Carrier Air Conditioning Company of America

39 Cortlandt St.
New York N.Y.

Catalog 13

Carrier Air Washers *and* Humidifiers

Applied to Public Office and Industrial Buildings

With Notes on Humidity

Patented in the United States
Canada and Foreign Countries

Carrier Air Conditioning Company of America

39 Cortlandt Street, New York, N. Y.

Partial Interior of Shop Showing Air Washers Under Construction

In General

This Catalog describes fully and treats of the necessity and application *only* of the three types of machines which are used for air washing, cooling, and controlling of humidity in public or semi-public buildings, offices, theatres, hospitals, banks, hotels, court-houses, etc.

Special Catalogs: At this time we have developed and are building four other standard types of humidifiers and dehumidifiers for various classes of industrial work, which are not described herein.

We issue special catalogs describing apparatus which has been designed for a special industry or application. If you have special problems, our engineers are at your service.

Research Laboratory: By way of introduction, let us state that in addition to the early experiments made when developing our apparatus, this Company maintains a corps of competent engineers continuously on research and experimental work. Every possible phase of air-conditioning that we have been able to conceive has been or is to be investigated. The tests of each condition extended over a considerable period of time, and from these tests we have accumulated the immense amount of data which has enabled us to determine all of the laws governing the washing, humidifying, dehumidifying, and the control of humidity by means of our apparatus. In addition we have been extensively investigating the effect of humidity and temperature upon various materials, among which may be mentioned: Paper, Silk, Wool, Cotton, Tobacco, Flour, Pottery and Powder.

Our Staff: Mr. W. H. Carrier, the inventor of our systems and apparatus, has received acknowledgment of his discoveries and contributions to science from scientists in this and other countries, and from foreign governments. In addition, we have in our employ a corps of engineers who are devoting their entire time to this one subject of air-conditioning, who are at the disposal of our customers.

Principles of Air Washer Design

There are three primary requirements in the design of an effective Air Washer and Humidifier:

1st. **The Spraying System:**

a. Must be uniformly distributed to treat all parts of the air currents alike.

b. It must finely atomize the water and thoroughly mix it with the air in order to wet and make heavy the smaller or minute particles of dust and dirt carried by the air. Large drops of spray or sheets of water will not wet these smaller particles.

c. The nozzles should discharge in the direction of the air flow so a minimum resistance is offered to the air current.

d. The spray nozzles should have large unobstructed orifices, so they will not clog.

e. Proper and adequate filtering arrangement must be provided to prevent dirt and other obstructions passing into the spray piping and nozzles. To prevent this trouble, the dirt must never be allowed to get into the spray system.

f. To use an inadequate water strainer and self-cleaning nozzles is not to be complimented any more than would be the use of a poorly designed steam supply to an engine with a dependence upon pop valves in the cylinders to remove water of condensation and prevent knocking out of a cylinder head.

Self-cleaning nozzles mean considerable operating mechanism to be kept in repair.

2nd. **Washing Surface:**

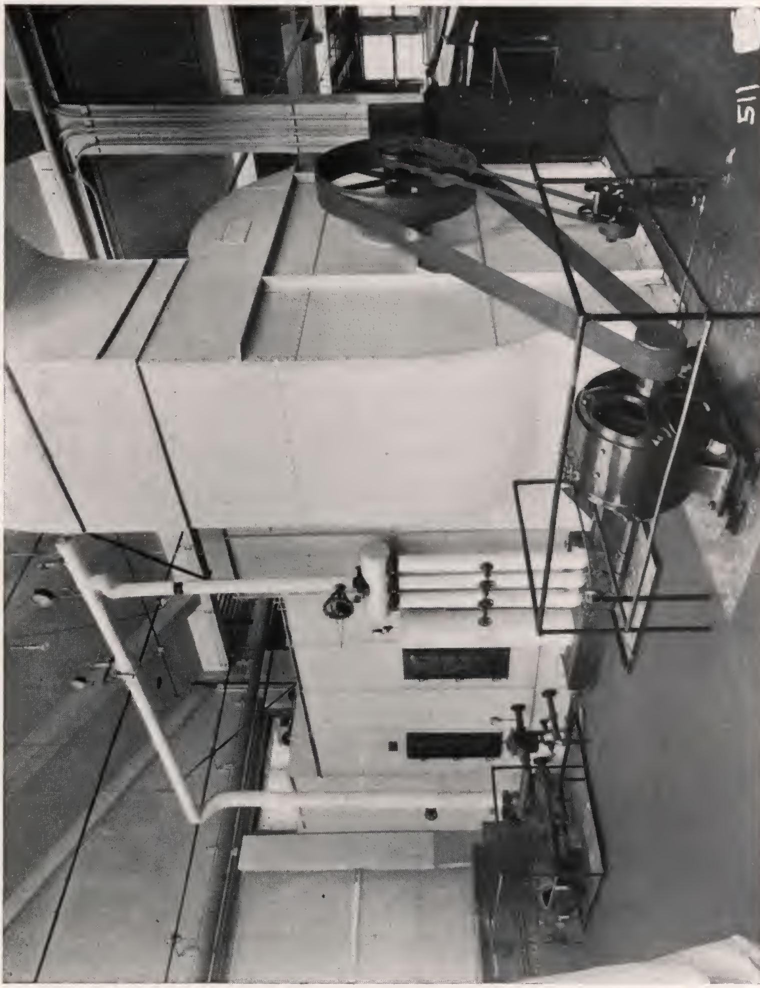
The removing of dirt, dust, soot and bacteria from the air is almost proportional to the amount of wetted surface to which it is exposed. Some of the heavier solid matter is precipitated to the tank by the spray, but the smaller particles, even after wetting, are still carried in suspension by the air current. In order to effectively remove this very fine material, the air must be broken up into thin layers or strata and passed over a surface kept flooded with running water. This surface should be arranged to provide changes in the direction of the air flow, in order to throw the dust particles against it and wash them to the tank.

3d. **Frictional Resistance** to the air is caused by the spray, the eliminator, and washing surface.

a. Where the water is atomized and the nozzles discharge with the air current, no resistance is produced except at high velocities. In fact the fan may be shut down and a current of air induced through the washer by means of the spray.

A spray system, in which an endeavor is made to provide sheets of water, produces considerable resistance. If a perfect curtain or spray sheet was maintained, no air could pass. It is therefore necessary for the air currents to actually punch holes in the sheet. These holes, which are often inches in diameter, may be seen with the naked eye showing that a thorough mixture of air and spray is not procured in this manner.

b. Eliminators and washing surface are so short that the surface friction amounts to practically nothing, as may be readily shown by passing the air at the same velocity between straight parallel plates of equal length. The greatest resistance is caused by the baffling of the air, changing its direction, and setting up eddy currents. This friction is in proportion to the angle through which the air current is deflected. The smaller the angle the less the resistance.



A Typical Carrier Installation

Showing Fan, Heater, Washer, Circulating Pump and Automatic Humidity Control at the John B. Stetson Plant, Philadelphia, Pa.

High frictional resistance means one or both of two things; viz., loss of power in the handling of the air, or the handling of less air.

These principles are fundamental and all of them are fulfilled only by the Carrier Washers.

Patents: The apparatus of the Carrier Air Conditioning Company of America is fully protected by American and Foreign Patents, which are basic in nature. We will vigorously defend our rights and protect our customers from any infringements.

Our Factory is located at Buffalo, N. Y., which offers shipping facilities second to no other city. Several hundred skilled mechanics are employed at the plant, which is equipped with the most improved machinery, enabling us to make quick shipment and prompt deliveries.

Operation of Carrier Air Washers: The air is drawn or blown through the spray chamber of the air washer and humidifier where it comes in contact with the very minutely atomized spray of water. A large number of spray nozzles are used and evenly spaced in the chamber, insuring a uniform distribution of the mist. No other company uses one-half as many nozzles. The mixture of the fine spray and the dust-laden air is very thorough, so that every particle of solid matter is made wet and heavy by the spray.

The evaporation of a portion of the spray water humidifies the air, and the amount thus evaporated depends upon the relative temperature of the water. The Carrier System of Humidity Control provides a very simple method of heating the water and varying its temperature to procure the humidity desired.

In summer when the water is not heated, the air is cooled by one of two different methods. First, where the same water is recirculated, the air is cooled by evaporation; that is, the heat necessary to evaporate the water is extracted from the air. This gives the greatest cooling on the hottest days, giving a drop in temperature to the air ranging from 8 to 20 degrees.

Second, the use of cold water in sufficient quantities will allow the air to be cooled and moisture condensed from it, thus lowering the humidity.

Angle Frame
Which Supports Casing and Tank. This Rigid Construction used on all Types of Carrier Washers

Leaving the spray chamber, the air then passes through washing surface. Four corrugated sheets are kept flooded with a film of water, so the dirt and other solid matter, which has been wetted by the atomizing sprays, will be thrown against these sheets and washed to the settling tank below, giving a high washing efficiency. The Carrier Washers provide from one and one-half to four times the amount of washing surface provided in any other make. A separate and independent means for flooding the washing surface is employed, a feature found in no other make.

The last two corrugations of the eliminator with the protruding lips, effectively remove all free or unabsorbed moisture and solid matter; the air leaving the washer being clean, free from dust, dirt, soot and bacteria, properly humidified and cooled.

The air then passes to the fan and tempering or heating coils to be heated sufficiently to maintain the required temperature in the building.

The spray water, which is recirculated, falls from the eliminator plates to the settling tank, passes through the suction screen, thence to the ejector (where it is heated in winter), then to the pump, and through the basket screen back to the sprays.

Types of Machines: While all of our air washers embody the same general principles, we have found it necessary to develop and standardize machines varying in detail for the various classes of service to be performed.

The machines described in the following pages are each especially adapted to certain classes of work, and for that particular condition they have no equal.

The machines designed for textile mills, turbo-generator cooling or dehumidifying are described in other publications which will be sent upon request.

Inspection Door
Easy to operate, allows ample opening and remains water tight when closed

Details Common to All Carrier Washers

The following details are common to all types of Carrier Washers:

The Casing is made in sections rigidly supported by an angle iron frame. The sides, top and tank are made separately, and are bolted together with rubber gaskets, joints thus providing for convenience in assembling and erecting, or for inspection and repairs. Additional bracing with angle iron is provided so no sheet wider than three feet is unsupported. Each casing is provided with inspection door described below. The angle frame is outside of the sheets, so no water comes in contact with angles. All seams, or exposed edges of the sheets, and rivet heads are soldered.

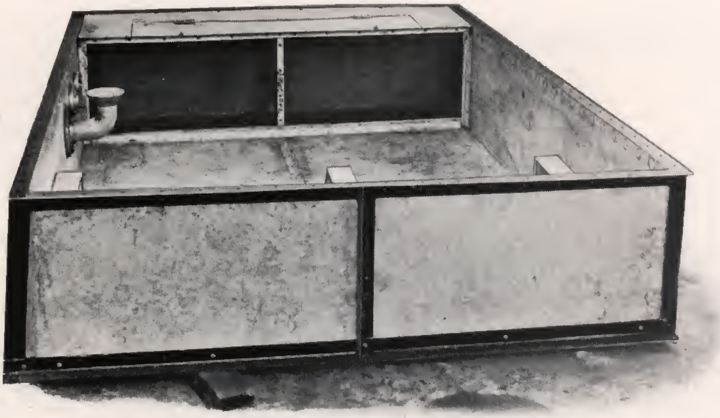
Inspection Door used in all Carrier Air Washers is a real rigid serviceable device that remains both water and air tight, and of sufficient size to actually allow access for inspection and cleaning. This door and its frame are both made of cast iron, sufficiently heavy to give strength and rigidity.

Set into the frame is a solid rubber gasket against which the door closes.

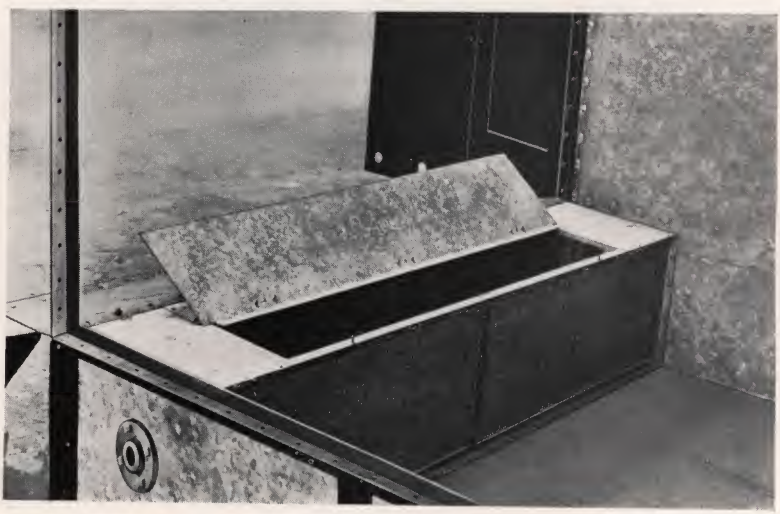
The door is held tight by means of cams, which are easily operated and pull solidly against the gasket, preventing any water leakage. These cams are provided on both sides, the hinges being so constructed as not to interfere with the action of the cams.

Each door carries at least two heavy 11" x 12½" glass panels on the larger sizes and 14⅝" x 8⅜" on the smaller washers.

Should there be any leak in this door a gutter is provided in the cast iron frame for catching the water and returning it to the tank.



Settling Tank
Showing Overflow on side and Eliminator Supports in foreground



Suction Strainer
Flange for Suction Pipe shown on side of Tank

Settling Tank: The settling tank, which is placed under the entire washer and eliminator, is 16 inches in height. A strong frame which is built of angle iron, encloses the settling tank, and to which it is firmly riveted, making a very rigid and substantial base to support the balance of the washer. All seams of the tank are riveted and soldered, and all rivet heads soldered.

The tank is provided with:

Automatic Float Valve which controls the water supply and maintains a constant water level in the tank.

An Overflow, which connects to the sewer and which is a guarantee against flooding the tank.

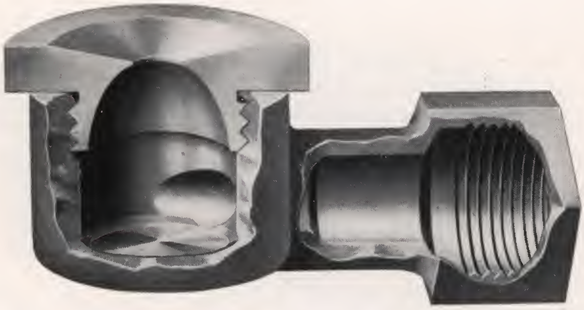
Drain Valve arranged under the bottom of the tank, and which connects to the sewer, so all the water may be drawn off for cleaning.

Suction Strainer: The settling tank is divided into two compartments by a wire cloth strainer, through which the water passes before entering the suction of the pump. This strainer offers a surface of more than one square foot for each foot in width of the tank. The area of the strainer being many times the area of the suction pipe provides a thorough filtering of the water at a very low velocity. The strainer is made of No. 12 mesh copper gauze. The opening in spray nozzles is 3/16 inches in diameter so there can be no clogging of the nozzles.

Over the top of the compartment formed between the strainer and the end of the tank to which the suction of the pump is connected, is placed a cover to prevent any dirt from falling in as the air passes over it. The swinging lid is easily opened to allow for cleaning the strainer when the tank is being cleaned.

The elimination of dirt from the water before it enters the spray system is far better than any effort to flush the piping and nozzles to remove the dirt after it has once entered.

Spray in Operation
From photo taken through Inspection Door with a flash light



SECTION OF NOZZLE

Spray Nozzle: The Carrier Spray Nozzle, though most effective, is very simple in construction. The water enters a small circular chamber tangentially, which gives it a whirling or centrifugal action. The approach to the discharge opening is conical in shape, so the rotation, or whirling speed of the water, is greatly increased as it approaches the discharge. The effect of this arrangement is to give a most minutely divided or atomized spray, which offers an enormous amount of surface for washing and evaporation.

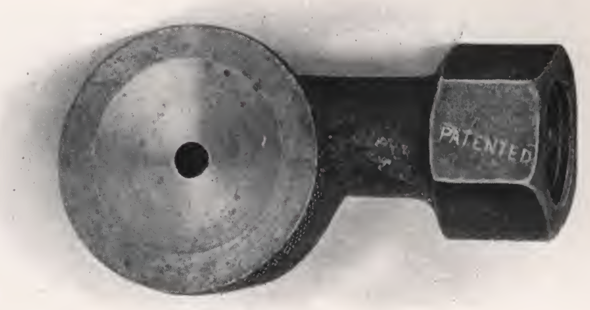
The construction of the nozzle is such as to make it very free from clogging with foreign material. The smallest hole is $\frac{3}{16}$ of an inch in diameter, yet it throws a perfectly atomized mist, by reason of the centrifugal principle upon which it operates.

We do not use the so-called self-cleaning or self-flushing nozzles, as there seems to be no more reason for letting dirt get into the spray piping system than would be the wisdom of allowing obstructions to get into your water supply system with flushing devices arranged with a hope of cleaning it out.

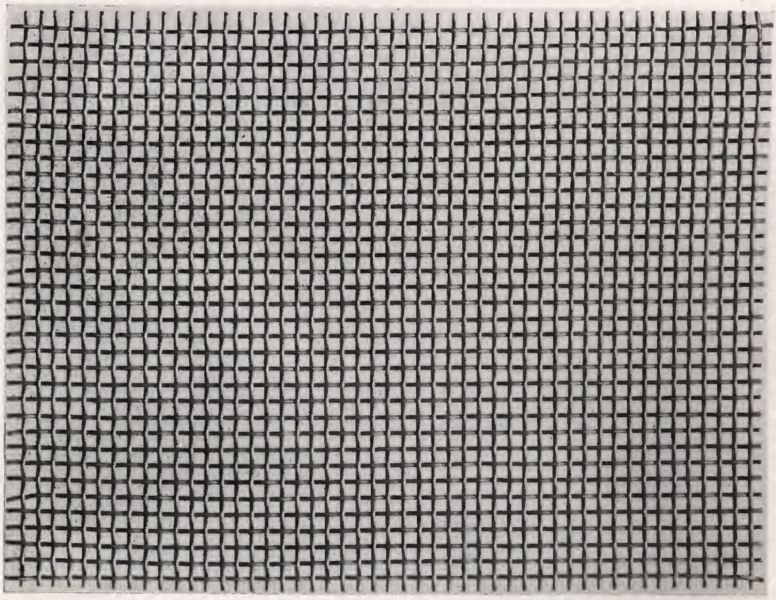
Our method is to thoroughly filter the water and effectively remove all dirt and foreign matter before it goes to the nozzles.

Although the discharge opening in the nozzle is much larger than those in general use, still every precaution is taken to insure the removal of any lint or dirt from the water before it enters the spray piping.

The water pressure required varies with the type of washer and work to be performed, but never exceeds twenty-five pounds per square inch.



Exact size used in all standard Carrier washers. Compare the size of the orifice with the openings in the strainer screen below.



Dirt, in order to reach the nozzle, must first pass through this fine screen; the exact size of mesh used being shown.

The area of orifice of the nozzle is eight times the area of each opening in screen; therefore, there is not the least possible chance of stopping up the spray nozzles from dirt which passes through the strainer.

In order to provide against an excessive stoppage of the strainer, at least this amount (12 sq. in.) of strainer screen is provided for each and every nozzle used in a Carrier Washer, giving a strainer surface two hundred and eighty times the area of the nozzle orifice.

Carrier Sprays in Operation in a Type A Washer

Spray Header
Note Flange each Side of Casing

Spray Piping: All pipe and pipe fittings used for water or spray piping of standard galvanized washers are of the best galvanized iron pipe and galvanized fittings. Small valves are all brass, and large valves are iron body, brass fitted.

Copper washers are provided with brass standpipes and fittings.

All standpipes are carried by a galvanized cast iron header, which is non-corrosive and rigidly supports the standpipes in proper alignment.

Wherever a water pipe connects to the inside of the washer, companion flanges and pure rubber gaskets are placed on each side of casing, making it impossible to have a leak at these points, and gives a finish to the apparatus.

Air-Distributing Plate
Across Inlet End of Washer

Distributing Plate: It is quite as necessary to distribute the air uniformly as it is the water.

Where the air enters the washer, a perforated plate is used at the inlet to distribute the air and equalize the velocity through the spray chamber. This plate is made of the same material as the casing and is braced with angles bolted to the casing, and on large sizes is provided with a door.

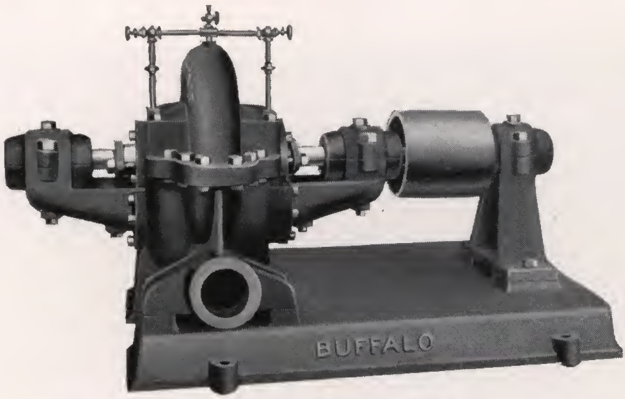
The resistance to the air flow offered by this plate is very small and it effectively prevents eddy currents from throwing the spray back out the inlet end of washer.

PUMP SUCTION CONNECTION
Which takes the water at a low level to prevent the possibility of air entering the Pump Suction

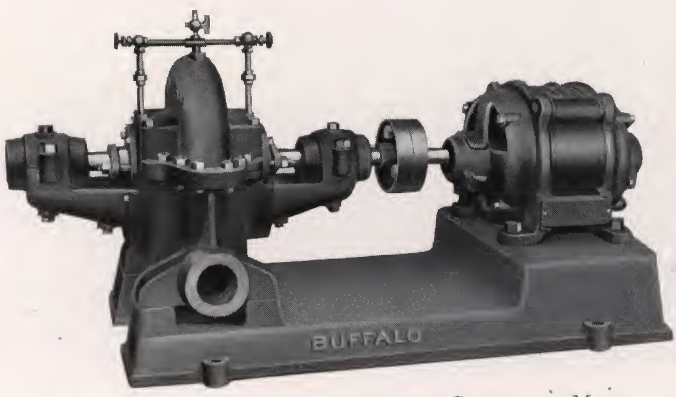
Pump: After years of practical operation and the trial of a great many types we have lately adopted an especially designed pump. It is of double suction centrifugal type with an enclosed impeller. The shell is split horizontally to allow of easy inspection without disturbing the pipe connections. There are two large bearings, one on each side to maintain the runner in its correct position, which allows the clearances to be made extremely small, a feature which is quite essential for high efficiency

The impeller is made in two parts, split at right angles to the length of the shaft, which allows the water passages to be finished. The parts are afterwards riveted together.

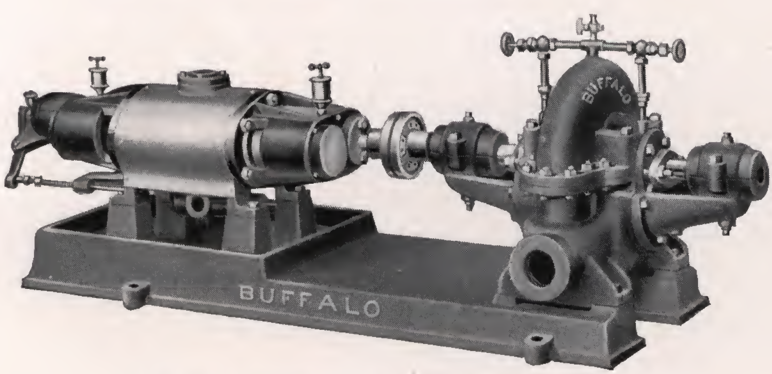
Pump is preferably driven by a direct connected electric



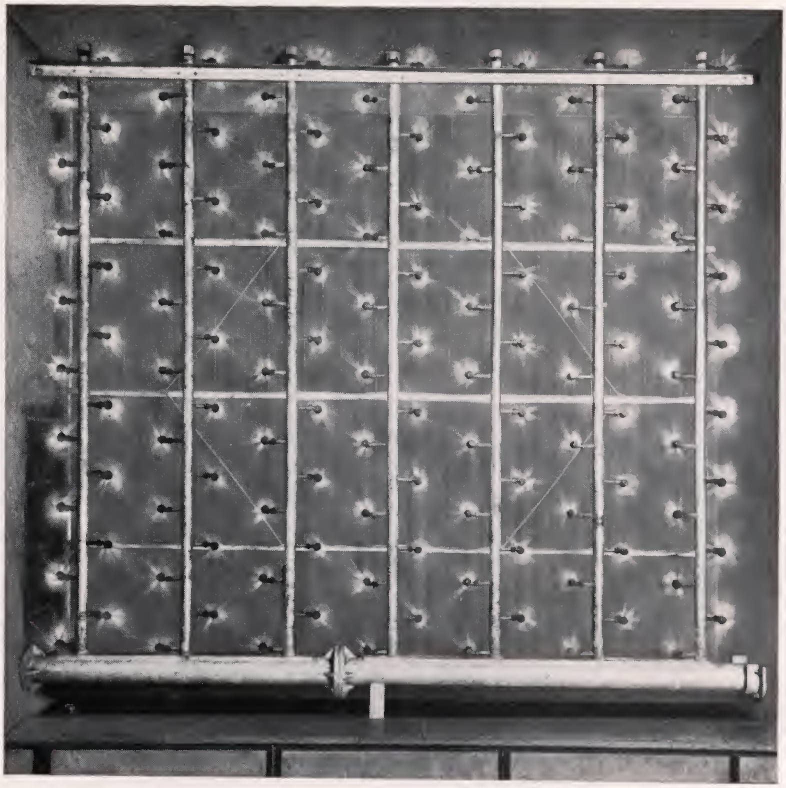
Double Suction Pulley Pump



Double Suction Pump With Direct Connected Motor



Double Suction Pump with Spiro Turbine



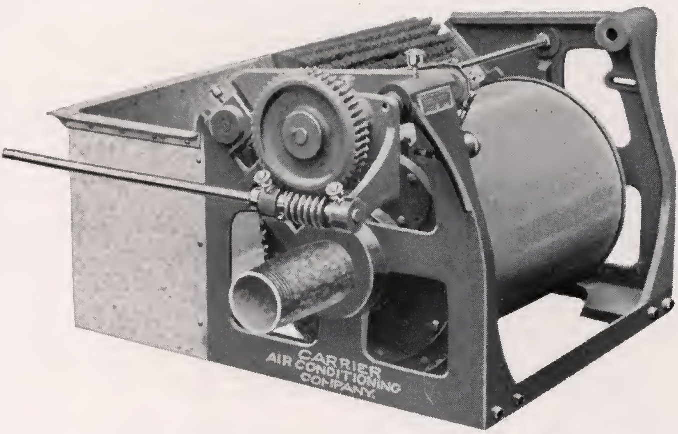
Sprays in a Carrier Washer. Note the Distribution

motor, but may be driven by a belt, steam turbine or other means most desirable.

