Evaporative Cooler Pad Cabinet Design

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The evaporative cooler pad cabinet makes possible a variety of cooling configurations tailored to fit most agricultural production systems. Propeller fans provide the other half of the cooling arrangement. Innovations in the greenhouse, poultry and dairy industries have contributed to the development of the improved evap-pad cabinet design illustrated on Plan A-186 (pages 8-9, centerfold).

The improved pad cabinet consists of a single or an odd number of horizontal pads. Water required to wet all pads is sprayed on the top pad only, and drips down through the rest. The latest model features sloping pads which greatly improve the maintenance access to the pads and the water-distribution system.

Horizontal Pad

Horizontal pad orientation is an important improvement over the vertical pad system for both positive and negative pressure applications. Field observations indicate the following advantages:

1. Dust accumulation in the pad is greatly reduced; hence, air flow resistance is more constant, pad cleaning time is eliminated and pad life substantially prolonged.
2. Pad sag and air leakage around the frame is eliminated.
3. Pad cost is reduced because bulk excelsior can be used instead of hand or machine-packed pads.
4. Easy access simplifies pad replacement and maintenance.
5. Pad area is not limited to available vertical wall space.
6. Light control and wall closing systems are simplified.
7. Multi-level pad cabinet arrangements permit design of multi-stage cooling and winter ventilation control.

Disadvantages of the horizontal orientation reported are:

1. Low-volume nozzles require more water filtering than drip pipes.
2. Multi-level systems may require additional baffling to prevent the pickup of free water in the air passing up through alternate pads.

Air Flow Exchange Design

Usual design practice requires an evaluation of building heat gain, internal loads, the seasonal wet bulb temperature pattern, etc. However, simple air exchange rules are adequate for many agricultural applications. Start by calculating the building volume. One air change per minute is usually sufficient to maintain a favorable environment. A static design pressure loss of 0.1 inch water gauge (0.1" W. G.) is satisfactory for negative pressure (pad at one end and fans at the other) applications of the pad-cabinet system. The static pressure specification must be increased for plenum and duct distribution applications.

Fan Selection

Propeller fans 30 to 48 inches in diameter provide a good compromise between flexibility and efficiency. Slow, belt-driven propeller fans are most efficient for low static pressure applications. However, direct drive units are often used to eliminate belt maintenance. Fan capacity is usually divided into four or more equal increments to provide several levels of ventilation. Estimate fan power requirements at one horsepower per 13,000 (± 2000) CFM (cubic feet per minute).

Insulation

Internal heat load depends upon the building use. Solar or external heat gain can be retarded by proper insulation. No special insulation is recommended for the side walls, but a minimum roof insulation resistance value of eight (R = 8) for livestock housing is recommended.

Pad Cabinet Design

Optimum air velocity at the pad face (pad face velocity) is 200 (±50) feet per minute (FPM). Total pad area is calculated by dividing the required air exchange volume in CFM by the pad face velocity (200 FPM). This design rule is shown on plan A-186 as 5 ft.^{2}/1000 CFM. The length of the evap-pad is normally dictated by the width or length of the building to be cooled. The total pad width is then divided into one, three or five horizontal pad levels to form a cabinet. The number of pad levels depends upon the required pad area, convenience and serviceability of the individual pad, number and proportion of the air openings required, and the wall heighth available. To simplify maintenance, limit the pad cabinet width of multi-level systems to about 3 feet. Air inlet and outlet areas between the pad levels are designed to provide a maximum cross-sectional air velocity of 600 FPM.

Aspenwood excelsior is the most efficient evaporative pad medium. Apply 0.75 to 1.0 lbs. of bulk excelsior (available in 50 to 100 lb. bales) per square foot of horizontal pad surface. This amount of pad material is nearly three times as much as is used in the ordinary package evap-cooler. Recent research by Benham and Wiersma** demonstrates that saturation efficiencies are substantially improved by increasing pad thickness, particularly in horizontal applications .

