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AUTH.NAME AUTHOR AFFILIATION
UHRIG,R.E. Florida Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
Office of Nuclear Reactor Regulation

SUBJECT: Responds to NRC 800403 ltr re facility fire protection program.Forwards info re alternate safe shutdown capabilty, automatic fire suppression sys & calculations demonstrating adequacy of screen wash pumps as alternate water source.

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FLORIDA POWER & LIGHT COMPANY

May 7, 1980
L-80-140

Office of Nuclear Reactor Regulation
Attention: Mr. Darrell G. Eisenhut, Acting Director
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Eisenhut:

Re: Turkey Point Units 3 & 4
Docket Nos. 50-250 & 50-251
Fire Protection

This letter is in response to A. Schwencer's letter of April 3, 1980 to Robert E. Uhrig concerning the Fire Protection Program at Turkey Point. Attachments 1 and 2 respond to Enclosures 1 and 2, respectively, of Mr. Schwencer's letter. Attachment 3 discusses alternate safe shutdown capability and automatic fire suppression systems. Attachment 4 contains calculations which demonstrate the adequacy of the screen wash pumps as an alternate water source. The numbering scheme corresponds to that of the NRC Fire Protection Safety Evaluation Report (SER) for Turkey Point Units 3 and 4 dated March 21, 1979.

Very truly yours,

For Robert E. Uhrig
Vice President
Advanced Systems & Technology

REU/MAS/cph

Attachment

cc: Mr. James P. O'Reilly, Region II
Harold F. Reis, Esquire

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ATTACHMENT I

Re: Turkey Point Units 3 & 4
Docket Nos. 50-250 & 50-251
Fire Protection

3.1.1 - Fire Detection Systems

The fourth sentence of the third paragraph should be clarified to read "The remote lamps divide the diesel generator building into four compartments, one for each diesel generator and one for each day tank, with a single remote lamp for each compartment" (revised portion underlined).

The electrical schematic (paragraph 5) has been corrected to correspond to the plan view on drawing 5177-100-E-12.

3.1.2 - Fire Water Supply

Fire water demand was recalculated to determine the adequacy of the screen wash pumps to provide back-up to the main fire pumps. Deluge system flow rates for the hydrogen seal oil unit, the auxiliary transformer and the main transformer were added to our analysis which was submitted to the NRC Staff on May 21, 1979 (see Attachment 4).

We do not intend to permanently connect the screen wash pumps to the fire water system. The fire water system is connected to the domestic water supply. Inleakage from the screen wash pumps through a permanent connection to the fire water system could contaminate the domestic water supply. Thus, a permanent connection is not considered feasible.

A temporary connection has been proposed, in lieu of a permanent hard pipe connection. Appropriate connections would be installed and a rolled up section of hose would be located in the area to facilitate rapid connection between the screen wash pumps and fire water system. If the screen wash pumps were connected to the fire water supply appropriate measures would then be taken to prevent and monitor inleakage to the domestic water supply.

3.1.6 - Water Suppression Systems

With respect to the five recommendations in the third paragraph:

1. Minimum pipe size will be one inch. This will be added to the appropriate Plant Change/Modification (PC/M).

2. At the present time we are not planning to use bushings. However, if we determine that bushings are applicable in this modification, then they will be added to the appropriate PC/M per NFPA 13 Section 3-13.3 (Reducers & Bushings) 1980 Edition.

3. Heat collectors will be provided on sprinkler heads. This was included in the appropriate PC/M.

4. We are not planning to use a water flow switch with annunciation in the Control Room. Our position is based primarily on the number of sprinkler heads and NFPA 13 Section 3-17.2 (Where Required) 1980 Edition. Furthermore, the Nuclear Turbine Operator and roving security guards provide the added safeguard of continuous personnel monitoring outside the switchgear rooms and surrounding areas.

5. The feed for switchgear room sprinkler heads will be independent of the feeds for the deluge systems. This was included in the appropriate PC/M.

The Fire Protection SER states that fixed water spray protection will be provided for the door of the switchgear rooms which face the main and auxiliary transformers. We have reconsidered this fire protection modification and we have decided to remove the existing door in each switchgear room that faces the transformer area. We will block up the door opening with an appropriate 3 hour fire rated wall. This change effects the following fire protection SER requirements: 3.1.6 (Water Suppression), 3.1.9 (Fire Doors) Section (2), and 3.1.13 (Curbs) Paragraph (1).

3.1.7 - Foam Suppression

We have confirmed that the diesel generator room penetrations are of sufficient size (4 inches) to accommodate portable foam equipment. The maximum outer diameter of the foam equipment is 3.23 inches.

Since the day tank rooms will have a 1-1/2 hour fire door with a wire/glass window, we have not included special day tank room penetrations in our modification plans. If necessary, portable foam suppression equipment can be introduced through the windows by punching the respective window out with a forcible entry tool or the foam nozzle.

ATTACHMENT 2

Re: Turkey Point Units 3 & 4
Docket Nos. 50-250 & 50-251
Fire Protection

3.2.1 - Smoke Detection Systems

In lieu of in-situ testing, an independent registered fire protection engineer will be contracted to perform an evaluation to certify the adequacy of smoke detection systems.

3.2.2 - Reactor Coolant Pumps

FPL is planning to install an oil collection system for each of the reactor coolant pumps for both units #3 and #4. The system will provide for removal of potential oil leakage to a safe location. Potential oil leakage accounted for in the design include 1) the lift oil system (pump, piping, etc.), 2) bearing oil cooler head flanges, 3) oil circulation pipeline flanges to and from the cooler, and 4) lower bearing oil reservoir. The oil collection system will be designed to withstand an SSE and not cause loss of operability of safety related equipment.

3.2.3 - Water Supply

Section 8.5.2 of the Fire Hazards Analysis (FHA) presents the design basis for the fire evaluations. The plant areas analyzed were those considered to be related to safe shutdown capability. Although fire suppression capability is available, no credit was assumed for mitigating the consequences of a design basis fire i.e., the fire is assumed to burn at its maximum burnout until the available fuel is consumed. The Fire Hazards Analysis concludes that safe shutdown conditions can be achieved and maintained for the postulate design basis fire without the use of the available fire suppression capability.

However, as stated in section 6.1 of the FHA, water for fire suppression is available from two sources. The gravity tank has a design capability of 100,000 gallons and the raw water storage tank has a design capacity of 500,000 gallons. Section 3.14 of the plant technical specifications concerning the Fire Protection System administratively places minimum water volumes to be contained in each of these separate tanks. The gravity tank (elevated storage tank) is specified to have a minimum of 30,000 gallons of water available for fire protection. The raw water storage tank is specified to have a minimum of 150,000 gallons available for fire protection. The tank capacities amd technical specifications illustrate that water is available on site for fire protection.

Based on our recalculations for the maximum area of water demand we have determined that the screen wash pumps provide an adequate alternate source of water for fire fighting. The calculations in support of this conclusion are in Attachment 4.

The B Fire Pump derives its power from nuclear unit 3 load center 3C, not nuclear unit 2 as stated in paragraph 4. The B Fire Pump is automatically loaded onto the diesel generators with no operator action required, hence, a loss of offsite power or a fire in the transformer area would not cause the loss of function of the B Fire Pump.

We do not plan to install a curb before resolving the alternate water supply and screen wash pump connection issues.

3.2.4 - Auxiliary Building Corridor

The "automatic sprinkler system" and "alternate shutdown capability" issues are discussed in Attachment 3.

The chemistry laboratories (hot and cold labs) and the new laundry facility will be provided with fire detection systems, 3-hour fire doors, and 3-hour fire dampers for ventilation ducts.

Barrels made of fire retardant material to collect clothing used by workers for contamination protection are presently located in the Auxiliary Building hallway.

3.2.5 - Cable Spreading Area

The "automatic gas suppression system" and "alternate shutdown capability" issues are discussed in Attachment 3.

A booster hose station for the cable spreading room has been installed, and we will install 1-1/2 hour access doors from the cable spreading room to the Turbine Building.

ATTACHMENT 3

Re: Turkey Point Units 3 and 4
Docket Nos. 50-250 and 50-251
Fire Protection

Florida Power & Light is currently evaluating automatic sprinkler system, automatic gas suppression system, and alternate safe shutdown capability requirements. The evaluation is being conducted in response to A. Schwencer's letter to Robert E. Uhrig of October 29, 1979. We expect to respond to these issues by June 5, 1980. However, the following comments are provided now in order to correct statements contained in Section 3.4, Auxiliary Building Corridor, and Section 3.5, Cable Spreading Area of Enclosure 2 of Mr. Schwencer's April 3, 1980 letter.

The NRC Staff's SER of March 21, 1979 questioned our licensed and approved cable separation criteria and requested Florida Power & Light to install a water sprinkler system where it was not needed and could pose a hazard for safety related electrical equipment. The bases for the Staff's conclusions appear to be contained in the first and second paragraphs on page 3-5 of Enclosure 2. The following discussion is intended to correct the Staff's interpretation of the applicability of the Sandia tests to Turkey Point.

Paragraph 1 Page 3-5: In all areas of Turkey Point 3 and 4 all cable tray systems are coated with Flamemastic 71A. IEEE-383 oily rag and gas burner cable tray fire tests conducted for Florida Power & Light showed no fire propagation along horizontal or vertical Flamemastic 71A coated cable. The results of these testing programs demonstrated that Flamemastic 71A was an effective cable fire proofing coating and that if a cable could be made to burn the fire would not spread. Hence, all areas of cable congestion at Turkey Point were fire proofed with Flamemastic 71A before the Browns Ferry fire.

Paragraph 2 Page 3-5: This paragraph, which is the pivotal basis in the Staff's argument, is not the result of a proper understanding of the Sandia fire test goals, criteria, or results. The full scale two-tray coating fire tests conducted by Sandia were established to determine if flame propagation would occur between trays as a result of a fire in the bottom tray. The Sandia test method is probably the most severe test method used to date because of the conservative test conditions, e.g. 1) open ladder cable trays, 2) very low cable fill percent because of figure eighting of cables in order to obtain heat and air venting openings, 3) used the worst of the unqualified cables, 4) used two 70,000 Btu/hr burners 5) both burners aligned to directly impact the coated cables a distance of 4.75 inches away.

In the Flamemastic 71A, Non-IEEE 383 cable test it took 10 minutes to ignite the cables in the bottom tray. Following this the cables in the bottom tray burned for 26 minutes, before self extinguishing, and achieved a maximum temperature of 1260°F. The cables in the top tray did not short, did not

burn, were undamaged and achieved a maximum temperature of only 167°F. In conclusion, the same coating system (Flamemastic 71A), with same application technique, on cables similar to those at Turkey Point passed the Sandia test.

Hence, the statement in the second paragraph, ..."The cable tray directly exposed to the fire in the Sandia tests suffered considerable damage and burned for approximately 42 minutes."... is not correct since the tray was not badly damaged and it burned for only 26 minutes. Further "...Coated cables in a tray 10-1/2 inches above the exposed tray were also damaged."... is incorrect since the cables were not damaged. Also ..."propagation of flames to the upper tray would have occurred if a larger exposure fire had been used..." is not at all true since additional burners might ignite the lower tray sooner but the tray probably would not burn any faster hence the upper tray would not be impacted. And finally ..."if the cables had been energized at rated current or if the coating had been applied and the cables arranged to simulate more closely a field installation"... the energization of cables is a trivial heat source compared to the test conditions and 1) the Flamemastic 71A coating was applied in the same way as is done in the field 2) field run cabling is not figure eighted inside of the trays hence less air space is available between the cables.

Further and contrary to the Staff's position, Flamemastic 71A also effectively seals in the combustible inventory associated with the cable insulation. The very severe Sandia fire test of the Flamemastic 71A coated non-IEEE 383 cables discussed above yielded a weight loss of only 7-1/2 pounds. This loss is attributable to burned cable insulation and pyrolized organic binder in the Flamemastic 71A, and in total has a heat release equivalent of approximately two changes of street clothing. This small amount of energy spread over the Auxiliary Building Hallway or Cable Spread Room will have an insignificant affect on temperatures.

Numerous changes in administrative controls and the recent completion of the new laundry facility have resulted in significant combustible reductions in the Auxiliary Building Hallway. Combustibles in the area are now primarily associated with four to five partially filled barrels of protective clothing (steel barrels with fused lids), some sheet plastic, and minor other items such as step off pads, tape, etc. It is further noted that the Auxiliary Building Hallway has 21 ionization early warning smoke detectors, a minimum of 5 fire extinguishers, 3 hose stations, excellent access and egress and there is a full time Nuclear Operator station manned 24 hours a day midway down the hall. We believe that all of these items in conjunction with the total fire proofing of the cable tray systems ensures that fire induced cable function loss cannot occur in the Auxiliary Building Hallway.

The Cable Spreading Room is a concrete structure and all cable trays are completely fire proofed with Flamemastic 71A and are fire stopped at the room boundaries. The Cable Spreading Room still contains the roll of computer paper and the small amount of exposed wire insulation on the back of three relay cabinets. Fire extinguishers and hose stations (with booster hose capability) are readily available to the Cable Spreading Room. Alarm of any one of 16 ionization early warning smoke detectors would bring immediate response from the nearby Control Room. It is therefore concluded that

sufficient protection is available to ensure that fire induced cable function loss cannot occur in the Cable Spreading Room.

We are completing safe shut down evaluations for these areas. The results will be completed by June 5, 1980.

# ATTACHMENT 4

Turkey Point Units 3 & 4
Docket Nos. 50-250 & 50-251
Fire Protection

## 1.0 Purpose

To calculate the maximum fire water demand for the largest sprinkler area under the turbine operating floor (2685 square feet) and the deluge systems for the hydrogen seal oil unit, for the auxiliary transformer and for the main transformer.

## 2.0 Scope

This analysis is applicable to the Turkey Point Nuclear Generating Station.

## 3.0 Reference

a) Crane Technical Paper No. 410
b) Cameron Hydraulic Data
c) NFPA Fire Protection Handbook 14th Edition
d) Turkey Point Plant Change/Modification 78-89, Deluge System Modification

## 4.0 Method of Analysis

Theory and analytical methods used are as prescribed in "Crane Technical Paper No. 410."

## 5.0 Basic Data and Assumption

a. Assume K for 1/2" sprinkler is 5.7
Note: Fire Protection Handbook pages 11-71
b. Assume 750 GPM for hose stream by calculating seven hydrants open with K factor of 167.8 for each hydrant butt (two butts per hydrant)
Note: Fire Protection Handbook pages 11-71

## 6.0 Summary Results

The flow/Ft$^2$ is 0.5 gpm when the following systems are actuated:
a) Turbine deck
b) Main transformer
c) Auxiliary transformer
d) $H_2$ Seal Oil System

7.0 Summary of Calculations

a) Sprinkler systems cal. per turbine's largest area (2685 square feet) ref. pages 2 to 11 includes hose stream calculations
b) Sprinkler systems cal. per turbine area and condensate pit area includes staff's original request for largest water demand. Note: Curbs will affectively eliminate this area ref. pages 11 to 18.
c) Deluge system cal. for $H_2$ Seal Oil System, Auxiliary Transformer, Main Transformer ref. pages 19 to 32
d) Calculation of system curve with analysis ref. pages 33 to 34

J. D. Rosenberger 5/2/80
[initials] 5/2/80



## 7.0 Body of Calculations

Equations Used

$$K = f\left(\frac{L}{D}\right)$$ ✓ (See Ref 1 page 2-8)

$$K_a = K_b\left(\frac{d_a}{d_b}\right)^4$$ ✓ (See Ref 1 page 2-10)

$$h_L = \frac{.00259\, K Q^2}{d^4}$$ ✓ (See Ref 1 page 2-15)

The equation for finding the k factor for parallel flow paths is determined by the following

1) $h_T = h_1 = h_2$ ✓

$$K_T = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{2}{\sqrt{K_1 K_2}}}$$ ✓

2) $V_T = V_1 + V_2$ → FOR EQUAL FLOW AREA ✓

$$h = K\frac{V^2}{2g}$$ ✓

$$V = \sqrt{\frac{h2g}{K}}$$ ✓

substituting in eq 2

$$\sqrt{\frac{h2g}{K_T}} = \sqrt{\frac{h_1 2g}{K_1}} + \sqrt{\frac{h_2 2g}{K_2}}$$

from eq 1

$$\sqrt{\frac{1}{K_T}} = \sqrt{\frac{1}{K_1}} + \sqrt{\frac{1}{K_2}}$$

$$\frac{1}{K_T} = \frac{1}{K_1} + \frac{2}{\sqrt{K_1 + K_2}} + \frac{1}{K_2}$$ ✓

BY J. D. Rosinberger DATE 5/2/80 — FPL FLORIDA POWER & LIGHT COMPANY — SHEET NO. 3 OF 36

CHKD. BY JQ DATE 5/2/80 — PROJECT NO.