The pressure required for complete atomizing and distributing of the water is from 18 to 25 pounds per square inch.

Double suction pumps cost more but are more efficient and better in every way; hence their exclusive use with Carrier washers.

The horizontally split shell provides for inspection of the pump without disturbing the pipe connections.



Carrier Self Cleaning Strainer for Special Conditions

Self-Cleaning Strainer: In installations where an excessive amount of dirt or other solid matter, especially where lint or fibrous material, is to be removed from the air, we recommend the use of a Carrier Self-Cleaning Rotary Strainer.

The strainer which sets in the tank under the washer is cylindrical in shape. The suction line to the pump runs through one of the trunnions upon which it revolves. The screen of the strainer is made of fine mesh copper wire cloth, so that any dirt getting through it will easily pass through the nozzle.

Cleaning Brush: The revolving strainer, as will be noted from the cut, has a stiff round brush which also revolves, and thus constantly sweeps the strainer and keeps it clean of all dirt. The dirt swept from the screen goes into a small tank so that it can not again mingle with the water.

The small tank should be cleaned once a week, except under very dirty conditions, an operation which takes not more than fifteen minutes.

A one quarter horse power motor will drive a strainer of the largest size.

This combination of large nozzle orifice in the nozzles and a self-cleaning strainer, is of great benefit in reducing the attention required by the apparatus.

One of Four Carrier Type "A" Washers Installed in Hotel McAlpin, New York

Details Characteristic of Carrier Type "A" Washers

Type "A" Carrier Air Washer and Humidifier is built for the most efficient washing and purifying of air under our varying atmospheric conditions, to give a reasonable cooling effect in summer either from contact with cold water or from evaporation, and is adapted for humidity control for the winter months.

In comparing this machine with any competing standard washer on the market, it will be found that:

1st. It has more than TWICE as many nozzles to evenly distribute the spray, and mix it with the dirt and dust.

2nd. It has more than FOUR times the washing surface provided to remove the dust and dirt.

3rd. It has FOUR times (or more) as many eliminators, breaking the air up into thin passages and bringing it into more intimate contact with the washing surface.

4th. It has eliminators which baffle the air through a SMALLER angle, giving a smaller resistance to passage of the air.

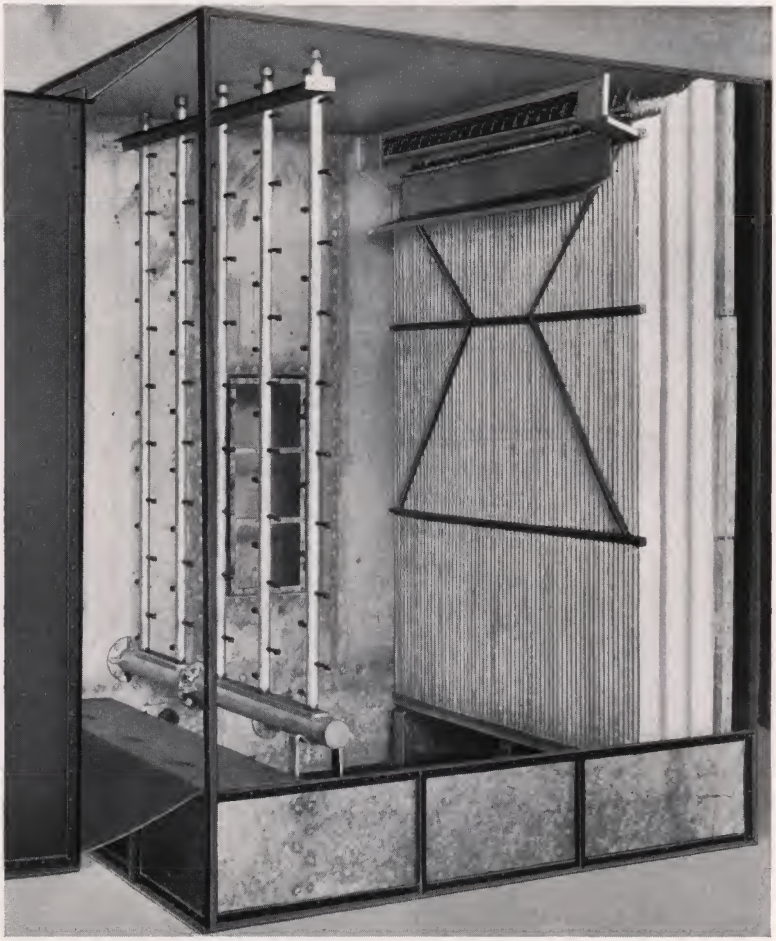
5th. It gives less resistance to the air than any other standard washer with the same velocity.

6th. It has nozzles which spray in the DIRECTION of the air flow, so practically no resistance is offered to the air current by the spray.

7th. It has ample WATER FILTERING surface and large orifice in nozzles to effectively prevent stoppage of spray system.

8th. It is the ONLY washer in which spray nozzles are placed 4 ft. in front of the eliminator, giving an ample spray chamber.

9th. The workmanship and material used are of the best. Every precaution is taken to make these machines the best washers and humidifiers built.



Interior of Carrier Type "A" Washer

10th. No other company builds a washer which has a special means for flooding the washing surface of the eliminators to increase the efficiency and to keep the plates clean.

11th. No other company builds a washer which provides means for washing during very humid weather in summer without an increase in humidity.

12th. No other company is able to furnish a reliable, accurate and simple automatic humidity control.

The Spray Chamber is seven feet 2⁵⁄₁₆ inches long which allows placing the spray nozzles four feet in front of the eliminators. This gives sufficient distance for a thorough mixture of the air, dirt and spray, but still places the nozzles sufficiently far from the air inlet to prevent the water being thrown out of the washer by eddy air currents.

This mixture of the atomized spray and the air is very thorough, completely filling the space between the nozzles and the eliminators, and is so thick that often the eliminators can hardly be seen from the inlet end of the washer.

The nozzles are uniformly distributed and not less than two and one-half nozzles are provided per each thousand cubic feet of air per minute.

Eliminator Design: There are three important considerations in the design of an eliminator:

1st. Elimination of the small particles of water which would be carried by the air currents.

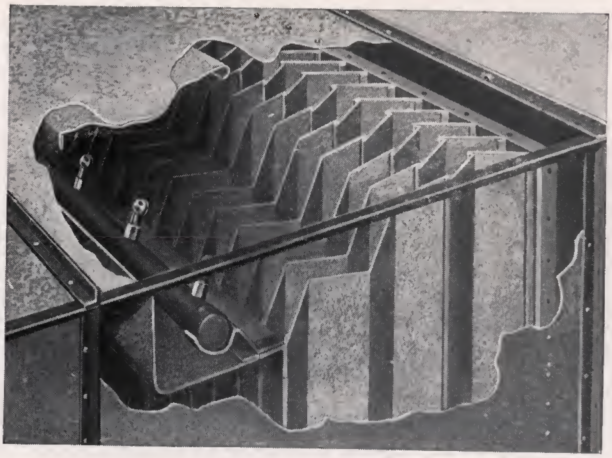
2nd. To produce as small a resistance to the passage of the air as possible.

3rd. To provide as large a wet surface as possible to procure the best washing effect.

To provide for elimination it is necessary that the direction of the air current be abruptly changed in order to throw the entrained moisture against the eliminator plates.

The wider the space between the plates, the greater the necessary angle through which the air is baffled.

For this reason an angle of deflection of the air of 60 degrees with the spacing of plates only 1⅛ inches apart (used in the Carrier Type "A" and "B" washers) eliminates more



PART OF CASING REMOVED SHOWING ELIMINATORS IN POSITION

effectively than a 90 degree angle ordinarily used with spacing of 4 to 6 inches.

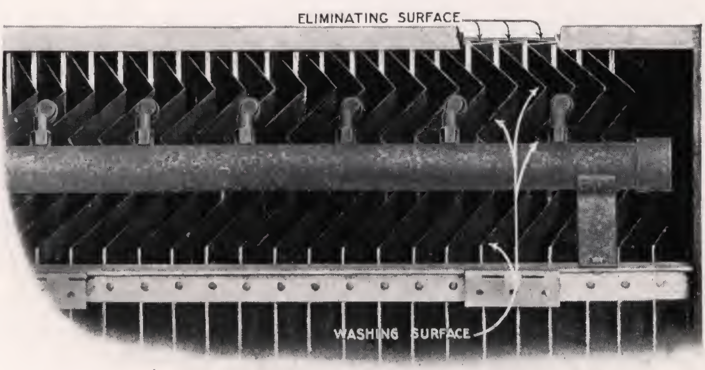
The resistance in an eliminator depends more upon the angle through which the air is baffled, and the eddy currents set up thereby, than upon the surface friction. In fact the resistance of the same amount of surface is so small that it would be very difficult to measure.

The resistance of this washer is less than .25 inch water gauge at the rated capacities.

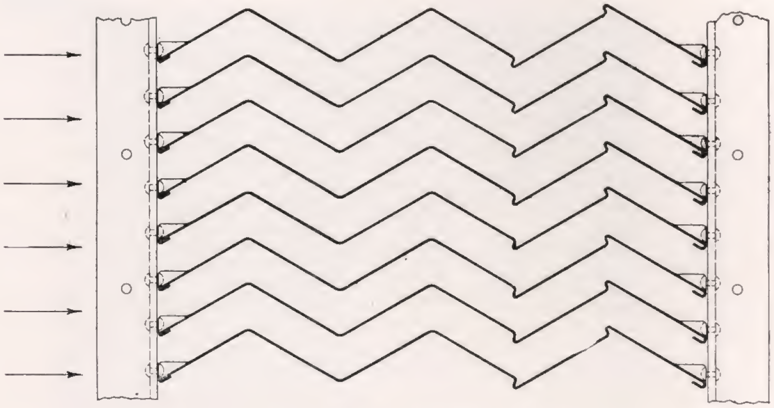
Eliminator Flooding: The flooding of the eliminators is done by an independent set of nozzles across the top. These nozzles distribute the water over the washing surface uniformly. The flooding is used continuously but provision is made for shutting off atomizing sprays in summer on very humid days. When the atomizing sprays are shut off, the increase in the humidity is so small that it practically amounts to nil. This is a feature possessed only by this and our Type "B" Washers.

SIDE VIEW OF ELIMINATORS SHOWING FLOODING NOZZLES

Washing Surface: The eliminators are so arranged that the first four corrugations are kept constantly flooded with a sheet of water which catches any solid matter, not already precipitated by the first set of sprays, and washes it to the settling tank. The wet surface exposed to the air thus obtained amounts to 19.5 sq. ft. of washing surface per 1000 cubic feet of air per minute, counting only the side of the corrugation against which the air impinges.



FRONT VIEW OF ELIMINATORS SHOWING WASHING SURFACE, AND NARROW PASSAGES THROUGH WHICH THE AIR PASSES

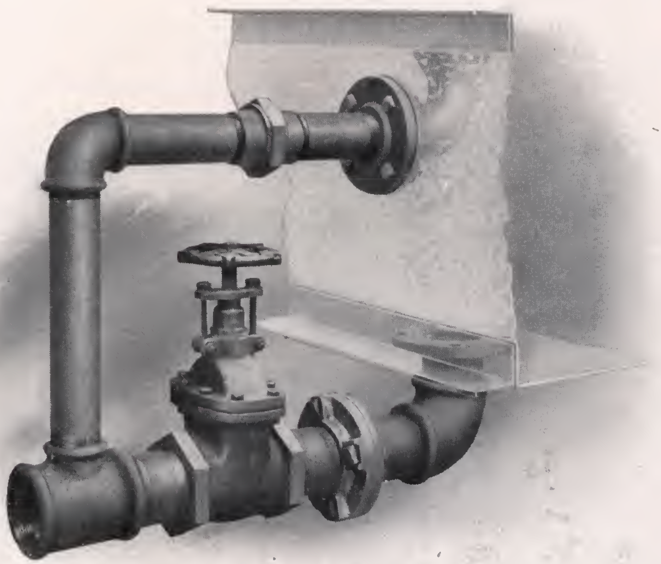


PLAN OF ELIMINATORS
Which set vertically with Crimped Gutters for removing Entrained Water and Narrow Passages through which the Air Passes

Eliminator Construction: These eliminators are made up of a series of corrugated plates spaced and set in a VERTICAL position on $1\frac{1}{8}$ *inch centers* across the discharge end of the spray chamber. Each eliminator is made of a single sheet so stamped as to form six corrugations, with three of the corrugations having stamped lips projecting. Plates are held together with angles at the top and bottom, and at intervals through the height to keep them evenly spaced. All the eliminators are galvanized or copper so that there is no chance of corrosion.

In making comparison with other machines, especially in the matter of prices, it must be borne in mind that the Carrier Type A washer has at least twice the weight of material and three to four times the amount of labor consumed in its construction.

This material and design are used only for the purpose of procuring results, viz., effective and uniform air washing in the removal of dust and bacteria with a low air resistance. At the same time to produce a machine which is conveniently arranged for operation and care.



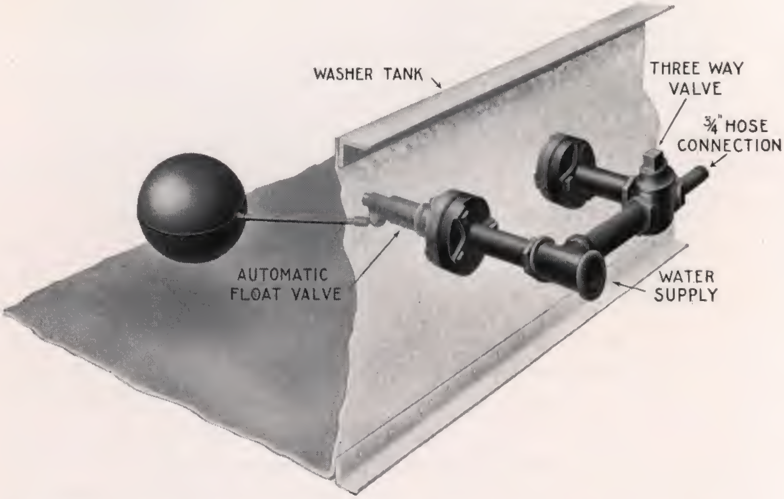
Overflow and Drain With Valve Outside of Tank
Water Supply Connections used on Types "A" and "B" Washers

Overflow and Drain: A flanged connection is placed in the bottom of tank with elbow and brass gate valve for draining off the water and accumulated dirt. An independent bell-mouth cast iron overflow is arranged in the tank to provide for draining off any surplus water and prevent any chance of flooding the tank. The overflow and drain are connected outside the tank to a tee from which the connection to the sewer is made.

Water Piping: A valve is provided for closing off the atomizing nozzles in very humid summer weather, while the flooding nozzles are kept in operation to procure the washing. When the atomizing nozzles are closed the increase in humidity procured by the flooding nozzles is practically nothing.

The pipes connecting the atomizing sprays and the flooding sprays are joined by a tee with the required valves. The pipe and fittings between the discharge of pump to this tee are not furnished with the washer.

The drain is from bottom of tank and is provided with gate valve and tee for sewer connection. The overflow is a special casting with flange bolted to tank. A companion flange is provided outside of tank with 2 inch pipe to tee in drain line. A flange is provided on tank for suction line to pump which is not furnished.

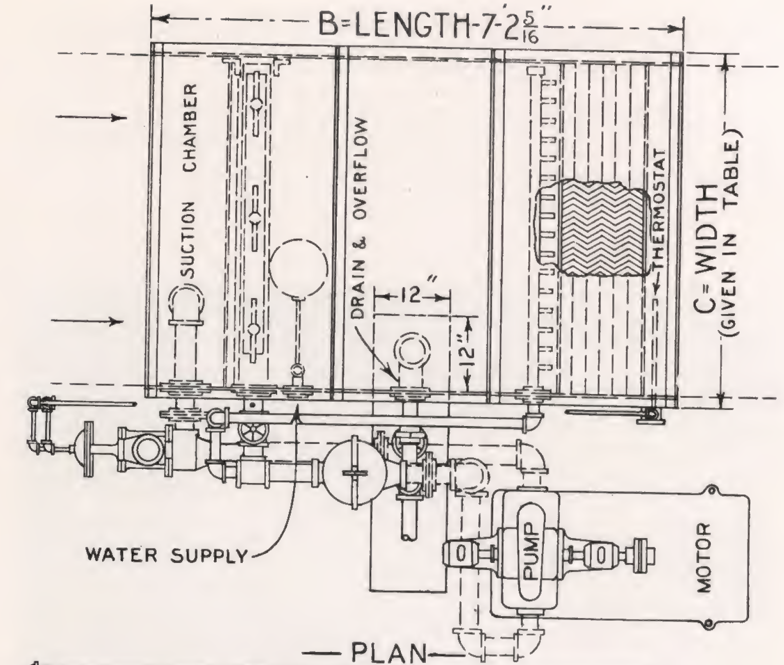


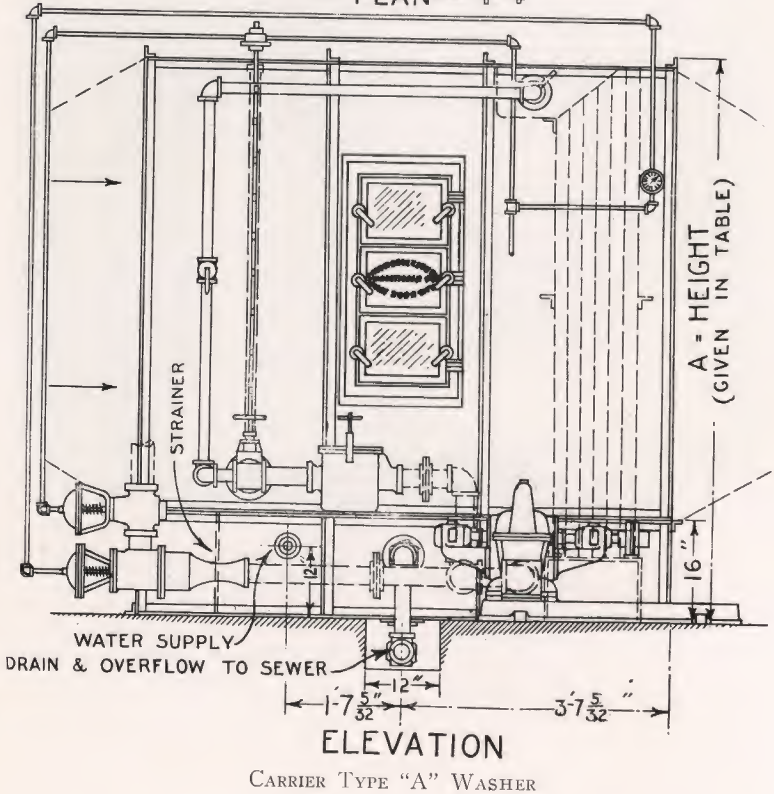
Water Supply Connections used on Types "A" and "B" Carrier Washers.

Water Supply is arranged as shown by cut. A tee is provided outside of the casing to which the customer provides a water supply line. Connected to one end of this tee is a ¾ inch valve and sufficient ¾ inch hose to reach to the opposite side of the tank, thus providing a convenient means for flushing and cleaning out tank.

The other connection from tee is run full size with flanges on either side of casing to a tee inside of washer. At one end of this latter tee is a full size valve which is used for quickly filling the tank after flushing and cleaning. At the other end of the tee is a ¾ inch globe valve and beyond that a ¾ inch float valve. The float valve is to keep a constant water level in tank, while the globe valve is to close supply to float valve when draining tank for cleaning.

Type A Interior
Showing Position of Suction Strainer and Flooding Nozzles





ELEVATION

Carrier Type "A" Washer

DIMENSIONS FOR CARRIER TYPE "A" AIR WASHER

Number	Capacity in C. F. M.	Height A Feet Inches	Length B Feet Inches	Width C Feet Inches	G. P. M. Circulated	Size Pump Inches	H. P. Motor	R. P. M. Motor	Size Water Supply Inches	Size Sewer Connection Inches
1—A	1500	4—1½	7—2 5/16	1— 5¼	14	1½	2	1700	¾	2
1—B	2100	5—1½	7—2 5/16	1— 5¼	16	1½	2	1700	¾	2
2—A	3100	4—1½	7—2 5/16	2— 9	28	1½	2	1700	¾	2
1—C	3200	7—1½	7—2 5/16	1— 5¼	23	1½	2	1700	¾	2
2—B	4400	5—1½	7—2 5/16	2— 9	32	1½	2	1700	¾	2
3—A	4800	4—1½	7—2 5/16	4— 0¾	42	1½	2	1700	¾	2
4—A	6400	4—1½	7—2 5/16	5— 4½	56	1½	3	1700	¾	2
3—B	6700	5—1½	7—2 5/16	4— 0¾	48	1½	2	1700	¾	2
2—C	6900	7—1½	7—2 5/16	2— 9	46	1½	2	1700	¾	2
4—B	9000	5—1½	7—2 5/16	5— 4½	63	1½	3	1700	¾	2
2—D	9400	9—1½	7—2 5/16	2— 9	57	1½	3	1700	¾	2
3—C	10500	7—1½	7—2 5/16	4— 0¾	69	1½	3	1700	¾	2
5—B	11300	5—1½	7—2 5/16	6— 8	79	2	3	1700	¾	2
4—C	14100	7—1½	7—2 5/16	5— 4½	92	2	3	1700	¾	2
3—D	14300	9—1½	7—2 5/16	4— 0¾	85	2	3	1700	¾	2
5—C	17700	7—1½	7—2 5/16	6— 8	115	2	5	1700	¾	2
3—E	18100	11—1¾	7—2 5/16	4— 1¼	102	2	5	1700	¾	2
4—D	19200	9—1½	7—2 5/16	5— 4½	114	2	5	1700	¾	2
6—C	21300	7—1½	7—2 5/16	7—11¾	139	2½	5	1700	¾	2
5—D	24100	9—1½	7—2 5/16	6— 8	142	2½	5	1700	¾	2
4—E	24300	11—1¾	7—2 5/16	5— 5	135	2½	5	1700	¾	2
6—D	29000	9—1½	7—2 5/16	7—11¾	171	2½	5	1700	¾	2
4—F	29400	13—1¾	7—2 5/16	5— 5	164	2½	5	1700	¾	2
5—E	31000	11—1¾	7—2 5/16	6— 8½	169	2½	5	1700	¾	2
7—D	33900	9—1½	7—2 5/16	9— 3½	200	2½	7½	1700	¾	2
6—E	36700	11—1¾	7—2 5/16	8— 0¼	204	2½	7½	1700	¾	2
5—F	37000	13—1¾	7—2 5/16	6— 8½	205	2½	7½	1700	¾	2
8—D	38800	9—1½	7—2 5/16	10— 7¼	228	3	7½	1700	¾	2
7—E	42900	11—1¾	7—2 5/16	9— 4	238	3	7½	1700	¾	2
9—D	43700	9—1½	7—2 5/16	11—11	256	3	7½	1700	1	2
6—F	44500	13—1¾	7—2 5/16	8— 0¼	247	3	7½	1700	¾	2
10—D	48600	9—1½	7—2 5/16	13— 2½	286	3	7½	1700	1	2
8—E	49100	11—1¾	7—2 5/16	10— 7¾	271	3	7½	1700	¾	2
7—F	52000	13—1¾	7—2 5/16	9— 4	288	3	7½	1700	¾	2
11—D	53500	9—1½	7—2 5/16	14— 6¼	315	4	10	1120	1	2
9—E	55000	11—1¾	7—2 5/16	11—11½	305	4	10	1120	1	2
12—D	59000	9—1½	7—2 5/16	15—10	343	4	10	1120	1	2
8—F	60000	13—1¾	7—2 5/16	10— 7¾	329	4	10	1120	¾	2
7—G	61000	15—2	7—2 5/16	9— 4½	326	4	10	1120	¾	2
10—E	62000	11—1¾	7—2 5/16	13— 3	340	4	10	1120	1	2
9—F	67000	13—1¾	7—2 5/16	11—11½	370	4	10	1120	1	2
11—E	68000	11—1¾	7—2 5/16	14— 6¾	374	4	10	1120	1	2
8—G	70000	15—2	7—2 5/16	10— 8¼	373	4	10	1120	¾	2
12—E	74000	11—1¾	7—2 5/16	15—10½	408	4	10	1120	1	2
10—F	75000	13—1¾	7—2 5/16	13— 3	412	4	10	1120	1	2
9—G	79000	15—2	7—2 5/16	12— 0	419	4	10	1120	1	2
13—E	80000	11—1¾	7—2 5/16	17— 2¼	442	4	10	1120	1	3
11—F	82000	13—1¾	7—2 5/16	14— 6¾	453	5	15	1120	1	3
14—E	87000	11—1¾	7—2 5/16	18— 6	477	4	15	1120	1	3
10—G	88000	15—2	7—2 5/16	13— 3½	466	4	15	1120	1	2

Additional sizes and capacities on request.

