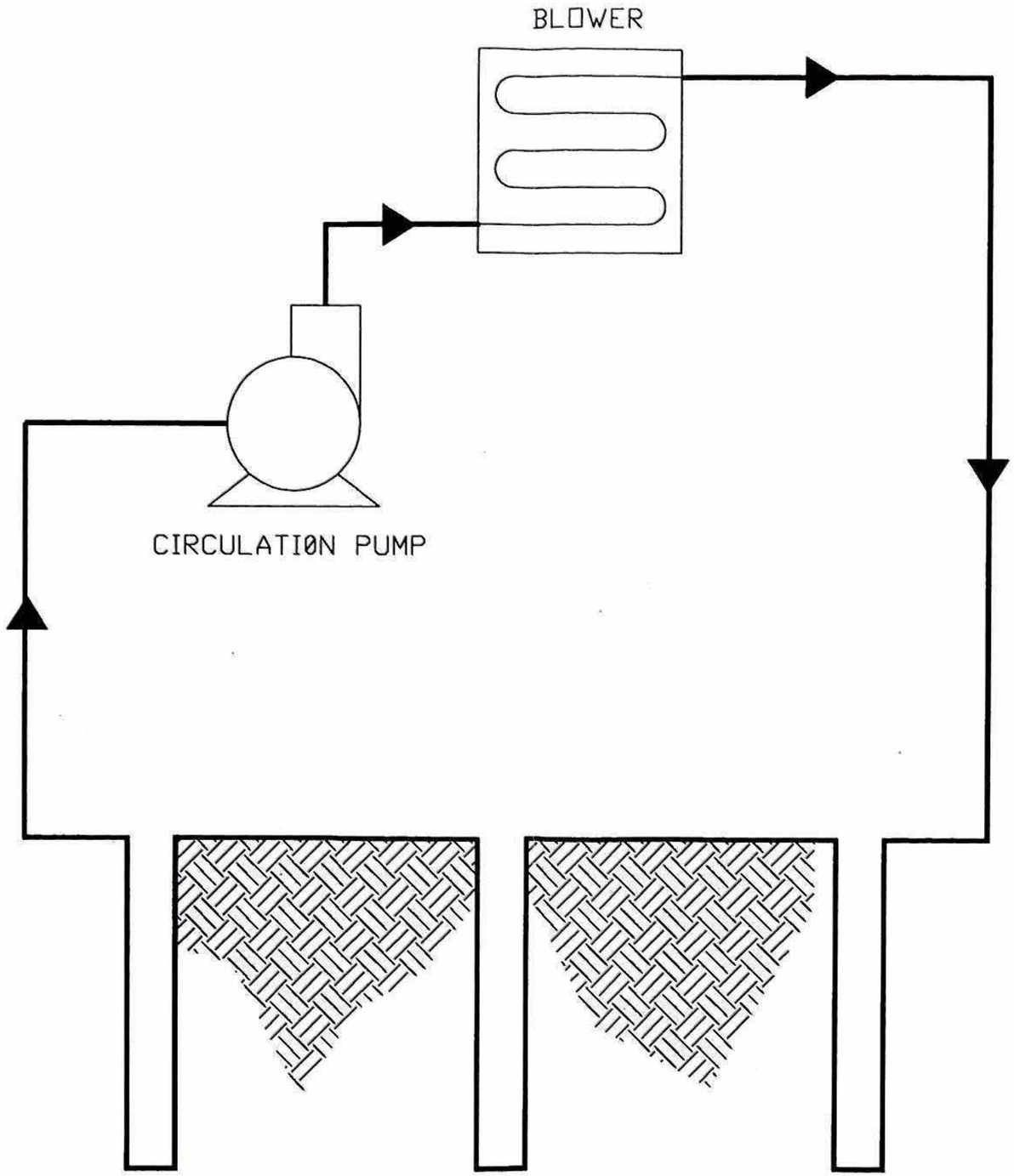
DRAWN RRH DATE 1/8/97	FLOW SCHEMATIC FOR SVE SYSTEM
CHECKED	SIZE B FSCM NO. DWG NO. 97001 REV 0
DESIGN J.JATKAR	SCALE NONE SHEET 3 OF 8