Turbine Area Only (See Iso Sheets 1, 2, and 3)

Calculate k for parallel sprinklers. k for each sprinkler is 5.7 for 1/2"

Correct k for equivalent size of 2"

$$K_{2"} = K_{1/2"}\left(\frac{d_{2"}}{d_{1/2"}}\right)^4$$

$$= 5.7\left(\frac{2.067}{.5}\right)^4$$

$$K_{2"} = \underline{1665}$$ ✓

$$K_{1+2} = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{2}{\sqrt{K_1 \cdot K_2}}}$$

$$= \frac{1}{\frac{1}{1665} + \frac{1}{1665} + \frac{2}{\sqrt{(1665)^2}}}$$

$$= 416.25$$ ✓

$$K_{1+2} = K_{3+4} = K_{5+6} = K_{7+8} = K_{9+10} = K_{11+12} = K_{13+14} = K_{15+16} = K_{17+18}$$

Calculate K for each flow path (see tables for additional K values)

$$K_{1-2} = 416.75 + 41 = \underline{457.75}$$ ✓

$$K_{1-2} = K_{3-4} = K_{5-6} = K_{7-8} = K_{9-10} = K_{11-12}$$

$$K_{13-14} = 416.75 + 46.88 = \underline{463.63}$$ ✓

$$K_{13-14} = K_{15-16} = K_{17-18}$$

Calculate k for each parallel flow path as shown on Iso sheet 1

$$K_A = \frac{1}{\frac{1}{457.75} + \frac{1}{457.75} + \frac{2}{\sqrt{(457.75)^2}}}$$

$= \underline{114.44}$ ✓

$K_A = K_B = K_C$

$$K_D = \frac{1}{\frac{1}{463.63} + \frac{1}{463.63} + \frac{2}{\sqrt{(463.63)^2}}}$$

$= \underline{115.91}$ ✓

$$K_{A'} = \frac{1}{\frac{1}{114.44} + \frac{1}{114.44} + \frac{2}{\sqrt{(114.44)^2}}}$$

$= \underline{28.61}$ ✓

$$K_{D'} = \frac{1}{\frac{1}{115.91} + \frac{1}{463.63} + \frac{2}{\sqrt{(115.91)(463.63)}}}$$

$= \underline{51.52}$ ✓

$$K_{A''} = \frac{1}{\frac{1}{28.61} + \frac{1}{114.44} + \frac{2}{\sqrt{(28.61)(114.44)}}}$$

$= \underline{12.72}$ ✓

To calculate $K_{A'''}$ the K values for the lines containing A'' and D' have to be included (See Tables)

$K_{T_{A''}} = 12.72 + 3.06 + .96 = \underline{16.74}$ ✓

$K_{T-D'} = 51.52 + 2.96 + .07 = \underline{54.55}$ ✓

$$K_{A'''} = \frac{1}{\frac{1}{16.74} + \frac{1}{54.55} + \frac{2}{\sqrt{(16.74)(54.55)}}}$$

$= \underline{6.93}$ ✓ This is the value of K at Junction I

Sheet 3

K factor for parallel sprinklers will be same as those for sheet 1 (See page 1) K = 416.25

$K_{37-38} = 416.25 + 43.57 = \underline{459.82}$ ✓

$K_{35-36} = 416.25 + 31.61 = \underline{447.86}$ ✓

$K_{35-36} = K_{33-34} = K_{39-40} = K_{41-42}$

$K_{43-44} = 416.25 + 18.69 = \underline{434.94}$ ✓

$K_{43-44} = K_{45-46}$

$$K_A = \frac{1}{\frac{1}{459.82} + \frac{1}{447.86} + \frac{2}{\sqrt{(459.82)(447.86)}}}$$

$= \underline{113.45}$ ✓

$$K_{A'} = \frac{1}{\frac{1}{447.86} + \frac{1}{113.45} + \frac{2}{\sqrt{(447.86)(113.45)}}}$$

$= \underline{50.2}$ ✓

$$K_B = \frac{1}{\frac{1}{447.86} + \frac{1}{447.86} + \frac{2}{\sqrt{(447.86)^2}}}$$

$$= \underline{111.97} \checkmark$$

$$K_C = \frac{1}{\frac{1}{434.94} + \frac{1}{434.94} + \frac{2}{\sqrt{(434.94)^2}}}$$

$$= \underline{108.74} \checkmark$$

$$K_{B'} = \frac{1}{\frac{1}{108.74} + \frac{1}{111.97} + \frac{2}{\sqrt{(108.74)(111.97)}}}$$

$$= \underline{27.58} \checkmark$$

To calculate $K_{A''}$ the k values for the lines containing A' and B' have to be included. (See tables)

$$K_{T-A'} = 50.2 + 14.11 = \underline{64.31} \checkmark$$

$$K_{T-B'} = 27.58 + 13.98 = 41.56 \checkmark$$

$$K_{A''} = \frac{1}{\frac{1}{64.31} + \frac{1}{41.56} + \frac{2}{\sqrt{(64.31)(41.56)}}}$$

$$= 12.77 \checkmark$$

This is the value of k at Junction T.

To fined the k value at Junction S the k values of the piping must be added to the k at Junction T. (See Tables)

$$K_S = 12.77 + 1.14$$

$$K_S = \underline{13.91} \checkmark$$ This is the value of k at Junction S.

BY J. D. Rosenberger DATE 5/2/80 FPL FLORIDA POWER & LIGHT COMPANY SHEET NO. 7 OF 36

CHKD. BY J.L. DATE 5/2/80 PROJECT NO.

Calculate k for parallel sprinklers

$K_{31+32}$ = 416.25 (See page 3 of calcs)

$K_{31+32} = K_{29+30} = K_{23+24} = K_{25+26} = K_{27+28}$

To calculate k at Junction R, find k for parallel flow paths (See sketch)

$K_A = 416.25 + 56.14 = \underline{472.39}$ ✓

$K_B = 416.25 + 43.86 = \underline{460.11}$ ✓

$$K_{A'} = \frac{1}{\frac{1}{472.39} + \frac{1}{460.11} + \frac{2}{\sqrt{(472.39)(460.11)}}}$$

$= \underline{116.55}$ ✓ This is the value of k at Junction R.

$K_{N+22} = 1665 + 51.25 = \underline{1716.25}$ ✓ (See tables)

$K_{M+19} = K_{N+22}$

$$K_C = \frac{1}{\frac{1}{1716.25} + \frac{1}{1716.25} + \frac{2}{\sqrt{(1716.25)^2}}}$$ (See sketch)

$= \underline{429.06}$ ✓

$K_{20+21} = K_{23+24} = K_{25+26} = K_{27+28} = 416.25$

$K_{N-20} = 416.25 + 21.98 = \underline{438.23}$ ✓ (See Tables)

$$K_D = \frac{1}{\frac{1}{429.06} + \frac{1}{438.23} + \frac{2}{\sqrt{(429.06)(438.23)}}}$$

$= \underline{108.40}$ ✓

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Calculate k at Junction P

$K_P = K_{A'} + K_{R-P}$ (See Page 7 and tables)

$= 116.55 + 7.29 = \underline{123.84}$ ✓

$K_{23-24} = 416.25 + 40.17 = 456.42 = K_{25-26} = K_{27-28}$

$K_E = \dfrac{1}{\frac{1}{123.84} + \frac{1}{456.42} + \frac{2}{\sqrt{(123.84)(456.42)}}}$ (See sketch)

$= \underline{53.54}$ ✓

$K_F = \dfrac{1}{\frac{1}{53.54} + \frac{1}{456.42} + \frac{2}{\sqrt{(53.54)(456.42)}}}$

$= \underline{29.71}$ ✓

$K_G = \dfrac{1}{\frac{1}{29.71} + \frac{1}{456.42} + \frac{2}{\sqrt{(29.71)(456.42)}}}$

$= \underline{18.86}$ ✓

To find k value at Junction L

$K_{T_G} = K_G + K_{L-28}$

$= 18.86 + 2.66 = \underline{21.52}$ ✓ See Tables

$K_{T_D} = K_D + K_{L-21}$

$= 108.40 + .98 = \underline{109.38}$ ✓ See Tables

$$K_{E} = \frac{1}{\frac{1}{21.52} + \frac{1}{109.38} + \frac{2}{\sqrt{(21.52)(109.38)}}}$$

$= \underline{10.33}$ ✓ This is the value of K at Junction L.

Calculate the value of K at Junction K

$K_{T_J} = K_J + K_{J-K}$

$= 13.91 + .09 = \underline{14.0}$ ✓ See Tables

$K_{T_L} = K_L + K_{L-K}$

$= 10.33 + 2.52 = \underline{12.85}$ ✓ See Tables

$$K_{K} = \frac{1}{\frac{1}{14.0} + \frac{1}{12.85} + \frac{2}{\sqrt{(14.0)(12.85)}}}$$

$= 3.35$ ✓

Sheet 1

Calculate the value of K at Junction J

$K_{T_K} = K_K + K_{K-J}$

$= 3.35 + .21 = \underline{3.56}$ ✓

$K_{T_I} = K_I + K_{I-J}$

$= 6.93 + .09 = \underline{7.02}$ ✓

$$K_J = \frac{1}{\frac{1}{7.02} + \frac{1}{3.56} + \frac{2}{\sqrt{(3.56)(7.02)}}}$$

$= \underline{1.21}$ ✓

This is the value of k at Junction J.

Calculate Total K

$$K_T = K_J + K_{J-⑧} + K_{⑧-flange}$$

$= 1.21 + .36 + .08$

$= \underline{1.65}$ ✓

In order to obtain a realistic system curve for the system, a flow path for hose streams must be considered. Assume three fire hydrants each with two butts open. Each butt has a K value equal to 167.8 for 2½" butts. K corrected to 2", $K = 167.8\left(\frac{2.067}{2.469}\right)^4$, K = 82.43. The overall K value for one hydrant equals:

$$K = \frac{1}{\frac{1}{82.43} + \frac{1}{82.43} + \frac{2}{\sqrt{(82.43)^2}}} = \underline{20.61}$$ ✓

The K value for three hydrants equals

$$K = \frac{1}{\frac{1}{20.61} + \frac{1}{20.61} + \frac{2}{\sqrt{(20.61)^2}}} = 5.15$$ ✓

$$K = \frac{1}{\frac{1}{20.61} + \frac{1}{5.15} + \frac{2}{\sqrt{(20.61)(5.15)}}}$$

$= \underline{2.29}$ ✓

The K for 7 hydrants would be $\underline{.42}$ ✓

The new k for the entire system will be

$$K_T = \frac{1}{\frac{1}{.42} + \frac{1}{1.65} + \frac{2}{\sqrt{(.42)(1.65)}}}$$

$$= .19 \checkmark$$

Calculate the total k with the turbine area and condensate pit area actuated with also an allowance made for hose streams.

Iso Sheet 4,5 and 6

Find the k value for the line between sprinkler 53 and Junction DD

$k_A = k_B = 416.25$ See page 3

$$k_C = \frac{1}{\frac{1}{416.25} + \frac{1}{416.25} + \frac{2}{\sqrt{(416.25)^2}}}$$

$= 104.06 \checkmark$ (for sprinklers only)

$k_{53\text{-}EE} = 104.06 + 48.09 = 152.15 \checkmark$ See Tables page 7

$k_{49\text{-}EE} = 1665 + 23.96 = 1688.96 \checkmark$ See calcs page 3 and tables

$$k_C = \frac{1}{\frac{1}{1688.96} + \frac{1}{152.15} + \frac{2}{\sqrt{(152.15)(1688.96)}}}$$

This is the value of k at Junction EE.

$= 90.01 \checkmark$

$K_{EE-DD} = 90.01 + 2.65 = \underline{92.66}$ ✓ See Tables

$K_{56-GG} = 1665 + 32.26 = \underline{1697.26}$ ✓ See calcs page 3 and tables.

$K_{55-GG} = 1665 + 39.19 = \underline{1704.19}$ ✓

$$K_{GG} = \frac{1}{\frac{1}{1697.26} + \frac{1}{1704.19} + \frac{2}{\sqrt{(1704.19)(1697.26)}}}$$

$= \underline{425.18}$ ✓ This is the value of k at Junction GG.

$K_{GG-FF} = 425.18 + 23.81 = \underline{448.99}$ ✓ See Tables

$K_{54-FF} = 1665 + 28.79 = 1693.79$ ✓ "

$$K_{CC} = \frac{1}{\frac{1}{448.99} + \frac{1}{1693.79} + \frac{2}{\sqrt{(448.99)(1693.79)}}}$$

$= \underline{195.66}$ ✓ This is the value of k at Junction CC.

$K_{CC-BB} = 195.66 + 1.55 = \underline{197.21}$ ✓ See tables

$K_{47-BB} = 1665 + 63.79 = \underline{1728.79}$ ✓ See calcs page 3 and table

$$K_{BB} = \frac{1}{\frac{1}{1728.79} + \frac{1}{197.21} + \frac{2}{\sqrt{(1728.79)(197.21)}}}$$

This is the value of k at Junction BB.

$= \underline{110.20}$ ✓

$K_{BB-AA} = 110.20 + 2.23 = \underline{112.43}$ ✓ See tables

$K_{DD-AA} = .29 + 92.66 = \underline{92.95}$ ✓ See Calcs page 12 and tables

$$K_{AA} = \frac{1}{\frac{1}{112.43} + \frac{1}{92.95} + \frac{2}{\sqrt{(112.43)(92.95)}}}$$

$= \underline{25.50}$ ✓ This is the value of k at AA

$K_{AA-Z} = 25.50 + .54 = \underline{26.04}$ ✓

$K_{OO-XX} = 3.45$ See tables

$K_{72-XX} = 1665 + 23.66 = 1688.66$ ✓ See calcs page 3 and Tables

$$K_{XX} = \frac{1}{\frac{1}{1688.66} + \frac{1}{3.45} + \frac{2}{\sqrt{(1688.66)(3.45)}}}$$

$= \underline{3.16}$ ✓ This is the value of k at Junction XX

$K_{XX-JJ} = 3.16 + 1.55 = \underline{4.71}$ ✓ See tables

$K_{71-JJ} = 1665 + 23.06 = \underline{1688.06}$ ✓ See calcs page 3 and tables

$$K_{JJ} = \frac{1}{\frac{1}{1688.06} + \frac{1}{4.71} + \frac{2}{\sqrt{(1688.06)(4.71)}}}$$

$= \underline{4.25}$ ✓ This is the value of k at Junction JJ.

Calculate the overall k for the sprinklers between JJ and II

$K_A = K_B = K_C = 416.25$ See calcs page 3

$$K_{A'} = \frac{1}{\frac{1}{416.25} + \frac{1}{416.25} + \frac{2}{\sqrt{(416.25)^2}}}$$

$= \underline{104.06}$ ✓

$$K_{C'} = \frac{1}{\frac{1}{1665} + \frac{1}{416.25} + \frac{2}{\sqrt{(1665)(416.25)}}}$$

$= \underline{185.0}$ ✓

$$K_{A''} = \frac{1}{\frac{1}{104.06} + \frac{1}{185.0} + \frac{2}{\sqrt{(185)(104.06)}}}$$

$= \underline{33.98}$ ✓

$K_{JJ-II} = 33.98 + 4.25 + 26.85 = \underline{65.08}$ ✓ See tables

$K_{63-II} = 1665 + 11.91 = \underline{1676.91}$ ✓ "

$$K_{II} = \frac{1}{\frac{1}{1676.91} + \frac{1}{65.08} + \frac{2}{\sqrt{(1676.91)(65.08)}}}$$

$= \underline{45.42}$ ✓

This is the value of k at Junction II.

Calculate the overall K for the sprinklers between II and HH.

$K_O = K_E = 416.25$ See Calcs page 3

$$K_{D'} = \frac{1}{\frac{1}{416.25} + \frac{1}{416.25} + \frac{2}{\sqrt{(416.25)^2}}}$$

$= \underline{104.06}$ ✓

$K_{II-HH} = 45.42 + 104.06 + 11.23 = \underline{160.71}$ ✓ See tables

$K_{58-HH} = 1665 + 53.06 = \underline{1718.06}$ ✓ "

$$K_{HH} = \frac{1}{\frac{1}{1718.06} + \frac{1}{160.71} + \frac{2}{\sqrt{(160.71)(1718.06)}}}$$

$= \underline{94.24}$ ✓ This is the value of K at Junction HH

$K_{HH-57} = 94.24 + 1.04 = 95.28$ ✓ See tables

$$K_{57} = \frac{1}{\frac{1}{1665} + \frac{1}{95.28} + \frac{2}{\sqrt{(1665)(95.28)}}}$$

$= 62.04$ ✓

$K_{57-Z} = 62.04 + 2.12 = \underline{64.16}$ ✓ See tables

$K_{AA-Z} = 26.04$ See calcs page 13

$$K_Z = \frac{1}{\frac{1}{64.16} + \frac{1}{26.04} + \frac{2}{\sqrt{(64.16)(26.04)}}}$$

This is the value of K at Junction Z.

$= \underline{9.72}$ ✓

$K_{Z-S} = 9.72 + .26 = 9.98$ ✓ — See tables

$K_{T-S} = 13.91 + 1.14 = 15.05$ ✓ — See calcs page 6 and tables

$$K_S = \frac{1}{\frac{1}{9.98} + \frac{1}{15.05} + \frac{2}{\sqrt{(9.98)(15.05)}}}$$

$= 3.03$ ✓ — This is the value of K at Junction S.

$K_{S-K} = 3.03 + .09 = 3.12$ ✓ — See tables

$K_{L-K} = 12.85$ — See calcs page 9

$$K_K = \frac{1}{\frac{1}{12.85} + \frac{1}{3.12} + \frac{2}{\sqrt{(12.85)(3.12)}}}$$

$= 1.40$ ✓ — This is the value of K at Junction K.

$K_{K-J} = 1.40 + .21 = 1.61$ ✓ — See tables

$K_{I-J} = 7.02$ — See calcs page 9

$$K_J = \frac{1}{\frac{1}{1.61} + \frac{1}{7.02} + \frac{2}{\sqrt{(1.61)(7.02)}}}$$

This is the value of K at Junction J.