Details of Carrier Type "B" Washers

Carrier Type "B" Washer With Automatic Humidity Control Installed in Administration Building of L. S. Starrett Co., Athol, Mass.

Details Characteristic of Carrier Type "B" Washers

Type "B" Carrier Washer and Humidifier has all of the splendid features of the Type "A" washer mentioned on page 25, with the addition of greater cooling in summer, either from contact with cold water or from evaporation.

1st. It provides for CONTINUOUS washing but delivering the air with a VARYING amount of humidity desired.

2nd. It delivers washed air as may be desired:

a. Without a PERCEPTIBLE increase in humidity.

b. With an increase of SIXTY PER CENT. in humidity.

c. With an increase of 85 PER CENT in humidity.

3rd. It will COOL and DEHUMIDIFY if a sufficient supply of cold water is available.

4th. It gives practically complete saturation when desired, thus COOLING in summer to the entering wet bulb temperature, when recirculating the water.

5th. It can be provided for continuous automatic humidity control THROUGHOUT the year.

The construction of the Type "B" Washer is very similar to our Type "A" machine, using the same:

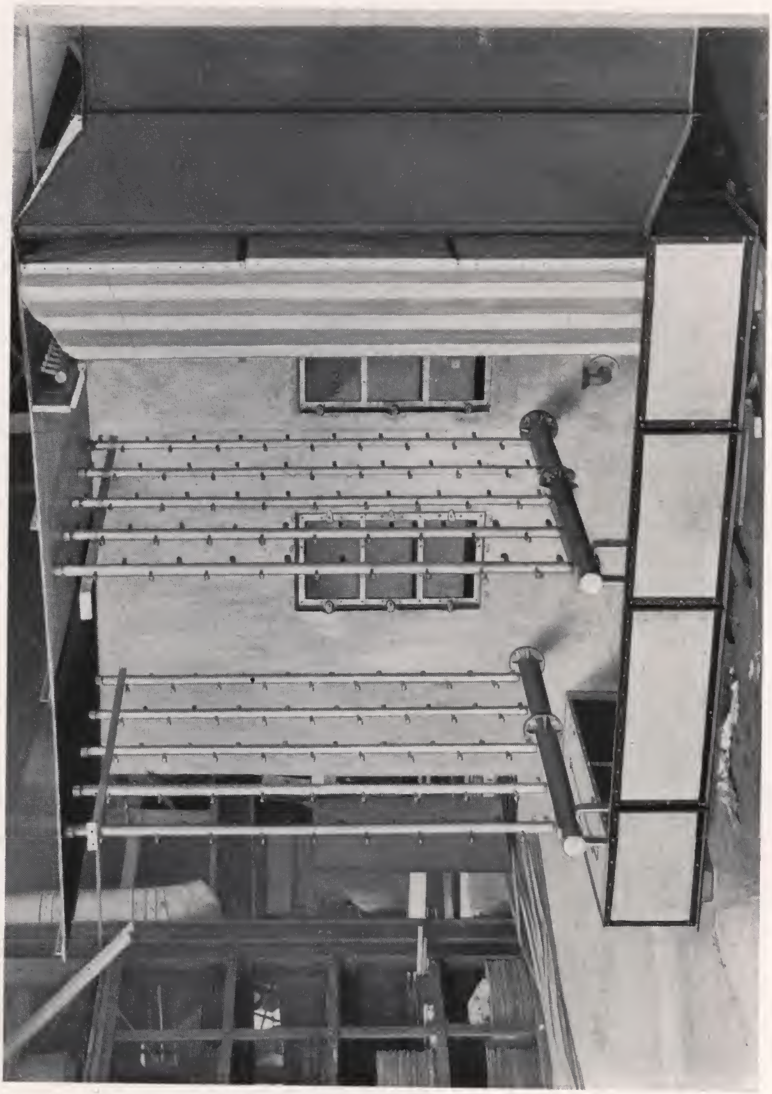
Eliminators. For description see page 27.

Water Supply. See page 31.

Overflow, Drain, and Suction Strainer. See page 30.

Nozzles, Tanks, etc., described in the foregoing pages.

In the details described below, however, are the differences which will be noted.



INTERIOR OF CARRIER TYPE "B" WASHER

The Spray Chamber which is nine feet three-eighths inches long, provides not only for a thorough mixture of the air, dirt and spray, but gives sufficient length of chamber to effect a very thorough exchange of the heat between the air and water.

Two Inspection Doors are provided to allow access to all parts of the washer; the detail of construction of these doors being the same as described on page 10.

Nozzles: There are at least five atomizing nozzles per each 1000 cubic feet of air per minute, in addition to the nozzles used for flooding the washing surface. This gives twice as many nozzles as our Type "A" or Type "C" Washers. The nozzle standpipes are arranged in two groups or banks, placed about three feet apart, with the last bank three feet from the eliminator plates.

Regulation: Valves outside the washer are provided on each bank of nozzles and also on the flooding nozzles over the washing surface. Either one or both banks of nozzles can be closed to regulate the humidity in summer, either by hand or automatically, while the washing is still being done by the flooded washing surface.

With both banks of nozzles closed, no appreciable increase in humidity of the air is produced.

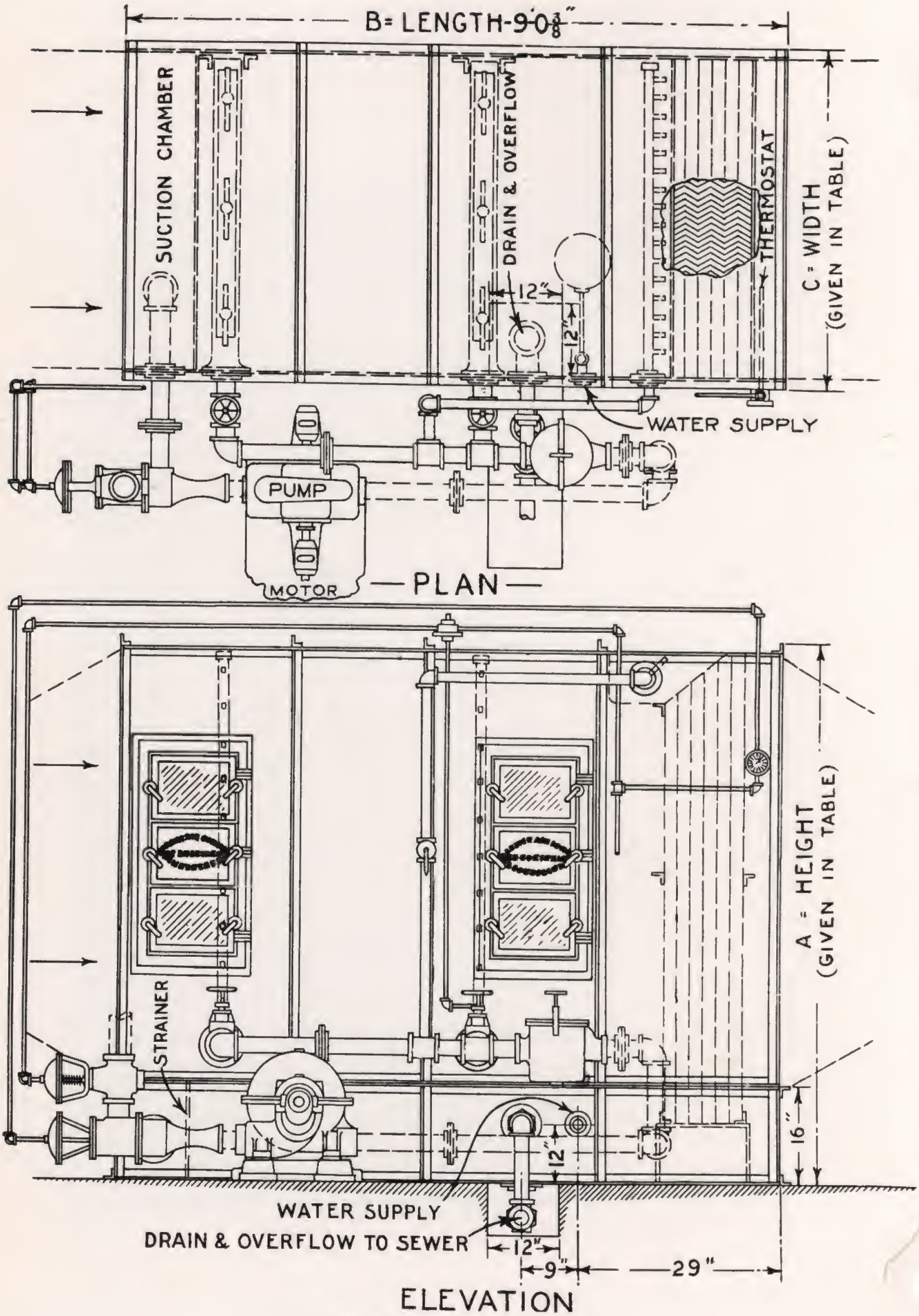
With one bank in operation (and the water recirculated without being heated) the humidity of the air will be increased about sixty percent.

With both banks of nozzles in operation, the humidity is increased about eighty-five percent.

Of course when the water is heated, the air leaves saturated with only one bank of nozzles in operation, as is described later under the heading "Humidity Control." This washer is adapted for continuous automatic humidity control throughout the year. The banks of sprays can be automatically opened or closed, and the temperature of the water also varied as required.

This washer gives greater flexibility for meeting the various atmospheric changes and procuring the desired results than any washer built.

In all other details it is constructed exactly like our Type "A" washer.

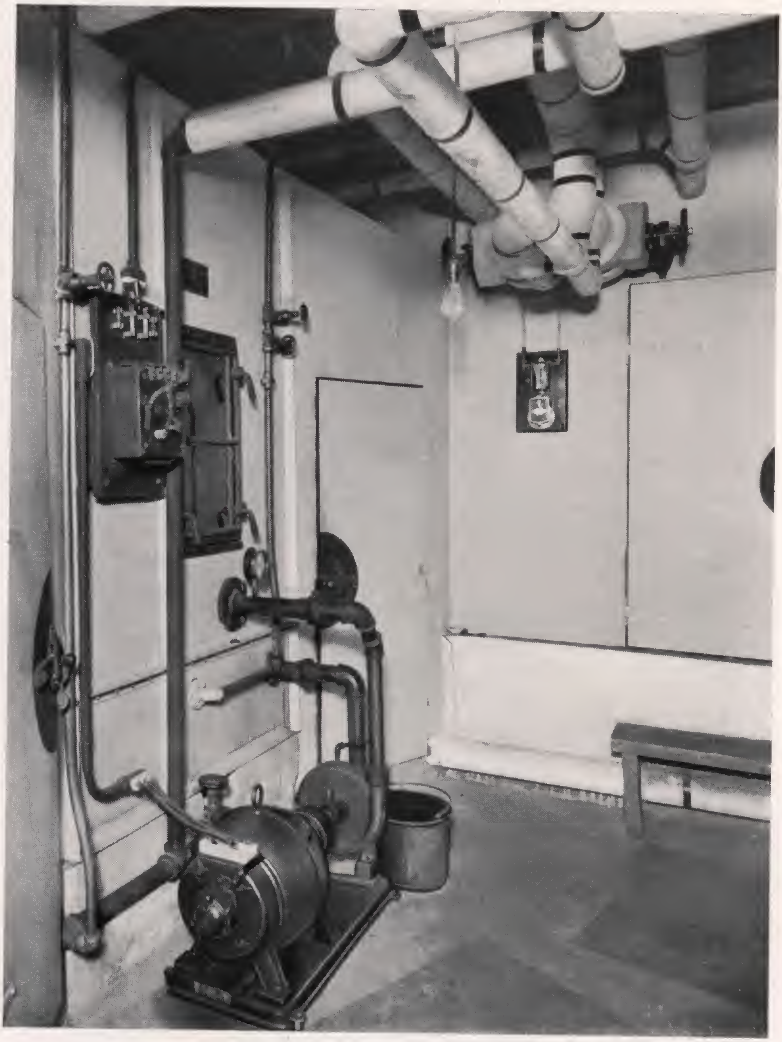


Carrier Type "B" Washer

DIMENSIONS FOR CARRIER TYPE "B" AIR WASHER

Number	Capacity in C. F. M.	Height A Feet Inches	Length B Feet Inches	Width C Feet Inches	G. P. M. Circulated	Size Pump Inches	H. P. Motor	R. P. M. Motor	Size Water Supply Inches	Size Sewer Connection Inches
1—A	1500	4—1½	9—0⅜	1— 5¼	23	1½	2	1700	¾	2
1—B	2100	5—1½	9—0⅜	1— 5¼	27	1½	2	1700	¾	2
2—A	3100	4—1½	9—0⅜	2— 9	46	1½	2	1700	¾	2
1—C	3200	7—1½	9—0⅜	1— 5¼	41	1½	2	1700	¾	2
2—B	4400	5—1½	9—0⅜	2— 9	54	1½	3	1700	¾	2
3—A	4800	4—1½	9—0⅜	4— 0¾	69	1½	3	1700	¾	2
4—A	6400	4—1½	9—0⅜	5— 4½	92	2	3	1700	¾	2
3—B	6700	5—1½	9—0⅜	4— 0¾	81	2	3	1700	¾	2
4—C	6900	7—1½	9—0⅜	2— 9	82	2	3	1700	¾	2
4—B	9000	5—1½	9—0⅜	5— 4½	106	2	5	1700	¾	2
2—D	9400	9—1½	9—0⅜	2— 9	104	2	5	1700	¾	2
3—C	10500	7—1½	9—0⅜	4— 0¾	123	2	5	1700	¾	2
5—B	11300	5—1½	9—0⅜	6— 8	133	2½	5	1700	¾	2
4—C	14100	7—1½	9—0⅜	5— 4½	164	2½	5	1700	¾	2
3—D	14300	9—1½	9—0⅜	4— 0¾	155	2½	5	1700	¾	2
5—C	17700	7—1½	9—0⅜	6— 8	205	2½	7½	1700	¾	2
3—E	18100	11—1¾	9—0⅜	4— 1¼	189	2½	5	1700	¾	2
4—D	19200	9—1½	9—0⅜	5— 4½	208	2½	7½	1700	¾	2
6—C	21300	7—1½	9—0⅜	7—11¾	247	3	7½	1700	1	2
5—D	24100	9—1½	9—0⅜	6— 8	259	3	7½	1700	¾	2
4—E	24300	11—1¾	9—0⅜	5— 5	250	3	7½	1700	¾	2
6—D	29000	9—1½	9—0⅜	7—11¾	311	4	10	1120	1	2
4—F	29400	13—1¾	9—0⅜	5— 5	308	4	10	1120	¾	2
5—E	31000	11—1¾	9—0⅜	6— 8½	313	4	10	1120	¾	2
7—D	33900	9—1½	9—0⅜	9— 3½	364	4	10	1120	1	2
6—E	36700	11—1¾	9—0⅜	8— 0¼	347	4	10	1120	1	2
5—F	37000	13—1¾	9—0⅜	6— 8½	385	4	10	1120	¾	2
8—D	38800	9—1½	9—0⅜	10— 7¼	415	4	10	1120	1	2
7—E	42900	11—1¾	9—0⅜	9— 4	440	4	10	1120	1	2
9—D	43700	9—1½	9—0⅜	11—11	466	4	15	1120	1	2
6—F	44500	13—1¾	9—0⅜	8— 0¼	463	4	15	1120	1	2
10—D	48600	9—1½	9—0⅜	13— 2½	520	4	15	1120	1	2
8—E	49100	11—1¾	9—0⅜	10— 7¾	501	4	15	1120	1	2
7—F	52000	13—1¾	9—0⅜	9— 4	540	5	15	1120	1	2
11—D	53500	9—1½	9—0⅜	14— 6¼	573	5	15	1120	1¼	2
9—E	55000	11—1¾	9—0⅜	11—11½	564	5	15	1120	1	2
12—D	59000	9—1½	9—0⅜	15—10	624	5	15	1120	1¼	2
8—F	60000	13—1¾	9—0⅜	10— 7¾	617	5	15	1120	1	2
7—G	61000	15—2	9—0⅜	9— 4½	616	5	15	1120	1	2
10—E	62000	11—1¾	9—0⅜	13— 3	628	5	15	1120	1	2
9—F	67000	13—1¾	9—0⅜	11—11½	694	5	15	1120	1	2
11—E	68000	11—1¾	9—0⅜	14— 6¾	691	5	15	1120	1¼	2
8—G	70000	15—2	9—0⅜	10— 8¼	707	5	15	1120	1	2
12—E	74000	11—1¾	9—0⅜	15—10½	754	5	15	1120	1¼	2
10—F	75000	13—1¾	9—0⅜	13— 3	772	5	20	1120	1	2
9—G	79000	15—2	9—0⅜	12— 0	792	5	20	1120	1	2
13—E	80000	11—1¾	9—0⅜	17— 2¼	817	6	20	1120	1¼	3
11—F	82000	13—1¾	9—0⅜	14— 6¾	849	6	20	1120	1¼	3
14—E	87000	11—1¾	9—0⅜	18— 6	881	6	20	1120	1¼	3
10—G	88000	15—2	9—0⅜	13— 3½	880	6	20	1120	1	2

Additional sizes and capacities on request.



Carrier Type "C" Washer Installed in the Lee-Higginson Building, Boston, Mass.

Details Characteristic of Carrier Type "C" Washers

Type "C" Carrier Air Washer and Humidifier is designed to meet the very popular demand for a machine without all the refinements of our Type "A" Washer, but still combining a high efficiency and a low first cost.

It is constructed of the same high grade workmanship and of exactly the same materials as our Type "A" and Type "B" Washers, and differs only in design. It is adapted for automatic humidity control during the winter months.

When compared with other competing standard washers, it will be found that:

1st. It has more than TWICE as many nozzles to spray the dirt and dust.

2nd. It has nozzles which spray in the DIRECTION of the air flow, so practically no resistance is offered to the air current by the spray.

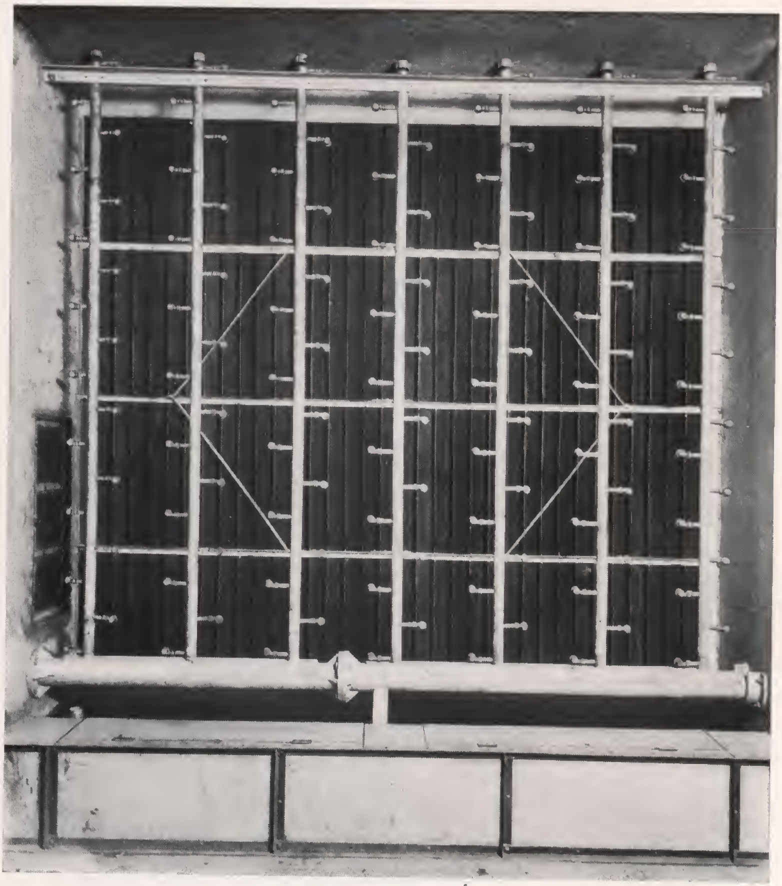
3rd. It has AMPLE water filtering surface and large orifices in nozzles to effectively prevent stoppage of the spray system.

4th. It has from 50 percent to 100 percent MORE washing surface to remove the dirt.

5th. It has MORE eliminators to break the air into thinner layers for the elimination of the dirt.

6th. It can be provided with the Carrier accurate, simple and dependable Automatic Humidity Control.

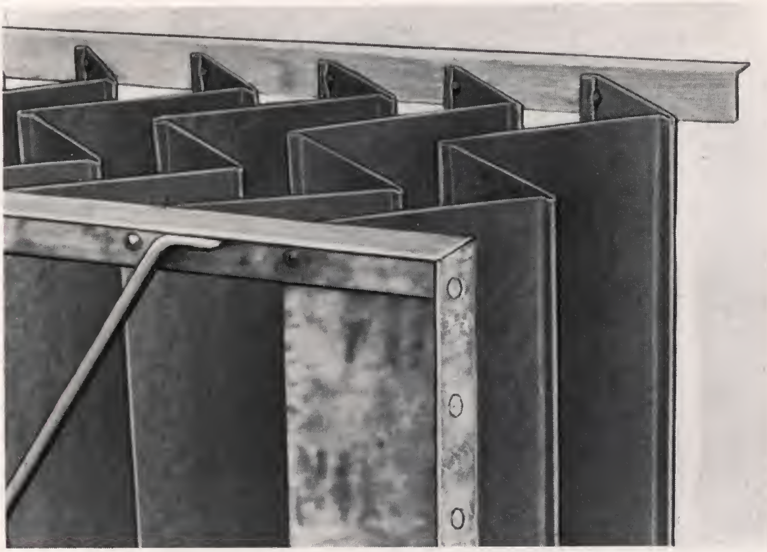
7th. The workmanship and material are of the very best.



INTERIOR OF TYPE "C" WASHER
Viewed from Air Inlet

Spray Chamber is four feet ten inches long enabling it to be used in many places where space is at a premium, and still giving sufficient room for the spray to completely cover the entire surface.

The nozzles are uniformly spaced so the spray is uniformly distributed, and as in our Type "A" Washer, not less than two and one-half nozzles are provided per each 1000 cubic feet of air per minute. The same adequate water-filtering system is used with the very large nozzle discharge orifice as in our other types of washers.



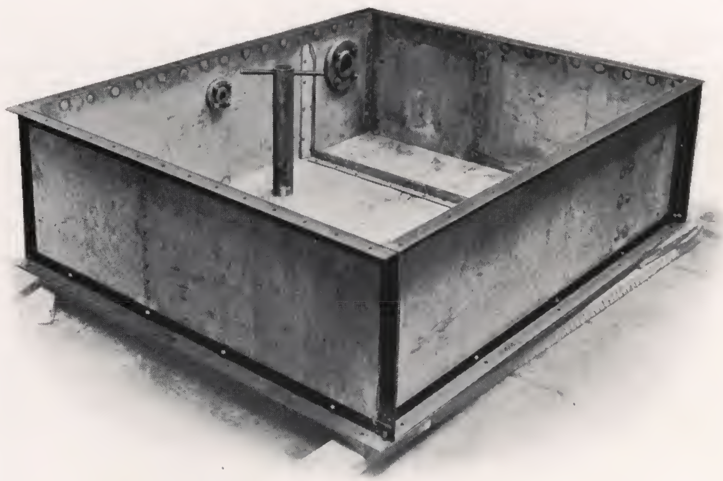
Carrier Type "C" Eliminators

Eliminators: The angle of deflection is 90 degrees with four corrugations, two of which have protruding lips preventing any entrained water being carried along the plate and out of the washer. The frictional resistance of this washer is less than .4 of an inch water gauge.

The plates are set vertically and spaced 3 inches center to center across the discharge end of the washer. Each eliminator is made of a single sheet with the protruding lips formed by crimping the sheet.

The plates are held together with angles at top and bottom and at intervals through the height to keep them evenly spaced and in proper alignment.

Two corrugations of each plate are kept wet by means of the atomizing nozzles giving 6½ sq. ft. of washing surface per 1000 cubic feet of air per minute.



Type "C" Tank
Showing combined Overflow and Drain Pipe and Angles which carry Suction Strainer

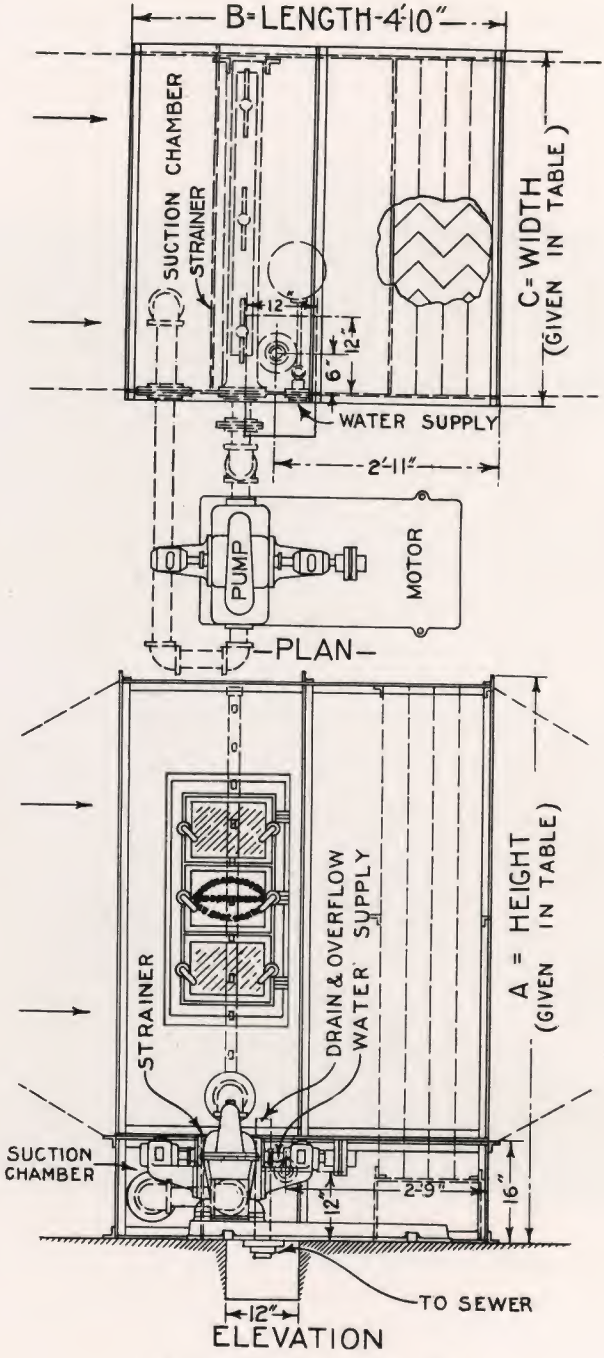
The Drain consists of a brass flange soldered to bottom of tank, without any obstruction in tank, allowing tank to be completely drained for cleaning.