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DO NOT SCALE DRAWING

DRAWN RRH DATE 1/8/97
CHECKED
DESIGN J.JATKAR

Jay Jatkar, Inc.
1335 Hunter Circle
Naperville, Il. 60540

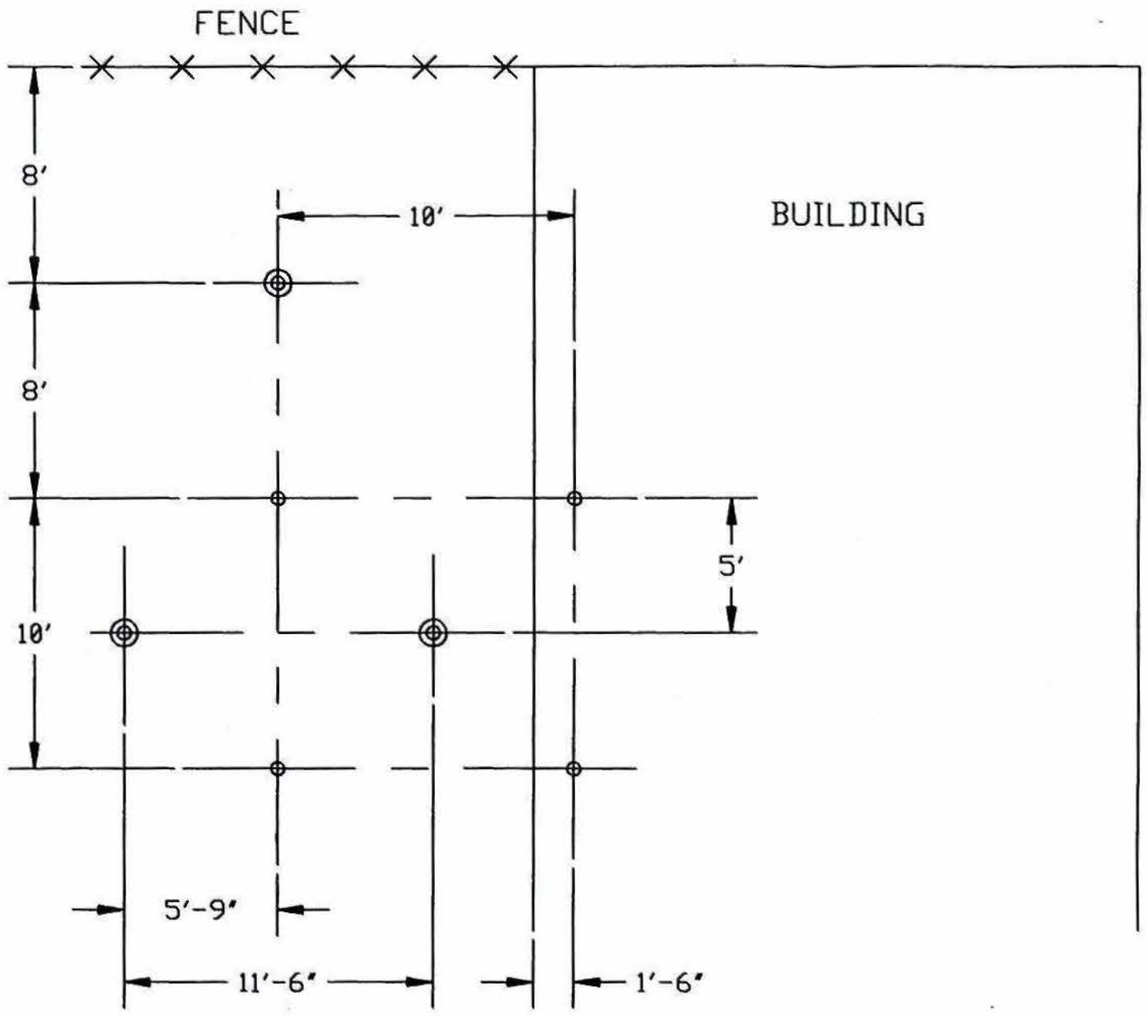
FLOW SCHEMATIC
FOR HEATING SYSTEM

SIZE B | FSCM NO. | DWG NO. 97001 | REV 0
SCALE NONE | SHEET 4 OF 8

LOCATION OF:

o ——— HEAT LINE

◎ ——— EXTRACT LINE



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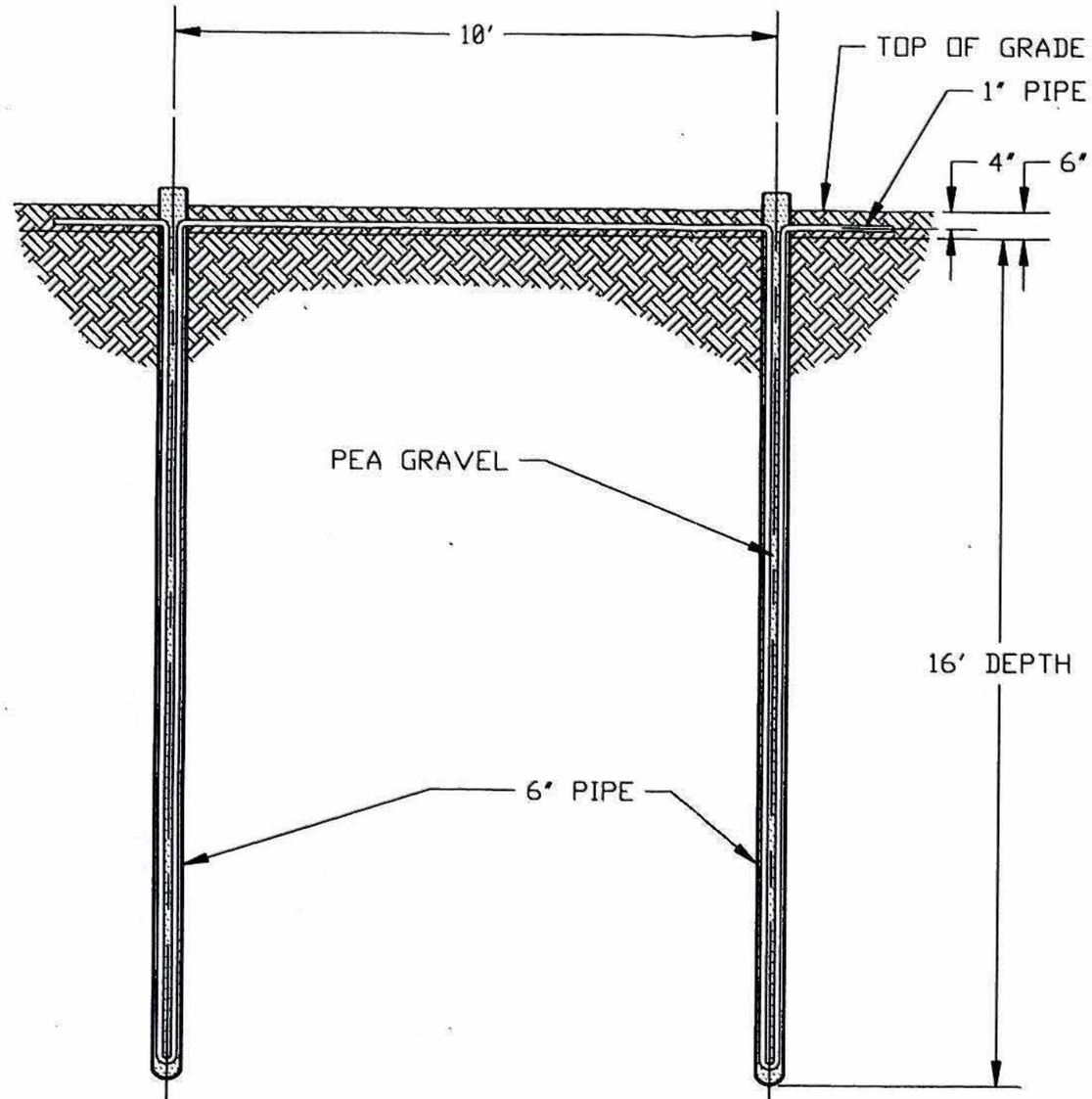
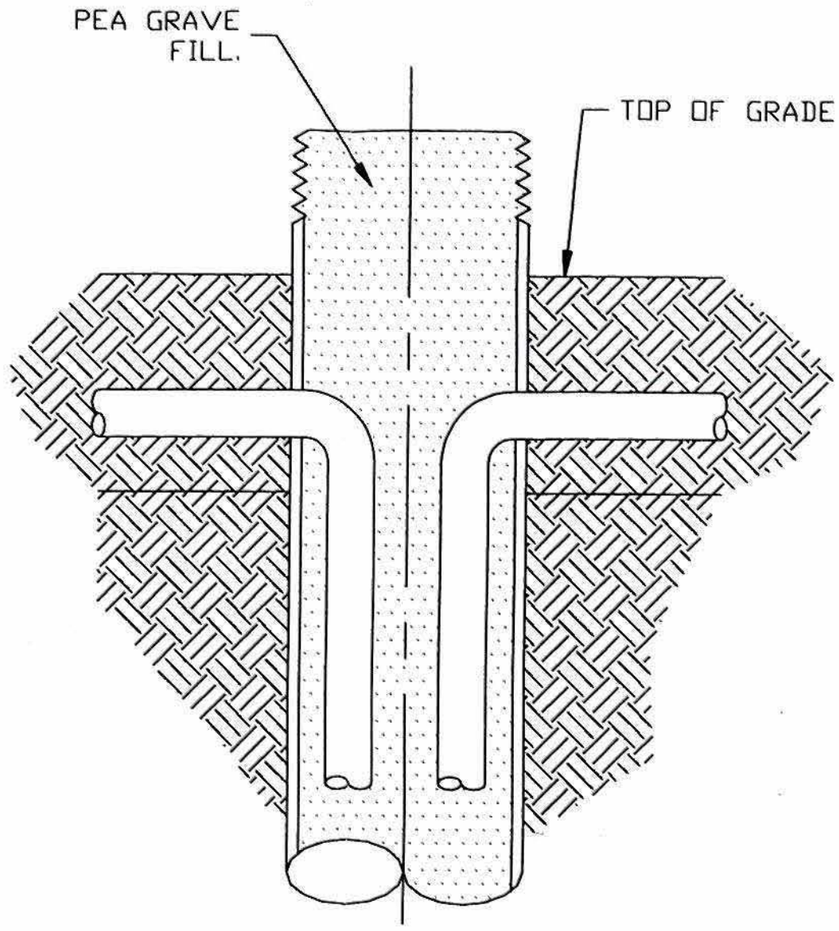
DRAWN RRH DATE 1/8/97	STA-RITE DELAVAN PILOT PROJECT
CHECKED	SIZE B FSCM NO. DWG NO. 97001 REV 0
DESIGN J.JATKAR	SCALE 1/64"=1'-0" SHEET 5 OF 8