$= .74$ ✓

$K_{J-⑪} = .74 + .36 = 1.10$ ✓ — See tables

Sketch - 7

Calculate the overall k values for the sprinklers

$K_A = K_B = K_C = K_D = K_E = K_F = 416.25$ — See calcs page 3

$$K_{A'} = K_{C'} = K_{F'} = \frac{1}{\frac{1}{416.25} + \frac{1}{416.25} + \frac{2}{\sqrt{(416.25)^2}}}$$

$= \underline{104.06}$ ✓

$$K_{A''} = \frac{1}{\frac{1}{104.06} + \frac{1}{104.06} + \frac{2}{\sqrt{(104.06)^2}}}$$

$= \underline{26.02}$ ✓

$$K_{F''} = \frac{1}{\frac{1}{1665} + \frac{1}{104.06} + \frac{2}{\sqrt{(1665)(104.06)}}}$$

$= \underline{66.60}$ ✓

$K_{36-Ⓜ} = 66.60 + 12.65 = \underline{79.25}$ ✓ — See tables

$K_{37-Ⓜ} = 26.02 + 19.82 = \underline{45.84}$ ✓ — See tables

$$K_{Ⓜ} = \frac{1}{\frac{1}{79.25} + \frac{1}{45.84} + \frac{2}{\sqrt{(79.25)(45.84)}}}$$

$= \underline{14.79}$ ✓ — This is the value of k at Junction Ⓜ

$K_{Ⓜ-Ⓚ} = 14.79 + 1.49 = \underline{16.28}$ ✓ — See tables

$K_{J-K} = 1.10$ See Calcs page 16

$$K = \frac{1}{\frac{1}{16.28} + \frac{1}{1.10} + \frac{2}{\sqrt{(16.28)(1.10)}}}$$

$= .69$ ✓

This is the value of k at Junction (K)

Calculate Total k for system

$K_{K-flange} = .08$ See tables

$K_T = .69 + .08 = .77$ ✓

In order to obtain a realistic system curve for the system a flow path for hose streams must be considered. Assume three fire hydrant with two butts open. Each butt has a k value equal 167.8. The overall k value for the hydrant equals:

$K = 2.29$ See calcs page 8

The new $K_T$ for the entire system will be

$$K_T = \frac{1}{\frac{1}{2.29} + \frac{1}{.77} + \frac{2}{\sqrt{(2.29)(.77)}}}$$

$= .31$ ✓

Hydrogen Seal Oil Cooler (See Iso Sheets)

Calculate k for sprinklers corrected to 2"

K for 668 is 7.0 1/2"
K for 668-WA 5.3 1/2"
K for 668-LT is 5.7 1/2"

$$K_{2"} = K_{1/2"}\left(\frac{d_{2"}}{d_{1/2"}}\right)^4 \qquad K_{2"} = 5.3\left(\frac{2.067}{.5}\right)^4 \qquad K_{2"} = 5.7\left(\frac{2.067}{.5}\right)^4$$

$$= 1548 \checkmark \text{ 668 WA} \qquad = 1665 \checkmark$$

$$= 7.0\left(\frac{2.067}{.5}\right)^4 \checkmark$$

668 $K_{2"} = 2044$

$K_{89} = K_{91} = 1548 + 13.11 = 1561.11$ ✓

$K_{90} = K_{92} = 2044 + 13.11 = 2057.11$ ✓

Calculate K for parallel sprinklers (See Iso Sheet )

$$K_A = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{2}{\sqrt{(K_1 K_2)}}}$$

$$= \frac{1}{\frac{1}{1561.11} + \frac{1}{1561.11} + \frac{2}{\sqrt{(1561.11)^2}}}$$

$= 390.28$ ✓

$$K_B = \frac{1}{\frac{1}{2057.11} + \frac{1}{2057.11} + \frac{2}{\sqrt{(2057.11)^2}}}$$

$= 514.28$ ✓

$$K_{A'} = \frac{1}{\frac{1}{390.28} + \frac{1}{514.28} + \frac{2}{\sqrt{(390.28)(514.28)}}}$$

$= \underline{111.47}$ ✓

$K_{O-N} = K_{A'} = 111.47$ ✓

$K_{88} = K_{90} = K_{94} = 2057.11$ ✓

$K_{93} = K_{95} = K_{89} = 1561.11$ ✓

$$K_C = \frac{1}{\frac{1}{2057.11} + \frac{1}{2057.11} + \frac{2}{\sqrt{(2057.11)^2}}}$$

$= \underline{514.28}$ ✓

$$K_D = \frac{1}{\frac{1}{1561.11} + \frac{1}{1561.11} + \frac{2}{\sqrt{(1561.11)^2}}}$$

$= \underline{390.28}$ ✓

$K_{C'} = K_A = 111.47$ ✓

$K_{P-N} = K_{A'} = \underline{111.47}$ ✓

$$K_N = \frac{1}{\frac{1}{111.47} + \frac{1}{111.47} + \frac{2}{\sqrt{(111.47)^2}}}$$

$= \underline{27.87}$ ✓

$K_{NM} = 27.87 + 5.65 + .11 + 3.42$
$= \underline{37.05}$ ✓

Auxiliary Transformer (See Iso sheet 9)

$K_{58}' = K_{61} = K_{63} = K_{64} = K_{68} = K_{72} = K_{73} = K_{81} = K_{87} = 2044 + 13.11 = \underline{2057.11}$ ✓

$K_{59} = K_{60} = K_{61} = K_{62} = K_{67} = K_{69} = K_{71} = K_{76} = K_{70} = 2044 + 13.72 = \underline{2057.72}$ ✓

$K_{65} = K_{66} = K_{74} = K_{75} = K_{77} = K_{78} = K_{79} = K_{80} = K_{82} = K_{83} = K_{84} = K_{85} = K_{86} =$
$1548 + 13.11 = \underline{1561.11}$ ✓

Since the value of the resistance coefficient of the piping is extremely small when compared to the resistance coefficient for the nozzles, the resistance of the piping can be neglected.

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## Auxiliary Transformer (Segment J'' – H)

| Source of $K_1$ | Source of $K_2$ | $K_1$ | $K_2$ | Total K |
|---|---|---|---|---|
| 68 | 70 | 2057.11 | 2057.11 | 514.28 |
| 68,70 | 69 | 514.28 | 2057.11 | 228.54 |
| 68,69,70 | 71 | 228.54 | 2057.72 | 128.57 |
| 68,69,70,71 | 72 | 128.57 | 2057.11 | 82.28 |
| 68,69,70,71,72 | 73 | 82.28 | 2057.11 | 57.14 |
| 68,69,70,71,72,73 | 74 | 57.14 | 1561.11 | 40.26 |
| 68,69,70,71,72,73,74 | 75 | 40.26 | 1561.11 | 29.89 |
| 68,69,70,71,72,73,74,75 | 76 | 29.89 | 2057.72 | 23.81 |

## Segment J'' – H

| Source of $K_1$ | Source of $K_2$ | $K_1$ | $K_2$ | Total K |
|---|---|---|---|---|
| 58 | 59 | 2057.11 | 2057.72 | 514.35 |
| 58,59 | 60 | 514.35 | 2057.72 | 228.61 |
| 58,59,60 | 61 | 228.61 | 2057.72 | 128.60 |
| 58,59,60,61 | 61' | 128.60 | 2057.11 | 82.30 |
| 58,59,60,61,61' | 62 | 82.30 | 2057.72 | 57.12 |
| 58,59,60,61,61',62 | 63 | 57.12 | 2057.11 | 41.97 |
| 58,59,60,61,61',62,63 | 64 | 41.97 | 2057.11 | 32.13 |
| 58,59,60,61,61',62,63,64 | 65 | 32.13 | 1561.11 | 24.57 |
| 58,59,60,61,62,61',62,63,64,65 | 66 | 24.57 | 1561.11 | 19.40 |
| 58,59,60,61,62,61',63,64,65,66 | 67 | 19.40 | 2057.72 | 16.72 |

## Segment L' – L

| Source of $K_1$ | Source of $K_2$ | $K_1$ | $K_2$ | Total K |
|---|---|---|---|---|
| 82 | 83 | 1561.11 | 1561.11 | 390.28 |
| 82,83, | 84 | 390.28 | 1561.11 | 173.46 |
| 82,83,84 | 85 | 173.46 | 1561.11 | 97.57 |
| 82,83,84,85 | 86 | 97.57 | 1561.11 | 62.44 |
| 82,83,84,85,86, | 87 | 62.44 | 2057.11 | 45.29 |

## Segment L'' – L

| Source of $K_1$ | Source of $K_2$ | $K_1$ | $K_2$ | Total K |
|---|---|---|---|---|
| 77 | 78 | 1561.11 | 1561.11 | 390.28 |
| 77,78 | 79 | 390.28 | 1561.11 | 173.46 |
| 77,78,79 | 80 | 173.46 | 1561.11 | 97.57 |
| 77,78,79,80 | 81 | 97.57 | 2057.11 | 65.79 |

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$K_{L''-L} = 65.79$ ✓

$K_{L'-L} = 45.29$ ✓

$$K_L = \cfrac{1}{\frac{1}{65.29} + \frac{1}{45.29} + \frac{2}{\sqrt{(65.79)(45.29)}}}$$

$= \underline{13.48}$ ✓

$K_{J'-H} = 23.81$ ✓

$K_{J''-H} = 16.72$ ✓

$$K_H = \cfrac{1}{\frac{1}{23.81} + \frac{1}{16.72} + \frac{2}{\sqrt{(23.81)(16.72)}}}$$

$= \underline{4.95}$ ✓

$K_{L-K} = 13.48 + .65 = \underline{14.13}$ ✓

$K_{H-K} = 4.95 + .24 = \underline{5.19}$ ✓

$$K_K = \cfrac{1}{\frac{1}{14.13} + \frac{1}{5.19} + \frac{2}{\sqrt{(14.13)(5.19)}}}$$

$= \underline{2.01}$ ✓

$K_{K-E} = 2.01 + .41$
$= \underline{2.42}$ ✓

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## Main Transformer

Given k factors at $\frac{1}{2}$ inch:

668 nozzle $k = 7.0$
668 WA noz $k = 5.3$
669 LT noz $k = 5.7$

These k factors must be converted to the equivalent k factors for 2" schedule 40 pipe. To do this the following formula was employed: $K_a = K_b \left(\frac{d_a}{d_b}\right)^4$

$d_a = 2.067$ in
$d_b = 0.5$ in

668 noz $k = 2044.47$ ✓
668 WA noz $k = 1547.95$ ✓
669 LT $k = 1664.78$ ✓

All nozzles have 2 nipples with one 90° elbow. Therefore, the total k for the nozzle is

$K_T = K_{spray\ head} + K_{nipples} + K_{elbow} = K_{SH} + K_{nip} + K_{elb.}$

Of course, all k factors will be adjusted to 2" equivalent K factors.

Table 1

| Nozzle Type | nipple size | $K_{SH}$ | $K_{nip}$ | $K_{elb.}$ | Total Adjusted K |
|---|---|---|---|---|---|
| 668 | 2 - 1"x4" | 2044.47 ✓ | 0.18 ✓<br>Adj = 2.71 ✓ | 0.69 ✓<br>Adj. = 10.40 ✓ | 2057.58 ✓ |
| 668 WA | 2-1"x4" | 1547.95 ✓ | 0.18 ✓<br>Adj. = 2.71 ✓ | 0.69 ✓<br>Adj. = 10.40 ✓ | 1561.06 ✓ |
| 668 WA | 2-1"x5" | 1547.95 ✓ | 0.22 ✓<br>Adj. = 3.32 ✓ | 0.69 ✓<br>Adj. = 10.40 ✓ | 1561.67 ✓ |
| 668 WA | 1-1x4" and 1-1"x8" | 1547.95 ✓ | 0.26 ✓<br>Adj. = 3.92 ✓ | 0.69 ✓<br>Adj. = 10.40 ✓ | 1562.27 ✓ |
| 669 LT | 2-1¼x5 | 1664.14 ✓ | 0.16 ✓<br>Adj. = 0.81 ✓ | 0.69 ✓<br>Adj. = ~~10.40~~ 3.4 | 1675.35 ✓ |
| 669 LT | 1-1x4 nipple | 1664.14 ✓ | 0.09 ✓<br>Adj = 1.32 ✓ | 0 ✓<br>Adj. = 0 | 1665.46 ✓ |

SOME NIPPLE SIZES FOR THIS TYPE NOZZLE ARE 1X5 - THIS IS A MINOR DISCREPANCY THAT DOES NOT AFFECT RESULTS [initials] 5/1/80

I, A total k for the top loop was now found by examining each segment and utilizing the formula:

$$k_T = \frac{1}{\frac{1}{k_1} + \frac{2}{\sqrt{k_1 k_2}} + \frac{1}{k_2}}$$

and the computer program listed in

In the following table (Table 2), all the source numbers refer to the circled nozzle numbers on the Main Transformer Deluge System top loop.

Table 2

| Source of $k_1$ | Source of $k_2$ | $k_1$ | $k_2$ | Total K |
|---|---|---|---|---|
| 10 | 11 | 2057.58 ✓ | 2057.58 ✓ | 514.40 ✓ |
| 10-11 | 12 | 514.40 | 2057.58 | 228.62 |
| 10-11-12 | 13 | 228.62 ✓ | 2057.58 ✓ | 128.60 ✓ = X-Y |
| 1 | 2 | 1561.67 | 1675.35 | 404.25 |
| 1-2 | 3 | 404.25 | 2057.58 | 194.08 |
| 1-2-3 | 4 | 194.08 | 1561.67 | 106.9 |
| 1-2-3-4 | 5 | 106.9 ✓ | 2057.58 ✓ | 70.46 ✓ |
| 1-2-3-4-5 | 6 | 70.46 | 1561.67 | 47.93 |
| 1-2-3-4-5-6 | 7 | 47.93 | 1675.35 | 35.07 |
| 1-2-3-4-5-6-7 | 8 | 35.07 ✓ | 2057.58 ✓ | 27.44 = ✓ Z-Y |
| 14d | 14b | 1665.46 | 2057.58 | 461.50 |
| 14c | 14a | 1665.46 | 2057.58 | 461.50 |
| 14d-14b | 14c-14a | 461.50 | 461.50 | 115.38 = 14a-R |

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| Source of $k_1$ | Source of $k_2$ | $k_1$ | $k_2$ | Total K |
|---|---|---|---|---|
| 14 | 15 | 1562.27 ✓ | 1562.27 ✓ | 390.57 ✓ |
| 14-15 | 16 | 390.57 | 2057.58 | 189.49 |
| 14-15-16 | 18 | 189.49 | 1675.35 | 106.11 |
| 14-15-16-18 | 19 | 106.11 ✓ | 2057.58 ✓ | 70.47 ✓ |
| 14-15-16-18-19 | 20 | 70.47 | 2057.58 | 50.18 = Y |
| 14-15-16-17-18-19-20 | 20′ | 50.18 | 2057.58 | 37.54 = R′-B |
| 30 | 31 | 2057.58 | 2057.58 | 514.40 |
| 30-31 | 32 | 514.40 ✓ | 2057.58 ✓ | 228.62 ✓ |
| 30-31-32 | 33 | 228.62 | 2057.58 | 128.60 = X-Y′ |
| 21 | 22 | 1561.67 | 1675.35 | 404.25 |
| 21-22 | 23 | 404.25 | 2057.58 | 194.08 |
| 21-22-23 | 24 | 194.08 ✓ | 1561.67 ✓ | 106.09 ✓ |
| 21-22-23-24 | 25 | 106.09 | 2057.58 | 70.46 |
| 21-22-23-24-25 | 26 | 70.46 | 1561.67 | 47.93 |
| 21-22-23-24-25-26 | 27 | 47.93 ✓ | 1675.35 ✓ | 35.07 ✓ |
| 21-22-23-24-25-26-27 | 28 | 35.07 | 2057.58 | 27.44 = Z-Y′ |
| 35d | 35b | 1665.46 | 2057.58 | 416.50 |
| 35c | 35a | 1665.46 | 2057.58 | 416.50 |
| 35d-35b | 35c-35a | 416.50 ✓ | 416.50 ✓ | 115.38 = 35d-R′ |

| Source of $k_1$ | Source of $k_2$ | $k_1$ | $k_2$ | Total $k$ |
|---|---|---|---|---|
| 34 | 35 | 1562.27 | 1562.27 | 390.57 = Y'-R' |
| 34-35 | 36 | 1562.27 | 2057.58 | 446.11 |
| 34-35-36 | 38 | 446.11 | 1675.35 | 194.10 |
| 34-35-36-38 | 39 | 194.10 | 2057.58 | 113.60 |
| 34-35-36-38-39 | 40 | 113.60 ✓ | 2057.58 ✓ | 74.49 = R'-B |

Next each segment was parilleled using the formula

$$k_T = \frac{1}{\frac{1}{k_1} + \frac{2}{\sqrt{k_1 k_2}} + \frac{1}{k_2}}$$

and the total k at (B) was determined

Top Loop (Values from Table 2)

| Source of $k_1$ | Source of $k_2$ | $k_1$ | $k_2$ | Total K |
|---|---|---|---|---|
| X-Y | Z-Y | 128.60 ✓ | 27.44 ✓ | 12.84 ✓ |
| (X-Y)-(Z-Y) | 14cd-R | 12.84 ✓ | 115.38 ✓ | 7.22 ✓ |
| (X-Y)-(Z-Y)-(14cd-R) | R-B | 7.22 ✓ | 37.54 ✓ | 3.49 ✓ |
| X-Y' | Z-Y' | 128.60 ✓ | 27.44 ✓ | 12.84 ✓ |
| (X-Y')-(Z-Y') | Y'-R' | 12.84 ✓ | 390.57 ✓ | 9.20 ✓ |
| (X-Y')(Z-Y')-(Y'-R') | 35cd-R' | 9.20 ✓ | 115.38 ✓ | 5.59 ✓ |
| (X-Y')-(Z-Y')-(Y'-R')-(35cd-R') | R'-B | 5.59 ✓ | 74.49 ✓ | 3.45 ✓ |
| (X-Y)-(Z-Y)-(14cd-R)-(R-B) | (X-Y')-(Z-Y')-(Y'-R')-(35cd-R')(R'-B) | 3.49 ✓ | 3.45 ✓ | 0.87 for Top Loop at (B) ✓ |

II. Next the bottom loop was considered.

In the following table (Table 7) all source numbers refer to circled nozzle numbers on the Main Transformer Deluge System bottom loop. $K_{eq} = \dfrac{1}{\frac{1}{K_1} + \frac{2}{\sqrt{K_1 K_2}} + \frac{1}{K_2}}$ was employed.

