# VOLUME III

6. FPE 403 FPE LAB (UL) 7TH Sem. A

7. FPE 421 FIRE EXT. & DET. SYS. 8TH Sem. A

8. FPE 404 FPE LAB (UL) 8TH Sem A

9. FPE 415 INDUST. HAZARD CONTROL. 7TH Sem. A

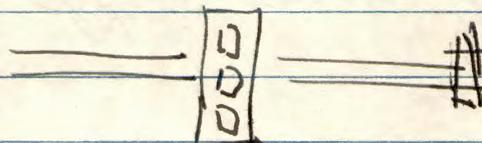
UL 403

303

| | |
|---|---|
| Oct 3 | Fire Pumps |
| Oct 17 | F.P. $H_2O$ Supplies |
| Oct 31 | Auto. Spkrs. |
| Nov 14 | Hydraulics of Spkr. Systems |
| Dec 5 | " " " " |
| Dec 19 | Extinguishers |

horiz. centrifugal pumps

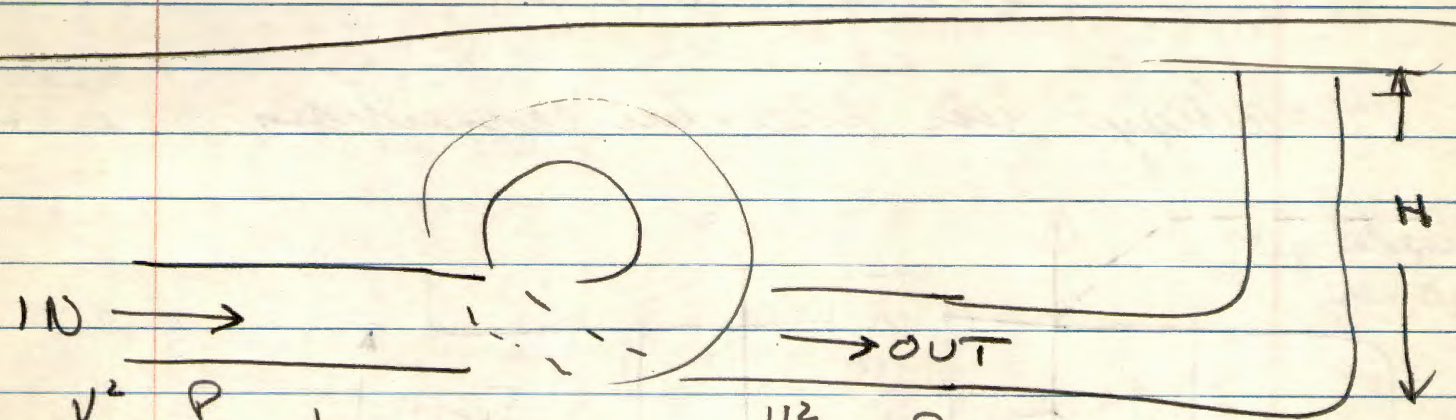
"Runner" = moving horiz part




inboard & outboard bearings?
Double suction balances
horiz forces on shaft.

except Multistage

Volute = internal passageways in case




$\frac{V^2}{2g} + \frac{P}{\omega} + h$ $\qquad$ $\frac{V_1^2}{2g} + \frac{P_1}{\omega} + h_1$

Pump imparts energy to water
Pump PUSHES ∴ must deliver $H_2O$
TO pump.
Pusher = 14.7 psi
Allow 15' max draft tho could possibly
draw 20-22 ft.

doesn't mean 15' CL pump to $H_2O$ level

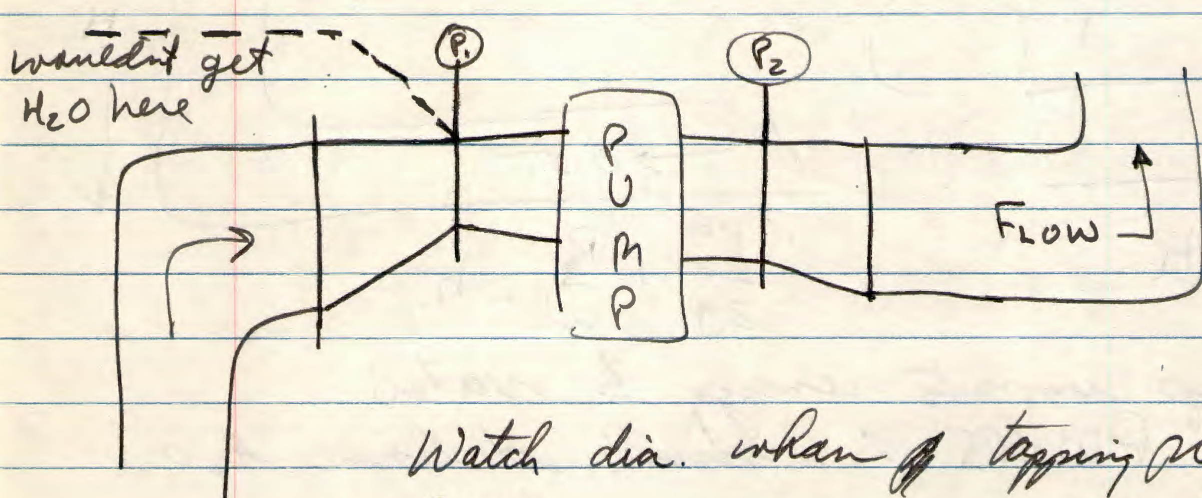
15' = distance between ℄ of pump & water
+ $h_f$ of hose or pipe to pump