CROSS SECTION
HEATING LINES

SCALE: 3/8"=1'-0"



ENLARGED VIEW

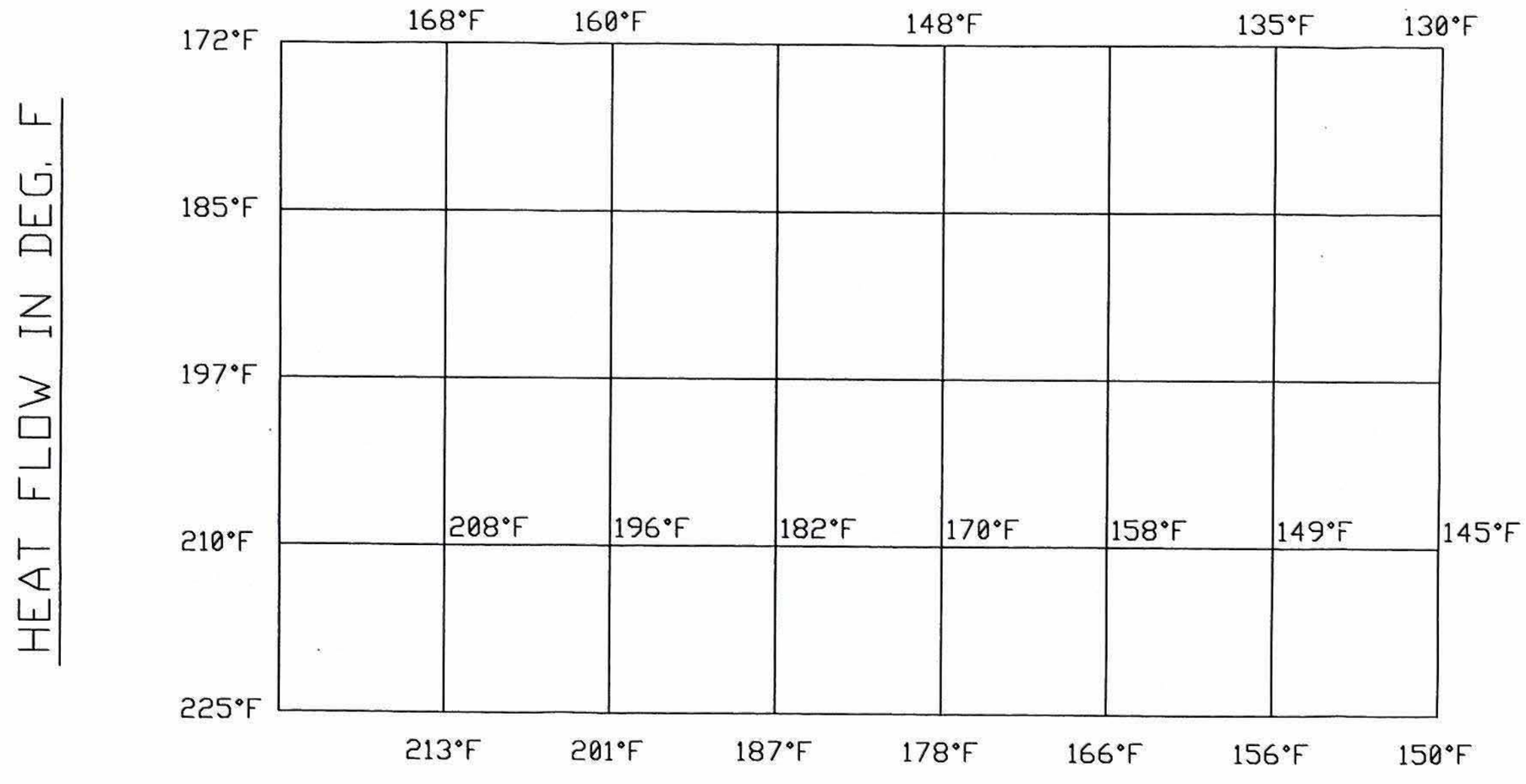
SCALE: NONE

NOTE:

WORK THIS DRAWING WITH SHEET 5 OF 8.