Table 7

| Source of $K_1$ | Source of $K_2$ | $K_1$ | $K_2$ | Total K |
|---|---|---|---|---|
| 50 | 49 | 1561.06 | 1561.06 ✓ | 390.27 ✓ |
| 50-49 | 41 | 390.27 ✓ | 1561.06 ✓ | 173.45 ✓ |
| 50-49-41 | 42 | 173.45 ✓ | 1561.06 ✓ | 97.57 ✓ |
| 50-49-41-42 | 43 | 97.57 ✓ | 1561.06 ✓ | 62.44 ✓ |
| 50-49-41-42-43 | 44 | 62.44 ✓ | 1675.35 ✓ | 43.87 ✓ |
| 50-49-41-42-43-44 | 45 | 43.87 ✓ | 1561.06 ✓ | 32.18 ✓ |
| 50-49-41-42-43-44-45 | 46 | 32.18 ✓ | 1561.06 ✓ | 24.61 ✓ |
| 50-49-41-42 43-44-45-46 | 47 | 24.61 ✓ | 1561.06 ✓ | 19.42 ✓ |
| 50-49-41-42-43-44-45-46-47 | 48 | 19.42 ✓ | 1561.06 ✓ | 15.72 = K''-D |
| 52 | 53 | 1561.06 ✓ | 1561.06 ✓ | 390.27 ✓ |
| 52-53 | 54 | 390.27 ✓ | 1561.06 ✓ | 173.45 ✓ |
| 52-53-54 | 55 | 173.45 ✓ | 1675.35 ✓ | 99.28 ✓ |
| 52-53-54-55 | 56 | 99.28 ✓ | 1561.06 ✓ | 63.32 ✓ |
| 52-53-54-55-56 | 57 | 63.32 ✓ | 1561.06 ✓ | 43.87 = K'-D |

Again the paths were examined in parallel as shown below.

$k_1 = (X'' - D) = 15.72$

$k_2 = (X' - D) = 43.87$

$$k_T = \cfrac{1}{\frac{1}{15.72} + \frac{2}{\sqrt{(15.72)(43.87)}} + \frac{1}{43.87}} = \boxed{6.15 \text{ for bottom loop at point D}}$$

To find the value at (C) the top and bottom loops were examined in parallel.

$$k_T = \cfrac{1}{\frac{1}{0.87} + \frac{2}{\sqrt{(0.87)\cdot(6.15)}} + \frac{1}{6.15}} = \boxed{0.46 \text{ at (C)}}$$

The k factor for the piping (3.25' of 4" sch 40) from C to E was added to determine the total $k_T$ at (E)

$K_{pipe} = (0.017)\frac{3.25'}{0.3355'} = 0.16$ ✓

Adjusted $k = (0.16)\left(\frac{2.067\,in}{4.026\,in}\right)^4 = \underline{0.01 \text{ for } C\text{-}E}$ ✓

Total $k_T$ at (E) $= 0.46 + 0.01 = \boxed{0.47}$

BY J. D. Rosenberger DATE 5/2/80 FPL FLORIDA POWER & LIGHT COMPANY SHEET NO. 32 OF 36

CHKD. BY J DATE 5/2/80 PROJECT NO.

Find Kind at Flange

$K_{K-E} = 2.42$ ✓ See calcs page

$K_{C-E} = .47$ ✓ See calcs page

$$K_E = \frac{1}{\frac{1}{2.42} + \frac{1}{.47} + \frac{2}{\sqrt{(2.42)(.47)}}}$$

$= .23$ ✓ This is the value of K at Junction E.

$K_{E-M} = .23 + .02 = .25$ ✓ See Tables

$K_{N-M} = 37.05$ ✓ See calcs page

$$K_M = \frac{1}{\frac{1}{37.05} + \frac{1}{.25} + \frac{2}{\sqrt{(37.05)(.25)}}}$$

$= .21$ ✓ This is the value of k at Junction M

$K_{M\text{-}Flange} = .21 + .05 = .26$ ✓ See tables

$K = .19$ ✓ This k is for Turbine area and hose streams. See calcs page 11

$$K_T = \frac{1}{\frac{1}{.19} + \frac{1}{.26} + \frac{2}{\sqrt{(.19)(.26)}}}$$

$= .06$ ✓ This is the K value for the entire system

FORM 73 REV. 7/74

# Calculation of System Curve

$h_L = \frac{.00259\, k\, Q^2}{d^4}$  k = .06 ✓  $d^4$ = 18.25 ✓  $P = \frac{h_L (1.03)}{2.31}$

| Q | h | P |
|---|---|---|
| 800 | 5.45 ✓ | 2.4 ✓ |
| 1200 | 12.26 ✓ | 5.5 ✓ |
| 1600 | 21.80 ✓ | 9.7 ✓ |
| 2000 | 34.06 ✓ | 15.2 ✓ |
| 2400 | 49.05 ✓ | 21.9 ✓ |
| 2800 | 66.76 ✓ | 29.8 ✓ |
| 3200 | 87.19 ✓ | 38.9 ✓ |
| 3600 | 110.36 ✓ | 49.2 ✓ |
| 4000 | 136.24 ✓ | 60.7 ✓ |
| 4400 | 164.85 ✓ | 73.5 ✓ |

Static elevation = 19.9 psi

When the system curve is plotted along with the pump curve, the operating point can be determined. With one pump operation the pump will not meet the system demand. With two pump operation the pumps will provide 3800 GPM @ 75 psi

750 gpm was assumed to be used for hose streams the actual value is

$h_L = \frac{.00259\, k\, Q^2}{d^4}$

$168.2 = \frac{.00259\,(.41)\, Q^2}{18.25}$ = 1680 GPM ✓

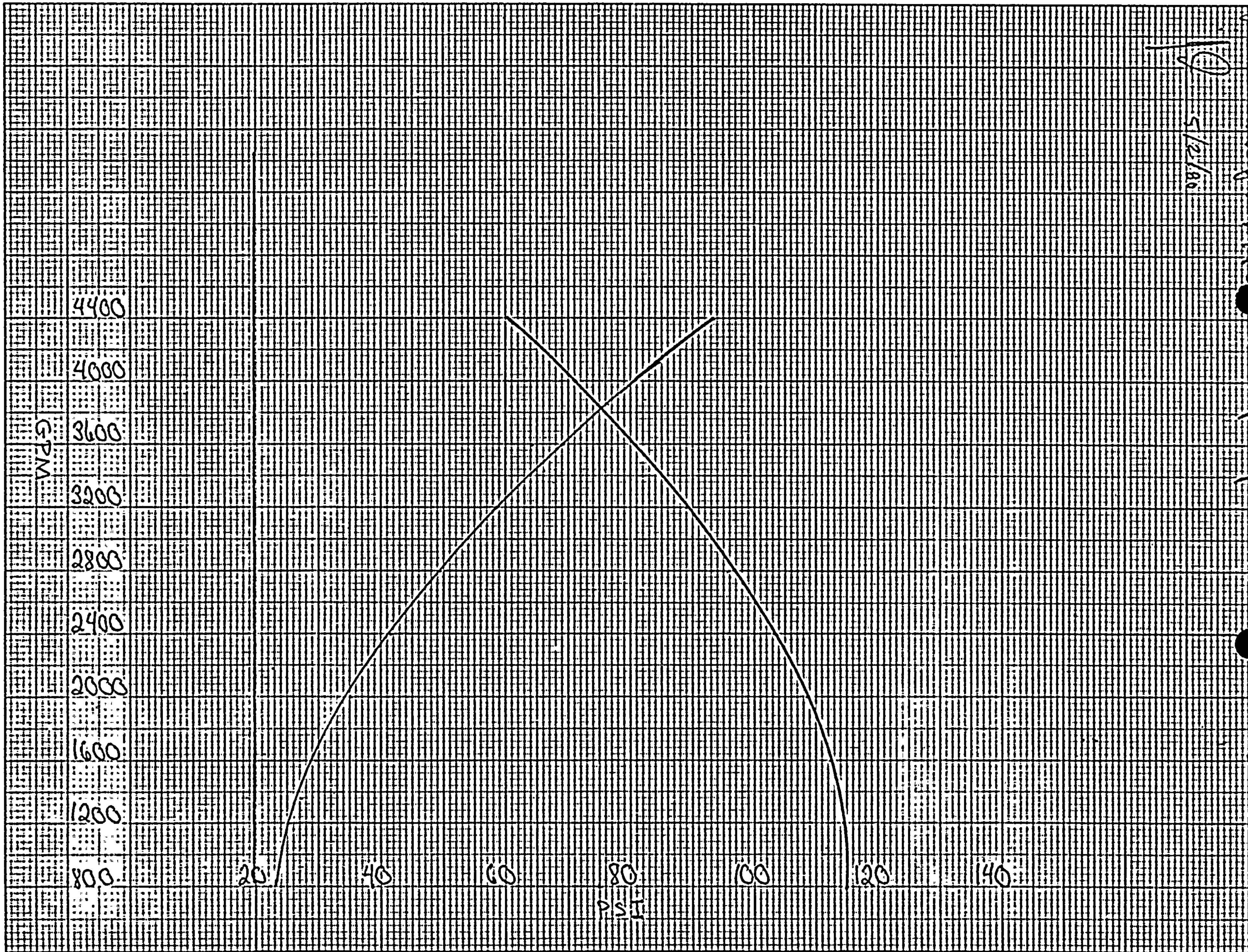
BY J. D. Rosenberger DATE 5/2/80 FPL FLORIDA POWER & LIGHT COMPANY SHEET NO. 34 OF 36

CHKD. BY DATE 5/2/80 PROJECT NO.

When the flow for the hose streams is subtracted from operating flow this leaves 2120 GPM to the system which gives .5 gpm/ft² for an area of 4240 ft².