The Overflow consists of a length of pipe of the proper height which is screwed into the brass flange of the drain connection. This pipe is removed when it is desired to drain the tank. A rod which serves as a wrench is provided for its operation.

Water Supply: A ¾ inch flanged pipe connection in side of casing is provided for the fresh air connection. On the inside of the casing is a duplicate flange and a ¾ inch float valve which maintains a constant water level.

Flanges are also provided on the outside of the casing for suction and discharge pipe to be run to the circulating pump. This supply and suction piping is not furnished with the washer.

THE SPRAYS OF A SMALL CARRIER TYPE "C" WASHER IN OPERATION



Carrier Type "C" Washer

DIMENSIONS FOR CARRIER TYPE "C" AIR WASHER

Number	Capacity in C. F. M.	Height A Feet Inches	Length B Feet Inches	Width C Feet Inches	G. P. M. Circulated	Size Pump Inches	H. P. Motor	R. P. M. Motor
1—A	1700	4—1½	4—10	1— 5¼	9	1½	2	1700
1—B	2300	5—1½	4—10	1— 5¼	11	1½	2	1700
1—C	3400	7—1½	4—10	1— 5¼	18	1½	2	1700
2—A	3500	4—1½	4—10	2— 9	18	1½	2	1700
2—B	4800	5—1½	4—10	2— 9	22	1½	2	1700
3—A	5400	4—1½	4—10	4— 0¾	27	1½	2	1700
4—A	7300	4—1½	4—10	5— 4½	36	1½	2	1700
3—B	7300	5—1½	4—10	4— 0¾	33	1½	2	1700
2—C	7300	7—1½	4—10	2— 9	36	1½	2	1700
4—B	9800	5—1½	4—10	5— 4½	43	1½	2	1700
2—D	9800	9—1½	4—10	2— 9	47	1½	2	1700
3—C	11000	7—1½	4—10	4— 0¾	54	1½	3	1700
5—B	12300	5—1½	4—10	6— 8	54	1½	3	1700
4—C	14900	7—1½	4—10	5— 4½	72	1½	3	1700
3—D	14900	9—1½	4—10	4— 0¾	70	1½	3	1700
5—C	18700	7—1½	4—10	6— 8	90	2	3	1700
3—E	18700	11—1¾	4—10	4— 1¼	87	2	3	1700
4—D	20000	9—1½	4—10	5— 4½	94	2	3	1700
6—C	22500	7—1½	4—10	7—11¾	108	2	5	1700
5—D	25200	9—1½	4—10	6— 8	117	2	5	1700
4—E	25200	11—1¾	4—10	5— 5	115	2	5	1700
6—D	30300	9—1½	4—10	7—11¾	140	2½	5	1700
4—F	30300	13—1¾	4—10	5— 5	144	2½	5	1700
5—E	31600	11—1¾	4—10	6— 8½	144	2½	5	1700
7—D	35400	9—1½	4—10	9— 3½	164	2½	5	1700
6—E	38000	11—1¾	4—10	8— 0¼	173	2½	5	1700
5—F	38000	13—1¾	4—10	6— 8½	180	2½	5	1700
8—D	40500	9—1½	4—10	10— 7¼	187	2½	5	1700
7—E	44500	11—1¾	4—10	9— 4	202	2½	7½	1700
9—D	45700	9—1½	4—10	11—11	210	2½	7½	1700
6—F	45800	13—1¾	4—10	8— 0¼	216	3	7½	1700
10—D	50500	9—1½	4—10	13— 2½	234	3	7½	1700
8—E	51000	11—1¾	4—10	10— 7¾	230	3	7½	1700
7—F	53500	13—1¾	4—10	9— 4	252	3	7½	1700
11—D	56000	9—1½	4—10	14— 6¼	258	3	7½	1700
9—E	57500	11—1¾	4—10	11—11½	259	3	7½	1700
12—D	61000	9—1½	4—10	15—10	281	3	7½	1700
8—F	61000	13—1¾	4—10	10— 7¾	288	3	7½	1700
7—G	62500	15—2	4—10	9— 4½	290	3	7½	1700
10—E	63500	11—1¾	4—10	13— 3	288	3	7½	1700
9—F	69000	13—1¾	4—10	10— 8¼	324	4	10	1120
11—E	70000	11—1¾	4—10	14— 6¾	317	4	10	1120
8—G	72000	15—2	4—10	11—11½	332	4	10	1120
12—E	76500	11—1¾	4—10	15—10½	346	4	10	1120
10—F	77000	13—1¾	4—10	13— 3	360	4	10	1120
9—G	81000	15—2	4—10	12— 0	373	4	10	1120
13—E	83000	11—1¾	4—10	17— 2¼	375	4	10	1120
11—F	85000	13—1¾	4—10	14— 6¾	396	4	10	1120
10—G	90000	15—2	4—10	13— 3½	414	4	10	1120
14—E	90000	11—1¾	4—10	18— 6	404	4	10	1120

Water supply ¾ inch, sewer connection 2 inches on all sizes. Additional sizes and capacities on request.

Details of Carrier Automatic Humidity Control

Carrier Automatic Humidity Control Applied to a Carrier Type "A" Washer

Carrier Automatic Humidity Control for Air Washers

The Carrier System of Automatic Humidity Control for Air Washers has many advantages over any other of the methods that have been proposed to accomplish this work.

1st. It is simple.

2nd. It is dependable.

3rd. It is extremely accurate.

4th. It is scientifically correct.

5th. It is a practical method.

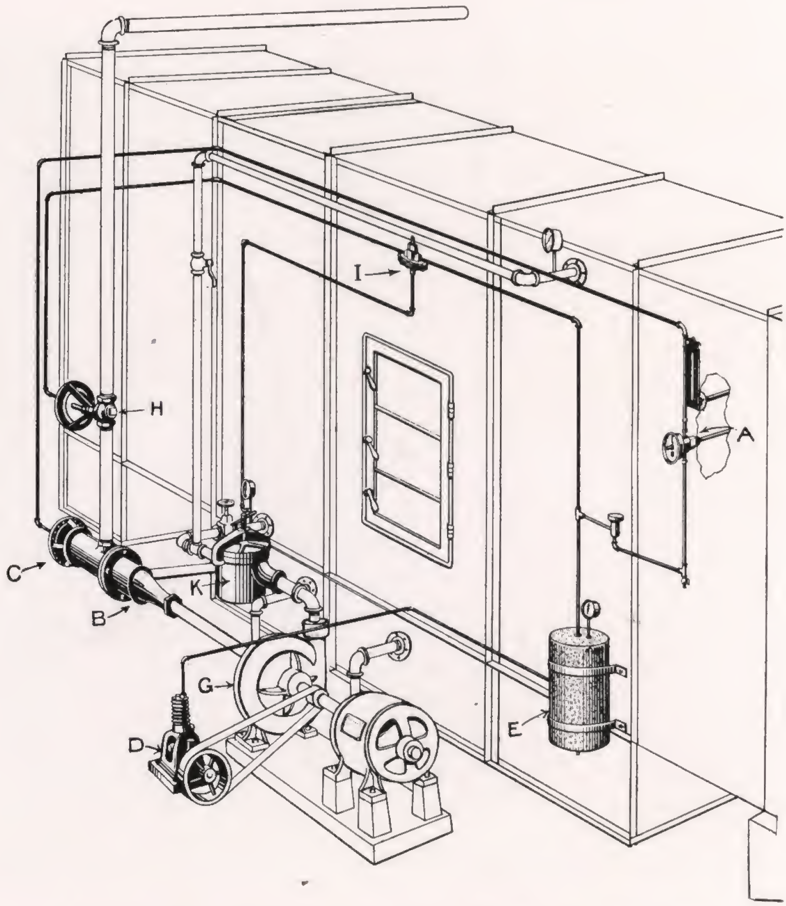
6th. It uses only a simple all-metal thermostat, instead of any form of hygrostat.

7th. It controls the temperature of saturation which accurately determines the amount of water vapor.

8th. It varies the spray water temperature in order to regulate the temperature of saturation, thereby successfully meeting every variation in the entering atmospheric conditions in a manner which it is impossible to obtain by the variation of a tempering coil or any other method.

Principle of Operation: The Carrier System of humidity regulation depends in principle upon the control of the dew point or saturation temperature leaving the air washer. Saturation is produced by heating the spray water. This water supplies the latent heat of evaporation, and, in addition, raises the temperature of the incoming air to the desired dew point; that is, to the temperature necessary to hold the required amount of moisture. The water temperature is varied as may be necessary to maintain a constant dew point under variable conditions of the entering air.

For a theoretical discussion see page 118.



CARRIER DEW POINT CONTROL WITH EJECTOR WATER HEATER

The General Arrangement of the humidity control system is shown on opposite page. The stem of a graduated thermostat shown at A is placed in the passage just beyond the eliminators, so that it is exposed to the temperature of the air leaving the washer, and its expansion or contraction is caused entirely by this temperature, and the variation due to its expansion is made to regulate this temperature.

The water heater of the ejector type shown at B is placed in the suction line to the pump. The heater operates like a barometric condenser, so that the temperature of the spray water is varied by varying the amount of steam furnished to the ejector.

The diaphragm steam valve shown at C is placed in the steam line which supplies the water heater. This valve is operated by compressed air pressure from the graduated thermostat A.

The air compressor shown at D furnishes compressed air at about 15 lb. pressure to the storage tank E. The compressor is driven by the same motor that drives the spray water circulating pump G.

The reverse acting diaphragm valve shown at H is normally closed, but is opened by compressed air from the tank E, passing through the safety valve, I.

This method is extremely sensitive, as any variation in the air temperature passing over the stem of the graduated thermostat produces a change in the air pressure on the diaphragm steam valve, causing the valve to partially open or close, thereby producing a new water temperature. In only a few seconds this water is sprayed into the air, affecting its temperature, giving to it more or less heat in accordance with the requirements of the thermostat. This air in about one second passes over the thermostat stem, imparting to it the change in temperature, thereby completing the cycle. The system, while sensitive, is not frail or delicate.

The Variation in the Amount of Work to be done is quite large. To illustrate: Supposing the requirement to be 60 percent relative humidity at 70 deg. F., which is the equivalent of 4.8 grains per cubic foot, which corresponds to a dew point of 55 deg. Then on a zero day, with ¼ gr. of water vapor per cubic foot in the entering air, the work per 1,000 cu. ft. of air is

$1{,}000 \times 55 \div 56$ .... =	982	B. t. u. sensible heat to raise the air from zero to 55 deg.
$1{,}000 \times (4.8 - 0.25) \times 1{,}080 \div 7{,}000$ =	700	B. t. u. heat of evaporation
Total heat required .... =	1,682	B. t. u. to increase vapor 4.55 grs. per cu. feet

Again, on a humid day of autumn or spring no heating of the water is required, since no additional moisture is needed, that is, when the entering wet bulb temperature reaches 55 degrees, there being no work to be done, no heat is required for evaporation.

A system of Automatic Regulation to be effective must meet any and all variation between the limits given *without re-adjusting*.

Water Temperature: In a Carrier washer using 4.5 gal. of water per 1,000 cu. ft. of air the necessary drop in the water temperature is $1{,}682 \div (4.5 \times 8.33 \times 1) = 45$ deg. This is about the maximum requirement.

If a tempering coil is used in front of the washer, of course the washer is relieved of a part of the work necessary in supplying the sensible heat. In the case of the first example just referred to, with the tempering coil heating the air, say to 50 deg., the amount of heat to be supplied by the water is

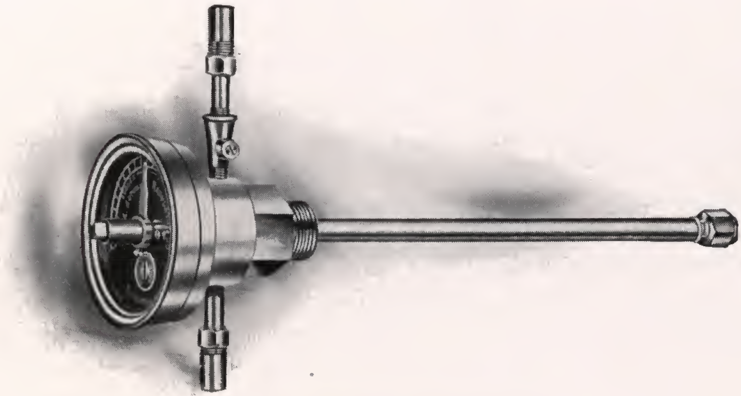
$1{,}000 \times 5 \div 56$ .... =	89	B. t. u. sensible heat
$1{,}000 \times (4.8 - 0.25) \times 1{,}080 \div 7{,}000$ =	700	B. t. u. latent heat
Total heat required .... =	789	B. t. u.

With the washer using 4.5 gal. of water per 1,000 cu. ft. of air, $789 \div (4.5 \times 8.33 \times 1) = 21$ deg. drop in water temperature is required to supply the heat. The conditions of the incoming air are changing constantly and continuously, so that the automatic control system must be extremely flexible to meet the great range of work required, if satisfactory results are to be procured.

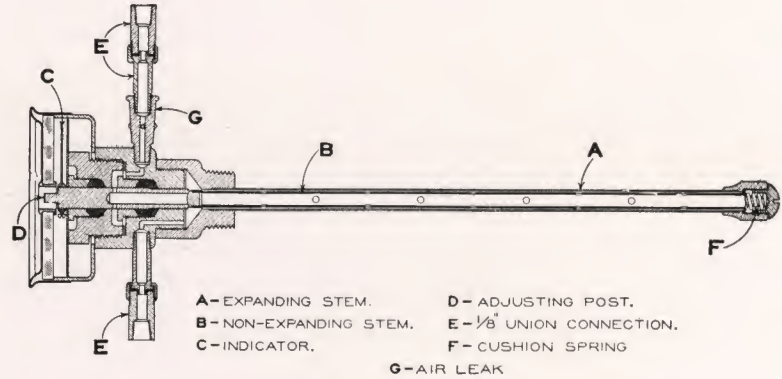
In any excepting Industrial installations, a dew point exceeding 55 degrees is never desired during cold weather, and as the final temperatures of the air and water are approximate, the temperatures to which the water is heated, even under maximum conditions, is not as high as is shown by the above figures.

Flexibility: It is seen that this method of automatic regulation is extremely flexible, covering all conditions which would be encountered in the heating season, and is at the same time simple, practical, accurate and dependable. With this method of humidity control it is not necessary to regulate automatically the tempering coils, as no harm is done if the temperature entering the washer falls below freezing. The coils are used in very cold weather to heat the air to any temperature, say between 25 and 45 deg., and thus relieve the spray water of some of the work.

We have, however, many successful installations in cold climates such as New York, Montreal and Buffalo where no tempering coils are used.

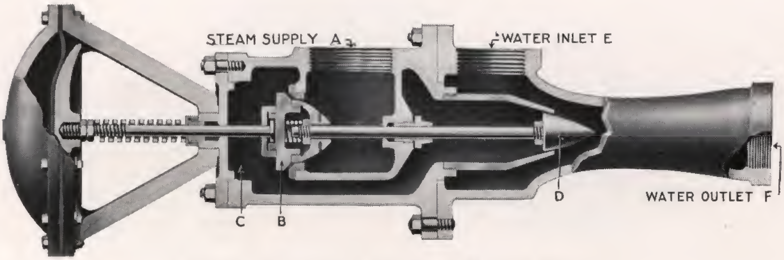


Carrier Dew Point Thermostat
(Description on next page)



Sectional View of Carrier Dew Point Thermostat

The Carrier Graduated Thermostat usually employed in maintaining a constant dew point is shown above. This consists of an outer expansive member A, usually brass, and an inner non-expansive member B, of nickel steel. These two members are firmly connected at the end F. The other end of the inner member B is provided with a bronze valve, ground to fit the adjustable valve seat D. Compressed air is admitted through the connection E, to the annular chamber, between the inner and outer tubes. As the outer member expands, the valve recedes from its seat, allowing the compressed air to escape into outlet connection G, which connects with the diaphragm valve controlling the temperature of the spray water, thus moving the valve so as to reduce the temperature of the dew point. When the dew point temperature falls below the point desired, the outer member contracts, closing off the air supply to the diaphragm valve, connected to G, and the air pressure to the diaphragm motor is released through the adjustable vent. This vent allows an air leak varying with the pressure on the diaphragm motor. Therefore, the relation of the area of opening through the valve G to the constant area of the vent opening G determines the graduated pressure on the diaphragm motor at any instant. This thermostat is sensitive while positive in action and simple in construction.



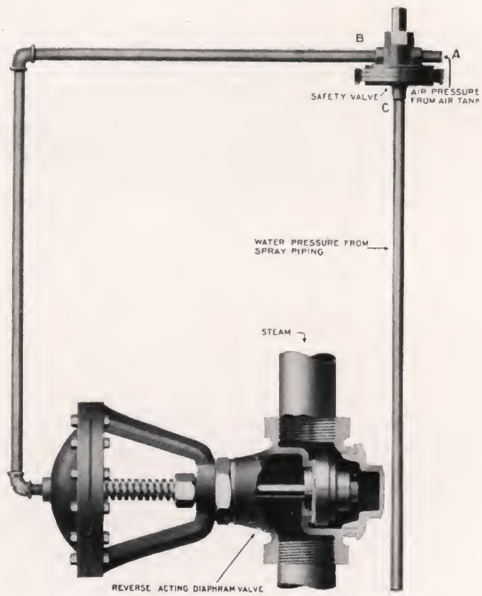
Carrier Noiseless Ejector Water Heater

Ejector Water Heater: The common difficulty usually experienced in the heating of water by an automatically controlled ejector is the noise produced when very little steam is being used. This noise is a water hammer occurring when a reduced amount of steam at low velocity enters a large volume of water and suddenly condenses. This causes a partial vacuum, which the water immediately fills, producing an impact which forces the valve against its seat.

The design of the heater shown above prevents the hammering of the valve. The diaphragm steam valve is made a part of the heater. The steam enters at A through the valve B into the chamber C; then through the orifice D. The water enters at E and passes out at F. The opening through the orifice D varies with and is approximately equal to the opening of the valve B for all positions of the latter. The valve and conical plug D are on the same stem and their position is controlled by the diaphragm. Air pressure causes the diaphragm to close the valve when too much steam is being supplied; that is, when the temperature of the air at the thermostat is too high. A reduction of air pressure allows the spring to open the valve wider. This water heater is the culmination of five years' experimenting to get an ejector that would be practically noiseless with varying quantities of water. It will operate with steam at 3 lb. or over.

For small washers the type shown on page 59 is used.

The Reverse Acting Diaphragm Steam Valve is located in the steam supply line running to the ejector water heater. It is held closed by a spring when the air pressure is relieved, or when it is low.



Reverse Acting Valve and Carrier Safety Relay

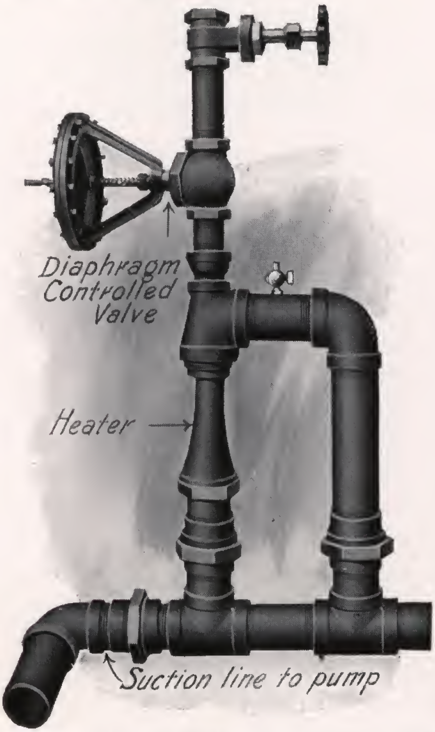
The Carrier Combination Safety Valve consists of a small double-seated air valve operated by a diaphragm and coil spring.

Compressed air direct from the tank enters at the connection A and outlet B connects with the diaphragm of the reverse acting steam valve. Water pressure from the centrifugal pump is connected to the under side of the metal diaphragm at C.

Should the water pump be shut down or should it for any reason lose its suction, the water pressure is released from under the diaphragm, or should the air pressure fail, the reverse acting diaphragm steam valve is closed. The combination of these two valves makes it necessary for the proper air and water pressures to be supplied to the apparatus before any steam can be used in the water heater. This arrangement makes it impossible for steam ever to enter the air currents and over-humidify the building on account of failure of air or water pressure.

Carrier Pot Strainer With Basket Removed

The Pot Strainer used in the discharge line of the pump is for the purpose of catching any scale or dirt which may be brought from the steam lines into the ejector. The suction strainer in the settling tank removes all dirt from the spray water, but the pot strainer is an additional insurance against stoppage of the spray nozzles.



Carrier Ejector Water Heater for Small Equipments

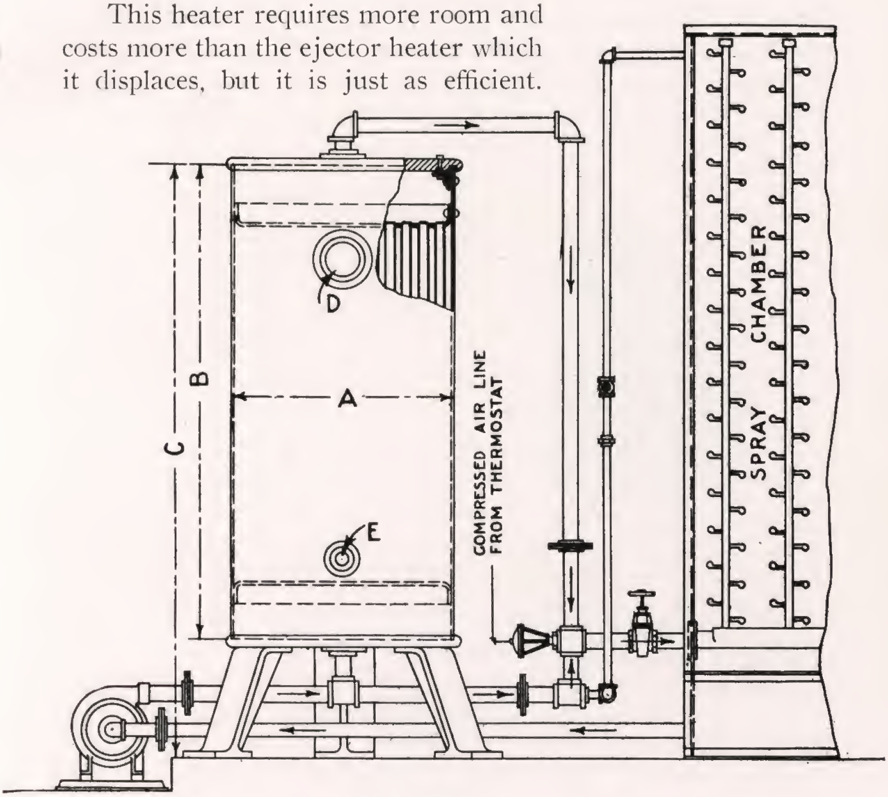
Carrier Closed Water Heater
Showing Steam and Drip Connections on the sides and Water Connections top and bottom

Closed Water Heater: Where steam is not available at a pressure of three pounds or over; that is, where a vacuum steam heating system or hot water heating is installed, an ejector heater cannot be depended upon for continuous and satisfactory service. In such plants a closed water heater is substituted for the ejector heater and safety device with the reverse acting diaphragm valve.

The water passes through the tubes at a high velocity, insuring a high efficiency of the heating surface. The steam or hot water heating medium is on the outside of the tubes.

The regulation could be effected by means of an automatic diaphragm valve on the steam supply operated by the dew point thermostat, but this method is somewhat sluggish and not so accurate as is the mixing of the heated water with some of the water which is bypassed around the water heater so the proper temperature is procured.

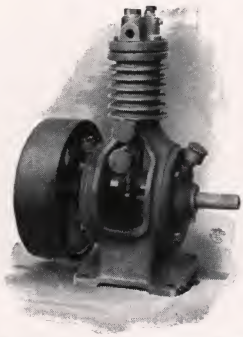
This heater requires more room and costs more than the ejector heater which it displaces, but it is just as efficient.