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ± .05 .XXX ± .010 ANGULAR ± 0.5° DO NOT SCALE DRAWING		Jay Jatkar, Inc. 1335 Hunter Circle Naperville, Il. 60540	
DRAWN RRH	DATE 1/8/97	PIPING SYSTEM (HEATING LINES)	
CHECKED		SIZE B / FSCM NO. / DWG NO. 97001	REV 0
DESIGN J.JATKAR		SCALE NOTED	SHEET 6 OF 8

TEMPERATURE ACROSS 7' X 4' CROSS SECTION
AFTER REACHING EQUILIBRIUM
TWO - DIMENSIONAL STEADY - STATE CONDUCTION



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ANGULAR ± 0.5°
DO NOT SCALE DRAWING

DRAWN	RRH	DATE 1/8/97
CHECKED		
DESIGN	J.JATKAR	

Jay Jatkar, Inc.
1335 Hunter Circle
Naperville, Il. 60540

TEMPERATURE GRADIENT CHART

SIZE	FSCM NO.	DWG NO.	REV
B		97001	0

SCALE NONE

SHEET 7 OF 8

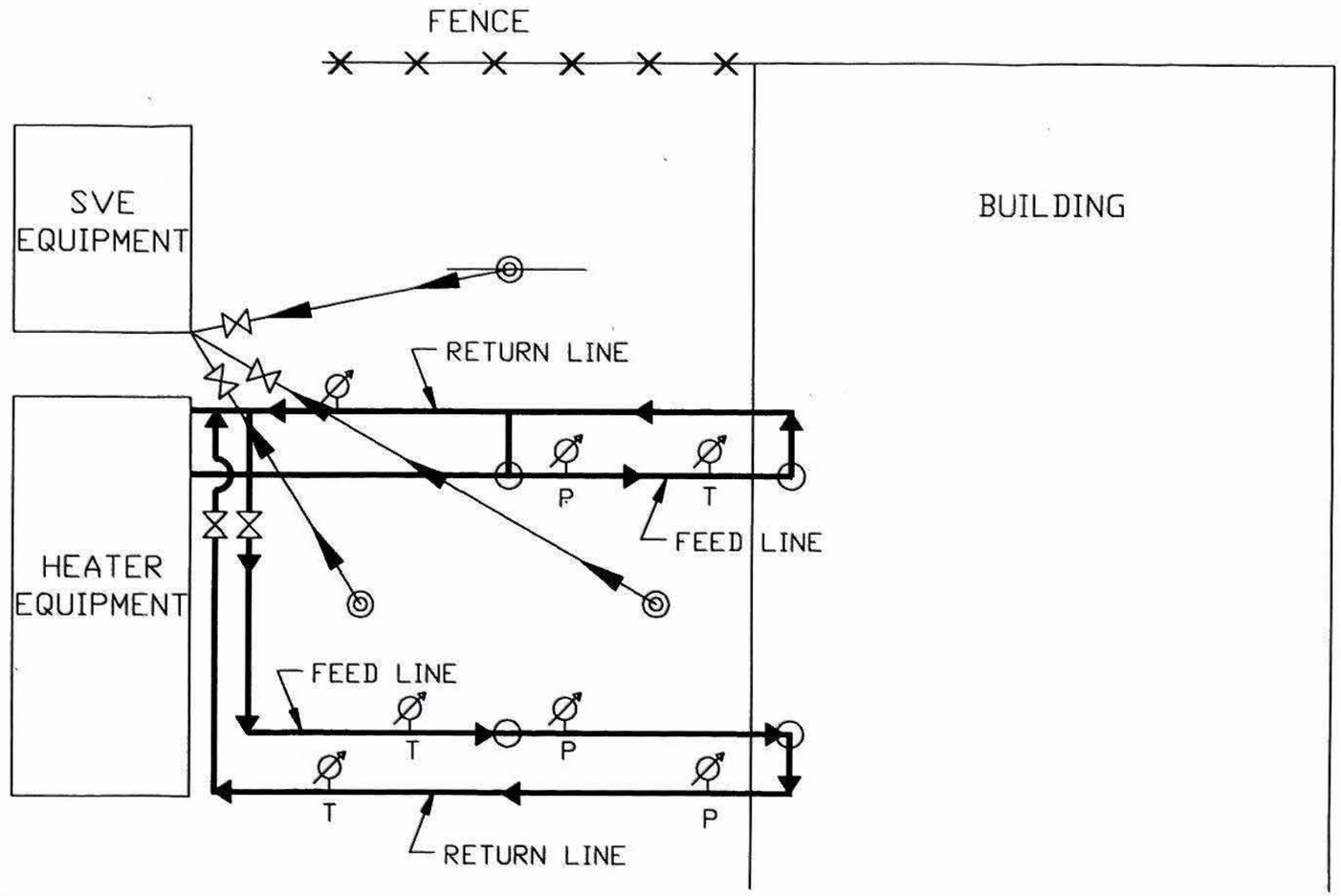
LOCATION OF:

HEAT LINE

EXTRACT LINE

P — PRESSURE GAUGE

T — TEMPERATURE GAUGE



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DO NOT SCALE DRAWING

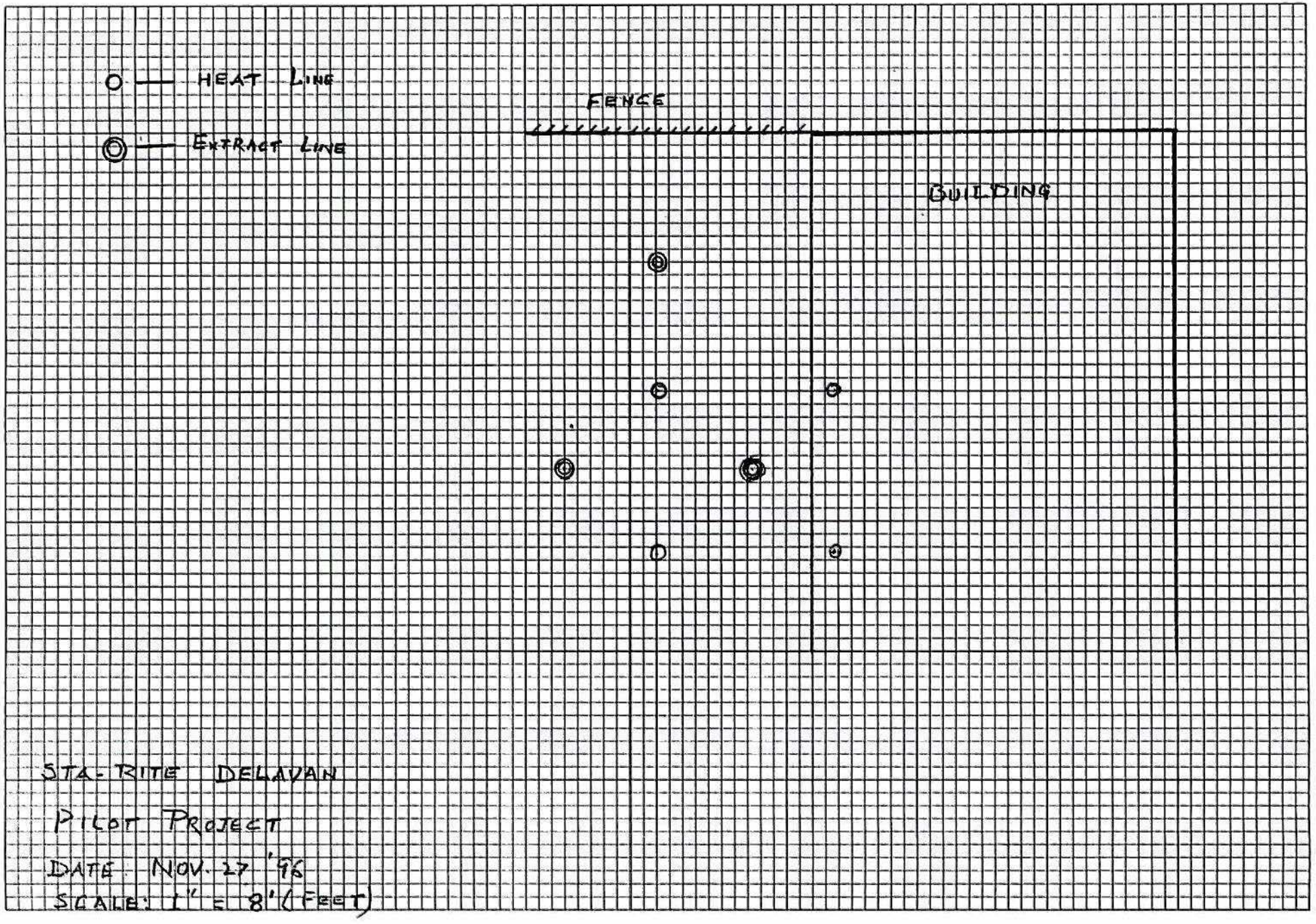
DRAWN RRH	DATE 1/8/97	
CHECKED		
DESIGN J.JATKAR		

Jay Jatkar, Inc.
1335 Hunter Circle
Naperville, Il. 60540

PIPING FOR HEATER AND SVE SYSTEM

SIZE	FSCM NO.	DWG NO.	REV
B		97001	0

SCALE 1/64"=1'-0" SHEET 8 OF 8



STA-RITE DELAVAN

PILOT PROJECT

DATE NOV. 27 '96

SCALE: 1" = 8' (FEET)