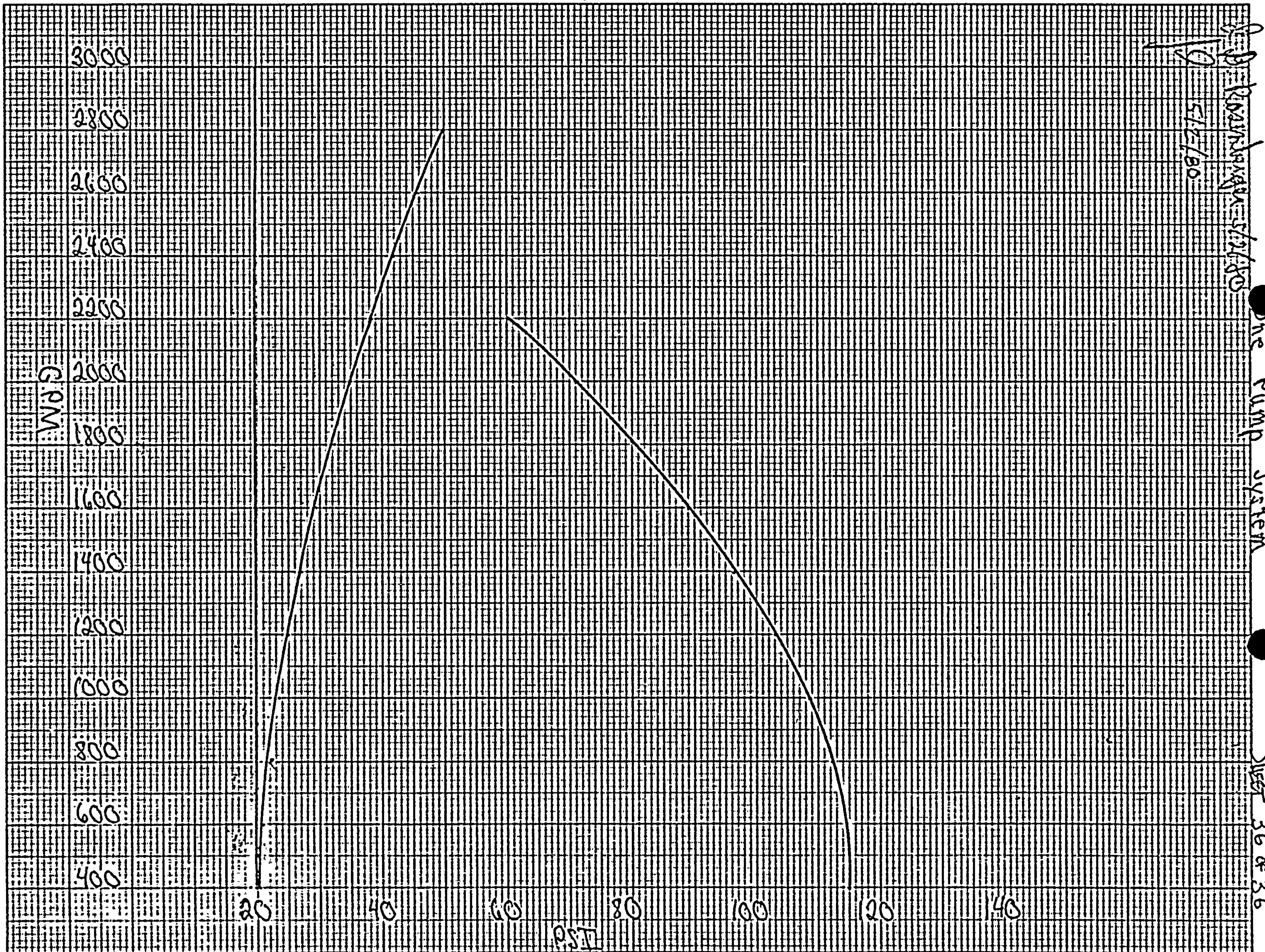
FORM 73 REV. 7/74

46 1473



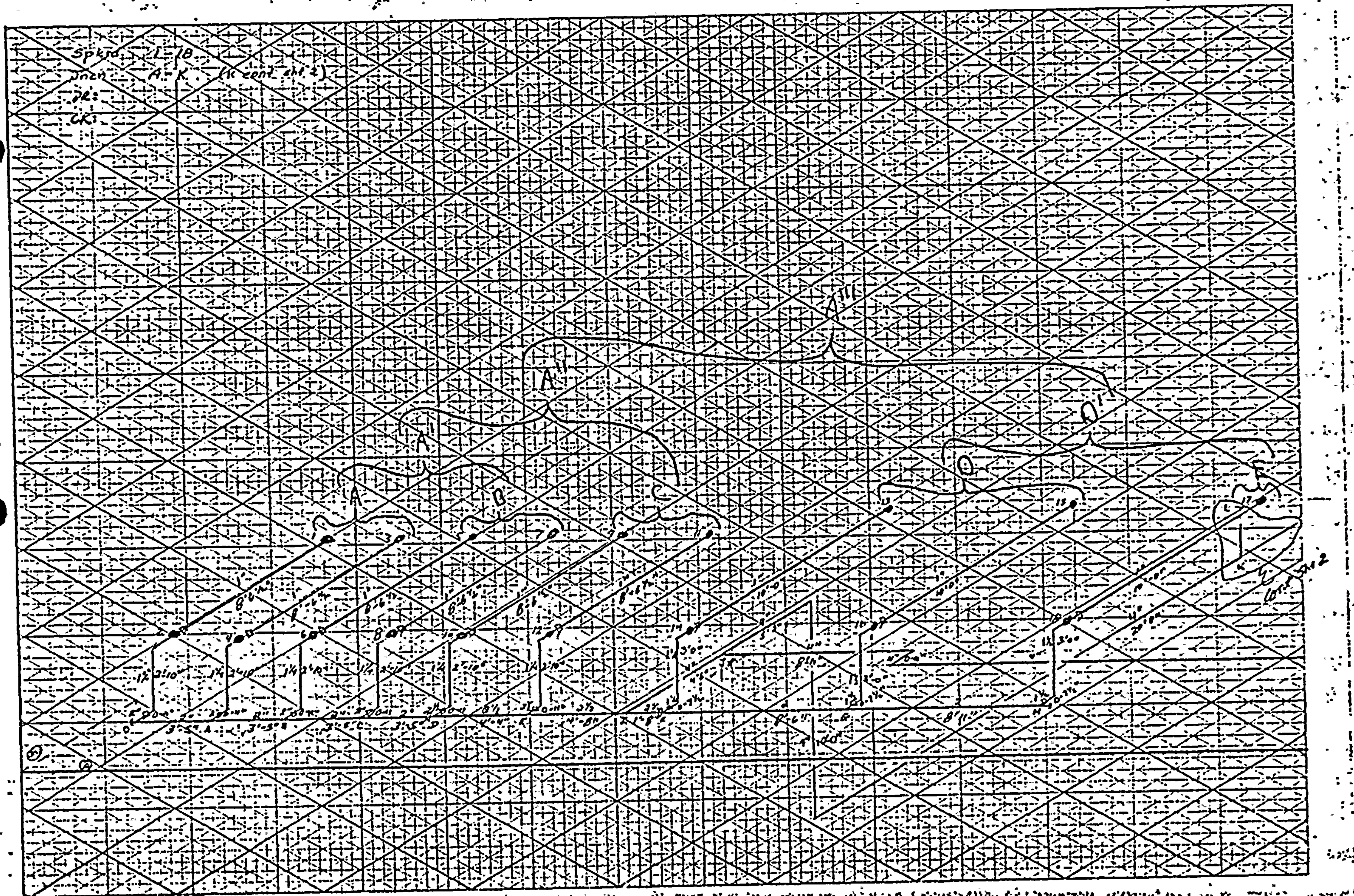

10 J. D. Rosenberger 5/2/80 5/2/80 2 Pump Operation

Sheet 35 of 36

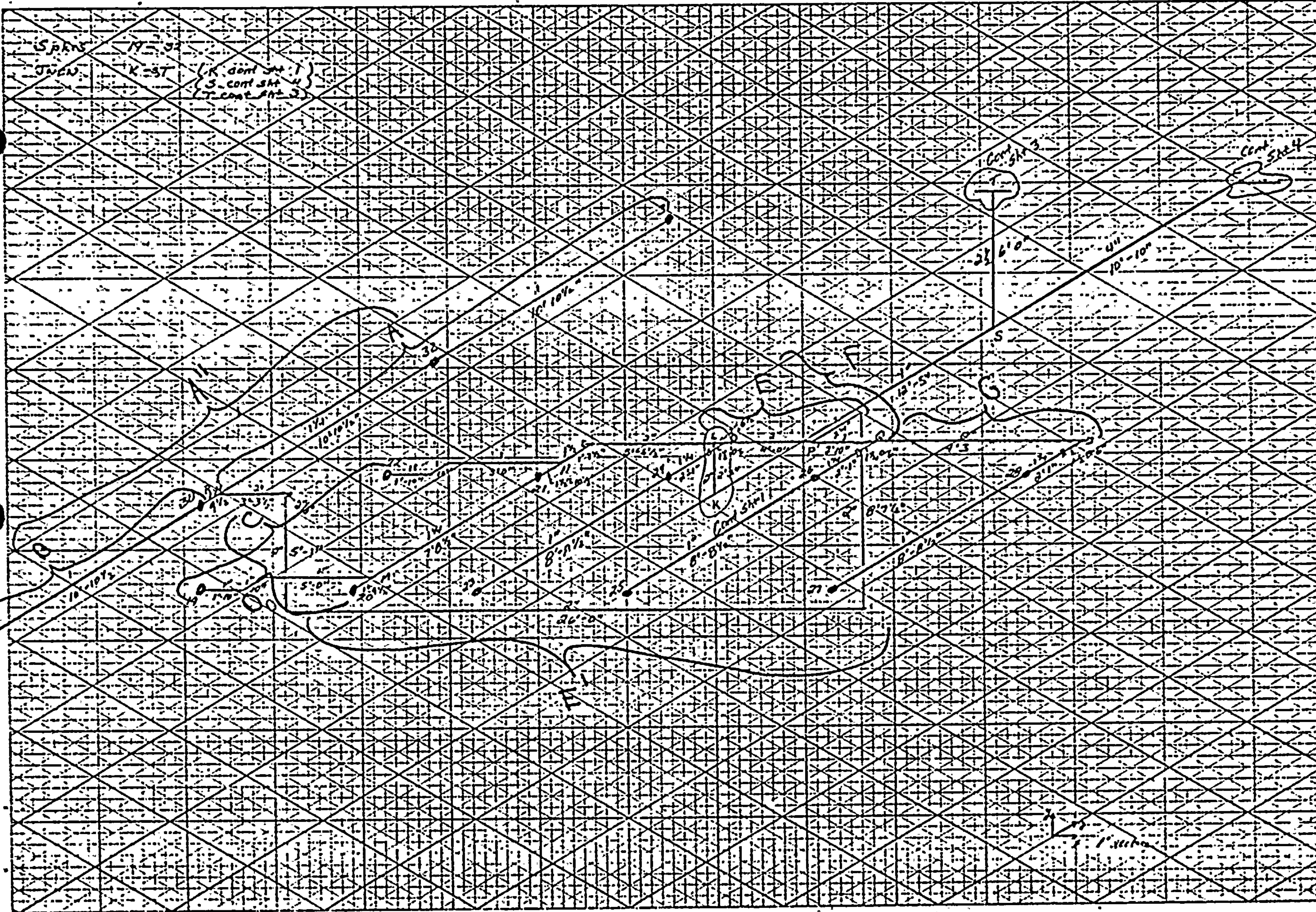

G.P.M.
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
20
40
60
80
100
120
140
PSI
5/2/80
One Pump System
Sheet 36 of 36

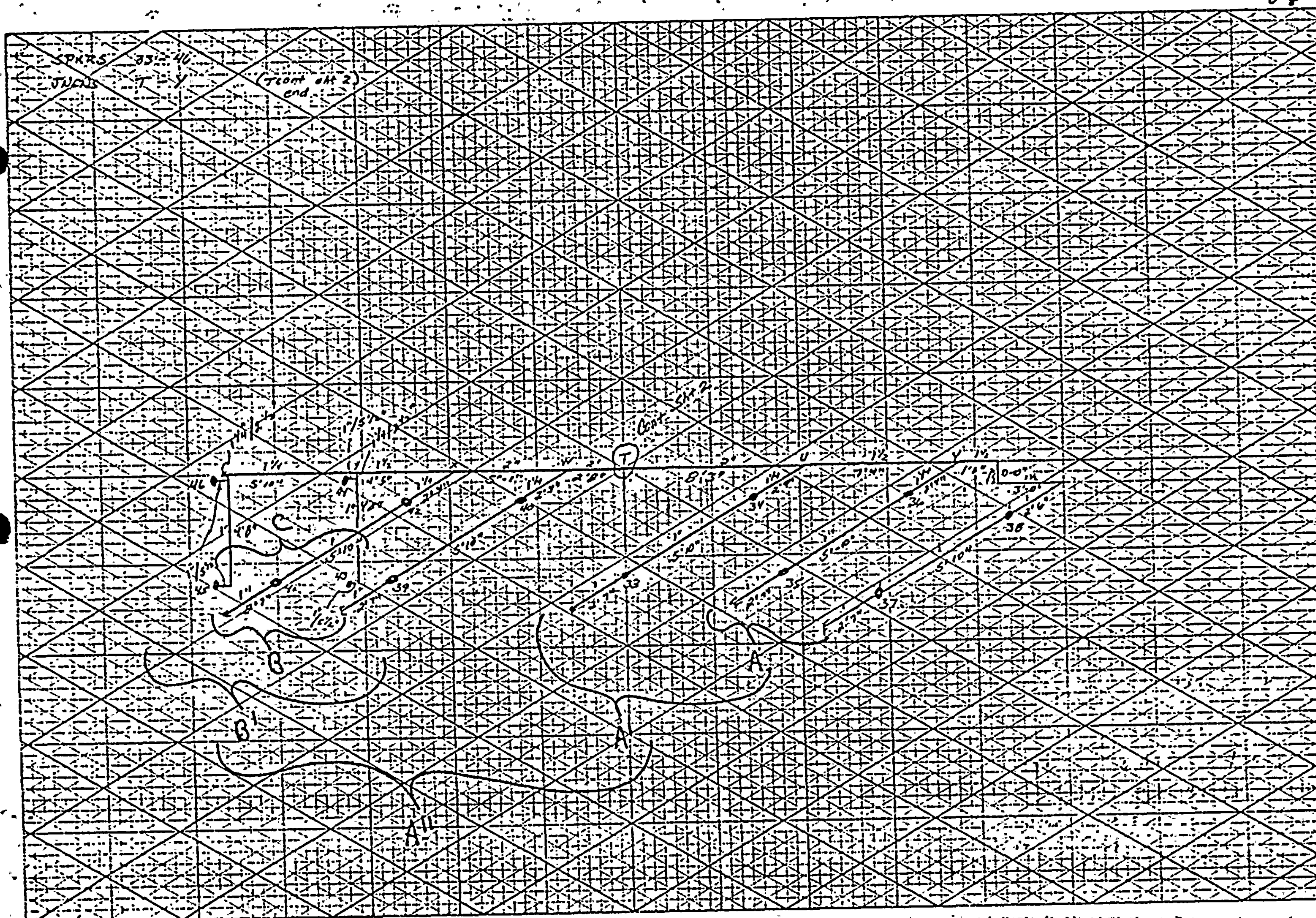
Appendix A

Isometric Drawings



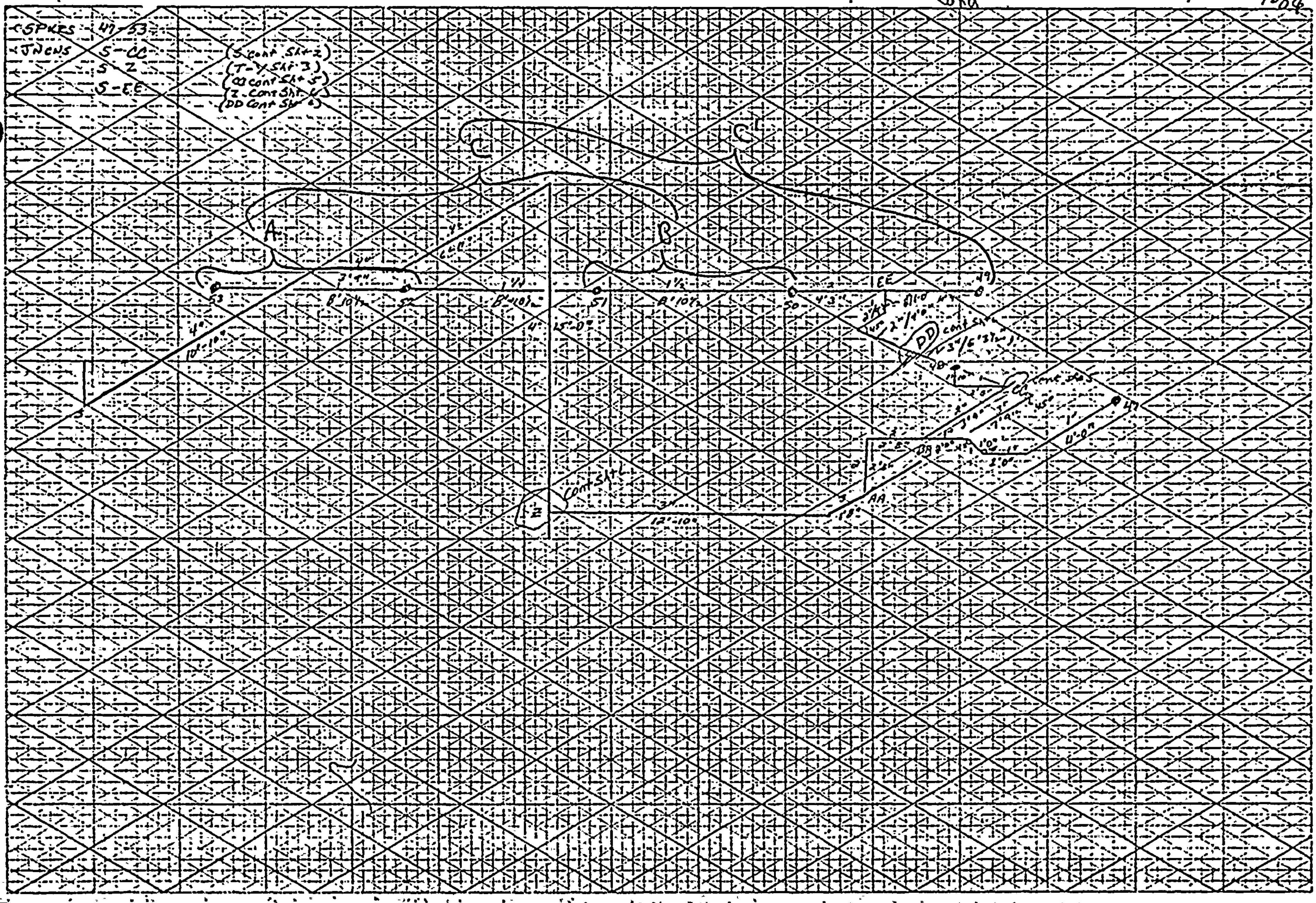

K+E ISOMETRIC-ORTHOGRAPHIC 47 4043


Spkrs 19-32
K-37
Cont Sht 3
Cont Sht 4
Cont Sht 1
10'-10"
26'-0"