Closed Water Heater Connected to Washer With Bypass and Mixing Valve

Maximum Cubic Feet of Air Handled	Number of Heater	A – In Inches	B—In Feet	C—In Feet	Steam Pipes		Weight
					D Supply	E Return	
13,000	2	20	3—6	4—7	3	1¼	850
16,000	3	20	4—0	5—1	4	1½	900
22,000	4	24	4—0	5—1	4	1½	1000
29,500	5	24	5—4	6—5	4	1½	1150
42,500	6	24	7—1	8—2	5	2	1400
50,000	7	30	5—4	1—6	6	2	1700
60,000	8	30	6—5	7—3	6	2	1900
82,500	9	30	8—2	9—6	8	2½	2200
103,000	10	36	7—9	9—1	8	2½	2800
125,000	11	36	9—0	10—4	10	3	3100
158,000	12	42	8—6	9—10	10	3	4000
205,000	13	42	10—6	11—10	12	3	4700
243,000	14	42	12—0	13—4	12	3	5200

The Mixing Valve is used with the closed water heater and is operated by the graduated action dew point thermostat, so that it takes intermediate positions to give the proper mixture of heated and bypassed water required.



Pulley Driven Air Cooled Air Compressor

Hydraulic Driven Air Compressor

Air Compressors: Where automatic temperature regulation is employed it is usual to procure for the automatic humidity control, compressed air from the same source.

Two types of Air Compressor are employed by this Company. One a belt driven air cooled compressor, with large bearing surfaces, and designed to withstand continuous hard service.

In small installations, or those having only one washer a hydraulic driven compressor is often found to be preferable to the belt driven machine. The water is taken from the circulating water used in the washer and is exhausted from the compressor back into the tank.

Where a building is equipped with automatic temperature regulation it is usual to take from that system the compressed air supply required for the Humidity Control. A ⅛″ pipe connection is needed for each washer.

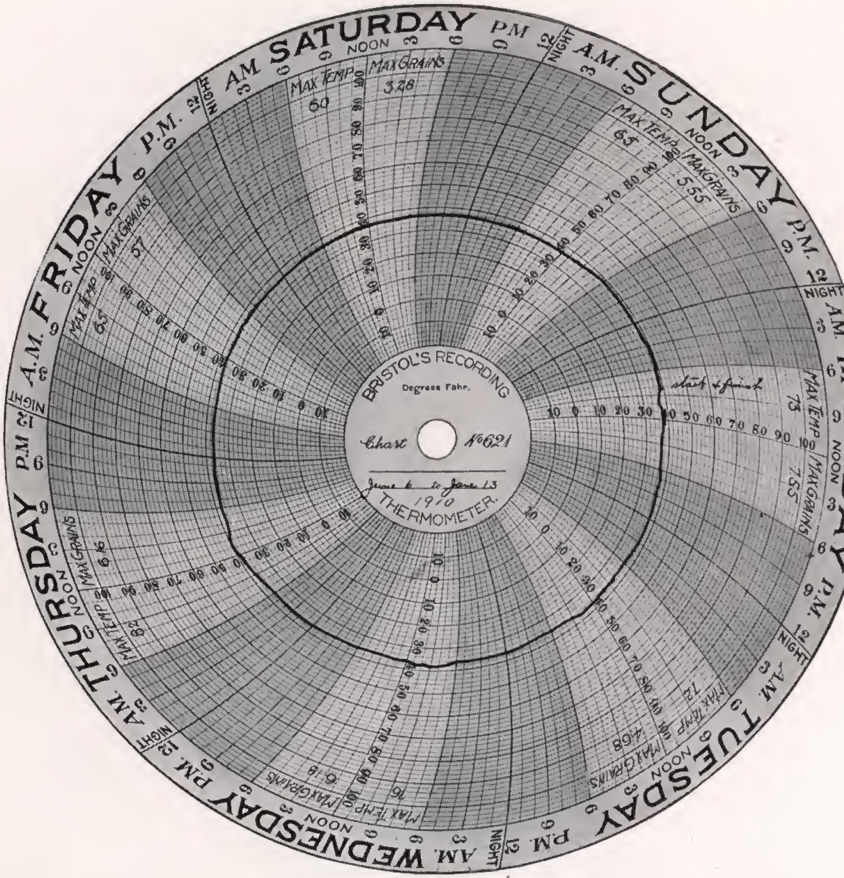
Temperature Control for Tempering Coil: If automatic control is for any reason desired for the tempering coil or coils, the thermostat should be placed in the fresh air, so it will be exposed to the temperature of the incoming air rather than to the temperature of the heated air. To illustrate:

Suppose one coil is thermostatically regulated and this coil has sufficient surface to increase the air temperature, say 15 deg., and the thermostat is set for 25 deg. When the outside temperature falls to 25 deg. this coil will be turned on full and the air heated to 40 deg. When the outside temperature rises above 25 deg. this coil is shut off and the air will go to the washer at temperatures varying between 25 and 40 deg., which is sufficiently close for the humidity control by this method.

The advantage of exposing the thermostat to the outside temperature rather than to the air leaving the tempering coil is that when the outside temperature falls below 25 deg. steam is turned on to the coil and is left on until the outside temperature rises above 25 deg.

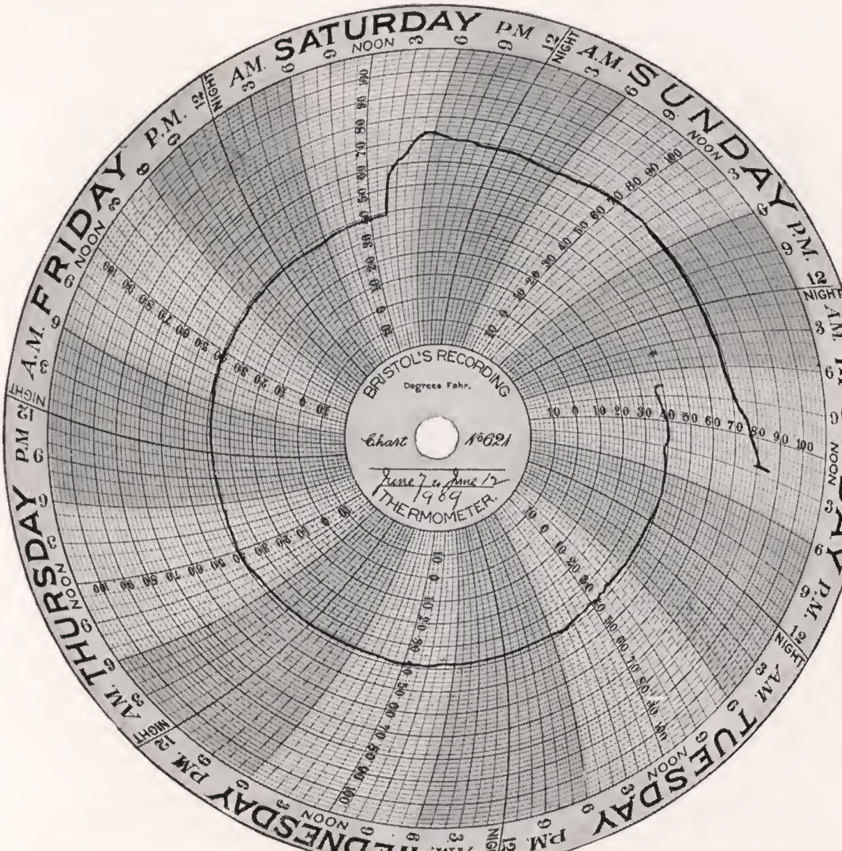
If, however, the thermostat was placed after the coil, whenever the temperature fell below that for which the thermostat was set the steam would be turned on the coil. As soon as the temperature rises a few degrees it would be again turned off. This continual turning on and off of the steam valve gives but little time to establish proper steam circulation, with the result that it is very probable only part of the coil will be heated; so troubles from stratification of cold and hot air will be experienced.

Pot Strainer Closed



CHARTS SHOWING THE ACCURACY OF THE CARRIER AUTOMATIC DEW POINT CONTROL

Accurate Automatic Absolute Humidity Regulation: The two charts shown above are photographs taken of charts from Bristol Recording Thermometers at the discharge of the Carrier Air Washer equipped with automatic control as described on foregoing pages and show the very splendid regulation procured. These charts were simply taken at random from a number of such records as we have, showing the accuracy of this system. It will be noted that these charts were taken in different months and under very widely varying outside atmospheric conditions. No adjustment or re-setting of any part of the apparatus is necessary to take care of these varying conditions.



NOTE HOW QUICKLY THE CONDITIONS CHANGE WHEN PLANT WAS SHUT DOWN AT 2 P.M. ON SATURDAY

For Industrial Work requiring great accuracy in the regulation of humidity, we have developed under our basic patents several types of automatic regulators. Each type is particularly suited to a certain kind of installation and work. Our engineering staff is at the disposal of those requiring such apparatus, to advise and recommend the type of regulator best suited to any plant.

Application of Carrier Air Washers and Humidifiers

The science of heating has and is receiving a great deal of study from engineers, and as a result of the united efforts of those who are working for the betterment of their profession, our heating plants are becoming better designed, better proportioned to the work to be accomplished, and far more efficient.

Ventilation and Cleanliness of our buildings and the necessity of pure air, about which we read so much, but of which in practice we see so little, are also receiving a portion of the attention they deserve, and gradually the general public is becoming educated to the fact that ventilation is not a luxury, but a hygienic and economical necessity. Those who have studied the subject are also convinced, that while ventilation is a necessity, the proper quality, as well as quantity of air should be furnished. That it is not sufficient to provide 20, 30 or 50 cubic feet of air per minute to each occupant of the room, but that this air must be properly washed or otherwise cleaned and purified in order to give even approximate ideal results.

A New Study: While there have been volumes written regarding heating and ventilating, and these have received the attention of some of our most eminent mechanical engineers, nearly or quite all until very recently have overlooked a subject almost as important and closely dependent upon these two—"Humidity."

The foremost and progressive engineers, students of public health and hygiene, now, however, are giving the subject much attention and study, with the result that the installation of air washers and humidifiers is increasing very rapidly each year.

The Anti-Tuberculosis Movement of the past few years has done more than anything, and probably everything else to impress the general public with the dangers of contagious diseases being procured from dust. There has been a growing demand for better means for dust elimination, and the engineers to meet this demand have installed air washers for those plants provided with mechanical ventilation. In fact, the use of air washers has grown very rapidly and today it may be said that their installation is almost universal in the better class of plants.

ONE WEEK'S DIRT
One pail per day from 9 a.m. until 4 p.m.

The Effectiveness of Air Washing

These pails contain dirt, mud, soot, bacteria of various sorts, and disease-breeding filth of all kinds. This muck was washed from the air used for ventilation of Public School No. 6, Brooklyn, New York, and shows the result of one week's run.

This mud was shoveled from the bottom of the washer settling tank after the water had been drained off. Of course all the finest dirt floating in the water was carried off.

Had it been possible to have strained the water as it was drained, no doubt five more pails would have been filled. These pails each contained approximately 25 lbs. of dry dust so this washer was collecting approximately one hundred and twenty-five pounds of dirt carrying disease.

Think of the economy of labor for cleaning the building and the great saving to the decorations and contents of the building by excluding this great amount of dirt.

Tale of Three Bottles

The Northwest Grammar School, located in the heart of the automobile garage section of Philadelphia, was troubled with partially burned gasoline, oil fumes, and odors throughout the building. The air supply to the ventilating apparatus was located near the entrance to a very busy garage.

The bottle on the right shows the clean, clear water used in the washer. The one on the left is filled with dirt swept from the inlet while the one in the middle contains a sample of the accumulated material in the tank. This sample was procured by drawing off the water slowly; then scraping up a bucket full of the conglomeration of dust, carbon, oil, gasoline and water. This pail was about one-fifth of the amount taken from the air in the one day's run, of six hours. The contents of the pail were allowed to settle and they stratified at different levels. The water was siphoned off, and the bottle filled.

A study of this bottle discloses three distinct lines. The lower two-thirds was filled with dirt and carbon. Condensed oil filled about three-quarters of an inch while the upper part was filled with condensed gasoline. The gasoline would burn freely when a lighted match was applied.

These bottles were exhibited by the Health Officer at the meeting of the National Convention of School Superintendents, held in Philadelphia early in 1913.

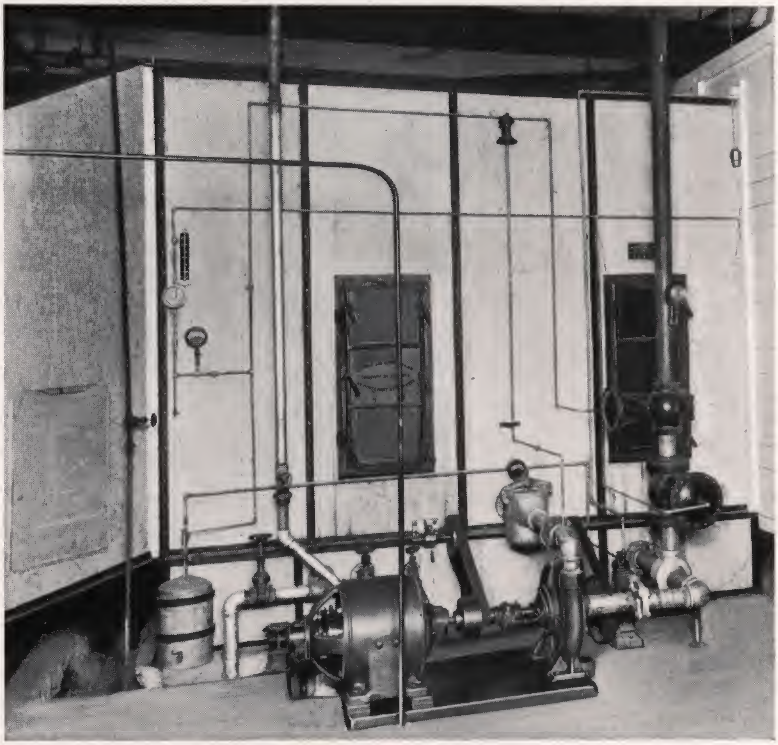
The odor from gasoline and oil fumes is not noticed in this school since the air washer was put into operation.

Necessity for Clean Air: In our cities the amount of solid matter carried in the air is enormous. The greater part of this consists of soot or unconsumed carbon from soft coal burning furnaces. In addition to this, all manner of impurities from the surface of the streets and sidewalks are kept in circulation by air currents. Dust and dirt brought into the building are usually evident on the walls and ceiling in the vicinity of a fresh air register or by the dust deposited on the furniture. Each year thousands of dollars' worth of fine goods are ruined on the shelves of stores by this means.

Location of Air Supply: These air currents carry filth and disease germs into our dwellings, schools, hospitals, offices and stores. How important it is, then, that the fresh air supply for the heating system should be above suspicion. But how can we arrive at this except by an air shaft extending to the roof? True, we avoid the street currents, but are even more subject to the black soot which defaces the walls and settles thickly on furniture and hangings. Disregarding the questionable success which the elevated air shaft may be so far as concerns avoidance of disease germs and filth, the *expense* is almost prohibitive. The higher the building, the larger the air shaft necessary to convey the supply and the longer it must be. *Floor space* is a more valuable item even than the cost of the shaft, and the modern office or bank building cannot afford to sacrifice it.

In the great majority of cases the location for the fresh air inlet at the basement level, either through basement windows or through the sidewalk openings, is most *convenient* and *inexpensive,* but without some sure means of purifying it the most thoughtless owner would not consider delivering into his building air *loaded* with the scum of the street.

Loss of Heat From Our Bodies: Our bodies have very aptly been likened to furnaces in which a food is burned producing a varying amount of heat, which must be dissipated and the proper regulation of the loss of this heat is probably the most important factor in producing bodily comfort. This heat must be extracted in three ways; viz., *Radiation;* which varies directly as the difference between the temperatures of the body and the surrounding atmosphere. *Convection;* which varies with the velocity or movement of the air, and the difference between the temperature of the body and surrounding atmosphere. *Evaporation;* which varies with the



Carrier Apparatus With Automatic Control Installed in Burson Knitting Company, Rockford, Ill.

amount of moisture brought to the surface of the skin through the pores, with velocity or movement of the air past the surface and the depression of the wet bulb temperature below that shown by the dry bulb thermometer.

Humidity in Heated Buildings: In schools and other public buildings, the humidity of the air is of more consequence than is usually supposed. The amount of moisture which air can hold at saturation per unit of volume increases very rapidly with the temperature as shown by the psychrometric chart on page 120. At 70 degrees it will hold 8 grains of moisture per cu. ft. while at 32 degrees it can hold but 2 grains per cu. ft., and at zero only 0.5 grain. Air normally has a humidity varying from 40 to 50 percent of saturation, while if much above or below these limits it becomes uncomfortable if not actually injurious to the health. Hence, air at 70 degrees should contain from 3.5 to 5.5 grains per cu. ft., while at 0 degrees it contains only about 0.3 grains and at 32 degrees about 1.25 grains, so that in the usual systems of heating, with 32 degrees outside, the humidity of the air when heated to 70 degrees would be only 15.5 percent, or about one-half the humidity of the dryest climate known.

It is this extreme dryness of the air in a heated room which produces many of the discomforts commonly noticed, but not fully explained, such as extreme thirst, a parched feeling in the nose and throat, lassitude and headache. The effect of this extreme dryness is undoubtedly very harmful to the mucous membrane in nose, throat and the lungs, and may be considered a contributing source of many throat and pulmonary diseases.

Ordinary Rooms Dryer Than a Desert:

Outdoor Temperature Degrees	Per Cent. Humidity (assumed)	Per Cent. Humidity of same air when heated to 70°
0	50	3
	80	5
15	50	6¼
	80	10
30	50	12¼
	80	19½
45	50	21¼
	80	34

Type "A" Washer With Automatic Control Installed in Northwest Grammar School, Philadelphia, Pa.

When heating to the ordinary room temperature of 70 degrees, the relative humidities will be only 5 percent and 20 percent respectively, with corresponding moisture deficits of 3 grains to 4 grains per cu. ft. This creates an artificial climate, dryer than that of any desert.

Hygienic Effects: From a hygienic standpoint, the relative humidity affects the mucous membrane of the nose, throat and lungs. Dry air readily absorbs moisture from the skin, drying and cracking the delicate tissue, and frequently causing throat irritation and consequent coughing. The injurious effect on the mucous membrane is especially aggravated by a wide indoor variation in humidity. In fact, the theory has been advanced that a copious supply of fresh air at a constant temperature and a fixed humidity in a sanitarium, would do much for the cure of lung, throat and nasal diseases, as much, for instance, as the comparatively fixed weather conditions in Arizona.

Is Artificial Humidity Desirable?

This is a question not for the engineer but for the medical fraternity to answer. The engineer's province is to provide apparatus, appliances or means to furnish the results which the physicians specify.

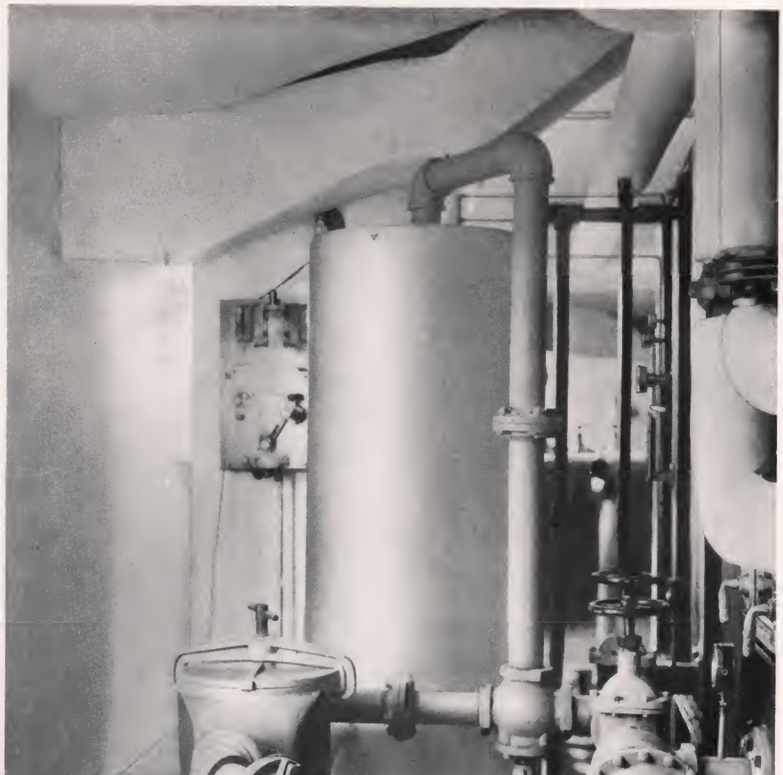
But few of us ever realize what is good for our bodies. It takes a lot of preaching to arouse the lay mind to any danger to his health.

We wish to quote from the following gentlemen who have studied this question from various viewpoints:

Dr. Henry Mitchell Smith, in a paper read before the Brooklyn Medical Society, entitled "Indoor Humidity," says:

"The point to be emphasized is that every time we step out of our houses during the winter season, we pass from an atmosphere with a relative humidity of about 30 per cent into one with a relative humidity of, on an average, 70 per cent. Such a sharp and violent contrast must be productive of harm, particularly to the delicate mucous membranes of the upper air passages.

"The skin and the mucous membranes of the respiratory passages are the principal sufferers, since these tissues are always kept moist with their own secretions and from them water is freely abstracted to satisfy this large saturation deficit, such air passing with every inspiration over the moistening surfaces nature has provided in the mucous membranes, calling for an enormous output of the fluid elements of these tissues.



Carrier Automatic Humidity Control Using Closed Water Heater and Mixing Valve. Installed in Bankers Trust Building, New York

This leads to glandular over-activity and its consequent evils, the elaboration of which subject the scope of this paper does not permit.

"The overheating of our houses has been accepted as a prominent cause of 'catarrh,' but I am confident that the low relative humidity and consequently the large saturation deficit of the aqueous vapor in the atmosphere of our rooms in winter is much more important than is the overheating in itself, and it may be doubted whether the so-called damp climate of the sea coast or the shores of large inland lakes is in itself so responsible for the above diseases, as has been generally supposed. It seems much more likely that the great contrast between the indoor and the outdoor relative humidity in those regions is the real factor.

"The former (65 to 68 deg. and 60 per cent) felt warm and balmy, the latter (72 deg. and 30 per cent) notwithstanding the higher temperature, chilly and dry, and the slightest motion of the air suggested a search for the source of suspected draughts.

"There is an indescribable sense of relaxation and 'poise,' contrasting strongly with the feeling of nervous tension so frequently experienced in overheated dry rooms.

"It was satisfactorily proven that one may live during the coldest weather with perfect comfort in a room at 65 deg. F. where the relative humidity is kept at about 60 per cent.

"During the experiments upon the sensations produced by different percentages of saturation and in order to obtain the opinion of persons having no knowledge of the existing conditions, one room was equipped with a moistening apparatus and the temperature kept at 65 deg to 68 deg., with a relative humidity of about 60 per cent. An adjoining room, without a moistening apparatus and heated by an ordinary steam radiator had an average temperature of 72 deg. to 74 deg., with a relative humidity of 30 per cent. In every instance, and without at all knowing what the temperatures were in the two rooms, the opinion was unhesitatingly expressed that the first room was several degrees warmer than the second.

"It is easier to 'take cold' in a room at 72 deg. with a relative humidity of 30 per cent than in a room of 65 deg. with a relative humidity at 60 per cent.

"Generally speaking, dry air is an excitant often causing sleeplessness and irritability, accompanied with a drier skin and quickened pulse. Moist air is more of a depressant, producing quiet sleep and slower circulation of the blood.

"After living in rooms with a lower temperature and proper relative humidity no one will be satisfied with the other conditions."

Prof. C. E. A. Winslow, associate professor of biology, College of the City of New York, and Curator of Public Health, American Museum of Natural History, in his paper "The Scientific Basis for Ventilation Standards," states:

"The really important factors which make for health or disease in the atmosphere are physical rather than chemical or bacteriological. Our ideal must be the conditioning of the air so that the human machine may operate at the highest level of health and efficiency.

"The chief factors in air conditioning for the living machine, which in most cases far outweigh all others put together, are the temperature and humidity of the air."

Type "A" Washer With Automatic Control Installed in the Office of the Ford Motor Company, Detroit, Mich.

Again Prof. Winslow, before the Congress of Technology under the subject of "Factory Sanitation and Efficiency," says:

"The main point in air conditions is, then, the maintenance of a low temperature and of a humidity not too excessive. At the same time, a too low humidity should also be avoided. We have little exact information upon this point, but it is a matter of common knowledge with many persons that very dry air, especially at 70 deg. F., or over, is excessively stimulating and produces nervousness and discomfort. It would probably be desirable to keep the relative humidity between 60 and 70 per cent."