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FIG. 2

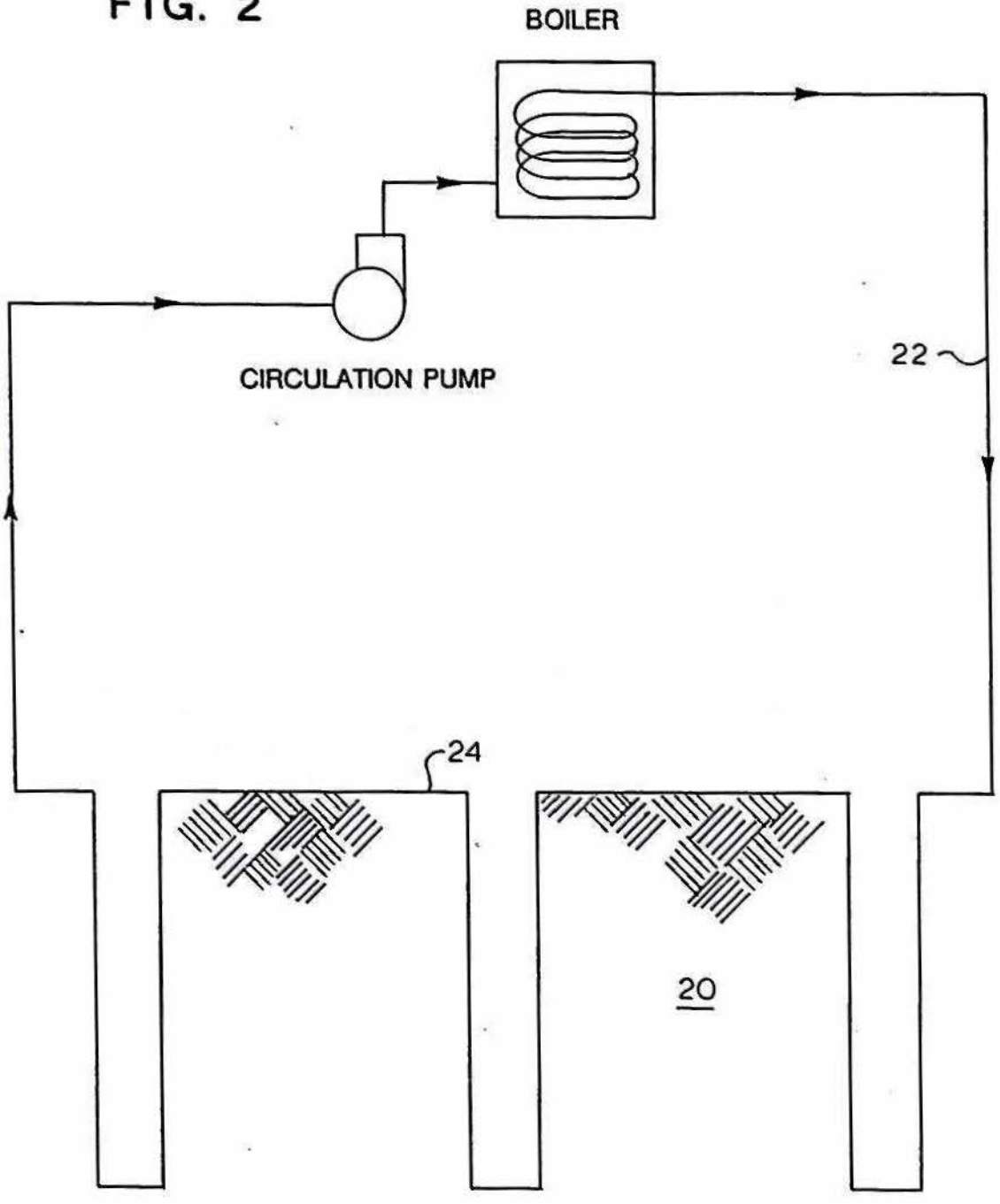
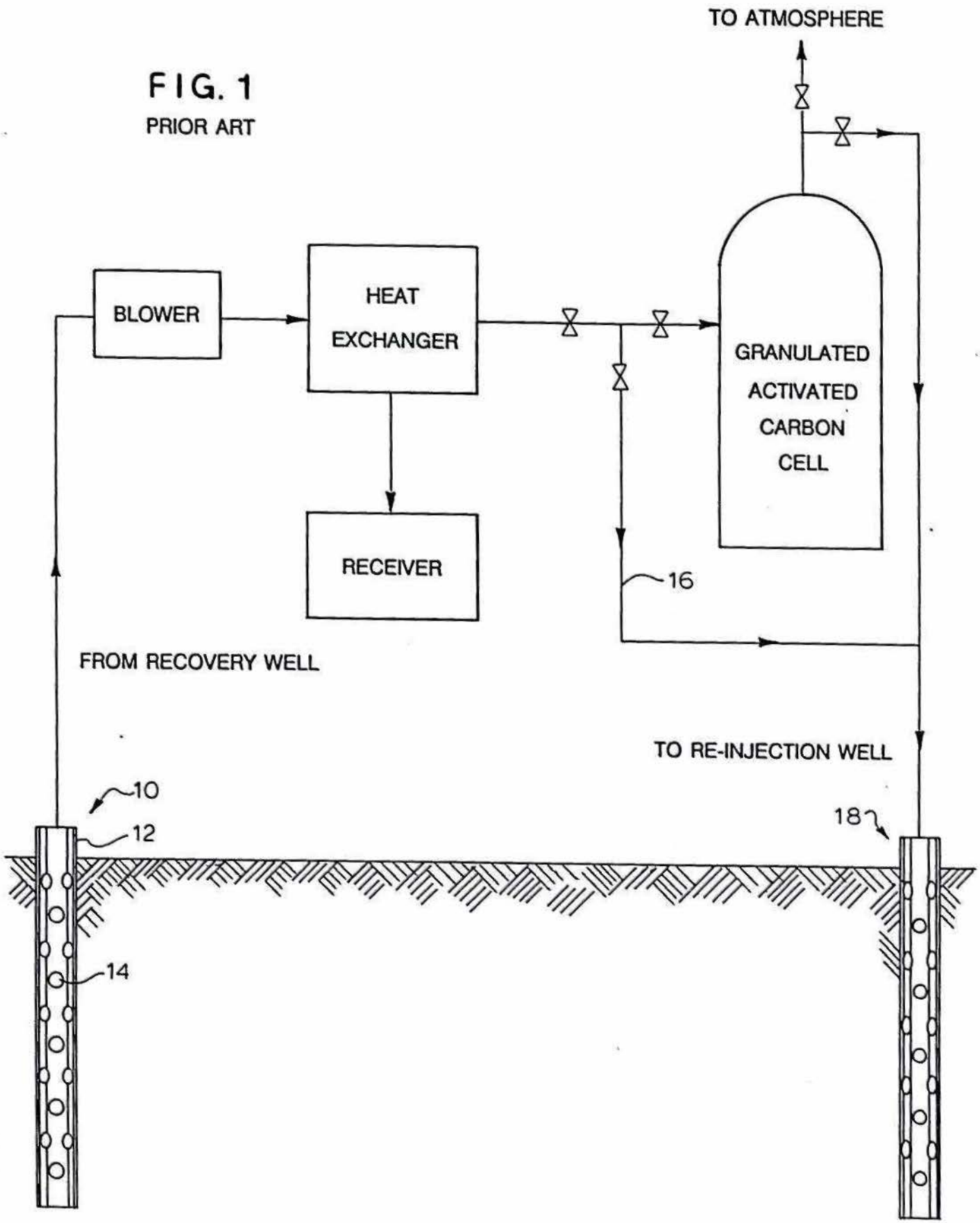
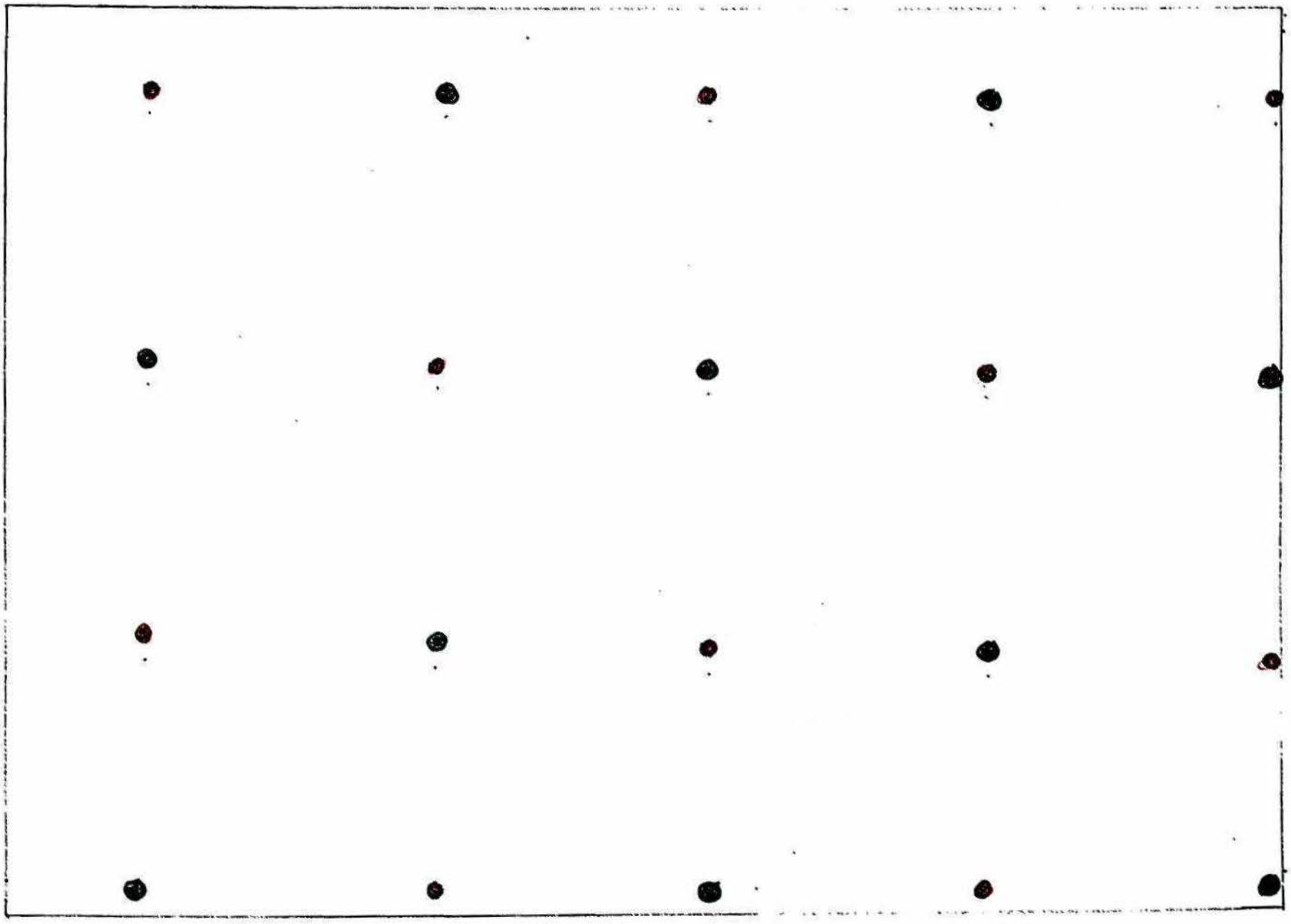