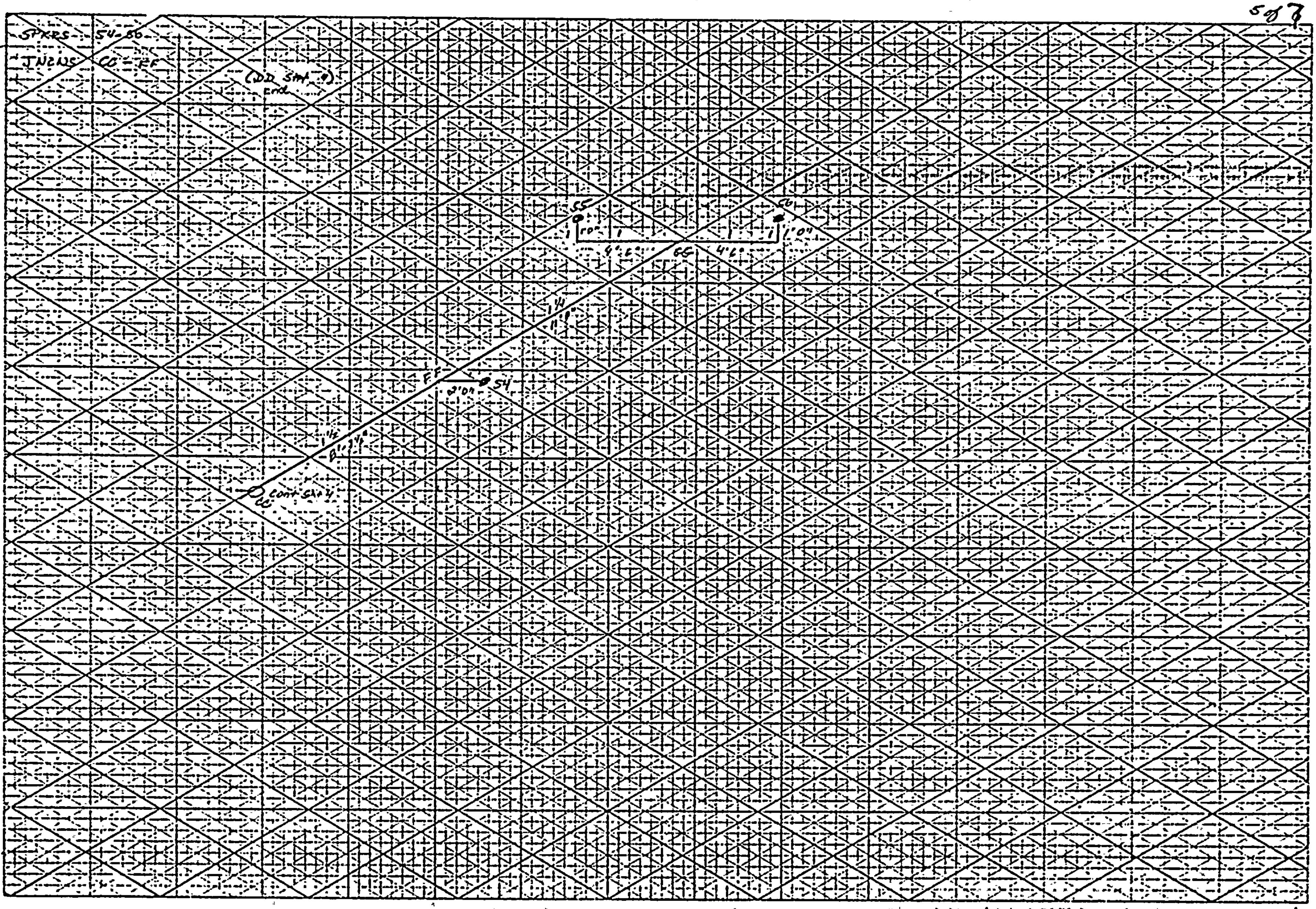

SPKRS 33-40
JNCNS T-Y
(T cont sht 2) end
Cont sht 2
T
A
A'
A''
B
B'
C

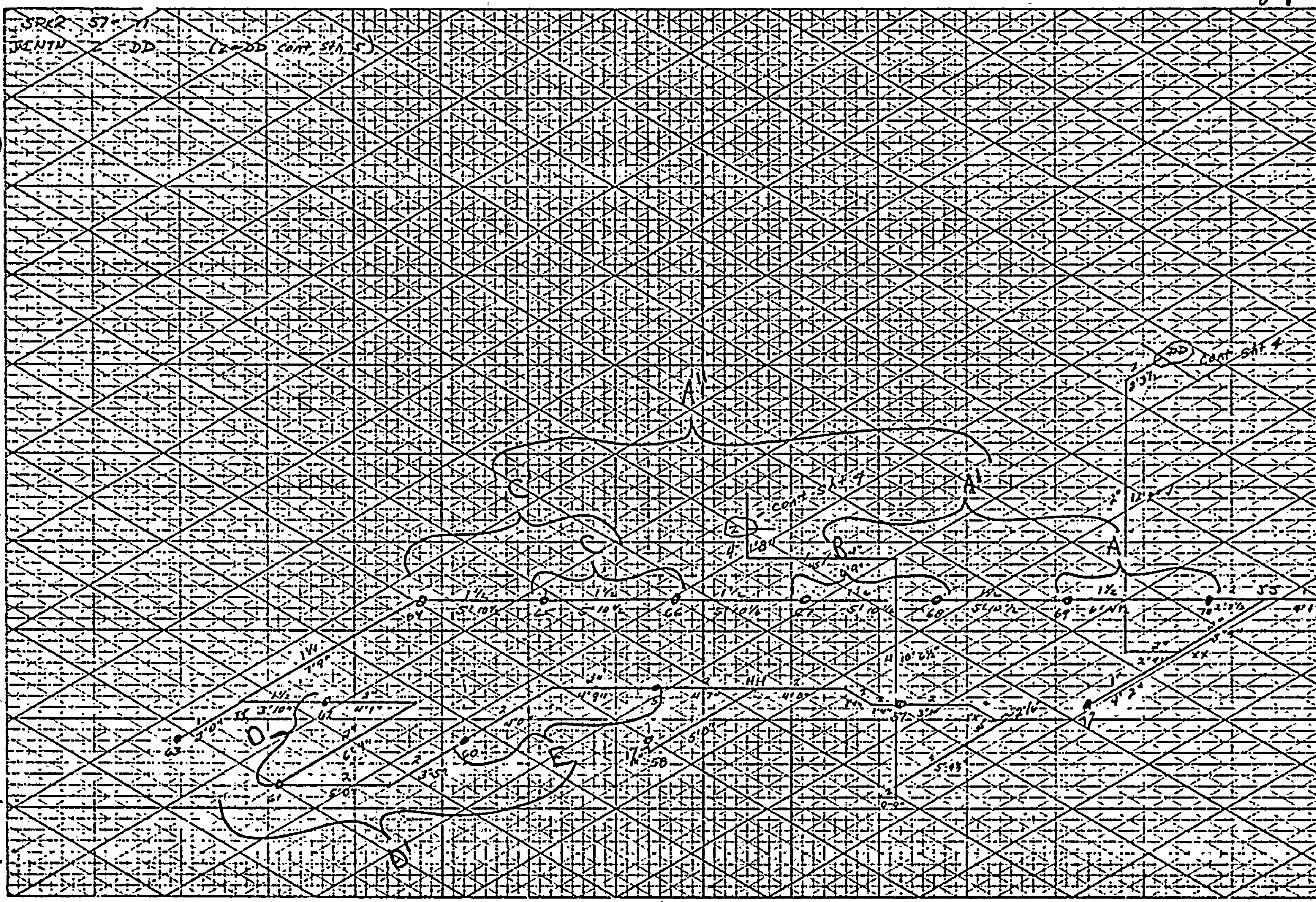
Cond

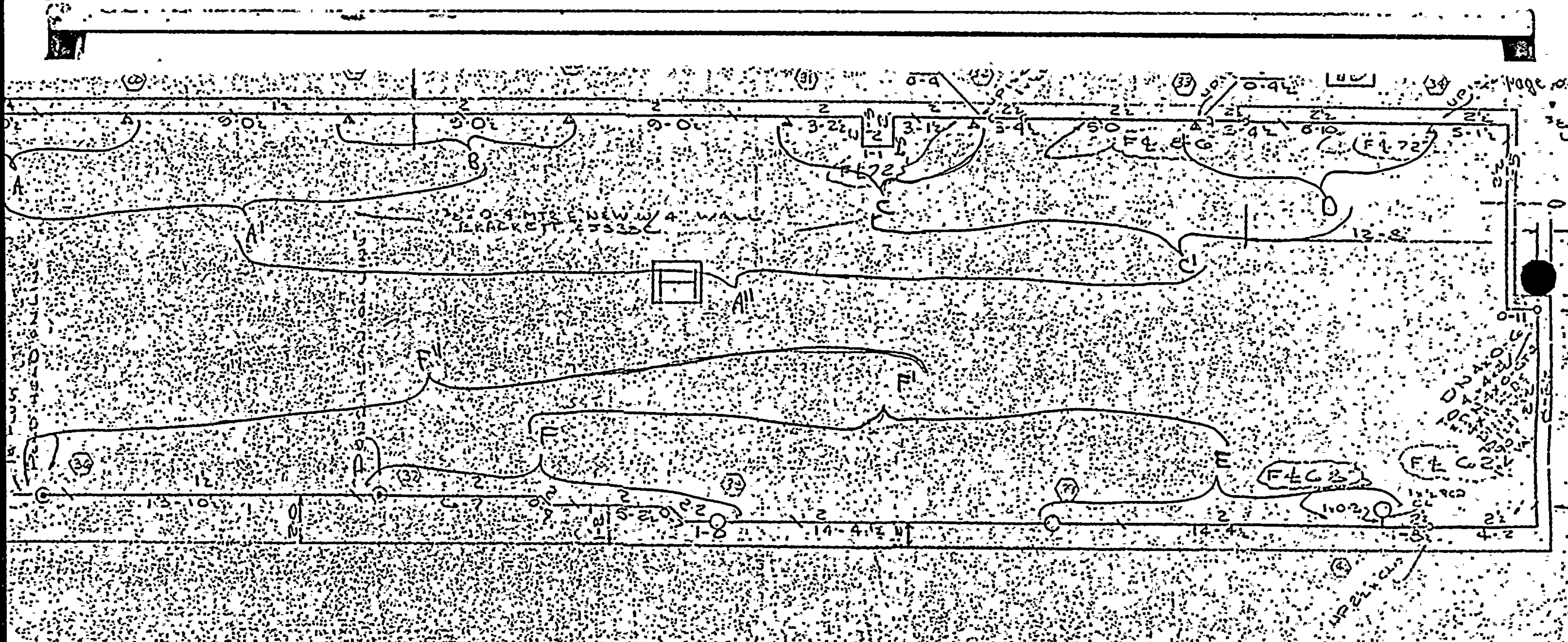





K+E ISOMETRIC-ORTHOGRAPHIC 47 4043


SPKRS 54-56
JNTNS CC-FF
(DD SHT 4) end
55
56
10"
1'0"
4'6"
GG
4'6"
1'4"
11'1"
FF
2'0"
54
1'4"
8'3"
CONT SHT 4
CC

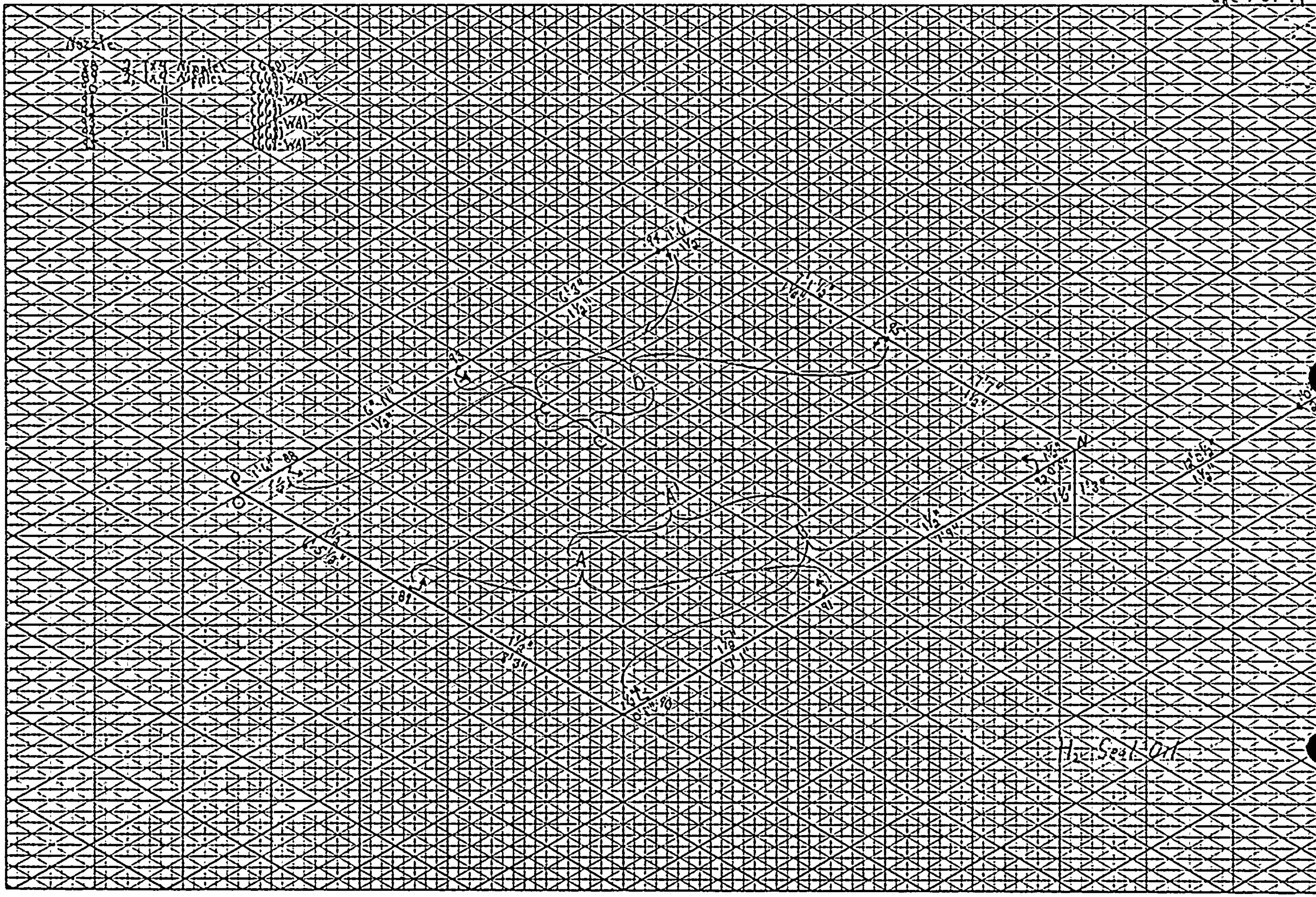

SPCR 57-71
JCNTN 2-DD
(2-DD CONT SHT 5)
DD CONT SHT 4
CONT SHT 4
A''
A'
A
B
C
C
D
D'
E
HH
XX
64
65
66
67
68
69
70
71
61
63
60
58
57