15' **TOTAL** @ certain flow - usually
($h_f$ depends on Q)

check @ 150% rated flow

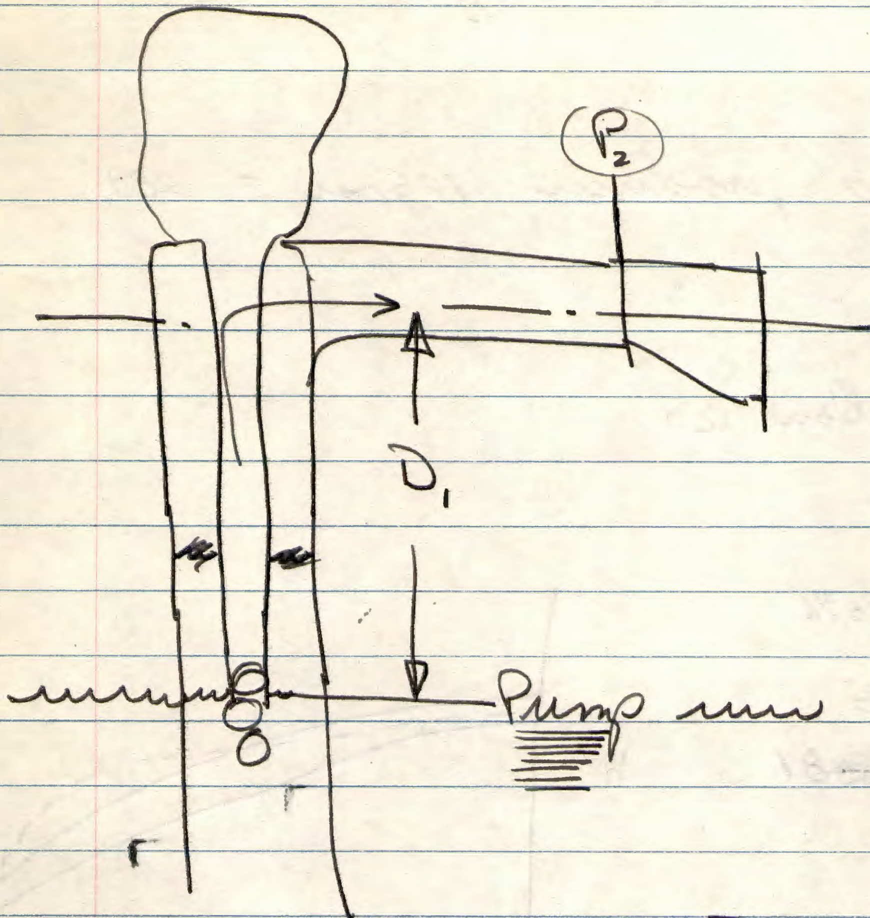
Req. every listed pump
to pump 150% rated cap @ 65%
rated pressure @ 15' lift.

always use eccentric connections




Watch dia. when ~~of~~ tapping pressure
gages.

NET HEAD = Bernoulli's ~~in~~ out eq. − Bernoulli's in eq.




| | FLOW | TDH ($Ft. H_2O$) Vertical OR RNHP (Rated net head pressure) Horiz. |
| --- | --- | --- |
| Pamphlet 20 req.: | 1. 0 flow | 140% rated pressure / 120% rated pressure |
| | 2. Rated flow | ≥ rated pressure |
| | 3. 150% Rated flow | 65% rated pressure |

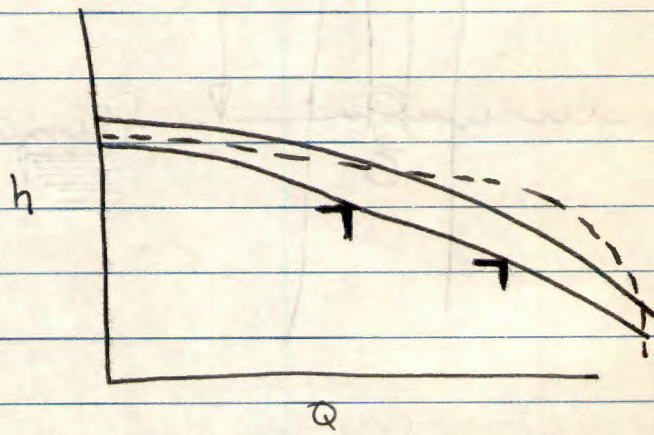
rated pressure is min pressure @ rated head.
curve always above rated pressure ⇒ if pump becomes less efficient will still meet req.