FIG. 1
PRIOR ART

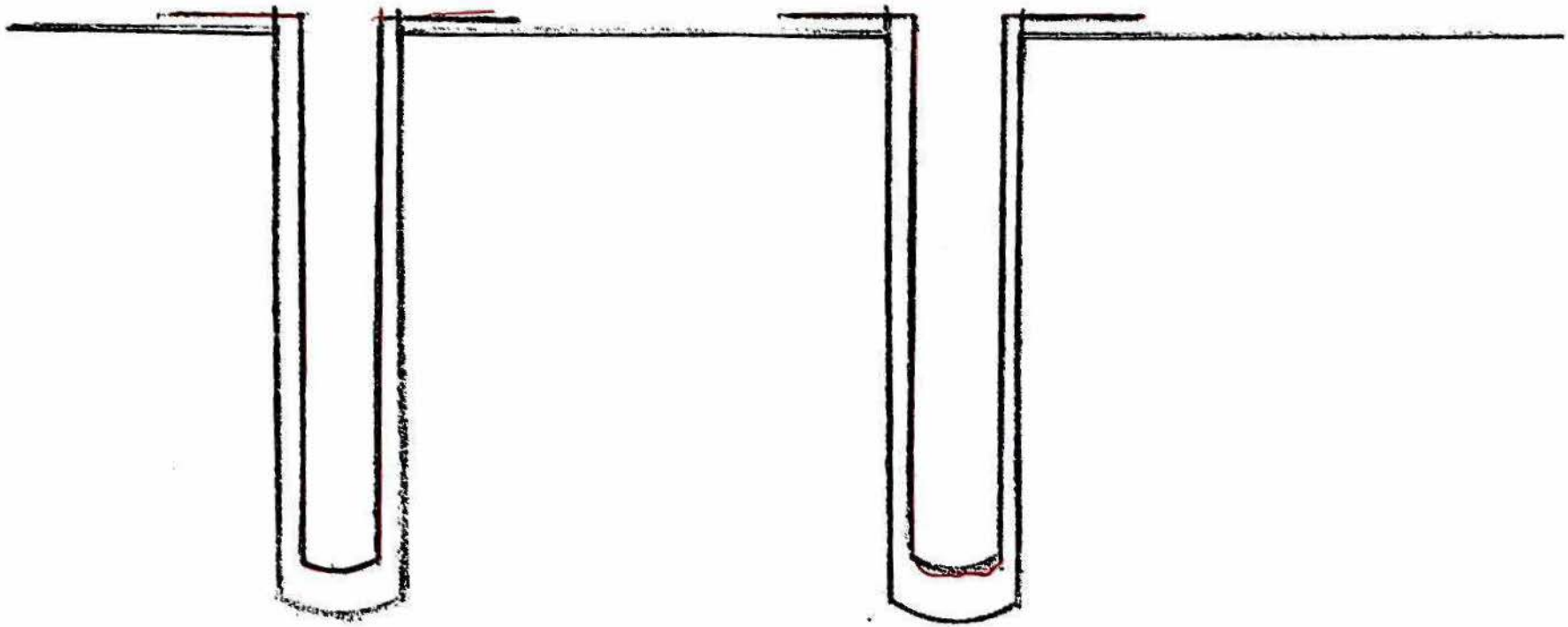


HEAT LINE

EXTRACTION LINE



HEATING LINE WITHIN 6 INCH PIPELINE



Time required to heat Soil to Above Temp	= 92 Hrs
Estimated Heat Loss	= 30%
Time Required to Reach the temp of 150 F	= 120 hrs = 5 Days
Total Cost	= $5,960
Vapor Pressure of TRICHLOROETHYLENE at 150 F	= 395mmHg
Heat of Vaporization	= 103 Btu per lb
TRICHOLOROETHYLENE Removed in 5 days	= 5 Tons
Additional Heating Time Required	= 8 days
Cost	= $ 3,200
Quantity of Additional TRICHOLORO ETHYLENE that can be removed	= 6.5 Tons
Time Required to Cool Soil to Room Temperature	= 2 Weeks
Total Time of Operation	= 1 Month
Energy Cost	= $ 9,160
Electrical Energy Cost (Estimated)	=$ 2,000