Prof. Theodore Hough, of the University of Virginia, in the *American Journal of Hygiene,* states:

"This objection to low humidity is due to the too rapid evaporation of water from the skin and air passages. The skin thereby becomes dry and tends to chap, cutaneous nerves are irritated in an unpleasant manner, with more or less disturbance of affairs in the central nervous system. Especially the drying of the conjunctival and sclerotic seems to be a matter of considerable importance. I suppose, too, that when the skin dries too quickly there is greater tendency to the deposition of the solids of perspiration in the ducts of the sweat glands. These ducts are not flushed out as they should be"

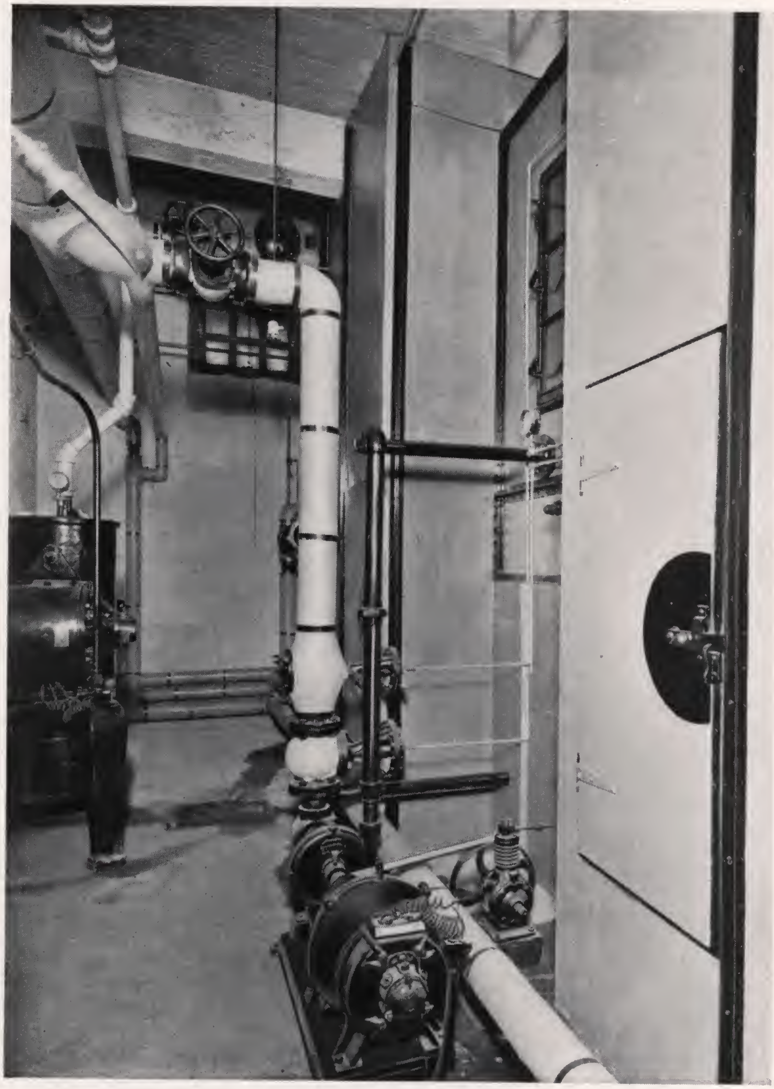
Dr. William Moir, master in surgery, Doctor of Medicine (Aberdeen), Diploma of Public Health (Cambridge), in testifying before the Parliamentary Committee of Ventilation of Weaving Sheds, stated:

"Personally I think that rheumatism—I do not mean acute rheumatic fever, but chronic rheumatism—is much more likely to be benefited by a high relative humidity figure than otherwise; and bronchial cases benefit very considerably by going into a humid atmosphere more than if it were a dry one."

He further states that a humidity up to 88 percent would not be injurious.

In an article by Dr. W. M. Wilson of the Weather Bureau, entitled "Atmospheric Moisture and Artificial Heating," the following is stated:

"The evaporation power of the air at a relative humidity of 30 per cent is very great, and when the tissues and delicate membranes of the respiratory tract are subjected to this drying process, a corresponding increase of work is placed upon the mucous glands in order to keep the membranes in proper physiological condition, so that nature, in her effort to compensate for the lack of moisture in the air, is obliged to increase the functional activity of the glands, and this increase of activity and the frequent unnatural stimulation, induced by the changing conditions of humidity from the moisture-laden air outside, to the arid atmosphere within our dwellings, finally results in an enlargement of the gland



Carrier Type C Washer Installed in the New England Historical and Genealogical Building, Boston, Mass.

tissues, on the same principle that constant exercise increases the size of any part of the animal organism. Not only do glands become enlarged, but the membrane itself becomes thickened and harsh, and sooner or later the surface is prepared for the reception of the germs of disease, which tend to develop under exposure to the constantly changing percentage of humidity.

"It might be interesting to notice some remarkable cases which have come under observation where catarrhal troubles have been relieved and apparently cured by simply introducing sufficient moisture into the air to bring the conditions to something near normal."

Drs. Thos. R. Crowder, J. A. Denny, and C. A. Schroyer, as a Committee on the Ventilation of Cars, read in the section on Preventive Medicine of the American Medical Association at its 62nd Annual Session held at Los Angeles, June, 1911, a report from which the following is copied:

"When the humidity is low, or the air motion is great a higher temperature is required than with high humidity and slower motion. Thus 70 deg. F. or more may be necessary to maintain comfort under certain conditions."

And again:

"The effects of a humidity which is too low may be partly overcome by maintaining a little higher temperature; the effects of a humidity which is too high, a condition only found in warm weather, can be overcome by air motion.

"Air has two principal functions: a chemical and a physical. It aerates the blood and it absorbs the body heat. For the performance of its chemical function it must contain a sufficient amount of oxygen and be free from poisonous gases; for the performance of its physical function it must have the proper temperature, humidity and motion to enable it to carry away the surplus body heat."

W. A. Evans, M.D., former health commissioner of Chicago, Ill., before the American Medical Association, may be quoted:

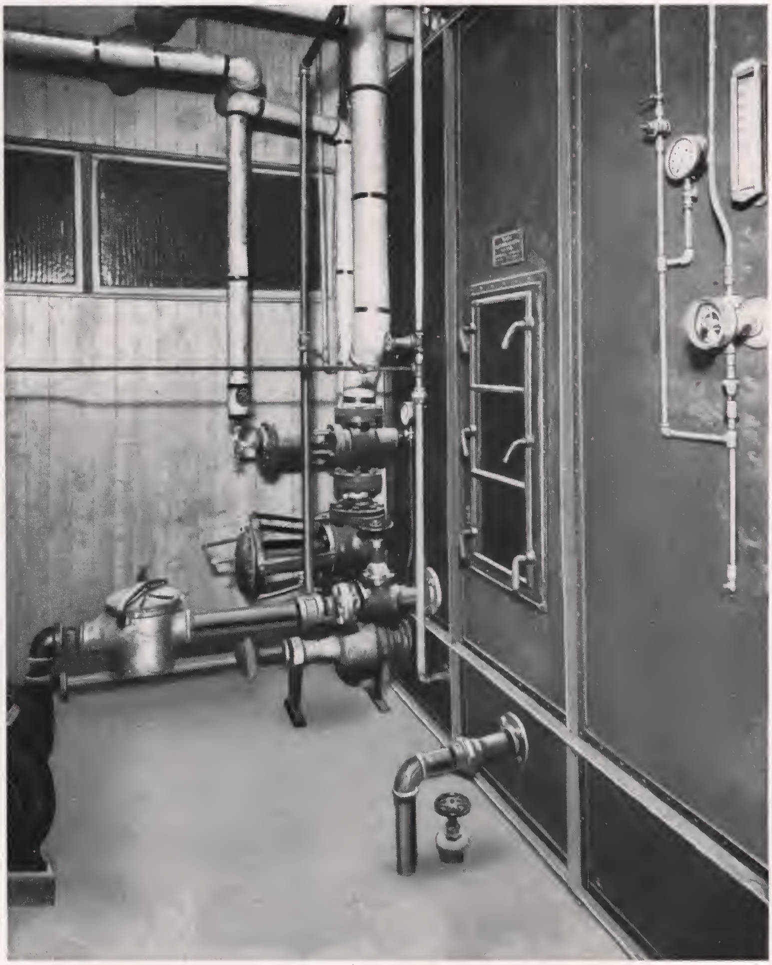
"What is the remedy proposed?

"1. Reduce the temperature of the rooms to a maximum of 68 deg. This temperature is more bracing. In such a temperature the exhaled air, being hot and moist, will rise right out of the breathing zone and be supplied by purer air.

"2. Raise the relative humidity to 60 per cent or 70 per cent. No possible objection can be raised to this except that it costs money to evaporate water and the windows will frost when the outside temperature gets to 20 deg. F. and below.

"If the relative humidity is raised to 60 per cent the pupils will be comfortable with a temperature of 68 deg. F.

"Some of the frosting of the windows can be prevented by putting a radiator under each window.



One of Three Carrier Type "A" Washers With Automatic Control Installed in the Western Pennsylvania Hospital, Pittsburg, Pa.

"But what harm does frosting do, anyway? Its harm is negligible as compared with the harm of over-dry air. It keeps out but little light, and under certain conditions of sunlight will give a mellower, softer light than the unobstructed pane."

Humidity: A Dust Preventive: Maintaining a moderate humidity prevents the drying out of the dust, thus rendering it less subject to draughts and other disturbances which would tend to scatter it over surrounding objects, and having less dust find its way to the radiator or other hot surfaces to be distilled.

Window Condensation: Objection is often raised to condensation on windows where humidifying is done. Windows are usually provided for the purpose of admitting light, and to allow a view of the surroundings from the inside. Frosting on the windows obstructs very little light, while it does interfere with vision, but this is usually not of much importance. When condensation occurs in sufficiently large quantities to run down on the window sill, it is objectionable and the best cure is to provide double windows, as a humidity of 35 percent to 40 percent will condense and flow on a window which the wind strikes on a cold day, viz., 10 deg. above zero F., or below.

The Cost of Humidifying, while not being by any means a minus quantity, as has been often stated, still can not be considered as prohibitory or excessive. The amount of power for running the circulating pumps for the spray water is small; the greatest expense being the heat necessary to procure the required evaporation in winter. One boiler horse power is required for each 3,500 cu. ft. of air per minute, to which is added one grain of moisture per cu. ft.

In a building with 21,000 cu. ft. of air supplied per minute, where it was desired to carry a relative humidity of 40 percent with 68 deg. temperature, the amount of moisture to be conveyed percent cu. ft. would be 3 grains. So it might be expected on a zero day to be necessary to have to add to the incoming air two and three-quarters grains per cubic foot.

$21{,}000 \times 2.75 \div 3{,}500 = 16.5$ boiler horse power of steam required.

Carrier Apparatus Installed in Ford Motor Company's Factory, Detroit, Mich.

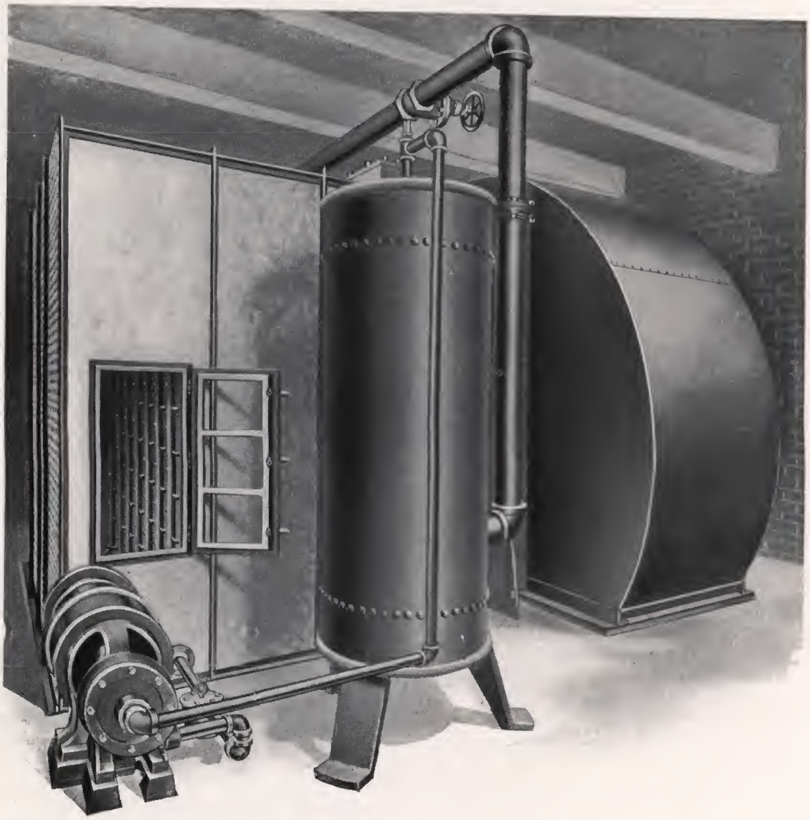
Relation to Heating: To understand more thoroughly the relation of humidity to heating, it is necessary to know that the temperature felt by the body, or the *sensible temperature,* as it is called, corresponds to the temperature of the wet bulb thermometer; hence, the dryer the air the greater is the difference between the actual and sensible temperatures. Dry air heated much above the normal will still be chilly, slight drafts are very noticeable and colds are easily contracted.

The excessive evaporation from the skin lowers the temperature of the body very rapidly, and as a result higher temperatures are required than would be necessary for comfort if the proper amount of humidity were present. On the other hand, if the percentage of humidity is excessive, the evaporation from the body is below normal, causing the slow evaporation from the body, with the result that the body heat is not radiated as speedily as is necessary for the comfort.

Importance of Regulating Humidity: From the above it is evident that the means for regulating the humidity should be considered side by side with proper ventilation in every school or other public building. The means provided for supplying and controlling the humidity in such buildings is fully explained in preceding pages. The effect of humidity is also quite marked in other ways, and deserves careful consideration from an economical standpoint.

Control of Temperature: The *inconsistency* of maintaining an absolutely constant room temperature by an elaborate thermostatic system is evident when we consider that the sensible temperature, upon which our feelings of comfort are based, is allowed to vary over a wide range. Personal sensations of heat or cold, as we have just shown, depend by no means on temperature only. A sudden increase in humidity frequently gives us the sensation of oppressive heat which the thermometer does not confirm. The greater evaporative power of air at low humidity accounts for the sensation of cold, and the evaporation of moisture from the body is the principal cause of irritation of the tissues.

No improvement in indoor atmospheric conditions can be expected until heating engineers and the public they serve realize that, with the ever-varying absolute humidity out of



One of Four Type "A" Washers With Automatic Control Installed in Luzerne County Court House, Wilkes-Barre, Pa.

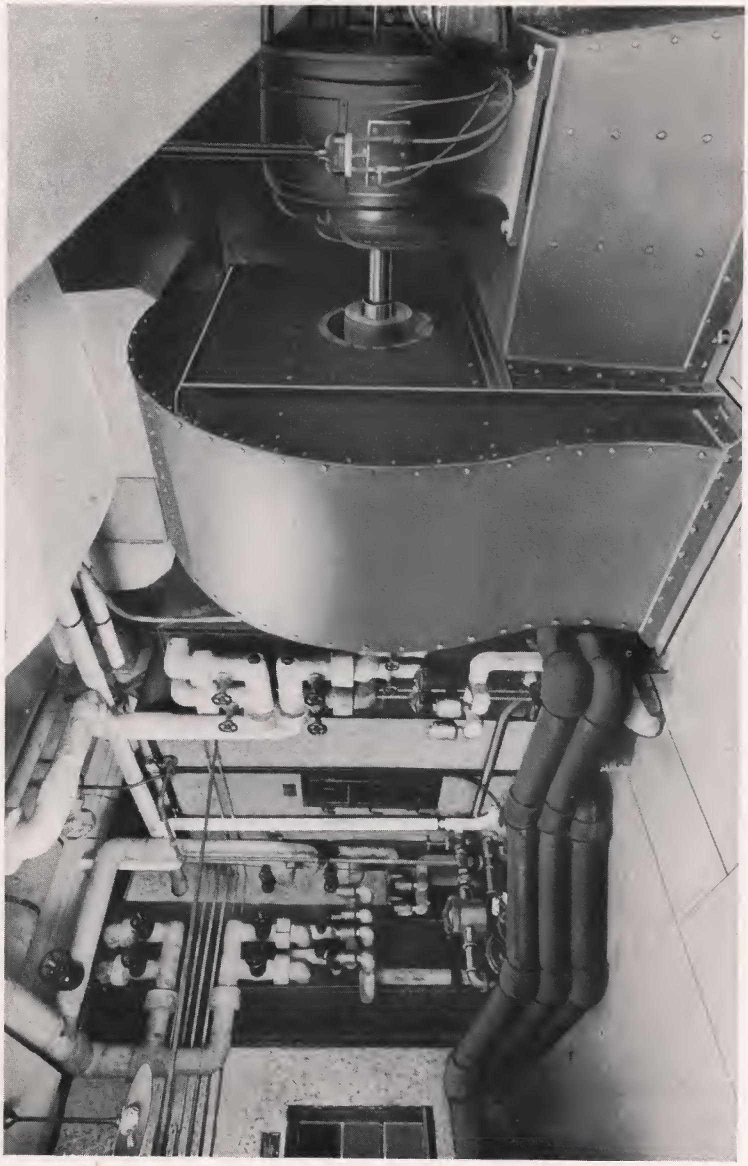
doors, no system of heating can be made satisfactory if the indoor relative humidity is disregarded. The most perfect automatic control of temperature will not fill the requirement, for a constant temperature is constant in its effects only if *accompanied* by a constant relative humidity.

The Problem: To furnish an air supply which is clean, pure, humidified, and properly heated or cooled—these, briefly, are the considerations which must be borne in mind. In order that it may not appear too simple, it must be remembered that the space allowed for the apparatus is *limited,* and that every particle of air passing at a high velocity must be thoroughly purified and *moistened* in the instant elapsing between entering and leaving the humidifying chamber. Not only this, but every particle of free moisture must be *separated* and removed from the air before passing further on. It is also essential that the proper temperature be maintained in the humidifying chamber to insure humidity control. These problems are all essentials, and we are prepared to state definitely that each and every condition laid down has been fully satisfied.

An Erroneous Idea of Weather Conditions: In summer it so happens that the hottest parts of the day, almost without exception, have comparatively a low relative humidity.

We often hear persons complaining of 85 degrees or 90 degrees temperature and 90 percent humidity; in fact, it is not unusual for writers upon the subject of humidity to make such reference. Such conditions never exist in our climate, as a careful survey of the climatic records will show.

The Actual Conditions: We often have 95 per cent, or even 100 per cent saturation early in the mornings, or on foggy days at temperatures in summer of 75 degrees or below. As the day grows warmer it will be found that the relative humidity decreases. There is just as much water vapor in the atmosphere, but owing to the increased temperature the moisture holding capacity has increased. (See page 113.) The lower the relative humidity the greater is the difference between the wet and dry bulb temperatures. New York City, as compared to other localities, usually has a high percentage of humidity, being surrounded as it is by water,



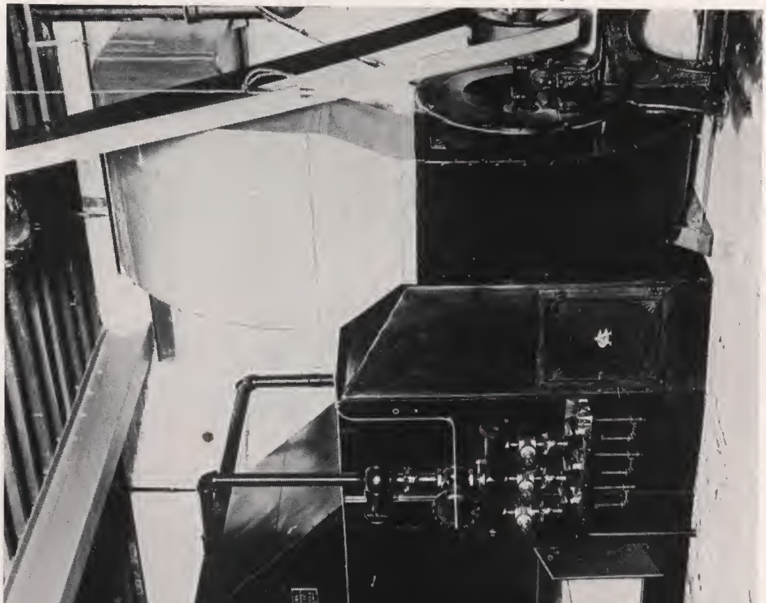
Carrier Dehumidifying Apparatus Installed in Hotel McAlpin, New York but whenever the temperature reaches 85 degrees it will be found that the percentage of humidity is below 65 per cent, and that on hot days the wet bulb thermometer registers about 15 degrees below the dry bulb temperature. In dry climates the depression of the wet bulb is still greater.

Cooling by Evaporation: As explained on page 116, when air is brought in contact with minutely divided or atomized spray water at ordinary temperatures, a portion of the water is evaporated, thus lowering the temperature of the air. The amount of cooling that is procured bears a direct relation to difference between the wet and dry bulb temperatures of the entering air.

A Carrier Air Washer and Humidifier, installed in one of the largest New York hotels during hot days, was able to deliver air to one of their dining-rooms at an average of 13 degrees below the outside temperature, thereby lowering the temperature of the room 10 degrees lower than when the Air Washer and Humidifier was not in use. These results were obtained when using the same water over and over and without causing a relative humidity in the room that was at all objectionable.

The cooling effect thus produced at a very low cost is of great importance to hotels, theaters, banks, stores and office buildings, not only because of the increased cleanliness and the more efficient work procured from the help due to the cooler and more invigorating atmosphere, but as an inducement to customers to visit those shops where they may be comfortable.

Effect Upon Our Comfort: In very hot weather as practically all the heat must be lost by evaporation with the higher temperature, perspiration is greatly increased in order to provide the required evaporation. The flow of perspiration to the surface of the skin is dependent upon the heat generated in the body and the pores of our skin, not unlike every other organ, rebel at being overworked. This excessive evaporation is very uncomfortable, even though all the heat may be dissipated. By increasing convection and radiation the perspiration is reduced and the losses are more uniformly distributed.



Carrier Dehumidifying Apparatus Installed in Acme Tea Company, Philadelphia, Pa.

It is not to be wondered at that providing conditions which distribute the heat losses more uniformly and nearer the normal ratio is found to be more desirable. There can be no question that with a stationary high temperature a moderately low humidity is more comfortable than a high humidity. On the other hand, we are convinced that under certain conditions low humidities and high temperatures are not so comfortable as high humidities and lower temperatures.

Limitations of Cooling by Evaporation: Cooling by evaporation has perhaps its limitations like almost everything else, and we are not prepared to say where this limit lies, but from the figures quoted, it will be seen that some of the humidities are very high.

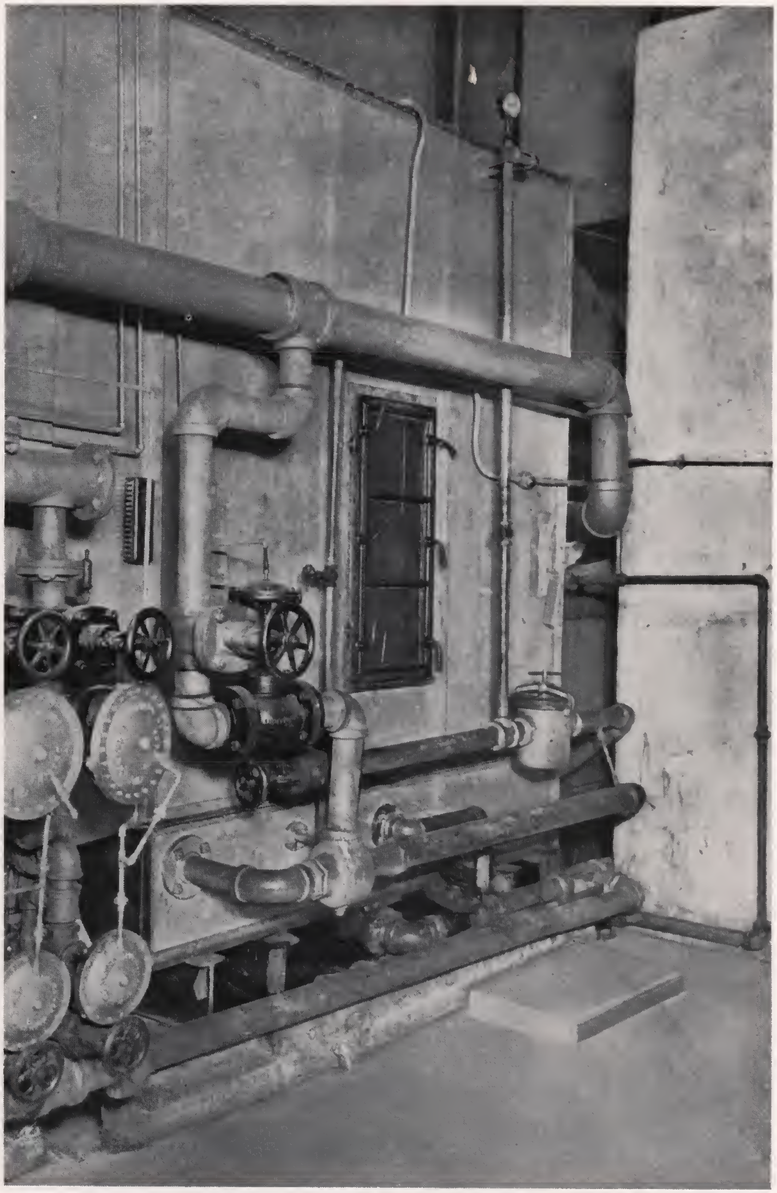
One thing that undoubtedly has considerable to do with our comfort is the "comparative condition." We can be quite comfortable in summer with conditions that would be uncomfortable in winter, or vice versa. We become accustomed to high temperatures or low temperatures and they cease to be disagreeable. A case has been given where 83 deg. and 84 percent humidity was more comfortable than the outside temperature of 93 deg. and 59 per cent humidity. The conditions were only comparatively comfortable, very much better than the natural outside atmosphere, but no one would desire such conditions except as an alternative for something worse.

Cooling by Refrigerating Machines: Where ideal results are desired for summer a few buildings in the past have been provided with ice machines for cooling and dehumidifying.

Those installations, generally speaking, which have been successful have used coils through which cold brine was circulated and over which the air for ventilation was passed.

The cold pipe surface cooled the air and condensed a portion of the moisture.

Carrier System of Dehumidifying: By the use of the Carrier System the water which is cooled by means of the ice machines is brought in direct contact with the air to be cooled. The cooling and dehumidifying effects are identical with the results obtained by use of the cold brine coils except that the Carrier System can be controlled more



Carrier Type "A" Washer With Humidity Control Installed in the Fifth-Third National Bank, Cincinnati, O.

easily. The advantages of the Carrier System are many; namely:

1st. The saving of power.

2nd. Saving in size of ice machines.

3rd. Saving in first cost.