e.g. pump rated @ 1000 gpm 100 psi = 231′

Assume pump produces 125 psi = 289′

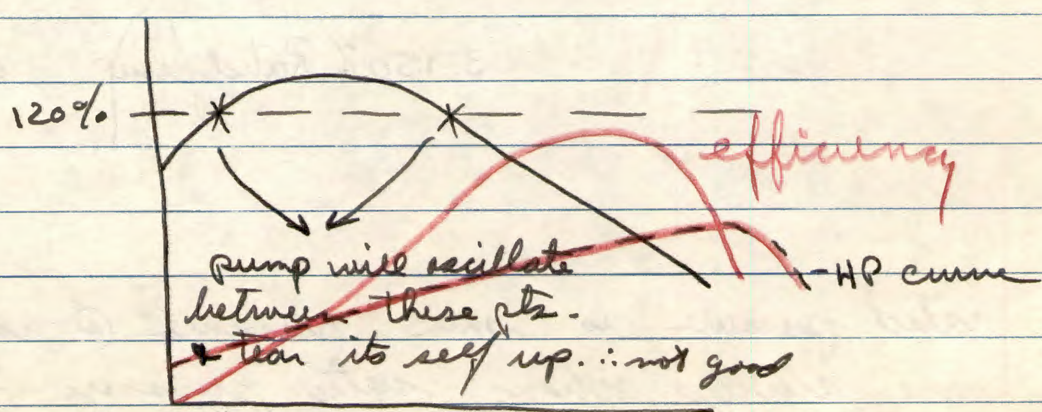
0 flow allow 120

| | 0 flow | 150% |
|---|---|---|
| psi | 120 | 65 |
| psi | 150 | 81 |




Want flat curve - - - - -

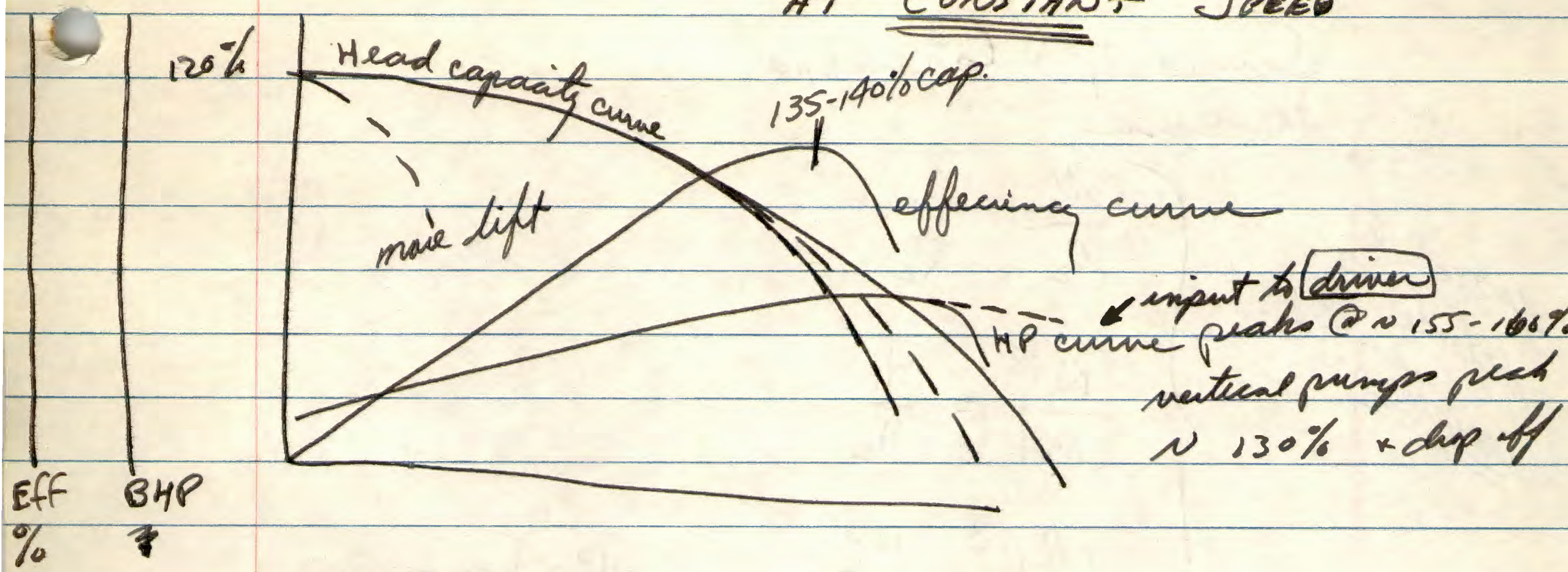
Unstable pump curve - won't list




REF → Centrifugal pumps + blowers - CHURCH

Typical Horiz. Centrifugal Pump

AT CONSTANT SPEED




Dotted H-C curves are "break off curves" representing changes in suction conditions.

HP will sometimes taper out also, but won't go up. ∴ can over load on driver because of too much pos. suction head.

Characteristic H-C curve is @ zero suction when you ad lift, it breaks off H-C curve to left + under characteristic curve.

## Similarity Relationships

N = Rpm

used to relate to constant speed

$$\frac{N_1}{N_2} = \frac{Q_1}{Q_2}$$

$$\left(\frac{N_1}{N_2}\right)^2 = \frac{H_1}{H_2}$$

$$\left(\frac{N_1}{N_2}\right)^3 = \frac{HP_1}{HP_2}$$ HP = horsepower

Most trouble occurs due to RPM & suction cond.

## Calculation of horsepower

$\frac{WORK}{TIME} = HP$ $\quad K \frac{Q \times height}{} = K \frac{gal - ft}{min}$

$\Rightarrow \frac{ft\ lb}{min}$

OUT PUT HP

$\frac{FT - GAL}{MIN} \approx \Rightarrow$ QP

put in sample calculations

convert to HP

INPUT HP

HP = Watts = $EI$ convert to hp.

On $3\phi$ HP($\sqrt{3}$) assume motor 90% eff.

$$HP = \frac{VA(eff)(Pf)\sqrt{3}}{746}$$ $Pf \cong 90\%$

must meas. amps in ea. phase
and take ave. meas volts
phase to phase.

D. A. LUCHT

($N$ = rpm.)

1. $\frac{N_1}{N_2} = \frac{Q_1}{Q_2}$ ($Q$ = Gpm)

$\left(\frac{N_1}{N_2}\right)^2 = \frac{H_1}{H_2}$ ($H$ = head ≡ ft of water)

$\left(\frac{N_1}{N_2}\right)^3 = \frac{HP_1}{HP_2}$ ($HP$ = horsepower) ✓

2. vertical turbin pumps. (centrifugal)
horizontal shaft (centrifugal) pumps. ✓

3. HEAD VS. FLOW CURVE.
EFFICIENCY VS. FLOW CURVE
INPUT ~~H~~ HORSEPOWER VS. FLOW CURVE. ✓

4. 1. must develope 150% of rated capacity at ≧ 65% of rated pressure

(-8) X 2. must not develope > 150% rated, ~~p~~ pressure at zero flow
120% max - vertical
140% max - horizontal

3. must develope rated flow at ≥ rated pressure.

5. NET HEAD MEASURE
(1) DISCHARGE PRESSURE
(2) " FLOW
(3) DISCHARGE ELEVATION
(4) ENTRANCE PRESSURE ±
(5) " FLOW
(6) " ELEVATION.

(-7)

$$\text{NET HEAD} = \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right) + \left(\frac{P_2}{w} - \frac{P_1}{w}\right) + (h_2 - h_1)$$

how? where V is converted to flow and other appropriate unit conversions calculated

D. LUCHT

90

Pipe & Fittings Listed under *Fire main equip.* Page 53 (1964) Fire Prot. List

Two Categories of Hyd.
1. Wet Barrel
2. Base Valve

Pipe
- CI
- Ductile Iron } check usually against ASA std.
- ⋮

*Under ground* pipe must be designed for the situation — Forces to which it will be subjected

(81) D. LUCHT

1\. The primary advantage to the Williams + Hazen formula is that through experiment it has been found to be the most accurate as compared to other empirical formulae. The disadvantage is that it requires a large amount of calculations (+ time) to get the answers, as compared to slide rule methods etc., (though most hydraulic slide rules are based on Williams + Hazen.) and multiple loop methods.

Factors to be known:

1. Williams - Hazen pipe ~~cof~~ coefficient.
2. diam. of pipe.
3. Flow OR friction loss, depending on which of the two is being solved for.

?

pipe org + velocity limited

-6

pipe length.

2\. $H_f = \frac{K\,Q^{1.85}}{C_1^{1.85}\,d^{4.87}}$   $d$ = diam.   $Q$ = flow

If the friction loss is found on basis of $C_1$ at a given flow, an "equivalent" value of flow may be found on the hydraulic ~~g~~ sliderule

And a new friction loss found in the same size for this equivalent flow.

how

(-10)

3. Would test:

1. available water supply from ~~___~~ each individual source with all others shut off.

How tests.

(-3)

2. available water supply from all supplies working together.