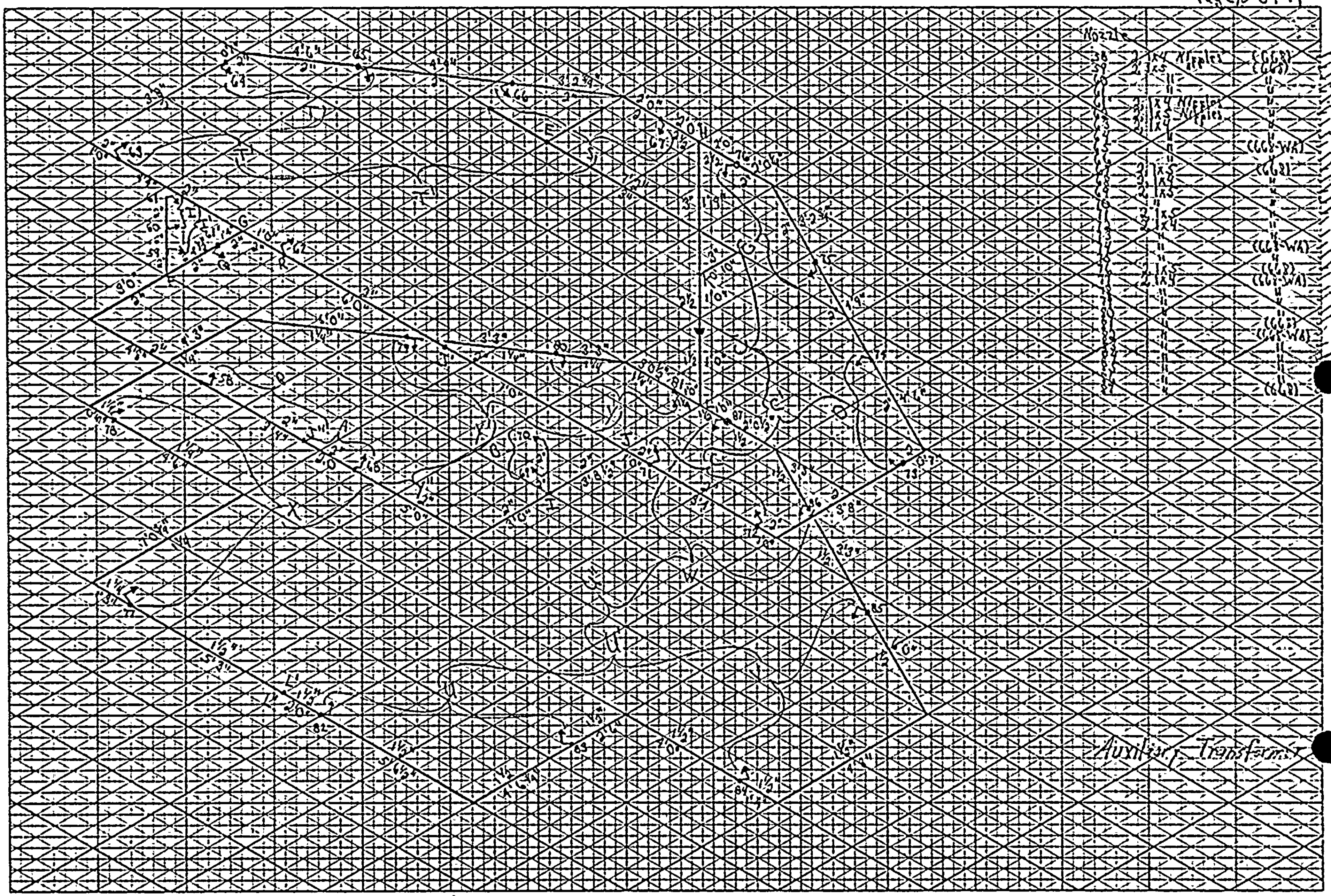


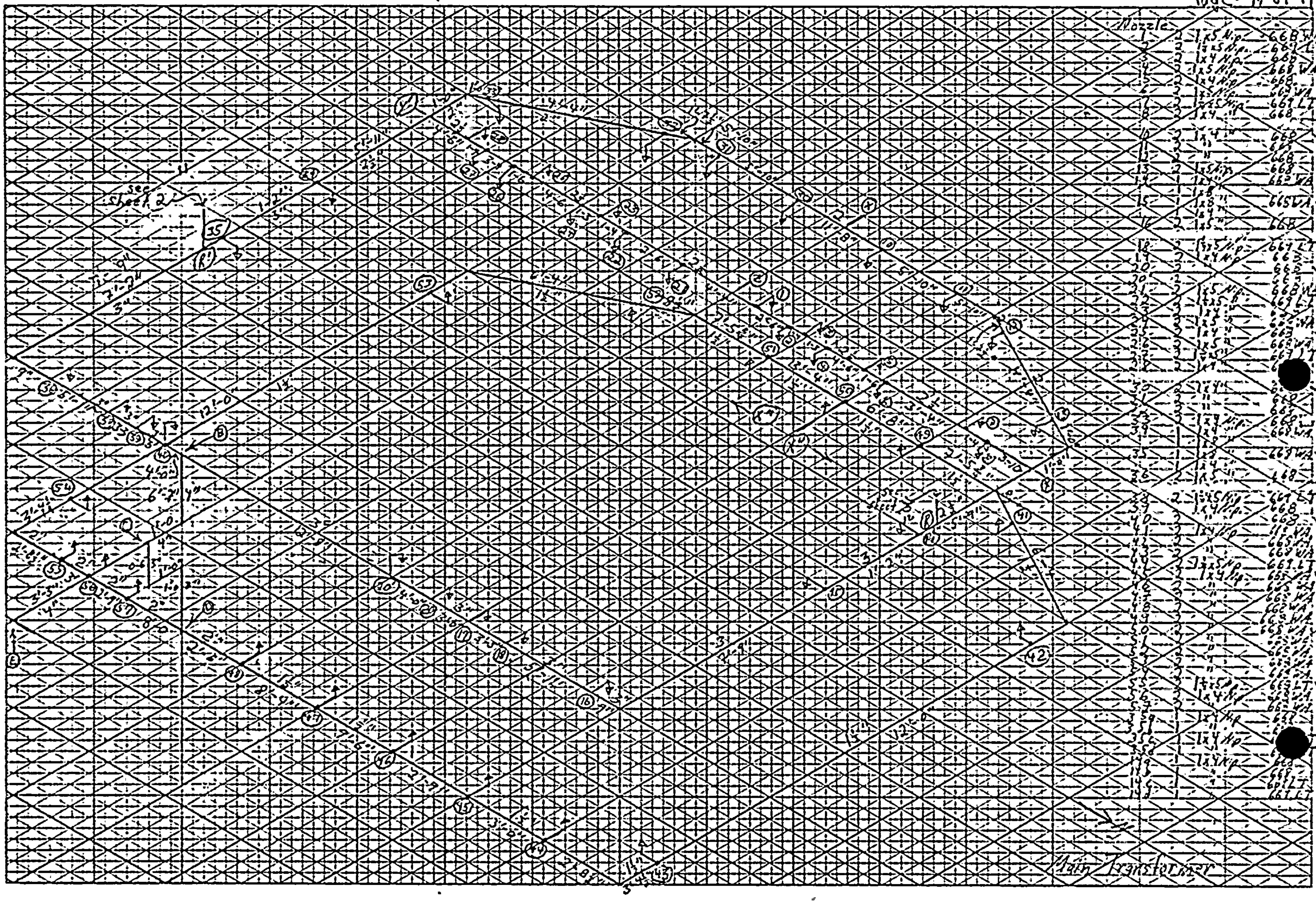

CONDENSATE PIT PIPING PLAN 1/4"=1'-0

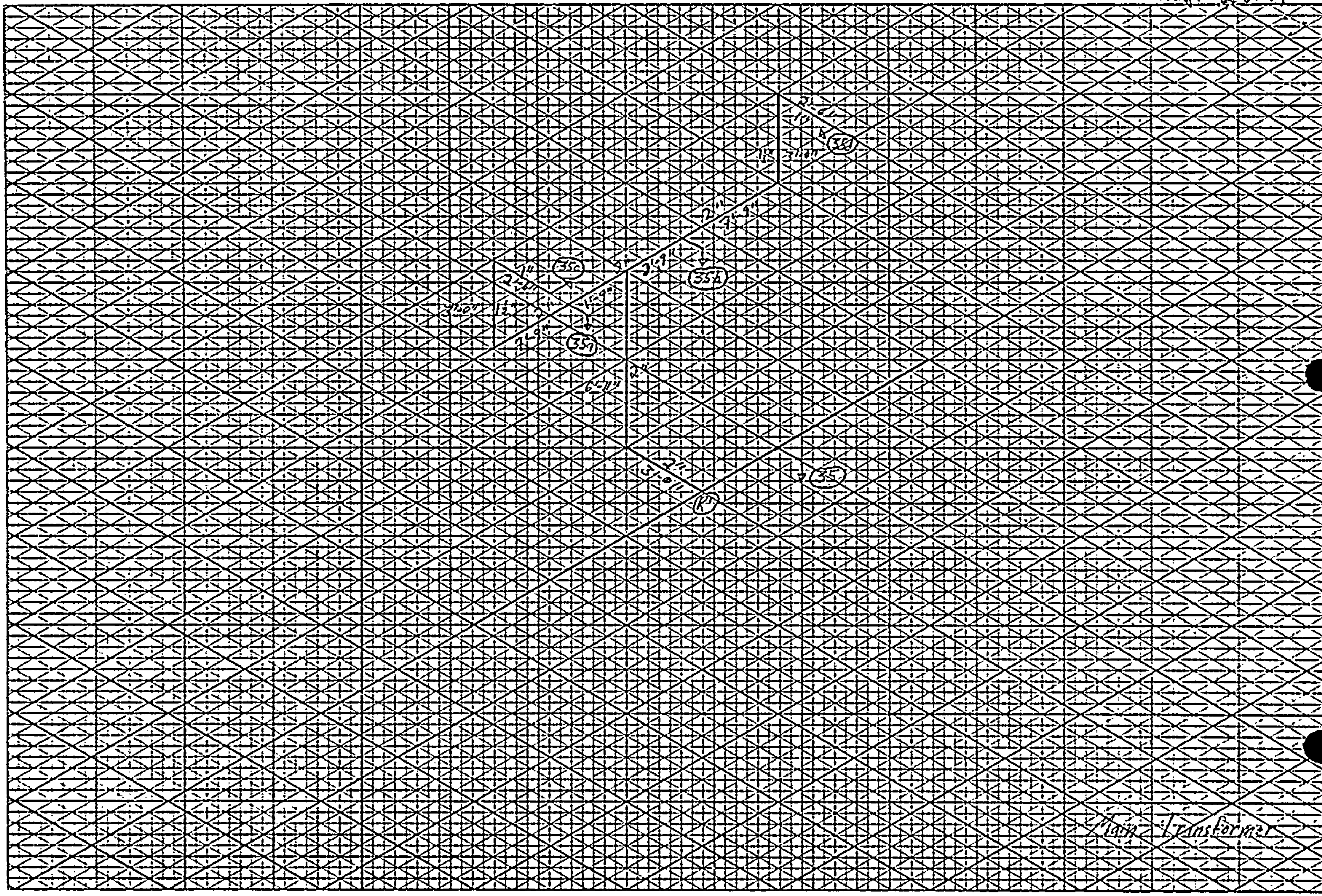
PROVIDE HEAT COLLECTORS OVER SIDEWALL & UPRIGHT HEADS ONLY - IF REQUIRED

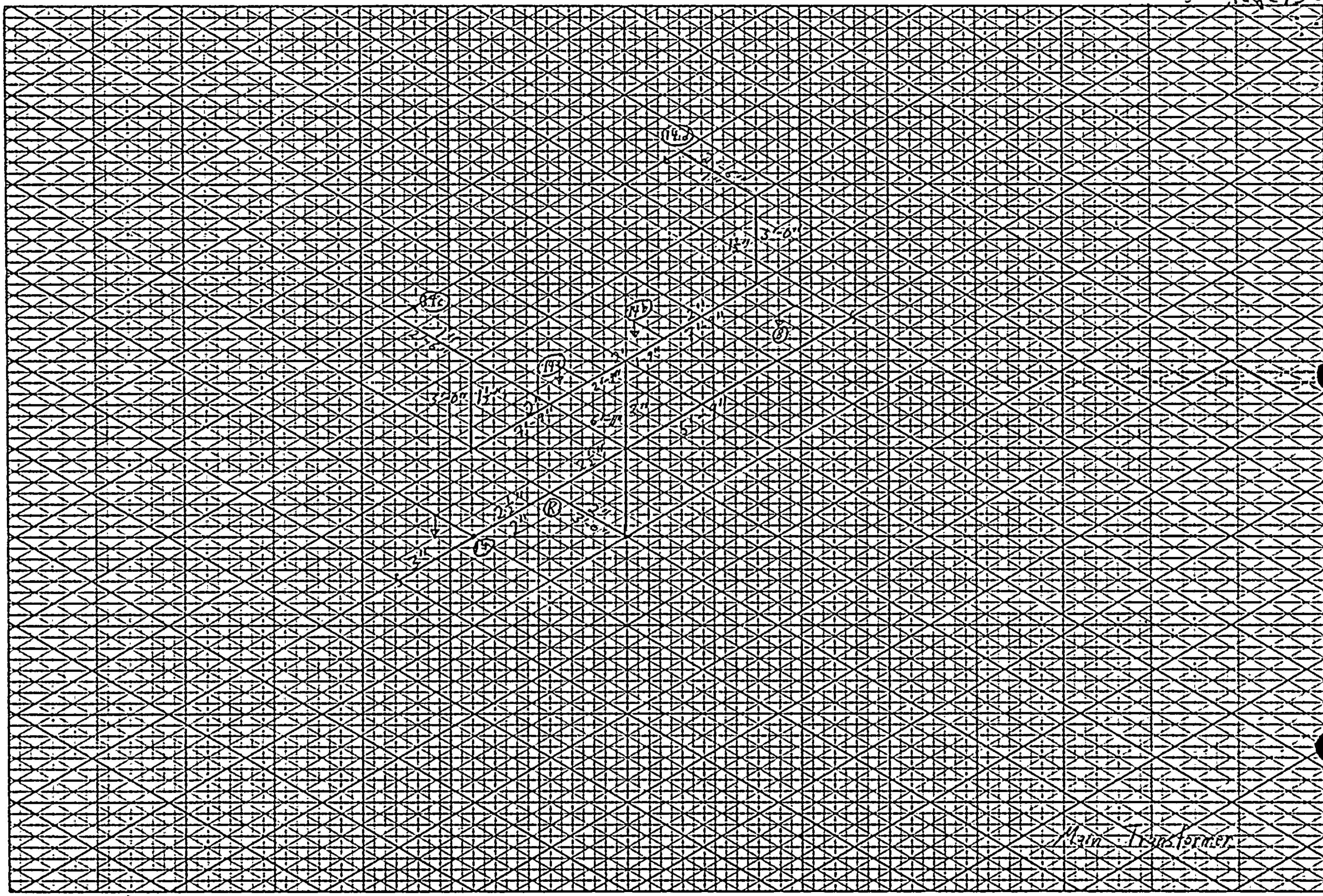
79 of 7

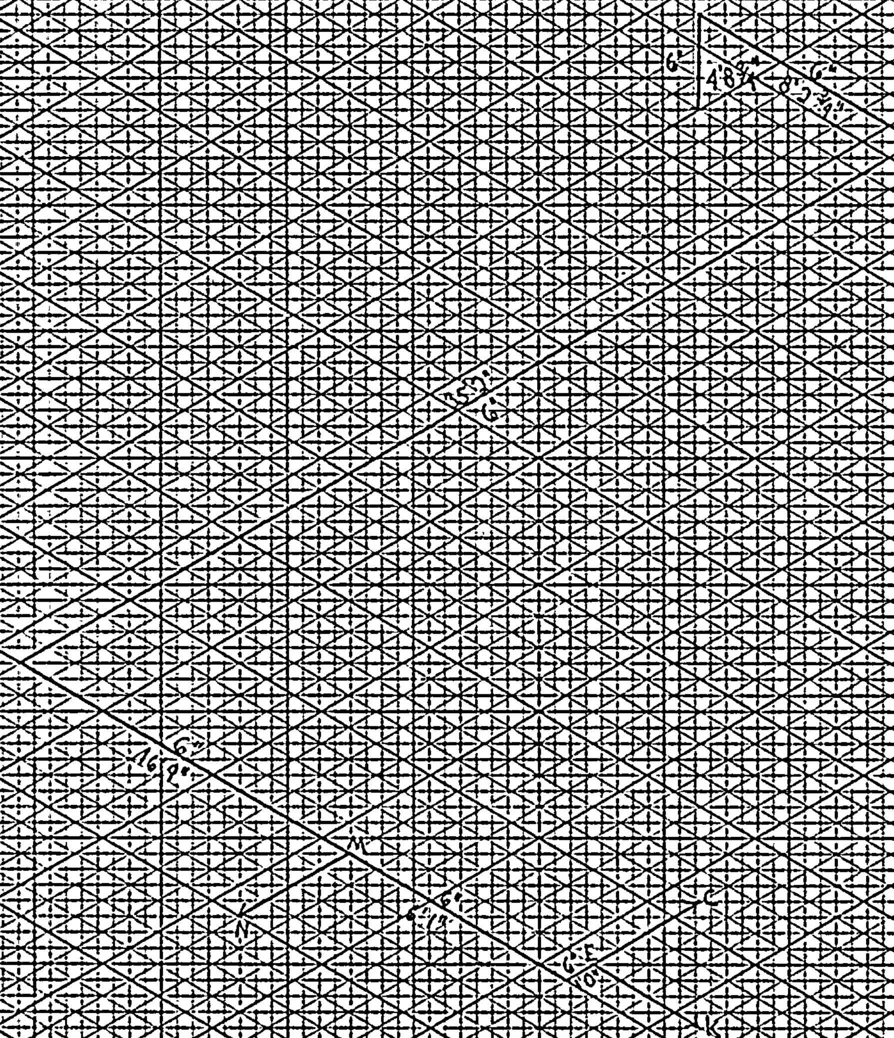

Nozzle
$H_2$ Seal Oil


Nozzle
Auxiliary Transformer


Nozzle
see sheet 2
Main Transformer


Main Transformer


Main Transformer


6'
4'8 3/4"
6"
15'3"
6"
6"
16'9"
M
N
6"
C
K

Appendix B

Calculation Tables

Turbine Area

| SPKR | size | Eq ft | K | K corrected to 2" | |
|---|---|---|---|---|---|
| 1 | 1" | 8.5 | 2.24 | 33.77 | 41 |
| | 1¼" | 3.7 | .71 | 3.57 | |
| 2 ells | 1¼" | 2.62 | .50 | 2.52 | |
| Tee | 2" | 10.3 | 1.14 | 1.14 | |
| 2 | | | | | |
| 3 | | | | | |
| Same as 1-2 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| Same as 1-2 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| Same as 1-2 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| Same as 1-2 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| Same as 1-2 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| | 1" | 10' | 2.63 | 39.65 | 46.88 |
| | 1¼" | 3.7' | .71 | 3.57 | |
| 2 ells | 1¼" | 2.62 | .50 | 2.52 | |
| Tee | 2" | 10.3 | 1.14 | 1.14 | |
| | | | | | |
| O | 2" | 14' | 1.54 | 1.54 | 3.06 |
| 4 Tees | 2" | 13.8' | 1.52 | 1.52 | |
| D | | | | | |
| | 2½" | 9' | .79 | .39 | .96 |
| 3 Tees | 2½" | 12.36 | 1.16 | .57 | |
| I | | | | | |
| H | 2" | 16.5' | 1.82 | 1.82 | 2.96 |
| 3 Tees | 2" | 10.35 | 1.14 | 1.14 | |
| F | | | | | |
| | 2½ | 1.67 | .15 | .07 | |
| I | | | | | |

| SPKR | | Size | Eq ft | K | K corrected to 2" | |
|---|---|---|---|---|---|---|
| 37 | | | | | | |
| | | 1" | 41 | 2.89 | 43.57 | |
| 38 | | | | | | |
| 35 | | | | | | |
| | | 1" | 7.4 | 1.95 | 29.4 | 31.61 |
| | | 1¼" | 2.3 | .44 | 2.21 | |
| 36 | | | | | | |
| 33 | | | | | | |
| | | Same as 35-36 | | | | |
| 34 | | | | | | |
| 39 | | | | | | |
| | | Same as 35-36 | | | | |
| 40 | | | | | | |
| 41 | | | | | | |
| | | Same as 35-36 | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| | | 1" | 4.7 | 1.24 | 18.69 | |
| 44 | | | | | | |
| 45 | | | | | | |
| | | Same as 43-44 | | | | |
| 46 | | | | | | |
| T | | | | K | | |
| | | 1½" | 12.7 | 1.99 | 5.4 | 14.11 |
| | 3 ells | 1½" | 12.09 | 1.89 | 5.13 | |
| | 2 tees | 1½ | 5.36 | .84 | 2.28 | |
| | | 2" | 8.25 | .91 | .91 | |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| V | | | | | | |
| T | | | | | | |
| | | 1¼ | 5.8 | 1.11 | 5.59 | 13.98 |
| | | 1½ | 4.4 | .99 | 2.69 | |
| | | 2" | 7.75 | .86 | .86 | |
| | 1 ell | 1¼" | 3.45 | .66 | 3.32 | |
| | 1 tee | 1½" | 2.68 | .42 | 1.14 | |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| Y | | | | | | |

| SPKR | | Size | Eq ft | K | K corrected to 2" | |
|---|---|---|---|---|---|---|
| T | | 2½" | 6.0 | .53 | .26 | 1.14 |
| | 2 tee | 2½" | 20.6 | 1.80 | .88 | |
| S | | | | | | |
| R | | | | | | |
| | | 1" | 10.88 | 2.86 | 43.11 | 56.14 |
| | | 1¼" | 10.88 | 2.08 | 10.46 | |
| | 1 tee | 1¼ | 2.68 | .51 | 2.57 | |
| 31 | | | | | | |
| R | | | | | | |
| | | 1" | 10.88 | 2.86 | 43.11 | 43.86 |
| | | 1¼" | .79 | .15 | .75 | |
| 29 | | | | | | |
| N | | | | | | |
| | | 1" | 7.67 | 2.02 | 30.45 | 51.25 |
| | 2 ells | 1" | 5.24 | 1.38 | 20.80 | |
| 22 | | | | | | |
| M | | | | | | |
| | same as N-22 | | | | | |
| 19 | | | | | | |
| N. | | | | | | |
| | | 1" | .79 | .21 | 3.17 | 21.98 |
| | 1 tee | 1" | 1.75 | .46 | 6.93 | |
| | | 1¼" | 7.71 | 1.47 | 7.40 | |
| | | 1½" | 2.5 | .39 | 1.06 | |
| | 1 tee | 1½" | 8.05 | 1.26 | 3.42 | |
| 20 | | | | | | |
| R | | | | | | |
| | | 2" | 35.08 | 3.87 | 3.87 | 7.29 |
| | 4 ells | 2" | 20.68 | 2.28 | 2.28 | |
| | 1 tee | 2" | 10.3 | 1.14 | 1.14 | |
| P | | | | | | |
| 23 | | | | | | |
| | | 1" | 8.71 | 2.29 | 34.52 | 40.17 |
| | | 1¼" | 2.08 | .40 | 2.01 | |
| | | 1½" | .50 | .08 | .22 | |
| | 1 tee | 1½" | 8.05 | 1.26 | 3.42 | |
| 24 | | | | | | |

| SPKR | | Size | Eq ft | K | K corrected to 2" | |
|---|---|---|---|---|---|---|
| 25 | | | | | | |
| | | same as | 23-24 | | | |
| 26 | | | | | | |
| 27 | | | | | | |
| | | same as | 23-24 | | | |
| 28 | | | | | | |
| L | | | | | | |
| | | 2" | 12.08 | 1.33 | 1.33 | |
| | 1 ell | 2" | 5.17 | .57 | .57 | 2.66 |
| | 2 tee | 2" | 6.90 | .76 | .76 | |
| 28 | | | | | | |
| L | | | | | | |
| | | 2" | 5.46 | .60 | .60 | .98 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| S | | | | | | |
| | | 4" | 12.42 | .63 | .04 | .09 |
| | 2 tee | 4" | 13.42 | .68 | .05 | |
| k | | | | | | |
| L | | | | | | |
| | | 2" | 2.25 | .25 | .25 | 2.52 |
| | 2 tee | 2" | 20.6 | 2.27 | 2.27 | |
| k | | | | | | |
| | | 4" | 35.17 | 1.78 | .12 | |
| | 2 ells | 4" | 20.20 | 1.02 | .07 | .21 |
| | 1 tee | 4" | 6.71 | .34 | .02 | |
| J | | | | | | |
| I | | 4" | 4.5 | .23 | .02 | .09 |
| | 1 tee | 4" | 20.1 | 1.02 | .07 | |
| J | | | | | | |
| | | 4" | 74.8 | 3.79 | .26 | |
| | | 6" | 28.2 | .69 | .01 | |
| | 2 ells | 4" | 20.2 | 1.02 | .07 | .36 |
| | 2 45's | 6" | 16.18 | .48 | .01 | |
| | 1 tee | 6" | 30.3 | .90 | .01 | |