4th. Saving in space.

5th. Saving in attendance.

6th. Ease and simplicity of regulation.

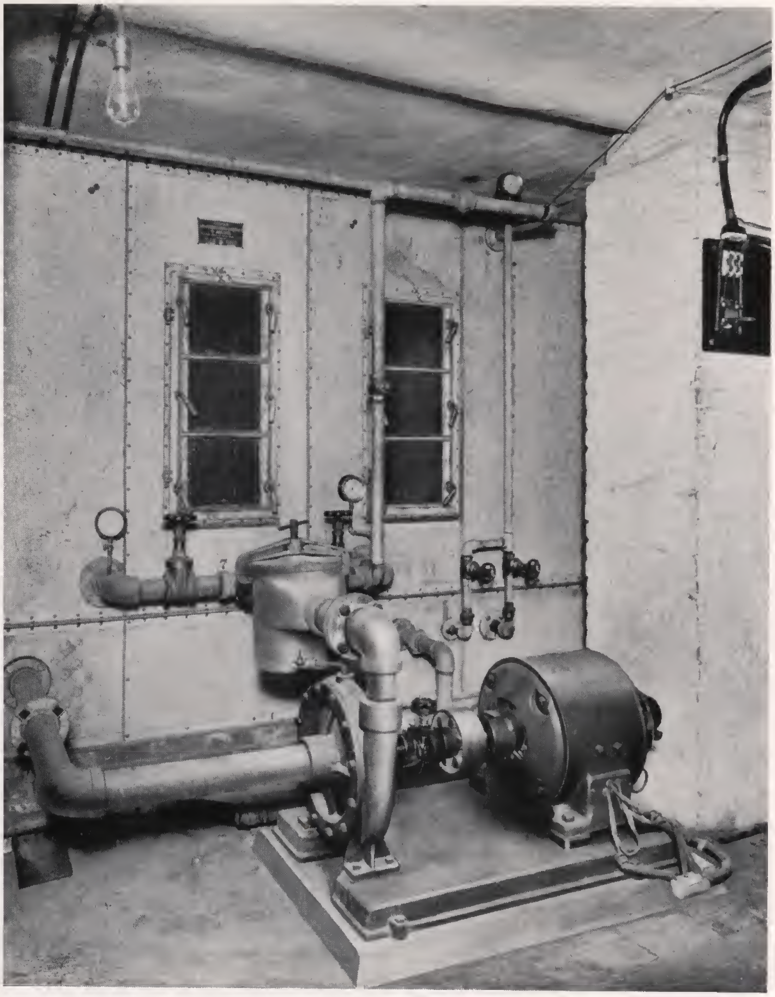
7th. A more efficient means of heat transfer, due to the intimate contact of the cold water and the air.

8th. The elimination of the trouble of ice or frost being deposited on the pipes, which has to be occasionally thawed off.

Well Water: In many localities an abundance of well water is available at temperatures ranging from 54 degrees to 60 degrees F. In such cases all results and benefits derived from an ice machine are procurable, except where unusually low temperatures and humidities are required. With the water entering at 54 degrees the air can be cooled to 60 degrees or lower, depending upon the relative amounts of air and water used.

Many large successful installations of the Carrier System, using both refrigerated water and cold well water have been in operation for several years.

Public Buildings and Offices: The Carrier Air Washer and Humidifier is adapted for use in all public buildings where health, comfort and cleanliness are factors considered. No heating and ventilating system is perfect or hygienic without it. In winter it relieves the oppressive and unhealthful dryness of the heated buildings by imparting to the air a natural and well regulated humidity—a feature particularly valuable in schools and offices. In summer it combines its functions as an effective medium for ventilation and purification of the air supplied with that of cooling. The reduction of temperature effected depends on the temperatures of air and water respectively; the average cooling effect is about 10 degrees, and the conditions governing this are covered more fully in the foregoing paragraphs.



Type "B" Washer Installed in Beacon Theatre, Boston, Mass.

Libraries and Banks: In libraries, where cleanliness of the air is of great importance, the system is invaluable, as it removes all traces of dust and soot, and a uniform relative humidity is very necessary for the preservation of books and records.

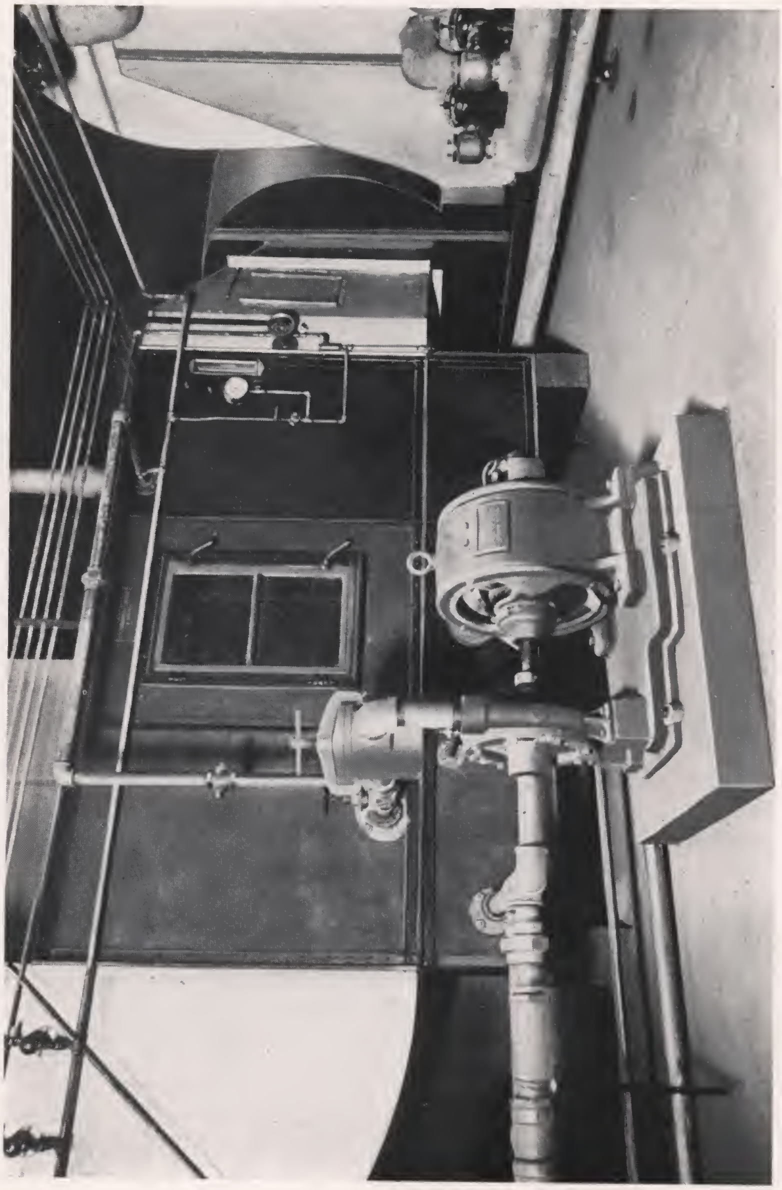
An eminent New York engineer, who was called upon to investigate the conditions in one of the large libraries in St. Louis, discovered that the lack of a proper percentage of humidity was ruining the leather bindings of the books within three years. Banks find it a valuable adjunct to the heating and ventilation. The La Crosse, Wisconsin, National Bank has the following to say in regard to the Carrier Air Washer:

"I am glad to state that the air washer which you installed in our new building is working very satisfactorily and we believe it to be as good as anything of the kind on the market. We do not hesitate to recommend it without reservation to anyone looking for an air-purifier."

Theaters and Churches: Any crowded hall or audience is in particular need of ventilation at all times and of cooling in summer. Large quantities of air are introduced through the various openings located about the auditorium and galleries where necessary to give a thorough distribution. To cool such a large volume sufficiently to produce a perceptible difference of temperature requires an abstraction of an immense amount of heat. To produce this cooling effect by passing the air over brine coils would require a large additional space, and on account of the inefficiency of the cooling surface, an expense for refrigerating apparatus nearly equal to the entire heating plant. Systems like this have been installed, but the cost has made such installations notable exceptions.

An atomized spray of water offers an enormous cooling surface as compared with either of the foregoing. The innumerable particles in intimate contact bring the temperature of the air nearly to that of the water, and this system offers by far the most practical and inexpensive means of cooling on a large scale wherever such cooling is combined with ventilation.

Hotels and Department Stores: Any merchant readily appreciates the great saving to his goods if dust and



Type "A" Washer With Automatic Control Supplying the Operating Room of Western Pennsylvania Hospital, Pittsburg, Pa.

dirt could be eliminated from his store. A proper installation of a Carrier Air Washer and Humidifier will entirely eliminate all dust brought in by the ventilating apparatus, and if the supply is ample all windows and doors can be kept closed, thus preventing any dirt from being blown in from the streets. The cooling of the building, however, is of the greatest importance, as the evaporation will keep the building at a cool and comfortable temperature.

A comfortable and clean establishment is a valuable asset to any store, hotel, or restaurant, and the proper humidity in a furniture store is very important to prevent the swelling or drying of the furniture. Silks, satins, worsteds, and cotton goods, if kept in an atmosphere with a proper humidity, retain their weight, lustre and "feel."

Mr. W. C. Grobheiser of the Manufacturers' Building Co., Grand Rapids, Mich., wrote us as follows:

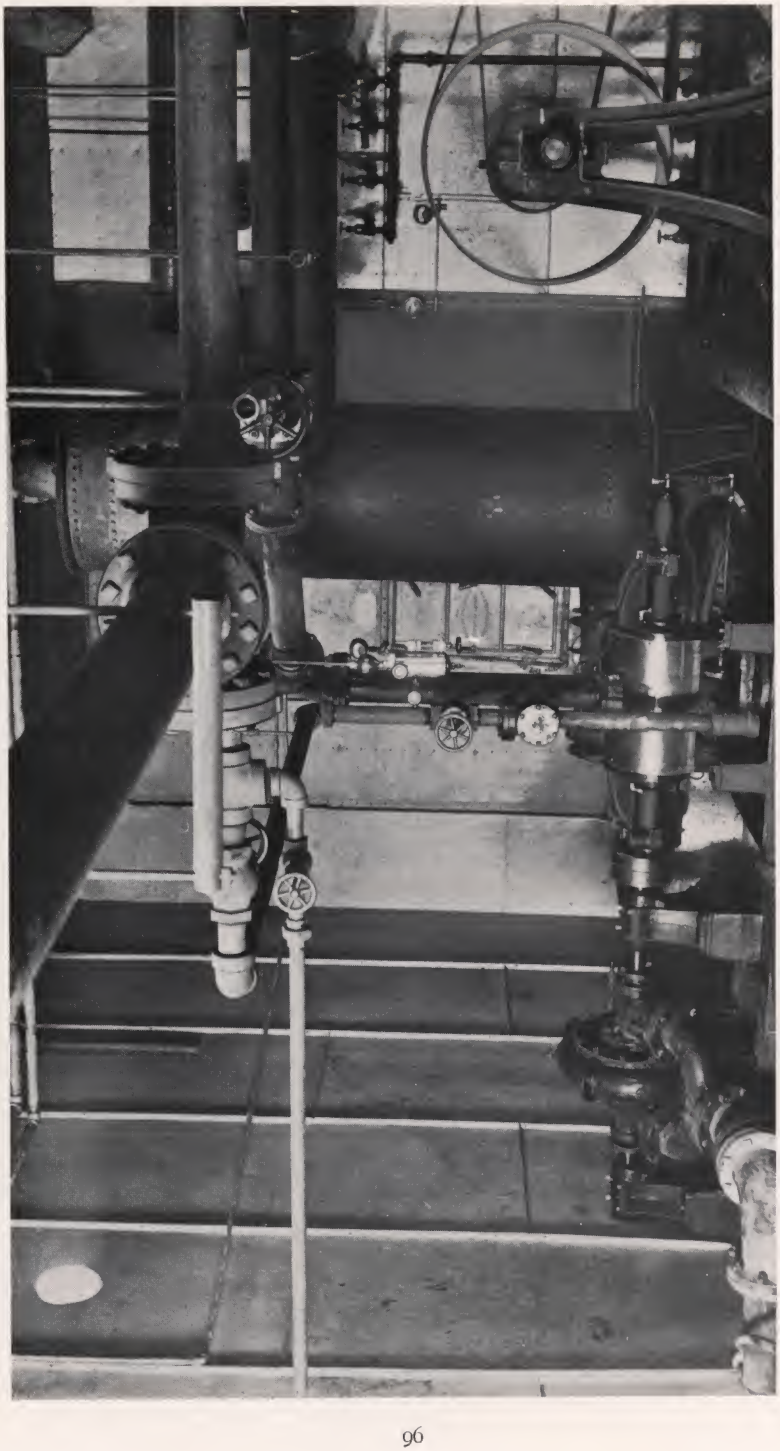
"In regard to the Air-Washer your Company installed for us in our exhibition building, I am pleased to say it has apparently given the best of satisfaction. Our Company, as you know, is composed entirely of manufacturers, who naturally are conversant with mechanical apparatus and who are quick to note defects in anything in the nature of machinery or appliances, or in the results obtained therefrom. I expected a criticism on this account, if there was any opportunity for it, as not all the members of our Company were thoroughly satisfied that it was policy to install an air-washer. But I am quite certain that in this respect they have been fully satisfied with the result obtained.

"We note one special feature in your air-washer that we think commendable, namely, that there is nothing in the nature of cloth screens or coke chambers to be replaced and cleaned, and as long as we have used your apparatus nothing has been required except to turn the current on the water pump.

"You may remember that in giving you our contract we made some very severe restrictions in regard to your successfully washing the air, distribute throughout the building and leaving it dry enough to not affect the drawer work in our furniture exhibits. Under ordinary conditions a damp day will swell the drawers so that they cannot be opened, and we feared this result in the use of your washer, and as the entire seven floors of our building are filled with furniture exhibits, almost every sample of which is handled daily, it is quite certain had the washer failed in its operation we should have heard from our many exhibitors, but after carefully inquiring among them I fail to find a single instance where there was a question in this respect.

"As you are aware we are adding to the capacity of our building and making changes in the heating system, and we may consult you in reference to changes we are making as we do not wish to make such important changes without consulting you.

"And if the system works as satisfactorily after we get these changes made, we shall certainly be very pleased with it and thoroughly satisfied that all your claims have been substantiated."



Type "B" Washer With Automatic Control Installed in the R. R. Donnelley Company, Chicago, Ill.

Lithographing and Color Printing Plants: Aside from the increased cleanliness due to the use of the Carrier Air Washer and Humidifier, the question of an even and uniform humidity is of the greatest importance to those printing establishments where close register work is done. With a constant temperature and a constant relative humidity there will be no expansion or contraction of the stock, no wrinkling of the edges and no changes in the stones after the job is once started through the press.

The following letter is self-explanatory.

DITTMAN-STEIDINGER COMPANY
COLOR PRINTING
251 WEST 19TH STREET

TELEPHONE 625 to 626 CHELSEA

NEW YORK January 6, 1913.

Attention of Mr. J. I. Lyle.

Carrier Air Conditioning Co.,
39 Cortlandt Street, City.

Gentlemen:

The Air Conditioning Plant which you installed in our pressroom last summer is and has been exceedingly satisfactory in its results to our work.

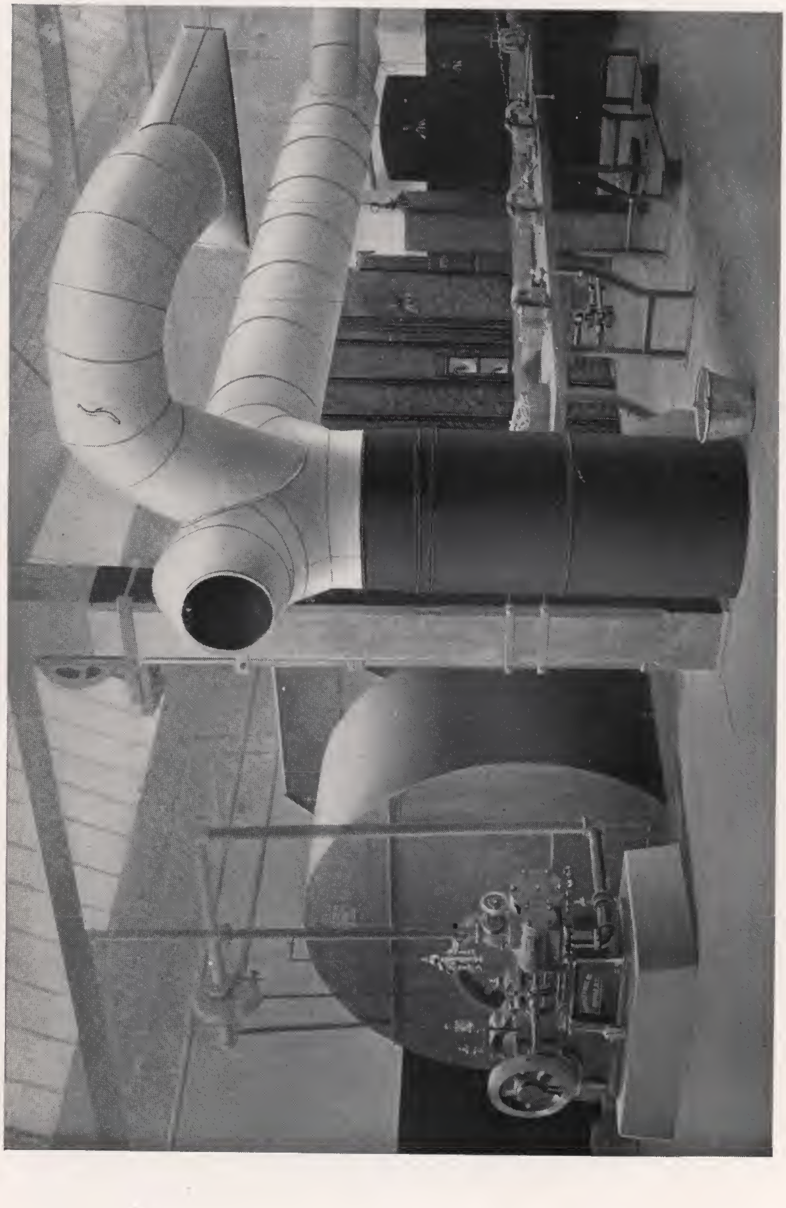
As an instance of what we mean, we would say that during last August we were able to run day and night shifts in our pressroom. As you know, the atmospheric conditions were severe during that time, but we were able to work without cessation, taking work from other printers who were unable to do the work owing to the conditions mentioned.

We consider "Air Conditioning" an absolute necessity for a pressroom equipped for the finest grade of printing.

Very truly yours,

DITTMAN-STEIDINGER COMPANY.

S. E. Dittman
Pres.



Type "A" Washer Installed in Warner Instrument Company, Beloit, Wis. A Type "B" Washer is also used in a later Installation.

The Schmidt Lithographing Company of San Francisco wrote our representative as follows:

"Referring to your recent request as to a statement from us whether we are perfectly satisfied with your Heating and Ventilating Plant which has been in a working condition for several months, we simply want to state that we consider this system one of the best investments we have ever made. By your arrangement of regulating the temperature and humidity throughout our plant, we have overcome all of the previous difficulties we have been having in the various branches of our business. We especially want to recommend your humidifying arrangement."

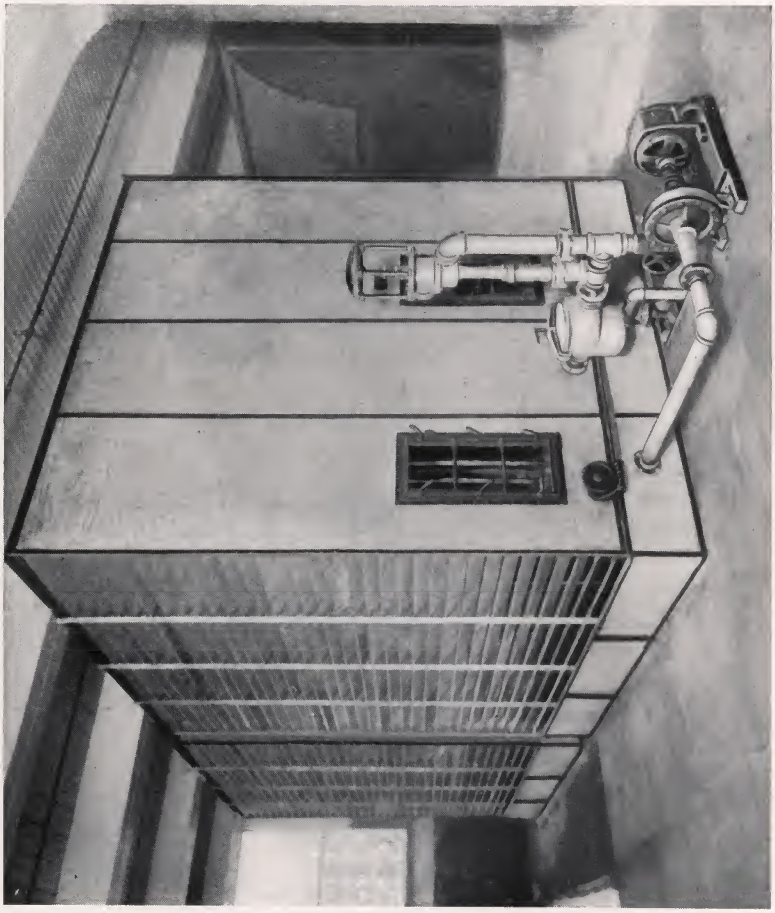
Industrial Plants: There are many plants where it is of the greatest importance to have all dirt, dust and other foreign matter removed from the air entering the building. This especially refers to writing and coated paper plants, watch factories, or where similarly fine and delicate work is performed. The Carrier Air Washer, by the elimination of dust falling on the product or work, makes it possible to produce a better output.

Mr. C. H. Warner, president of the Warner Instrument Company, wrote an inquirer as follows:

"This system was installed in Oct. 1907, and therefore has been in use for one year, giving us perfect satisfaction. The air washer removes all dust, soot, etc., from the air, including all insects, leaving the air perfectly sweet and clean as it enters the building. During the last summer we found that we could lower the temperature about six degrees by the use of the Air Washer, which made the building much more comfortable for our workmen."

Since this letter was written we have sold this Company a Type "B" Washer with Humidity Control for their new building.

Dust Collecting: In smelting works and reclaiming plants, small particles of precious metals are carried along with the furnace gases. From the buffing and polishing wheels of jewelry factories and silversmiths a great deal of valuable metal is continually being lost. Settling chambers, dust collectors, operated by centrifugal force, and screen devices have been used with only partial success, due to the fact that the heavy rouge and lint are caught, but the larger part of the valuable metal is in very fine particles, which escape with the air.



Carrier Apparatus With Automatic Control Installed in Farr Alpaca Company, Holyoke, Mass.

The Carrier Air Washer removes and collects practically all this fine metal. In some plants the value of the metal collected in a few months is sufficient to pay the entire cost of the equipment.

One of our earliest installations was made in connection with smelting furnaces, where the saving has been enormous.

Textile Mills: We issue a special catalog of the application of Carrier Apparatus in Textile Mills. The Carrier System has revolutionized the humidifying of these mills as it cools them in summer, keeping the temperature below the outside on hot days. The Carrier Automatic Humidity and Temperature Control maintains the atmospheric conditions constant, allowing a maximum production with more healthful conditions for the operatives, and with stronger and better yarns and cloth.

This telegram was received in response to our telegraphic inquiry regarding conditions in the Lewiston Mill of the Susquehanna Silk Mills.

Form 168

THE WESTERN UNION TELEGRAPH COMPANY

INCORPORATED

25,000 OFFICES IN AMERICA. CABLE SERVICE TO ALL THE WORLD

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ROBERT C. CLOWRY, PRESIDENT — BELVIDERE BROOKS, GENERAL MANAGER

RECEIVED AT the WESTERN UNION BUILDING, 195 Broadway, N. Y. ALWAYS OPEN — JUNE 22, 1910

2:43 p.m.

Q 273 p 16 COLL

LEWISTOWN, PA. 22

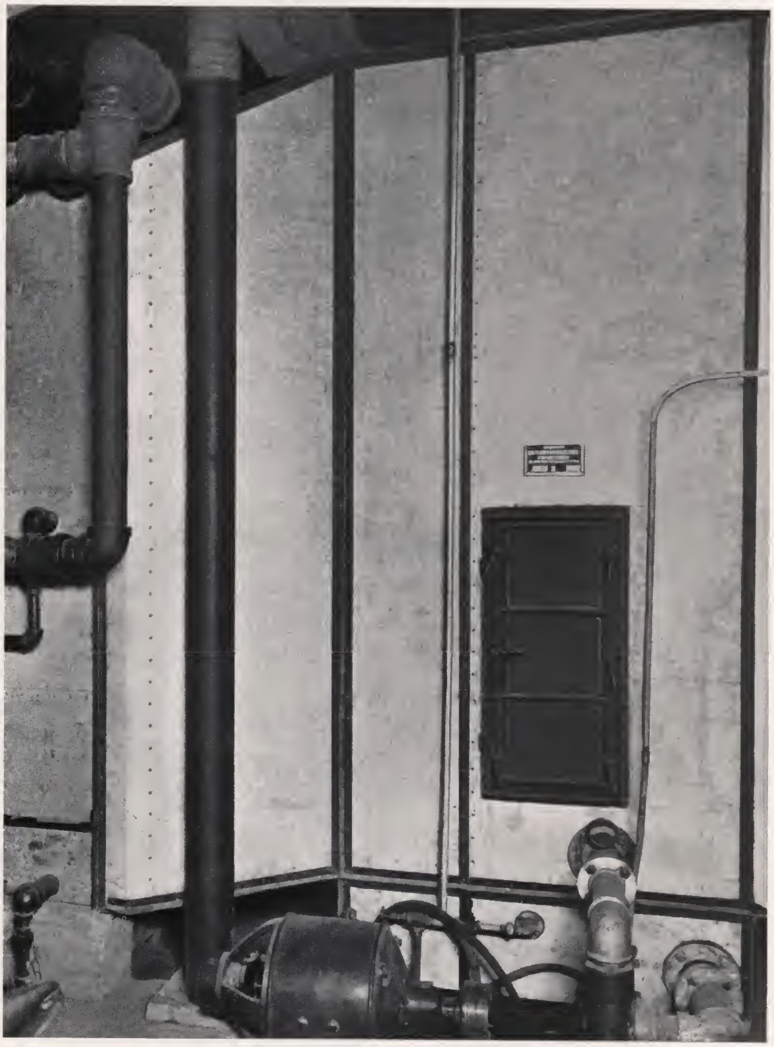
CARRIER AIR CONDITIONING CO.