Minimum Data to be taken:

how many 1. Flows at various points of interest.

how many 2. residual pressures (to find friction losses)

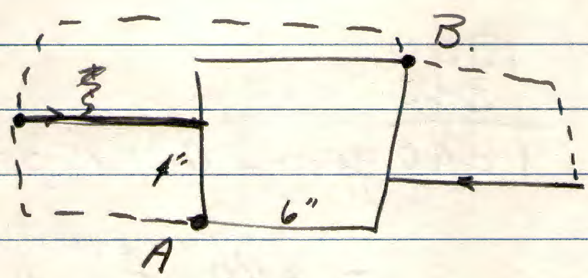
3. elevation difference

LUCHT

1. First of all ~~...~~, all pipes would be converted to equivalent lengths of 8" pipe. @C=100

2. all sources would be connected to another source and/or the point of withdrawal of water by imaginary pipes having zero flow.

e.g.

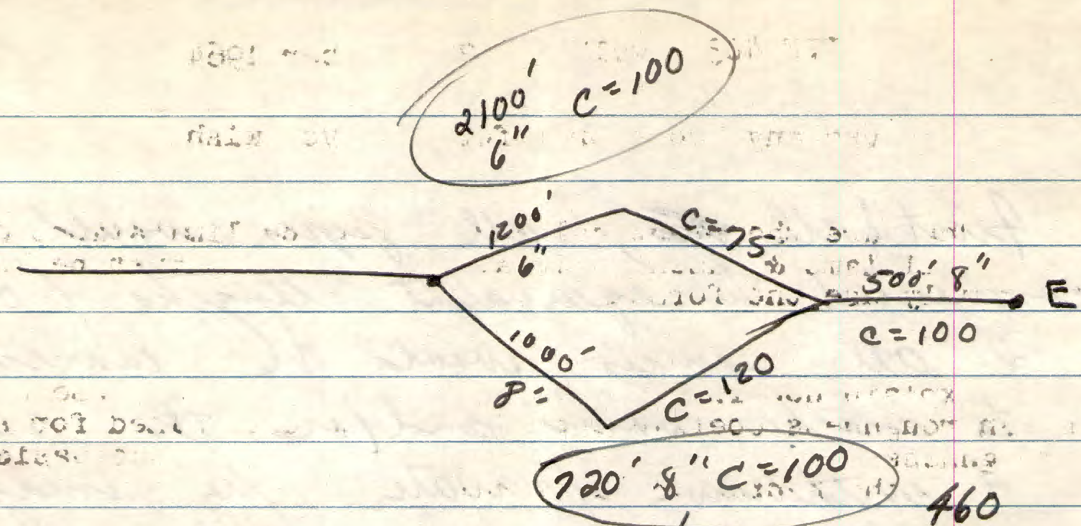



3. The ~~...~~ O'connor method would be used to find the flow in each pipe

4. the friction loss in each pipe would be calculated knowing the flow in each pipe, length, diameter, and C value.

5. these friction losses would be added together using any path ~~...~~ between the pts.

5.

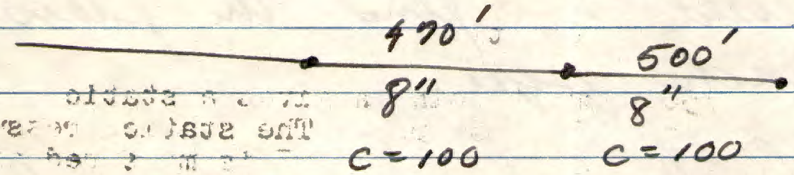


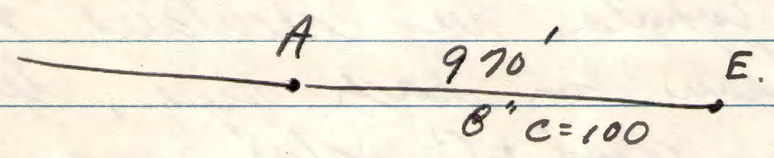

1200' 6" C=75 ~~500~~ $h_f$ = 15 psi ~~700~~ 460 gpm = ~~1220~~ 340 gpm
C=100 C=75

1000' 8" C=120 $h_f$ = 15 psi 1100 gpm = 1300 gpm
C=100 C=120

⇒ 1300
340
1640 gpm $h_f$ = 15 psi

= 470' 8" C=100




@ 1000 gpm $h_f$ = 12.8 psi

FPE 403 QUIZ No. 2- October 1964

Use any books or references you wish.

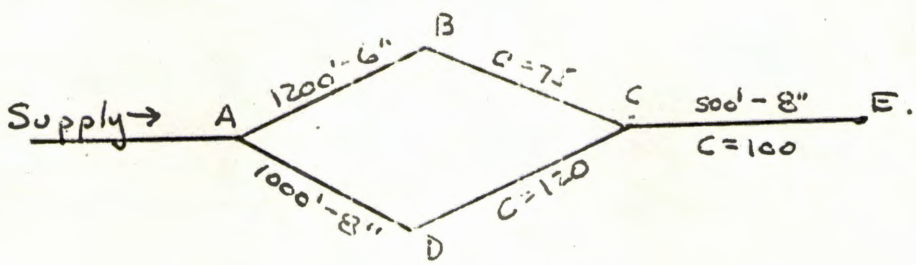
1) What are the practical advantages and limitations of use of the Williams & Hazen formula? What factors must be known to effectively use the formula?

2) Explain how friction loss values obtained by use of some given roughness coefficient ($C_1$) can be determined for some other roughness coefficient ($C_2$). You may refer to the basic formula or to the hydraulic slide rule.

3) What test (s) would you make to analyze an available water supply system for fire protection purposes? What minimum data must be taken?

4) Describe the method of calculating friction loss (pressure drop) between two points in a loop system, having two sources of supply and three different sizes (I.D.) of pipe.