(K)

| SPKR | | Size | Eq. ft | K | K corrected to 2" | |
|---|---|---|---|---|---|---|
| (K) | | | | | | |
| | | 6" | 61.2 | 1.82 | .02 | .08 |
| | 4 ells | 6" | 60.8 | 1.80 | .02 | |
| | L/D = 145 y pattern globe | 6" | 72.5 | 2.15 | .03 | |
| | tee | 6" | 30.3 | .90 | .01 | |
| Flange | | | | | | |
| 53 | | | | | | |
| | | 1" | 8.88 | 2.34 | 35.28 | |
| 52 | | | | | | |
| | | 1¼ | 8.88 | 1.70 | 8.56 | |
| 51 | | | | | | |
| | | 1½ | 8.88 | 1.39 | 3.78 | |
| 50 | | | | | | |
| | | 2" | 4.25 | .47 | .47 | |
| EE | | | | | | |
| | | 1" | 4.3 | 1.13 | 17.03 | 23.96 |
| | 1 tee | 1" | 1.75 | .46 | 6.93 | |
| 49 | | | | | | |
| EE | | | | | | |
| | | 2" | 5.79 | .64 | .64 | 2.65 |
| | 1 ell 90° | 2" | 5.17 | .57 | .57 | |
| | 1 ell 45° | 2" | 2.76 | .30 | .30 | |
| | 1 tee | 2" | 10.3 | 1.14 | 1.14 | |
| 56 | | | | | | |
| | | 1" | 5.5 | 1.45 | 21.86 | 32.26 |
| | 1 ell 90° | 1" | 2.62 | .69 | 10.40 | |
| GG | | | | | | |
| | | 1" | 5.5 | 1.45 | 21.86 | 39.19 |
| | 1 ell 90° | 1" | 2.62 | .69 | 10.40 | |
| | 1 tee | 1" | 1.75 | .46 | 6.93 | |
| 55 | | | | | | |
| GG | | | | | | |
| | | 1¼" | 11.0 | 2.10 | 10.57 | 23.81 |
| | 2 tee | 1¼" | 13.75 | 2.63 | 13.24 | |
| FF | | | | | | |
| | | 1" | 2.0 | .53 | 7.99 | 28.79 |
| | 1 tee | 1" | 5.25 | 1.38 | 20.8 | |
| 54 | | | | | | |

| SPKR | Size | Eq-Ft | K | K corrected to 2" | |
|---|---|---|---|---|---|
| FF | | | | | |
| | 1½" | 8.63 | 1.35 | 3.67 | 4.81 |
| | 1 Tee 1½" | 2.68 | .42 | 1.14 | |
| CC | | | | | |
| | 1" | 4.25 | 1.12 | 16.88 | |
| | 1 ell 90° 1" | 2.62 | .69 | 10.40 | 48.08 |
| | 1 Tee 1" | 5.25 | 1.38 | 20.80 | |
| 48 | | | | | |
| CC | | | | | |
| | 2" | 3.75 | .41 | .41 | 1.55 |
| | 1 tee 2" | 10.3 | 1.14 | 1.14 | |
| 47 | | | | | |
| | 1" | 9.0 | 2.37 | 35.73 | |
| | 1 ell 90° 1" | 2.62 | .69 | 10.40 | 63.79 |
| | 2 ell 45° 1" | 2.80 | .74 | 11.16 | |
| | 1 tee 1" | 1.75 | .46 | 6.93 | |
| BB | | | | | |
| | 2" | 4.75 | .52 | .52 | |
| | 1 ell 90° 2" | 5.17 | .57 | .57 | 2.23 |
| | 1 tee 2" | 10.3 | 1.14 | 1.14 | |
| AA | | | | | |
| | 3" | 13.0 | .92 | .19 | |
| | 1 ell 45° 3" | 4.09 | .29 | .06 | .29 |
| | 1 tee 3" | 5.11 | .36 | .07 | |
| DD | | | | | |
| AA | | | | | |
| | 3" | 14.5 | 1.02 | .21 | |
| | 1 ell 90° 3" | 7.67 | .54 | .11 | .54 |
| | 1 tee 3" | 15.3 | 1.08 | .22 | |
| Z | | | | | |
| DD | | | | | |
| | 3" | 2.3 | .16 | .03 | |
| | 2" | 14.5 | 1.60 | 1.60 | |
| | 1 ell 90° 2" | 5.17 | .57 | .57 | 3.45 |
| | 1 ell 90° 3" | 7.67 | .54 | .11 | |
| | 1 tee 2" | 10.3 | 1.14 | 1.14 | |
| XX | | | | | |

| SPKR | Size | Eq-ft | K | K corrected to 2" | |
|---|---|---|---|---|---|
| 72 | | | | | |
| | 1" | 4.2 | 1.11 | 16.73 | 23.66 |
| | 1 tee 1" | 1.75 | .46 | 6.93 | |
| XX | | | | | |
| | 2" | 3.75 | .41 | .41 | 1.55 |
| | 1 Tee 2" | 10.3 | 1.14 | 1.14 | |
| JJ | | | | | |
| | 1" | 4.08 | 1.07 | 16.13 | 23.06 |
| | 1 tee 1" | 1.75 | .46 | 6.93 | |
| 71 | | | | | |
| JJ | | | | | |
| | 2" | 2.6 | .29 | .29 | |
| | 1½" | 35.75 | 5.59 | 15.19 | 26.85 |
| | 1¼" | 7.75 | 1.48 | 7.45 | |
| | 1 ell 90° 1½" | 4.03 | .63 | 1.71 | |
| | 1 Tee 1¼" | 2.30 | .44 | 2.21 | |
| II | | | | | |
| | 1" | 3.0 | .79 | 11.91 | |
| 63 | | | | | |
| II | 1½" | 3.8 | .59 | 1.60 | |
| | 1 tee 1½" | 8.05 | 1.26 | 3.42 | 11.23 |
| | 2" | 32.17 | 3.55 | 3.55 | |
| | 4 ells 90° 2" | 20.68 | 2.28 | 2.28 | |
| | 1 tee 2" | 3.45 | .38 | .38 | |
| HH | | | | | |
| | 1" | 5.5 | 1.45 | 21.86 | 53.06 |
| | 1 ell 90° 1" | 2.62 | .69 | 10.40 | |
| | 1 tee 1" | 5.25 | 1.38 | 20.80 | |
| 58 | | | | | |
| HH | | | | | |
| | 2" | 6.67 | .74 | .74 | 1.04 |
| | 2 ells 45° 2" | 2.76 | .30 | .30 | |
| 57 | | | | | |
| | 2" | 10.71 | 1.18 | 1.18 | |
| | 2 ell 45° 2" | 5.52 | .61 | .61 | |
| | 2 ell 90° 2" | 10.34 | 1.14 | .14 | 2.12 |
| | 4" | 17.63 | .89 | .06 | |
| | 2 ell 45° 4" | 10.74 | .54 | .04 | |
| | 2 ell 90° 4" | 20.2 | 1.02 | .07 | |
| | 1 tee 4" | 6.71 | .34 | .02 | |

| SPKR | Size | Eq-ft | k | $K_{corrected}$ | |
|---|---|---|---|---|---|
| Z | | | | | |
| | 4" | 36.5 | 1.85 | .13 | .26 |
| | 3 ells 90° 4" | 30.3 | 1.54 | .11 | |
| | 1 Tee 4" | 6.71 | .34 | .02 | |
| S 36 | | | | | |
| | 1½" | 13.88 | 2.17 | 5.90 | 12.65 |
| | 2" | 41.88 | 4.62 | 4.62 | |
| | 2½" | 14.58 | 1.28 | .63 | |
| | 4 ells 45° 2" | 11.04 | 1.22 | 1.22 | |
| | 1 ells 90° 2½" | 6.17 | .54 | .27 | |
| ⟨M⟩ 27 | | | | | |
| | 1¼" | 9.04 | 1.73 | 8.71 | 19.82 |
| | 1½" | 9.04 | 1.41 | 3.83 | |
| | 2" | 28.38 | 3.13 | 3.13 | |
| | 4 ells 90° 2" | 20.68 | 2.28 | 2.28 | |
| | 2½" | 31.04 | 2.72 | 1.34 | |
| | 2 ells 90° 2½ | 12.34 | 1.08 | .53 | |
| ⟨M⟩ | | | | | |
| | 4" | 157.3' | 7.97 | .55 | 1.49 |
| | 4 ells 45° 4" | 21.48 | 1.09 | .08 | |
| | 14 ells 90° 4" | 141.4 | 7.16 | .50 | |
| | 5 tees 4" | 100.1 | 5.07 | .35 | |
| | 6" | 1.0 | .03 | — | |
| | 1 tee 6" | 30.3 | .90 | .01 | |

| SPKR or Junction | Size | Eq ft | k | K corrected to 2" | |
|---|---|---|---|---|---|
| O | | | | | |
| | 1½" | 6.46 | 1.01 | 2.74 | |
| 89 | | | | | |
| | 1½" | 8.25 | 1.29 | 3.50 | 5.48 |
| 1 90° Ell | 1½" | 4.03 | .63 | 1.71 | |
| | 1½ | .67 | .10 | .27 | |
| 90 | | | | | |
| | 1½" | 7.08 | 1.11 | 3.02 | |
| 91 | | | | | |
| | 1½" | 7.75 | 1.21 | 3.29 | |
| 92 | | | | | |
| | 1½" | .67 | .10 | .27 | |
| N | | | | | |
| P | | | | | |
| | 1½" | 1.5 | .23 | .62 | |
| 88 | | | | | |
| | 1½" | 6.92 | 1.08 | 2.93 | |
| 93 | | | | | |
| | 1½" | 6.25 | .98 | 2.66 | |
| 94 | | | | | |
| | 1½" | 8.63 | 1.35 | 3.67 | 5.38 |
| 1 ell 90° | 1½" | 4.03 | .63 | 1.71 | |
| 95 | | | | | |
| | 1½" | 7.58 | 1.19 | 3.23 | |
| N | 1½" | 13.29 | 2.08 | 5.65 | |
| | 2" | 1.0 | .11 | .11 | |
| 2 90° Ells | 1½" | 8.06 | 1.26 | 3.42 | |
| M | | | | | |

Aux Transformer



| SPKR or Junction | | Size | Eq ft | K | K corrected to 2" | |
|---|---|---|---|---|---|---|
| 58 | 1 tee | 2" | 3.45 | .38 | .38 | 1.23 |
| | | 2" | 7.67 | .85 | .85 | |
| F | | | | | | |
| | | 2" | 2.38 | .26 | .26 | .64 |
| [illegible] | 1 tee | 2" | 3.45 | .38 | .38 | |
| 61' | | 2" | 1.33 | .15 | .15 | |
| G | | | | | | |
| | | 2" | 4.33 | .48 | .48 | .86 |
| [illegible] | 1 tee | 2" | 3.45 | .38 | .38 | |
| 63 | | 2" | 4.67 | .52 | .52 | 1.47 |
| | 1 90° Ell | 2" | 5.17 | .57 | .57 | |
| [illegible]4 | 1 tee | 2" | 3.45 | .38 | .38 | |
| 64 | | 2" | 5.08 | .56 | .56 | 1.32 |
| | 1 45° Ell | 2" | 2.76 | .30 | .38 | |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 65 | | | | | | |
| | | 2" | 4.75 | .52 | .52 | .90 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 66 | | | | | | |
| | | 2" | 5.23 | .58 | .58 | 1.26 |
| | 1 45° Ell | 2" | 2.76 | .30 | .30 | |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 67 | | | | | | |
| | | 2½" | 2.0 | .18 | .09 | .27 |
| | 1 tee | 2½" | 4.12 | .36 | .18 | |
| H | | | | | | |

| SPKR or Junction | | Size | Eq ft. | k | k connected to 2" | |
|---|---|---|---|---|---|---|
| H | | | | | | |
| | | 2½ | 2.0 | .18 | .09 | .27 |
| | 1 tee | 2½ | 4.12 | .36 | .18 | |
| 76 | | | | | | |
| | | 2" | 5.25 | .58 | .58 | |
| | 1 45° Ell | 2" | 2.76 | .30 | .30 | 1.26 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 75 | | | | | | |
| | | 2" | 4.75 | .52 | .52 | .90 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 74 | | | | | | |
| | | 2" | 5.08 | .56 | .56 | |
| | 1 45° Ell | 2" | 2.76 | .30 | .30 | 1.24 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 73 | | | | | | |
| | | 2" | 4.67 | .52 | .52 | |
| | 1 90° Ell | 2" | 5.17 | .57 | .57 | 1.47 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 72 | | | | | | |
| | | 2" | 3.33 | .37 | .37 | .75 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 71 | | | | | | |
| | | 2" | 1.00 | .11 | .11 | 1.24 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| J | | | | | | |
| | | 2" | 7.0 | .77 | .77 | |
| J' | | | | | | |

| SPKR or Junction | | Size | Eq ft | K | K corrected for 2" | |
|---|---|---|---|---|---|---|
| J' | | | | | | |
| | | 2" | 6.0 | .66 | .66 | 1.04 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 62 | | | | | | |
| | | 2" | 1.0 | .11 | .11 | .49 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| G | | | | | | |
| J | | | | | | |
| | | 2" | 3.71 | .41 | .41 | .79 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| I | | | | | | |
| | | 2" | 3.5 | .39 | .39 | 1.91 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| | 1 tee | 2" | 10.3 | 1.14 | 1.14 | |
| 70 | | | | | | |
| I | | | | | | |
| | | 2" | 8.00 | .88 | .88 | 1.83 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| | 1 90° Ell | 2" | 5.17 | .57 | .57 | |
| 68 | | | | | | |
| | | 2" | 2.0 | .22 | .22 | |
| J" | | | | | | |
| | | 2" | 3.33 | .37 | .37 | .75 |
| | 1 tee | 2" | 3.45 | .38 | .38 | |
| 58 | | | | | | |

| SPKR or Junction | Size | Eq ft | K | K corrected to 2" | |
|---|---|---|---|---|---|
| L" | | | | | |
| | 1½" | 5.25 | .82 | 2.23 | 3.37 |
| 1 tee | 1½" | 2.68 | .42 | 1.14 | |
| 77 | | | | | |
| | 1¼" | 12.81 | 2.45 | 12.33 | 21.18 |
| 1 tee | 1¼" | 2.30 | .44 | 2.21 | |
| 2 90° Ells | 1¼" | 6.90 | 1.32 | 6.64 | |
| 78 | | | | | |
| | 1¼ | 11.08 | 2.12 | 10.67 | 17.96 |
| 1 tee | 1¼ | 2.30 | .44 | 2.21 | |
| 1 90° Ell | 1¼ | 3.45 | .66 | 3.32 | |
| 1 45° Ell | 1¼ | 1.84 | .35 | 1.76 | |
| 79 | | | | | |
| | 1¼ | 3.25 | .62 | 3.12 | 5.33 |
| 1 tee | 1¼ | 2.30 | .44 | 2.21 | |
| 80 | | | | | |
| | 1¼" | 6.29 | 1.20 | 6.04 | 10.01 |
| 1 45° Ell | 1¼" | 1.84 | .35 | 1.76 | |
| 1 tee | 1¼ | 2.30 | .44 | 2.21 | |
| 81 | | | | | |
| | 1¼ | 1.0 | .19 | .96 | 3.17 |
| 1 tee | 1¼ | 2.30 | .44 | 2.21 | |
| L | | | | | |
| | 1½ | 1.0 | .16 | .43 | 1.57 |
| 1 tee | 1½ | 2.68 | .42 | 1.14 | |
| 87 | | | | | |

| SPKR or Junction | Size | Eq ft | k | $K_{corrected\ to\ 2"}$ | |
|---|---|---|---|---|---|
| 87 | | | | | |
| | 1½" | 5.29 | .83 | 2.25 | 4.31 |
| 1 45° Ell | 1½" | 2.15 | .34 | .92 | |
| 1 tee | 1½" | 2.68 | .42 | 1.14 | |
| 86 | | | | | |
| | 1½" | 3.25 | .51 | 1.39 | 2.53 |
| 1 tee | 1½" | 2.68 | .42 | 1.14 | |
| 85 | | | | | |
| | 1½" | 11.58 | 1.81 | 4.92 | 7.97 |
| 1 45° Ell | 1½" | 2.15 | .34 | .92 | |
| 1 90° Ell | 1½" | 4.03 | .63 | 1.71 | |
| 1 tee | 1½" | 2.68 | .42 | 1.14 | |
| 84 | | | | | |
| | 1½" | 6.5 | 1.02 | 2.77 | 5.62 |
| 1 90° Ell | 1½" | 4.03 | .63 | 1.71 | |
| 1 tee | 1½" | 2.68 | .42 | 1.14 | |
| 83 | | | | | |
| | 1½" | 10.10 | 1.58 | 4.29 | 7.14 |
| 1 90° Ell | 1½" | 4.03 | .63 | 1.71 | |
| 1 tee | 1½" | 2.68 | .42 | 1.14 | |
| 82 | | | | | |
| | 1½" | 2.0 | .31 | .84 | |
| L' | | | | | |
| L | | | | | |
| | 1½" | 1.0 | .16 | .43 | .65 |
| | 2½" | 1.0 | .09 | .04 | |
| 1 tee | 2½" | 4.12 | .36 | .18 | |
| k | | | | | |

| SPKR or Junction | Size | Eq ft | k | K corrected to 2" | |
|---|---|---|---|---|---|
| H | | | | | |
| | 3" | 1.75 | .12 | .02 | .24 |
| 1 tee | 3" | 15.3 | 1.08 | .22 | |
| K | | | | | |
| | 3" | 8.00 | .56 | .12 | .41 |
| 1 tee | 3" | 5.11 | .36 | .07 | |
| 1 tee | 3" | 15.3 | 1.08 | .22 | |
| E | | | | | |
| 2, 1x4" Nipple | 1" | .67 | .18 | 2.71 | 13.11 |
| 1 90° Ell | 1" | 2.62 | .69 | 10.40 | |
| 2, 1x5" Nipple | | | | | |
| | 1" | .83 | .22 | 3.32 | 13.72 |
| 1 90° Ell | 1" | 2.62 | .69 | 10.40 | |
| G | | | | | |
| | 2" | 3.5 | .39 | .39 | 1.72 |
| 1 90° Ell | 2" | 5.17 | .57 | .57 | |
| 2 Tees | 2" | 6.90 | .76 | .76 | |
| F | | | | | |
| E | | | | | |
| | 6" | 7.08 | .21 | .003 | .02 |
| 1 90° Ell | 6" | 15.2 | .45 | .01 | |
| 1 Tee | 6" | 10.1 | .30 | .004 | |
| M | | | | | |
| | 6" | 64.88 | 1.93 | .03 | .05 |
| 3 90° Ell | 6" | 45.6 | 1.35 | .02 | |
| Flange | | | | | |