Water System

In the multi-level pad cabinet illustrated, water in an amount sufficient to keep all pads wet is sprayed on the top pad only. Excess flow drips down to the pads below. In a recent study,** pad water recycled at 7 to 10 times the evaporation rate appears to give the best results. Calculate the pad water flow requirement at 0.4 (±.1) GPM per 1000 CFM of air flow.

Uniform water distribution depends upon the nozzle pattern. Lawn sprinkler heads, solid cone, and mist nozzles have been used successfully. Smaller nozzles provide more uniform water distribution and larger volume

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Table 1. Friction Head Loss in Feet per 100′ Plastic Pipe[1]

Pipe Dia. Inches	*Friction Head Factor for Flow Rate in GPM* 5	10	15	20	30	40	50	60
1.0	**1.8**	**6.3**	**14.**	*	*	*	*	*
1.25		**1.7**	**3.5**	**6.0**	**13.**	*	*	*
1.50				**2.8**	**6.0**	**10.2**	**15.**	*
2.0						**3.0**	**4.6**	**6.5**

* *Excessive Velocity*

nozzles (0.5 GPM or more) plug less frequently.

Pump horsepower can be estimated by: $$\text{h.p.} = \frac{Qh}{2000}$$

where: Q = pad water flow, GPM
h = pump head, feet = lift ′ + nozzle pressure ′ + friction loss ′ and 2000 assumes a pump efficiency of 50%

Lift head is the elevation difference from the water supply surface to the nozzles. Multiply the nozzle pressure in psi by 2.31 to obtain head in feet. Friction loss in the pipe distribution system can be estimated from Tables 1 and ‘2.

The estimated pump head of 59′ from the example on plan A-186 was calculated as follows:

1. Lift head estimate = 8′
2. Nozzle pressure head = 15 psi × 2.31′/psi = 35′
3. Friction head
   a. From Table 1, a 30 GPM pad water flow will require a minimum pipe diameter of 1.25″. The friction head factor is 13′/100′ of plastic pipe.
   b. From Table 2, the fitting head losses in equivalent length of 1.25″ diameter pipe are 3′ + 35′ + 7′ + 3′ + 3′ + 12′ = 63′ respectively for coupling, globe value, el, coupling, union and tee.
   c. Add the 63′ of fitting pipe equivalent to the estimated 61′ of distribution pipe for a total pipe length equivalent of 124′.
   d. Friction head = 13′/100′ × 124′ = 16′.

When a suction lift condition exists, a self-priming centrifugal pump is recommended.

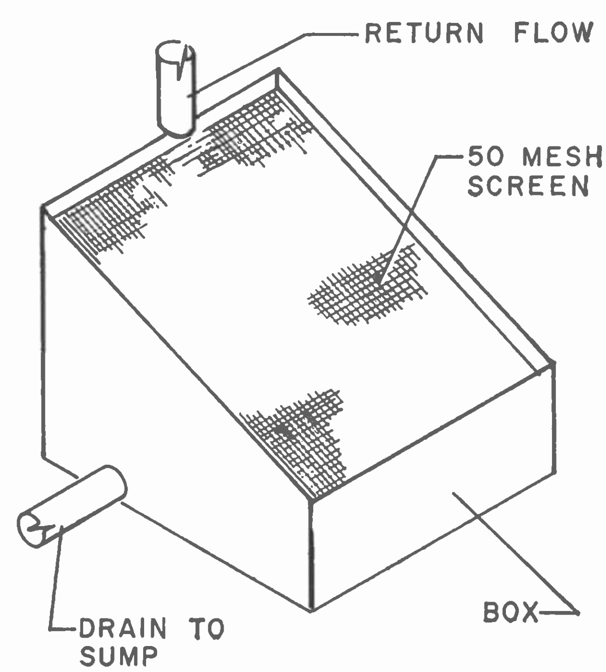
The water flow rate should be adjustable. This can be accomplished by installing a hose-bibb by-pass and globe valve in series on the pump discharge line. Adding a hose-bibb at the end of the spray line improves nozzle cleaning and line flushing procedures.