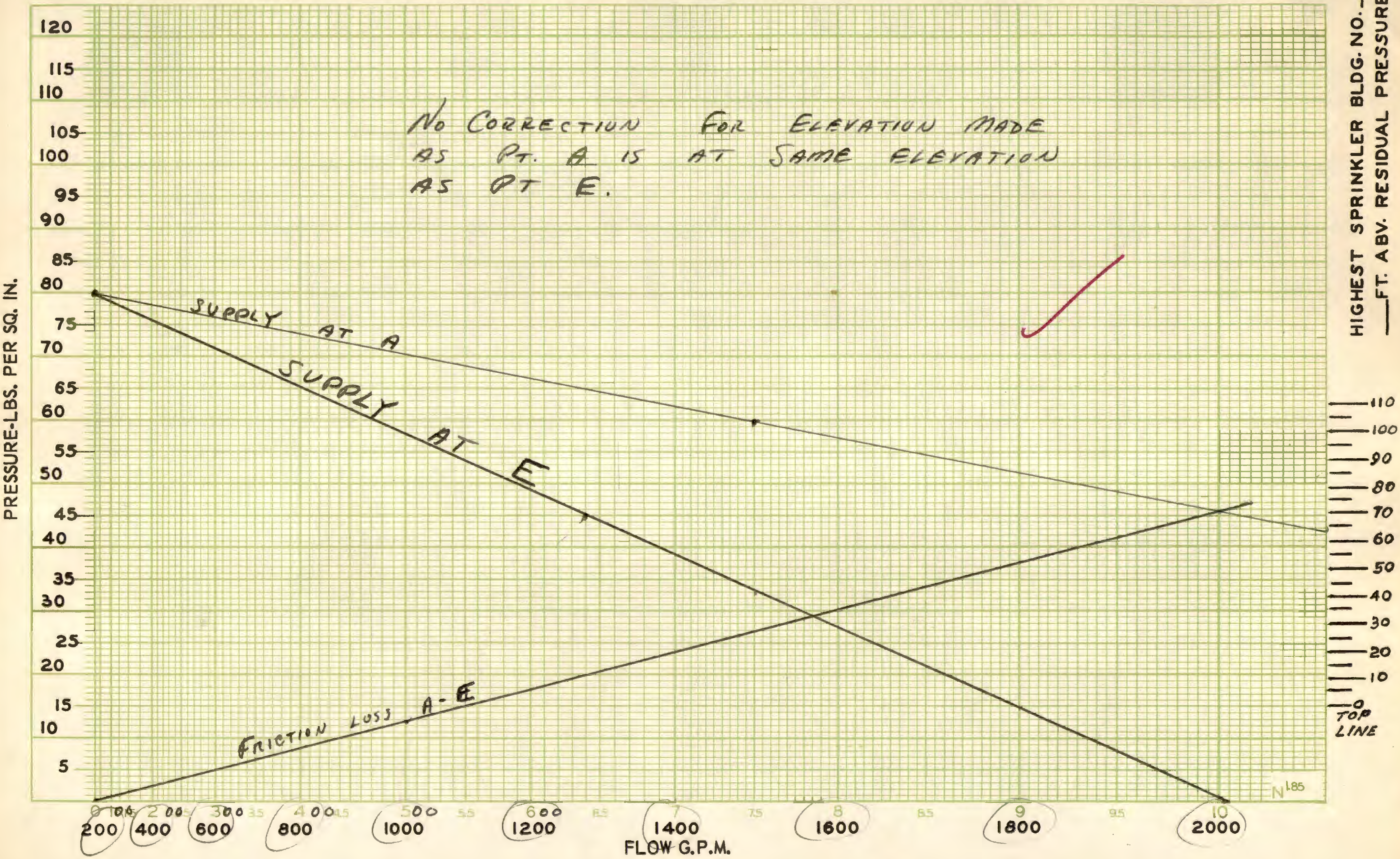
5)




Given the following information:

A flow test of 1500 gpm at point A gives a static pressure of 80 psi and a residual of 50 psi. The static pressure at point C is measured as 100 psi and at point E is measured as 80 psi. Calculate the supply available (supply curve) for a sprinkler system connection at point E.

FILE NO. ______ PROPERTY ______ LOCATION ______ DATE ______ BY LUCHT



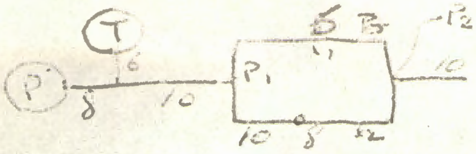

# HYDRAULICALLY DESIGNED SYSTEMS

HAZARD ______ LOCATION ______ TYPE SYSTEM ______ DESIGN DENSITY G.P.M./SQ.FT. ______

CALCULATED SYSTEM DEMAND G.P.M. ______ LBS. ______ ACTUAL SYSTEM DISCHARGE TEST G.P.M. ______ LBS. ______ DATE ______

D. LUCHT

Loop System Problem




$P_1 - P_2$ over $l_1$ = $P_1 - P_2$ over $l_2$ = $P_1 - P_2$ over equiv. pipe of Hyp. length $l_3$ & Dia. $D_3$

$$P_1 - P_2 = \Delta P \cong \frac{l_1 K_1 Q_1^{1.85}}{C_1 D_1^{4.87}} = \frac{l_2 K_2 Q_2^{1.85}}{C_2 D_2^{4.87}} = \frac{l_3 K_3 Q_3^{1.85}}{C_3 D_3^{4.87}}$$

$C_1, C_2, C_3$ are known

$K_1 = K_2 = K_3$

$$\therefore \quad \frac{l_1 Q_1^{1.85}}{D_1^{4.87}} = \frac{l_2 Q_2^{1.85}}{D_2^{4.87}} = \frac{l_3 Q_3^{1.85}}{D_3^{4.87}}$$

$$Q_3 = Q_1 + Q_2$$

$l_1, l_2$ are known

$D_1, D_2$ are known

Thus $Q_1, Q_2, Q_3$ and $D_3$ can be computed

For any assumed known Value of $Q_3$, it is possible to compute $Q_1$ $Q_2$, $D_3$, $l_3$

Once $l_3$, $D_3$ are known the loss / ft. can be computed for any given value of $Q_3$ and the avail flow & pressure loss can be calculated for any segment.

learn color codes

## Calibration Test

70 Water is to be discharged through the test foam-water sprinkler at selected pressures and the rate-of-flow for each pressure in gallons per minute is to be determined by observation of a flowmeter. **The water discharge rates (gallons per minute) shall be within the range of such rates as shown in Table I.**

## Distribution Test—Rotating Table

71 This is a test to determine the concentration of water over the discharge pattern of foam-water sprinklers of either the upright or pendent styles.

72 A sample foam-water sprinkler is to be installed in its normal position (either upright or pendent) 4 feet above a row of ten 1-foot square test pans mounted on a rotating table (1 revolution per minute) which has its pivot placed directly below the test sprinkler.

73 With the table and its pans rotating, water is to be discharged for 3 minutes from the test sprinkler at a rate of 15 gallons per minute. The water caught in each pan is to be measured and calculations made to determine the rate at which water reached the several areas in terms of gallons per minute per square foot for concentric circular areas at several horizontal distances from the discharging sprinkler.