NOTE: All the above costs are estimated at this time

VAPOR PRESSURE OF TRICHLOROETHYLENE - C_2HCL_3										
Vapor PR MM Hg	1	5	10	20	40	60	100	200	400	760
TEMP C	-43.8	-22.8	-12.4	-1	11.9	20	31.4	48	67	86.7
VAPOR PRESSURE OF WATER - H_2O										
Vapor PR MM Hg	4.579	6.101	8.045	10.518	13.634	17.535		200	400	760
TEMP C	0	4	8	12	16	20		48	67	86.7
Vapor PR MM Hg	25.756	31.824	55.324	92.51	149.38	233.7		200	400	760
TEMP C	25	30	40	50	60	70		48	67	86.7
Vapor PR MM Hg	355.1	525.76	633.9	682.7	733.24	760		200	400	760
TEMP C	80	90	95	97	99	100		48	67	86.7
LATENT HEAT OF VAPORIZATION OF TRICHLOROETHYLENE										
	Heat of Vaporization = 103 Btu/lb									

TEMPERATURE ACROSS - 7' × 4' CROSS SECTION

AFTER REACHING EQUILIBRIUM

TWO - DIMENSIONAL STEADY - STATE CONDUCTION

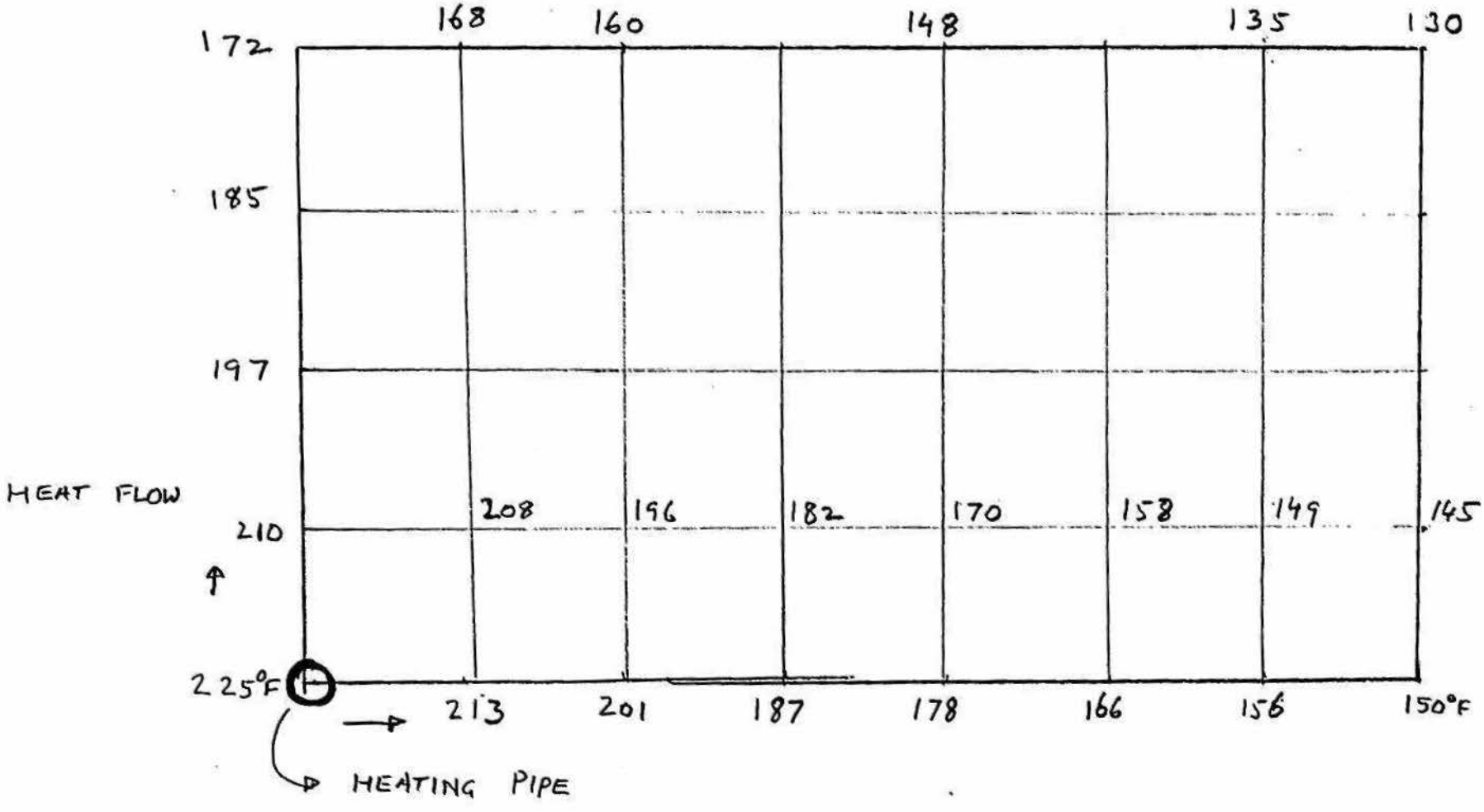


FIG-1.

HEAT REQUIREMENT/TIME FOR STA-RITE DELAVAN SITE

FOR REMOVAL OF TRICHLOROETHYLENE

BASIS

PLANT I (SIZE)	=163 ft X 62.5 ft X 10ft	= 3773 cubic yd
Weight of Soil	= 3773 X 2.7 T	= 10187100 lbs
m	= 10,187,100 lbs	
Avg Heat Capacity	= 0.45	
T	= (150 F - 50 F)	=100 F
Average Soil Temp	= 50 F	
Soil to be heated to	= 150 F	
Heat Required to heat (to 150 F)	= 10,187,100 X 0.45 X 100	= 458,419,500 Btu
Cost to Heat	= 458,419,500 X 1.0 / 100,000	= $4584