Size the recirculation reservoir to hold at least 0.3 gallons of water per square foot of pad area. A coating of bituminous asphalt applied to the inside of the reservoir will help prevent leaks and corrosion. A portion of the circulating water should be bled off to remove salts. A typical domestic water supply in Arizona contains about 800 ppm of dissolved salts. As water evaporates, the salt concentration is increased and must be controlled by a bleed-off system. Salt concentration builds up to a precipitating level within a few hours so periodic draining of the system is impractical. A continuous bleed-off rate of 0.05 GPM per 1000 CFM will limit the salts to about two concentrations. This water can be used to irrigate landscaping. Salt-tolerant landscape materials will tolerate water with 2000 to 3000 ppm with careful irrigation management. A bleed-off yield from a 100,000 CFM cooler is about 5 GPM; almost adequate to irrigate one acre of bermuda grass.

Filter

In the horizontal pad system, dust, salt and some fibers are constantly washed out of the pads. The dust will settle out in the sump, and must be washed out periodically. A series of screens and filters may be used to prevent nozzle plugging. A simple 50-mesh inclined screen mounted below the return flow seems to be the most effective (see Fig. 2). Supplemental and/or alternative filtering systems that have been used are three or four thicknesses of plastic screen banded to the pump inlet, a 50-mesh in-line sediment filter mounted on the recirculating pump discharge, and swimming pool filters. Every effort should be made to keep insects out of the system.

Fig. 2. Inclined Screen Filter



Maintaining System Efficiency

Cooling efficiency depends upon the uniform distribution of air and exposure to uniform pad moisture. Large holes in the pad must be corrected so all incoming air will pass through a uniform wet pad medium. The building must be reasonably air tight to insure control of the conditioned air.

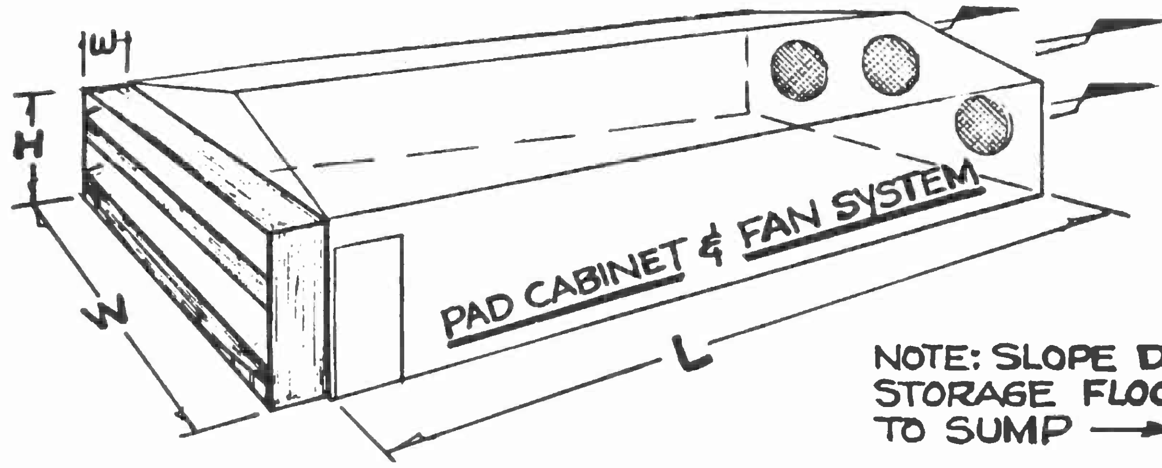
Cleaning the water distribution nozzles and replacing the sump water should be done at least weekly. Daily inspection to assure efficient operation should be a routine procedure.