74 **The results obtained in the rotating-table tests shall have values in terms of gallons per minute per square foot which will approximate or be in excess of the values indicated by the curve shown on Figure 5.**

### ROTATING-TABLE DISCHARGE VALUES

In gallons per minute per square foot at indicated horizontal distances from vertical line through centerline of foam-water sprinkler located 4 feet above test pans on rotating table.

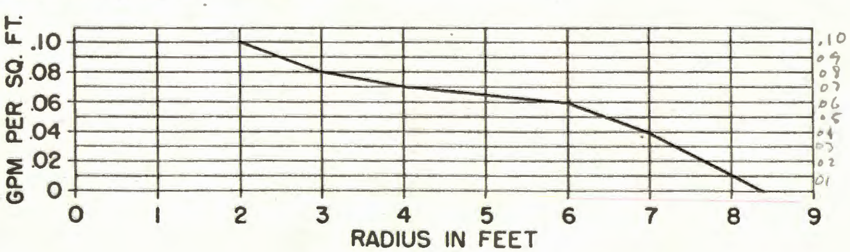



FIGURE 5

75 The curve shown on Figure 5 does not include value points at distances of 1 and 2 feet from the center. In this area, discharge values are purposely not specified and may be higher than or lower than the trend suggested by the curve.



## Water Distribution Tests—16-Pan Arrangement

76 To further evaluate the distribution pattern of the discharge from foam-water sprinklers, distribution tests are to be made employing four test sprinklers installed at the corners of a rectangular piping grid measuring 7½ feet by 12 feet (maximum spacing under Extra-Hazard Occupancy) (Section 7, NBFU No. 13) and 10 feet by 10 feet. The piping grid is to be located 7½ feet above a group of 16 pans (arranged to form a 4-foot square), representative of the areas of the top of the wood crib used in the fire tests of sprinklers described in a following section. Water is to be discharged from the test sprinklers for 10 minutes at an average flow rate of 15 gallons per minute per sprinkler. The water caught in the pans is to be measured and calculations made to determine the average quantity of water reaching the test pans in terms of gallons per minute per square foot.

77 **The average concentration of water reaching the 16 pans shall be not less than 0.166 gallons per minute per square foot for the 7½- by 12-foot spacing and not less than 0.150 gallons per minute for the 10- by 10-foot spacing. The average concentration of water reaching any individual pan shall be not less than 90 percent of the average concentration required for all 16 pans.**

## Foam Quality Tests

78 **Foam quality tests shall be made using a single test sample foam-water sprinkler installed in its normal position (upright or pendent) at an elevation of 3 feet above the floor.**

79 **Air-foam solution (premixed) employing either 3 percent or 6 percent air-foam liquid concentrates shall be supplied under inlet pressures of 20, 30, 50, and 75 pounds per square inch to the test sprinkler.**

80 **The air-foam discharging from the test sprinkler under the above conditions shall be subjected to the following examinations and tests, with the data being recorded for evaluation.**

**A. Visual evaluation of the quality of the foam based on its blanket-forming characteristics.**

**B. Analyses of samples of the foam to develop values of foam "expansion" and "25 percent time." Definitions of these terms and description of the test methods to be followed in making the analyses are given in Section IV of this Standard.**

1. "Expansion" values of foams produced by foam-water sprinklers have ranged from 4 to 10. "25 percent time" values have ranged from 15 seconds to 1 minute.
2. These "value" ranges were developed when producing foam, under "no-fire" conditions, from foam-water sprinklers at inlet water pressures ranging from 20 to 100 pounds per square inch; when using water taken from two sources which ranged in temperature from 40 to 90 F; and with test foam-water sprinklers located from 3 to 20 feet above the floor.

## Fire Tests — Class A

### WATER DISCHARGE

81 Two Class A fire tests of foam-water sprinklers are to be made, employing water discharging from the sprinklers as the extinguishing agent at the rate of 15 gallons per minute per sprinkler in one test and at the rate of 25 gallons per minute in the second test.

82 The standard Class A fires normally used in fire tests of automatic sprinklers are to be employed in similar tests of foam-water sprinklers.

83 The test setup is to consist of four foam-water sprinklers installed at the corners of a 10- by 10-foot piping grid on the ceiling near the center of a fire-test room, 60 by 60 feet in dimensions and 16 feet high from floor to ceiling. The piping grid is to be connected to the test-station water-supply piping system and also is to be pipe-connected to a source of air-foam liquid concentrate.

84 The standard Class A fires employed in these tests combine the use of a gasoline torch with a crib of wood weighing approximately 350 pounds.

85 The gasoline torch, supplied with gasoline at the rate of 1 gallon per minute, is to be directed vertically upward from under the center of the wood crib which is 4 feet square and 21½ inches high, with its top area 7½ feet above the floor and 7½ feet below the deflectors of the test sprinklers.

86 The test routine to be followed starts with the ignition of the gasoline torch (1 gallon per minute of gasoline) which is to be allowed to burn for 1 minute before manual establishment of flow of water from the test sprinklers at the predetermined rate of 15 gallons per minute from each sprinkler in one test and at 25 gallons per minute in a second test.

87 The fire test is to be continued for 30 minutes.

88 At the end of the 30-minute period, the gasoline flow to the torch is to be stopped and water flow to the sprinklers shut off.

89 The wood test crib, which was weighed prior to the tests, is to be again weighed 24 hours after test completion to determine the weight loss during the fire exposure.

90 The temperatures existing at the ceiling level are to be recorded on a chart-type recorder to which a thermocouple centrally located above the test crib is to be connected. The recorded temperatures are to be reviewed for determination of maximum temperatures and the time of occurrence after start of the fire exposure and before extinguishing agent discharge; and for the controlled ceiling temperatures during extinguishing-agent discharge.

91 Performance of foam-water sprinklers in Class A fire tests discharging water is to be considered acceptable when the wooden crib weight loss does not exceed 20 percent and the ceiling temperature following application of water recedes to a value not exceeding 600 °F throughout the remainder of the 30-minute test period.



## Fire Tests — Class B

### AIR-FO

92 **Class B fire tests of foam-**
**(1) fuel consisting of a 2-inch d**
**in a 10- by 10-foot by 16-inch d**
**centrates of either 3 percent or**
**nition of both is required; and**
**number) installed at the corners**
**a 100-square foot protection area**

93 The test piping grid shoul
sprinklers 20 feet above the floo

94 The test setup locates the f
sprinklers.

95 The Class B fire-test routine

A. A 15-second preburn o

B. Employment of test air
quirements of paragrap
solutions. **If only one ty**
**is to be considered, onl**
**If additional liquid co**
**tional fire test for each**

C. A discharge of air foam
klers at a foam-solution
60 gallons per minute fo

**D. Continuation of the air**
**foam solution per minu**
**during which time peri**
**the following:**

**1. Ability of the disc**
**burning-fuel surface**

**2. Cohesiveness of the**

**3. Time elapsing to pro**

**4. Time elapsing to ex**
**licks of flame in the**

**5. Time elapsing to co**

**6. At completion of t**
**measurement of the**

**7. The air-foam disch**
**water discharged fro**
**the rate of 15 gallon**
**continue for 20 min**

**Subparagraphs 6 and 7 of p**

~~47~~ 68

D. LUCHT

-23

X 1. 35 feet

-10

✓ 2. $2 NaHCO_3 + H_2SO_4 \rightarrow 2CO_2 + 2H_2O + Na_2SO_4$

✓ 3. $.4(30) = 12$ B

4. $6 NaHCO_3 + Al_2(SO_4)_3 \cdot 18H_2O \rightarrow 6CO_2 + 2Al(OH)_3 + 3 Na_2SO_4 + 18H_2O$ ✓

-10 5. No, the extinguisher should not freeze up.

6. Stored pressure. ✓ X
Pump tank.
-2 Cartridge Operated ✓ X
Soda-acid.
Foam
ABC multipurpose dry chemical

~~-10~~ -10 7. yes, ~~bulk~~ fell > $4\frac{1}{2}$"
over 80% disch. on tilt test

Jim Kern

8. Potassium Bicarbonate
Sodium Bicarbonate
Mono-ammonium Phosphate
Bi Ammonium Phosphate ✓

9. Class A test
( Crib, excelsior, wood wall )
Class B test
Flammable liquid test
Class C
Electrical Conducting properties of the unit.
✓

(-3) 10. a. one unit for each 2500# floor area, with ~~min~~ maximum travel distance of 100'
b. one unit for each 1250# floor area, with maximum travel distance 50'
c. } one unit / 625# floor area in vacinity
d. } not > 50' travel distance.
-1

-2

1. What are the range requirements for soda-acid and foam extinguishers?

2. Give the reaction for a soda-acid extinguisher.

3. What fire extinguishing classification would be assigned a stearate treated soldium bicarbonate type dry chemical extinguisher that successfully extinguished three 30 sq. ft. test fires in 8.2, 7.6, and 7.9 seconds respectively?

4. Give the reaction for a foam extinguisher.

5. A 10 lb. $CO_2$ extinguisher discharges 7 lb. 9 oz. of agent to gas point when conditioned at 70 F. When conditioned at -40 F, the extinguisher discharges 7 lb. 10 oz. when the discharge is stopped by a freeze-up. Is this acceptable? Why or why not?

6. Name 6 types of extinguishers suitable for use on Class A fires.

7. A 5 lb. dry chemical extinguisher discharges 4 lb. 1 oz. in 7.6 seconds when operated at an angle of 45 degrees backward from vertical and conditioned at 70 F. The bulk of the discharge fell beyond 4-1/2 ft. from the nozzle with a maximum range of 11 ft.

Is this test result acceptable? Why or why not?

8. What are four types of dry chemical?

9. What types of tests are used to determine the fire extinguishing classification of a 10 lb. Multi-Purpose (ABC) type extinguisher?

10. What are the requirements for spacing of extinguishers in the following?

(a) Class A - Light Hazard Occupancies
(b) Class A - Ord Hazard Occupancies
(c) Class B - Spill Fire Conditions
(d) Class B - Deep Layer Fire Conditions

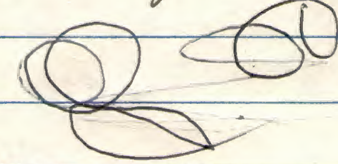
Crane Technical Bulletin #410
– hydraulic manual –

Abstract: Brief explanation of what one might expect to find in report

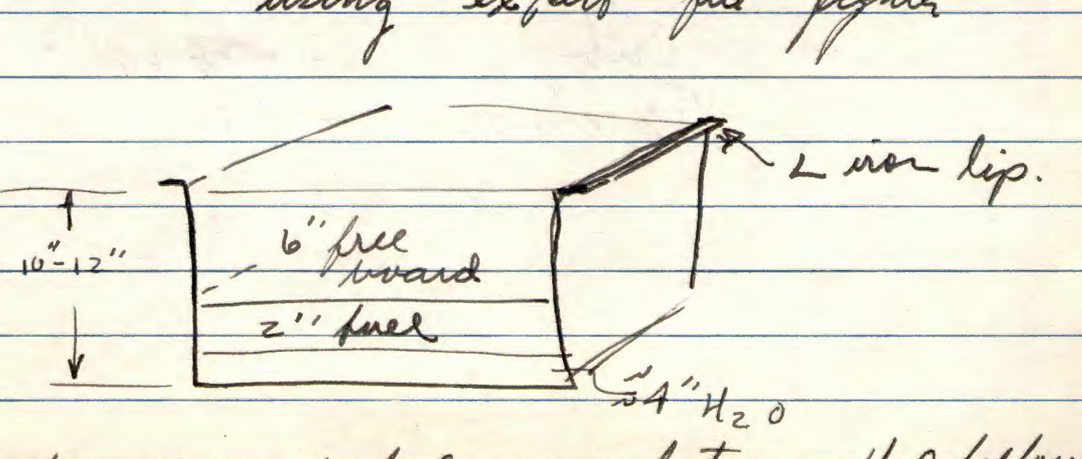
1. purpose of expt. (very general & brief)
2. what was done – " " "
3. What Results Indicate w.r.t. purpose

the last thing you write for the report.

Ratings
Classification of Extinguishers & fires
A, B, C, D



A – ord. Combustibles
B – flammable liq. gases & greases.
rate on relative extinguishing effectiveness using expert fire fighter




6" freeboard + 2" fuel mandatory – $H_2O$ follows
∴ cant use < 8" pan

amt of deep ~~[illegible]~~ layer fire wh. can consistently be ext. by expert fire fighter.

$\frac{F_T^2}{2\frac{1}{2}}$ = extinguishing rating

safety factor, since operator is an expert, (40%)

fuel is a std. fuel, but isnt gasoline

it is "Standard Stove & lighting fuel"

Class C

Based on ability of an extinguisher to be safe for use on electrical fire.

eg. cant use metal horn

rating is numberal
Classif. is type

Class A:

relative ext. potential on 3 types of fires.