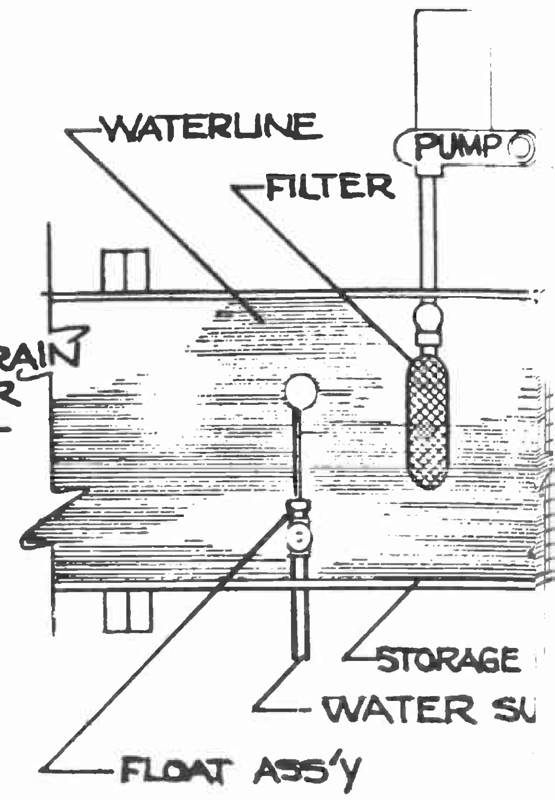
Pads are usually replaced annually. Replacement just prior to the most demanding season of the year provides maximum cooling when it is most needed.

Table 2. Friction Head Loss in Equivalent Feet of Pipe Fitting.[2]

Fitting Type	*Equivalent Length in Feet — Nominal Size* 1″	1.25″	1.5″	2.0″
Coupling or Union	**3**	**3**	**3**	**3**
90° EL	**6**	**7**	**8**	**9**
Tee	**9**	**12**	**13**	**17**
Check Valve	**7**	**9**	**11**	**13**
Globe Valve	**25**	**35**	**45**	**55**

[1, 2] *Data after MWPS-14*





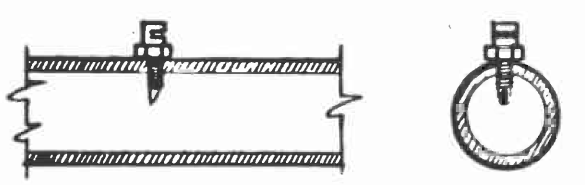
PAD CABINET DESIGN – EXAMPLE

ASSUME:

1.) ONE AIR CHANGE PER MINUTE
2.) i.e. BLDG W/ L=200', W=50', H = 7.5'

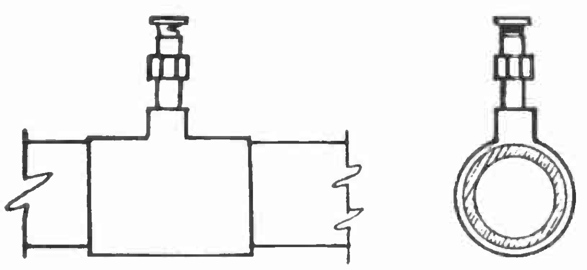
CALCULATE:

1. FAN CAPACITY = 200 x 50 x 7.5 = 75,000 CFM
2. PAD AREA = 75,000 CFM x 5 FT^2/1000 CFM = 375 FT^2
   3 LEVELS @ 2.5' WIDE & 50' LONG = 375 FT^2 [OK]
3. INLET VELOCITY = 75,000 CFM ÷ 3'x50' = 500 FPM < 600 [OK]
4. PAD WATER FLOW = 75,000 CFM x .4 GPM/1000 CFM = 30 GPM
5. NOZZLE PATTERN = 30 GPM ÷ 50' = .6 GPM/FT
   SELECT: HALF CIRCLE FLAT SPRAY NOZZLES AT .3 ± .03 GPM @ 15 PSI; 6" O.C.



A) USE 5/32" DRILL & 10-32 MACHINE TAP INTO PVC
B) HAND TIGHTEN 3 OR 4 TURNS.

ALTERNATE: ADJUSTABLE FULL OR HALF CIRCLE SHRUB HEADS AT .6 ± .1 GPM @ 15 PSI, 1' O.C.



A) SPACE NOZZLES TO AT LEAST A DOUBLE OVER-LAP PATTERN
B) DIRECT SPRAY DOWNLINE.