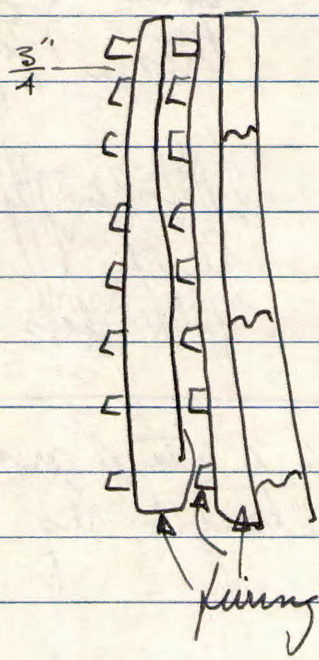
| | INDOOR | OUTDOOR |
|---|---|---|
| Panel | 1-6 A | |
| Crib | 1- ~~[illegible]~~ 6A | 10, 20, 30, 40 |
| Excelsior | 1- 6A | |

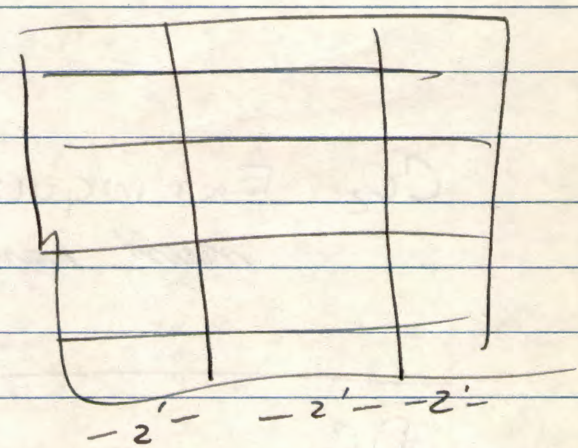
~~[illegible]~~

Panels

| | | |
|---|---|---|
| 1A | 8' x 8' | } 1" x 6" tongue & groove backing w. rows of firring strips |
| 2A | 10' x 10' | |
| 3A | 12' x 12' | |
| 4A | 14' x 14' | |
| 6A | 18' x 18' | |

~ 50# / unit of rating



Extinguishers.

8 Anti-freeze ext.

4 matls. used.

| Stored Pressure, | Cartridge Operated, | Mech. Pump. |
|---|---|---|
| copper<br>brass<br>bronze } 350<br>500psi<br>factory test pressure<br>~~Stainless Steel~~<br>~~Cu Ni~~<br>~~fibre glass.~~ | Stainless Stl. 500psi<br>CuNi 350<br>fibreglass<br>225psi<br>factory test pressure | Steel |
| 6 x Stored pressure strength req. | 5 X normal op. pressure strength req. | |

$CO_2$ EXTINGUISHERS.

must have safety relief 2650 - 3000psi

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D.C.

Cart. op.
Stored Pressure
Disposable }

$NaHCO_3$ — regular
— foam compatible

$KHCO_3$ ⊂

$(NH_3)_2PO_4$ ⊂ Same

$NH_3PO_4$ ⊂

∴ 8 Dry Chemical

S/A

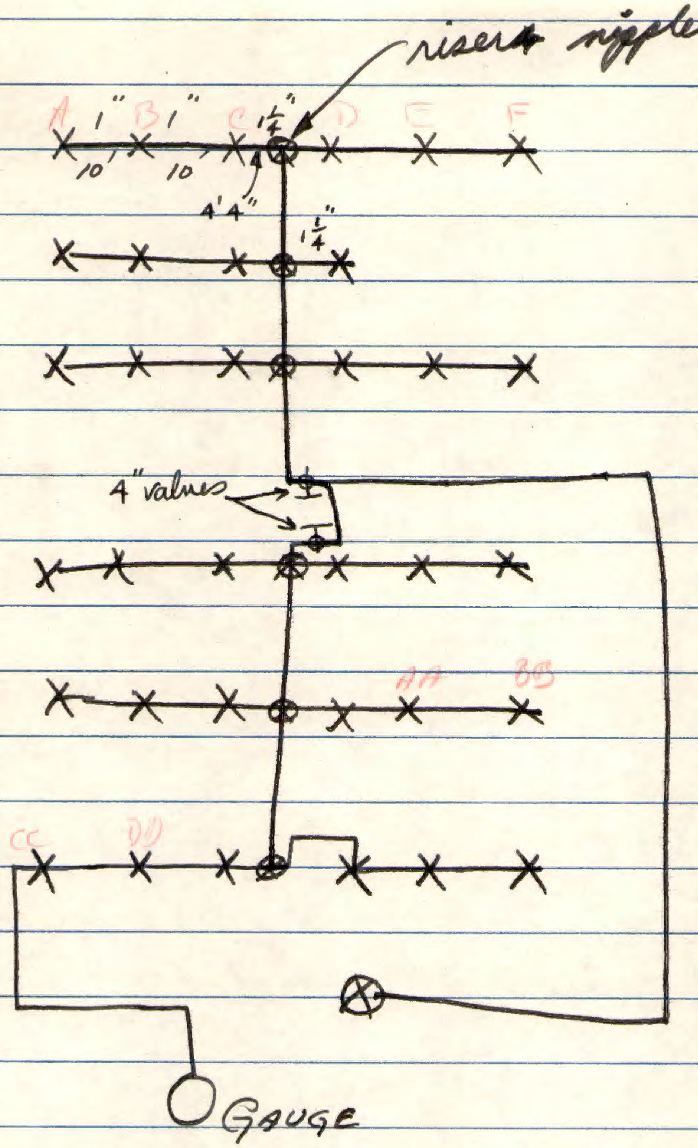
$2\,NaHCO_3 + H_2SO_4 = Na_2SO_4 + 2H_2O + 2CO_2$

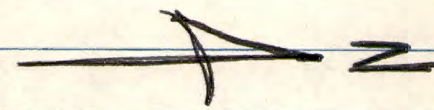
Foam

$6\,NaHCO_3 + Al_2(SO_4)_3 \cdot 18H_2O$

$\longrightarrow 6CO_2 + 3\,Na_2SO_4 + \underset{18}{\wedge}H_2O + 2\,Al(OH)_3$

FPE 403 12-5-64




Pipe put in
in 1955
schedule 40
Black Steel Pipe