6. PUMP H.P. = Qh/2000 = 30 GPM x 59'/2000 = .89
7. BLEED-OFF = 75,000 CFM x .05 GPM/1000 CFM = 4 GPM

CABINET LINING SUGGESTIONS

1.) USE 3/16 OR 1/4" CEMENT ASBESTOS BD. FOR CABINET, SPLASH & DRAIN STORAGE LININGS.
2) WATERPROOF W/ 2" NYLON MESH TAPE TO CORNERS & SEAMS. COAT W/ EMULSIFIED ASPHALT. ALTERNATE: USE FIBERGLASS TAPE. COAT W/ 1#/5 FT^2 POLYETHLENE RESIN. VENTILATE OR USE GAS MASK. CLEAN BRUSH W/ ACETATE.

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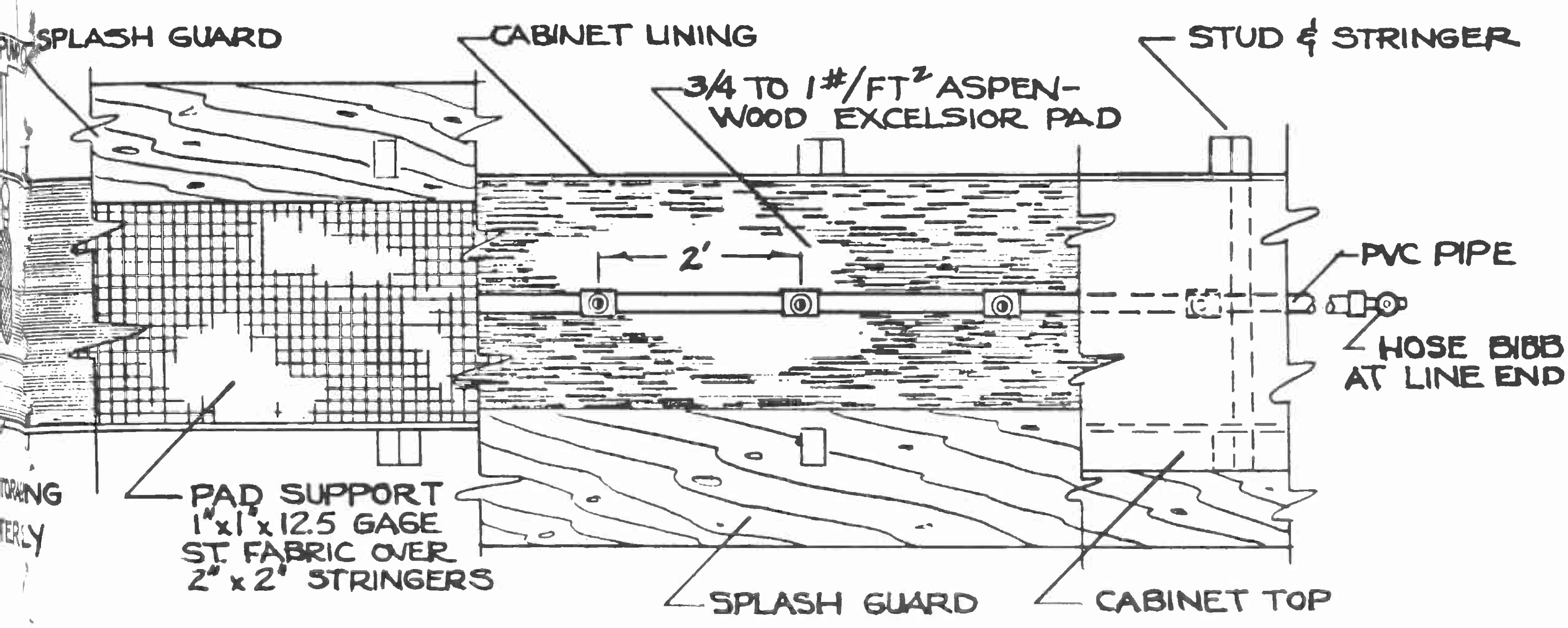
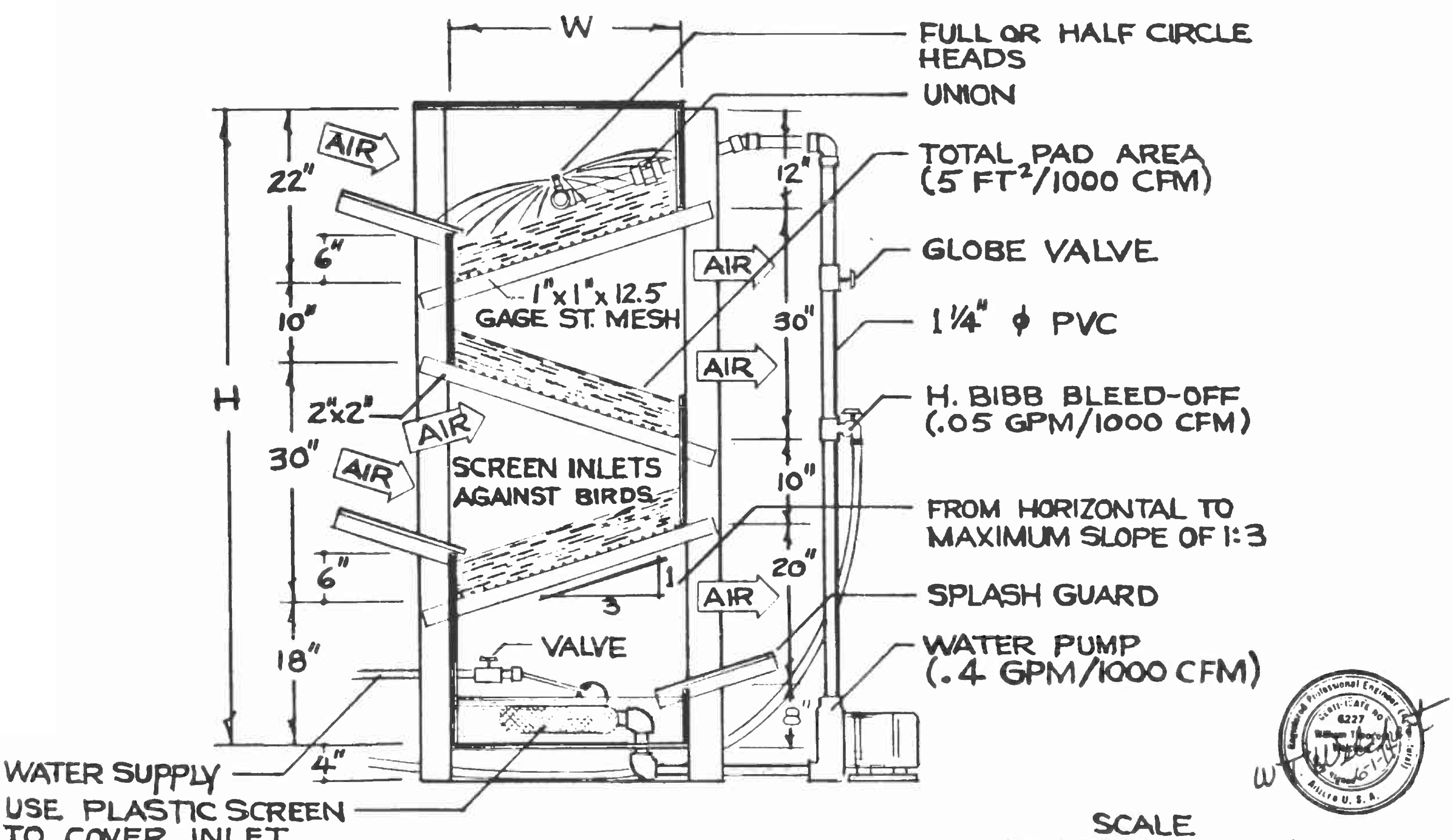
EVAP. COOLIN



W—(AT VARIOUS LEVELS LEFT TO RIGHT: WATERLINE, FIRST PAD SUPPORT, TOP PAD, CABINET TOP, & END WATER DISTRIBUTION LINE.)



TYPICAL SECTION

SCALE
0 4" 12" 2' 3'

PAD CABINET

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SHEET 1 OF 1