NEW YORK

TEMPERATURE OUTSIDE DRY BULB NINETY EIGHT HUMIDITY FORTY FOUR

INSIDE DRY EIGHTY THREE HUMIDITY SEVENTY FIVE

SUSQUEHANNA SILK MILLS



Carrier Type C Washer Installed in National Theatre, Detroit, Mich.

Drying and Humidifying: The drying of nearly all products of manufacture is accomplished by passing air over the product that has been heated to a high temperature, so its relative humidity is low. The capacity of absorbing moisture is even more dependent upon the relative humidity than upon the temperature, although both are the direct factors which determine the rapidity of drying.

In many cases it is most important that the air used for drying should be properly cleaned.

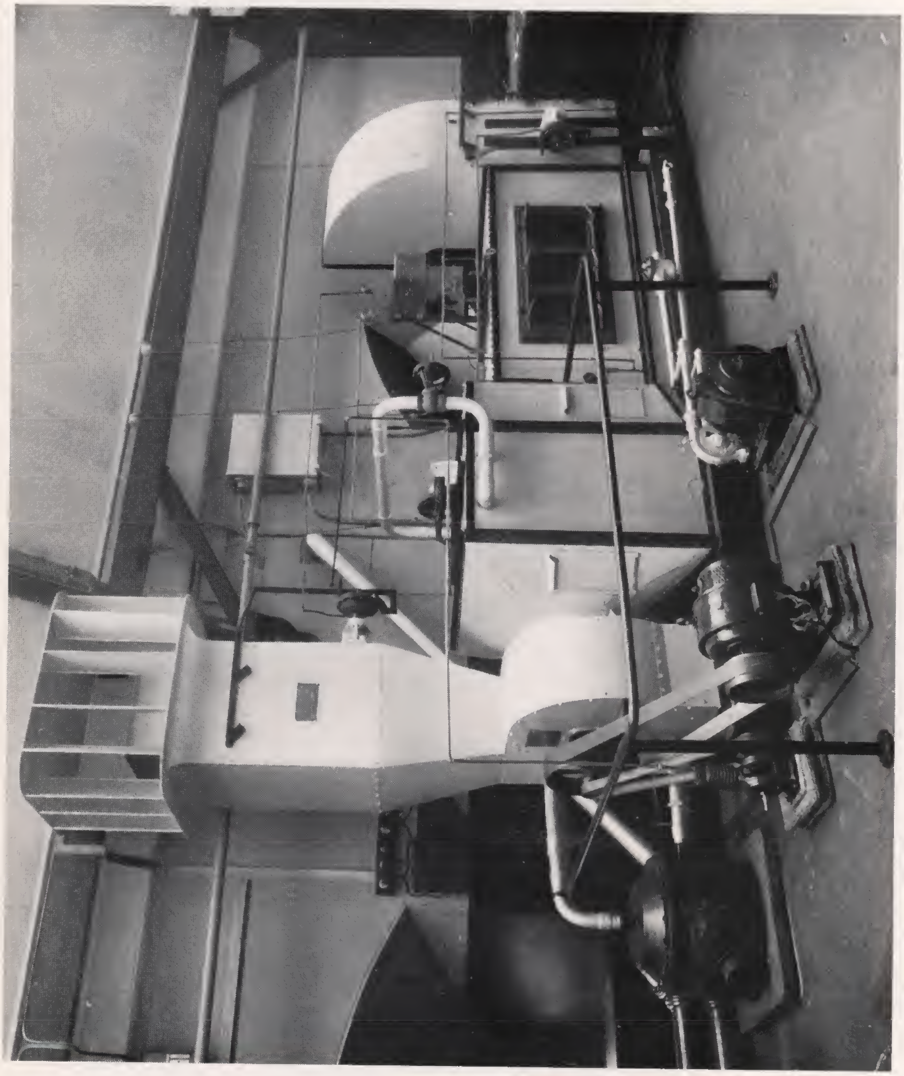
Drying of Terra Cotta, Pottery, Etc.: In the drying of many substances, such as art pottery, terra cotta, and smelting retorts, it is essential that the drying shall be gradual and uniform. In such cases the Carrier Air Washer and Humidifier with the Carrier Automatic Humidity Control is of an inestimable assistance. In such plants the humidity is usually very high at the beginning of the drying and is reduced gradually, allowing the product to dry evenly, uniformly and without cracks, checks, and rendering it less porous than when it dries too rapidly during the first stages.

The following is an extract from a letter written by the Trenton Potteries Company to another Company engaged in the same kind of business, in reply to a request for certain information regarding the system which we installed in their plant:

"In reply to your favor of the 20th inst. would state, the Carrier Air Conditioning Co. of America with offices at 39 Cortlandt St., New York, N. Y., have done considerable work for our Company, and a few months ago installed quite a good sized plant for controlling the moisture as well as the heat in the dry room, and fulfilled the promises they made to us.

"We believe them to be a thoroughly reliable company, and their engineer with whom we dealt is a very careful man and think you could rely upon any representations that they would make.

"Will be glad to know if you now have any system whereby you control both the moisture as well as the heat in your drying rooms, and if so, what was the old time necessary to dry your product, and what is the time you now consume. In our case, the old style dry rooms, it was a case of five weeks, which we have now worked down to three in this new installation, and whether the minimum time has yet been reached is a question that would require considerable experimenting, about which the writer would be glad to converse with you should you make the call."



Carrier Apparatus in the Chamber of Commerce Testing House, Manchester, England

Low Temperature Drying: Where the nature of the product is such that it is desirable to dry at low temperatures, the Carrier System presents the most economical solution of the problem, as the air is cooled, dehumidified, and then the temperature is slightly raised so it will absorb more moisture.

Among these products whose nature is such as to make it important that they be dried at low temperatures, are pottery, photographic films, electrolytic board and glue. Successful installations of the Carrier System in plants of this character are now in operation.

Turbine Generator Cooling: This Company has developed a special design of an air washer and humidifier for washing and cooling of air used in the ventilation of generators, which is known as our "Type G."

We issue a special catalog on this subject which we will gladly send upon request.

By the use of this machine, stopping or clogging of the small air passages in the generator, with the consequent loss in efficiency, is prevented and cost of frequent cleaning eliminated.

An overload of 10 per cent to 15 per cent can be carried by the generator with the same final winding temperatures in the generator, and with the same safety that would ordinarily be experienced under normal load.

The saving on a hot day thus procured is quite appreciable.

The machine is compact and can be run with a very low maintenance and operating cost without any fire risk as in the case of cloth screens which have been used in the past.

Laboratories: Where extremely sensitive and accurate physical and chemical weights or experiments are made, the removal of dust and the accurate regulation of humidity and temperature are of vital importance. This Company's apparatus was selected in competition with the whole world by the Royal Exchange Testing House, Manchester, England. Equipments have also been furnished the Edison Laboratories, Orange, N. J., the General Electric Co., Schenectady, N. Y., and others.

Humidity

By
Willis H. Carrier and J. I. Lyle

Vapor Pressure and Law of Partial Pressures

Water vapor exists in the air purely as a mixture in relation to its other elements. This vapor, according to Dalton's law, is capable of exerting a certain maximum vapor pressure dependent entirely on its temperature and regardless of the presence of the gases or vapors. For example, assume 1 cu. ft. saturated with vapor of alcohol at 100 deg. cent. having a vapor pressure of 1697.6 mm., and add, without an exchange of heat, to this 1 cu. ft. saturated with water vapor at 100 deg. cent. having a vapor pressure of 760 mm. This will give 1 cu. ft. of the mixture saturated with both water vapor and alcohol vapor at 100 deg. cent., having as a total pressure the sum of the two separate saturated vapor pressures, or 2457.6 mm. Similarly, an equal volume of a third saturated vapor might be added without affecting the other two. But if, on the other hand, it is attempted to include, without an exchange of heat, an additional amount of either of the saturated vapors, a corresponding condensation of the particular vapor added would result. In the same manner, an unlimited amount of a gas, such as air, could be added without an exchange of heat to a cubic foot of water vapor without affecting its condition of saturation, giving a combined pressure equal to the gas pressure plus the vapor pressure.

The established temperature-pressure relationship of saturated water vapor is shown by curve and tables, pages 120 to 126. This is the well-known temperature-pressure curve of steam.

Partial Saturation: When the temperature of a definite weight of saturated vapor is increased, without change in pressure, it is said to be superheated. Its specific volume is increased, in accordance with the law of gases, in direct proportion to the increase of absolute temperature, while its density is changed in an inverse proportion. The air simply affects the humidity by its temperature.

Water vapor does not spread so rapidly in air as in a vacuous space, as a certain amount of time is required for its diffusion.

Use of Terms: While the above is the accepted theory among scientists, and is really the only theory on which all of the phenomena of evaporation of water can be fully explained, still it is the common usage to consider that "air absorbs moisture." It was therefore considered best in submitting this publication to waive claims on scientific exactness of terms in favor of common usage. Use will be made of the accepted terms, namely, "the absorption of water by air," or "saturated air."

Absolute Humidity: Absolute Humidity is the weight of a cu. ft. of water vapor at a given temperature and percentage of saturation, and is usually expressed as grains per cu. ft. On page 121 is given a table of the amount of water vapor per cu. ft. at different temperatures and percentages of saturation.

Relative Humidity: Relative Humidity is the ratio of the weight of water vapor in a given space, to the weight which the same space will hold when fully saturated at the same temperature, and of course is expressed in percentage. Under normal conditions, the external air has a relative humidity varying from 40 per cent to 90 per cent of full saturation, and an absolute humidity depending upon external temperature. When the relative humidity is much above or below these limits, ill effects are experienced. The higher the temperature the more noticeable is the effect of moisture deficiency.

Dew Point: Dew Point is the temperature at which saturation is obtained for a given weight of water vapor. In other words, the dew point is the temperature where any reduction in temperature would cause condensation of some of the water vapor in form of dew particles. Every amount of moisture must have a dew point, for the temperature can always be so lowered that condensation must take place by any further reduction.

Measurement of Humidity: The quantity of moisture mixed with air under different conditions of temperature and degrees of saturation may be measured by four distinct methods, chemical, hygroscopic, dewpoint, and evaporative or psychrometric.

Probably the most convenient of all methods, and the one generally employed, is to observe the temperatures of evaporation. This is the difference between temperature readings of the wet and dry bulb thermometers.

Stationary thermometers in relatively stagnant air will not give accurate results. It is necessary that the thermometers be in a strong current of air.

Dewpoint Method: The dewpoint method was first brought into use by Daniels and by Regnault, and adopted by the United States Weather Bureau in the determination of the values used in their psychrometric tables. The dewpoint is measured directly by observing the temperature at which moisture begins to form upon an artificially cooled mirror surface. Determination by this method is extremely delicate and when suitable precautions are taken, is considered very accurate. However, it is questionable whether the true dewpoint is ever quite as low as indicated by this method. The temperature is usually taken by a thermometer placed in a thin silver tube filled with sulphuric ether or other volatile liquid, which produces cold by evaporation. The temperature of the exterior of this tube is undoubtedly at the true dewpoint, but it is questionable whether the thermometer at the center of the tube registers this dewpoint with absolute accuracy. The exterior surface of the tube must often be cooled 25 or even 50 deg. below atmospheric temperature in order to reach the dewpoint.

In any case a considerable quantity of heat must pass through the tube to the cooling medium from the external air by convection, and to a less extent from external objects by radiation. The internal resistance to the transfer of heat of a thin plate of metal, forming the wall of the tube, is in itself negligible; however, as any one who has studied the subject of heat transmission will recognize, the surface resistances are appreciable. On the outside there is the resistance of the surface exposed to the water vapor at low tension and on the inside the more considerable resistance of the liquid surface. There is therefore every reason to believe that the interior ether is at a slightly lower temperature than the exterior dewpoint. This conclusion conforms with conditions demonstrated by other observers in tests upon the temperature of the exterior of radiating or convecting surfaces. The extreme accuracy of the results obtained by the dewpoint method at high temperatures and low humidities would, therefore, seem greatly in question.

Evaporative or Psychrometric Method: The evaporative or psychrometric method is independent of and preferable to all other methods in scope and accuracy. It is of special interest in relation to the art of air conditioning, because the same fundamental phenomena are involved and subject to the same theory. It is of service not only in the art of air conditioning, but also a departure in the science of meteorology. It provides a method, remarkable for simplicity and accuracy, for the determination of the specific heat of air, which present methods have failed to establish, within an unquestioned accuracy of 2 per cent.

This method of moisture determination depends upon the cooling effect produced by the evaporation of moisture in a partially saturated atmosphere. This is usually measured by covering the bulb of an ordinary mercurial thermometer with a cloth or wick saturated with water and comparing its temperature with that of a thermometer unaffected by evaporation.

The temperature of the wet bulb is affected in a measure by radiation from surrounding objects. It is therefore very susceptible to air currents which serve to increase the evaporation and therefore decrease the percentage of error due to radiation. On this account, the earlier and more convenient form of hygrometer using a stationary wet bulb is very unreliable, considerable correction being necessary for radiation. The sling psychrometer advocated by the United States Weather Bureau overcomes this error to a great extent by increasing the ventilation and consequent rate of evaporation to such a degree that the heat received by radiation becomes a small percentage of the total heat transformation.

The Carrier Laws

The following principles underlie the entire theory of the evaporative method of moisture determination, as well as of air conditioning, discovered and formulated by W. H. Carrier:

(A) *When dry air is saturated adiabatically the temperature is reduced as the absolute humidity is increased, and the decrease of sensible heat is exactly equal to the simultaneous increase in latent heat due to evaporation.*

(B) *As the moisture content of air is increased adiabatically the temperature is reduced simultaneously until the vapor pressure corresponds to the temperature, when no further heat metamorphosis is possible. This ultimate temperature may be termed the temperature of adiabatic saturation.*

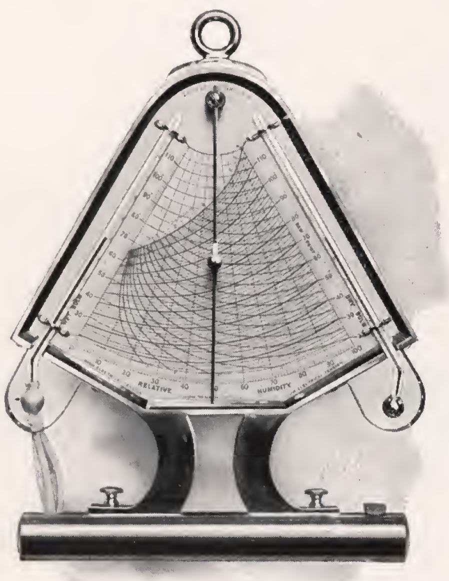
(C) *When an insulated body of water is permitted to evaporate freely in the air, it assumes the temperature of adiabatic saturation of that air and is unaffected by convection; i.e., the true wet-bulb temperature of air is identical with its temperature of adiabatic saturation.*

From these three fundamental principles there may be deduced a fourth:

(D) *The true wet-bulb temperature of the air depends entirely on the total of the sensible and the latent heat in the air and is independent of their relative proportions. In other words, the wet-bulb temperature of the air is constant, providing the total heat of the air is constant.*

Dry Bulb Thermometer: The dry bulb thermometer should be an accurate instrument preferably having the divisions marked on the glass tube of the thermometer. It should not be placed too close to the wet bulb, thereby preventing its being affected by the moist and cool air around the wet bulb.

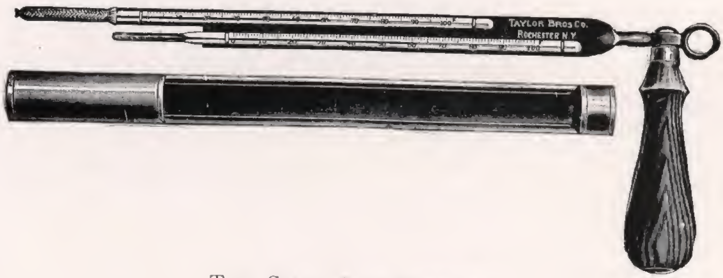
Wet Bulb Thermometer: The wet bulb thermometer, which gives a depressed reading in proportion to the evaporation therefrom, should be covered with soft muslin drawn tightly and neatly over it and thoroughly wetted in clean water. Clean muslin should be used, as the evaporation of the water will soon leave in the meshes a small quantity of solid matter which stiffens it and prevents its ready absorption of moisture.



Hygrodeik

Hygrodeik: While the hygrophant is the most common instrument used, the hygrodeik is very convenient, as the relative and absolute humidities can be read direct from the curves without further calculations.

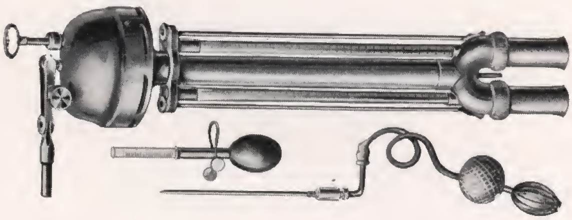
List Price each, Polished Brass Frame $15.00



The Sling Psychrometer

The Sling Psychrometer: This instrument consists of a wet and dry bulb thermometer, provided with a handle, as shown above, which permits of the thermometers being whirled rapidly. This instrument is convenient to use as it may be carried about a room or building by an observer and readings taken easily and rapidly. This is probably the most accurate instrument in general use, and is the one used by the United States Weather Bureau.

List Price, each $9.00



The Aspiration Psychrometer

The Aspiration Psychrometer: The aspiration psychrometer shown herewith is more accurate than the sling psychrometer as it will be noted from the cut that the bulbs of the two thermometers are enclosed in highly polished tubes so the temperature is not affected by radiation from surrounding objects.

A circulation of air is induced through the tubes by a small suction fan located in the top of the instrument. This fan is driven at a constant speed by means of the clockwork, which will drive the fan several minutes with one winding, giving a uniform strong current to produce a rapid evaporation from the wet bulb.

The small rubber bulb is used to moisten the wick or muslin covering the wet bulb.

This instrument is a German invention and is built with great accuracy and finish.

Relation of Wet Bulb to Dry Bulb Temperature: A careful study of the government psychrometric tables will show that the ratio of wet bulb temperature rise to dry bulb temperature rise is practically constant for any given percentage of humidity. For any range of temperature, for example, at 70 degrees and 60 per cent humidity, the wet bulb depression is 9 degrees, and for each degree rise of the dry bulb, the wet bulb must rise .876 degrees in order to maintain the humidity constant at 60 per cent. Similarly at 70 degrees, 80 per cent humidity, the wet bulb depression is 4½ degrees, and for each degree rise in the dry bulb, there must be a corresponding rise to .94 degrees in the wet bulb in order to maintain constantly 80 per cent of humidity.

Dew Point and Dry Bulb Temperatures: The relation of the dew point to the dry bulb temperature is both interesting and necessary to understand the methods of controlling humidity. This relation can be best illustrated by the following tables:

1. Grains of water vapor per cubic foot held by air when saturated at several temperatures.

Degrees	Grains
63	6.35
68	7.48
73	8.78
78½	10.11
82½	11.80

As the air is saturated, the temperatures given are the dew points for the various amounts of moisture. It is well to bear in mind that any given number of grains of moisture per cubic foot has a fixed and definite dew point or temperature of saturation.

2. Grains of water vapor per cubic foot held by air at 80 per cent relative humidity at several temperatures.

Degrees	Grains
70	6.38
75	7.49
80	8.74
85	10.19
90	11.83

Now compare the weights given for the first temperature in each table. We find that air 80 per cent saturated at 70 degrees holds 6.38 grains per cubic foot, and that air at a dew point of 7 degrees lower, or 63 degrees, holds 6.35 grains, or practically the same amount.

By comparing the others in succession it will be found that air at 80 per cent saturated holds the same amount of moisture per cubic foot as air approximately seven degrees lower in temperature but completely saturated.

It could similarly be shown that air 70 per cent saturated contains, the same weight of water vapor as air fully saturated 11¼ degrees lower.

Therefore, the principle of relative humidity control depends not upon the dry bulb temperature nor the dew point temperature, but upon the difference between the two.

Therefore, for relative humidity control it matters not what the dry bulb temperature is, nor the temperature of the dew point, but it depends upon the *difference between the two.*

The dew point depression below the dry bulb temperature for the different percentages of humidity is as follows:

Approximately	Degrees
80	7
75	9
70	11¼
65	13¼
60	16¼
55	19

When air is brought in contact with a cold surface the action is exactly the reverse of that given in the preceding discussion, except that if the surface is sufficiently cold, after the dry and wet bulb temperatures reach the dew point, then the dew point will be lowered and particles of water deposited on the surface.

The Action of Wet and Dry Bulb Thermometers During Evaporation: If a cubic foot of air at a temperature of 87 degrees, containing 4.076 grains per cu. ft., with the wet bulb temperature at 65 degrees, is passed through a fine spray of heated water, the temperature of which is above 50 degrees, it will absorb the moisture. It will be found then that the dry bulb temperature will immediately begin to fall, but the wet bulb temperature will remain absolutely constant at 65 degrees until the dry bulb temperature has dropped to the wet bulb temperature, namely, 65 degrees. As the absorption takes place of course the dew point will be gradually rising from 50 degrees to 65 degrees when saturation is obtained.

This table shows the relative temperature recorded by the thermometers during the absorption of moisture:

Dry Bulb	Wet Bulb	Dew Point	Grs. of Moisture per Cu. Ft.	Relative Humidity or Per Cent. Saturation
87°	65°	50°	4.08	30
82°	65°	55°	4.65	40
78°	65°	57°	5.13	50
75°	65°	59°	5.61	60
72°	65°	61°	5.96	70
69°	65°	63°	6.18	80
67°	65°	64°	6.52	90
65°	65°	65°	6.78	100

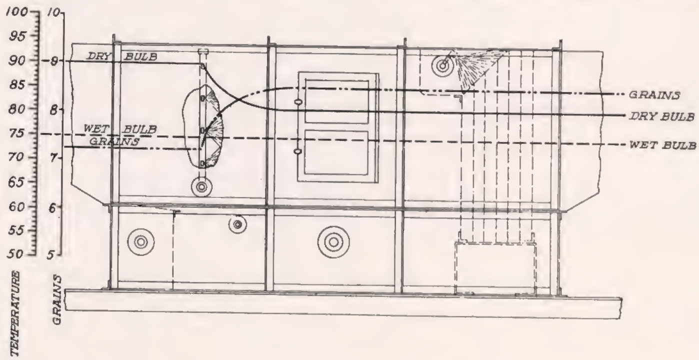
It will be noted in the first line of the table that with 4.08 grains of moisture per cu. ft. the dry bulb temperature was 87 degrees, but the absorption of a little over one grain of moisture, increasing the amount to 5.13, lowered the dry bulb temperature to 78 degrees; in other words, at the ordinary temperatures the absorption of one grain of moisture per cu. ft. lowers the dry bulb temperature approximately 8½ degrees.

Dehumidifying: Jet and barometric steam condensers were the first types used and are still more extensively installed than the surface type. The condensation of water vapor from the atmosphere by means of a direct contact spray of cold water operates on exactly the same principle as the jet condenser.

If air is brought in contact with cold water in sufficient quantities, the temperature of the air will be reduced without absorption of moisture, due entirely to the transmission of the heat from the air to the water. In this case the dry bulb and wet bulb temperatures will both fall gradually until the dew point is reached, at which point, of course, both wet and dry bulb temperatures register the same. The temperature will then continue to fall, depending on the relative amount and temperature of water used; with a reduction of dew point, necessarily a certain amount of moisture will be given up by the air, thus lowering the dew point and reducing the number of grains contained in the air per cu. ft.

Physical Laws of Humidifying and Cooling with Air Washers

To analyze properly the action of the automatic humidity control, attention is called to a few of the general physical laws governing the humidifying of air by means of air washers.



Cooling by Evaporation: Air is passed through an air washer, with the water being recirculated and not heated, viz.: where the heat necessary for evaporation must be procured from the air.

The erroneous statement is often made that a washer will give 60 or 70 or 80 or even 90 per cent relative humidity. This statement is incorrect, as no washer when recirculating the water will give a constant relative humidity to the air leaving, unless the water is heated sufficiently to give complete saturation. The wet bulb temperature of air is always lower than the dry bulb temperature, excepting under conditions of complete saturation. When the air is passed through an air washer the dry bulb temperature is lowered and the wet bulb temperature is unaffected. That is, *the wet bulb temperature is constant.* It is just the same after passing through the water as it was before.

Hence, in the figure the air entering at 90 deg. dry bulb temperature and 75 deg. wet bulb temperature, it will be noted that the wet bulb temperature, as shown by the dotted line, does not change when striking the spray, while the dry bulb temperature does change, and drops 9 deg. (down to 81 deg.). The entering difference between the wet and dry bulb temperatures is $90 - 75 = 15$ deg. If complete saturation were procured, the air would be cooled to the wet bulb temperature, giving a cooling effect of 15 deg. The ratio of the cooling done in the above washer to what it is possible to do is $9 \div 15 = 60$ per cent.

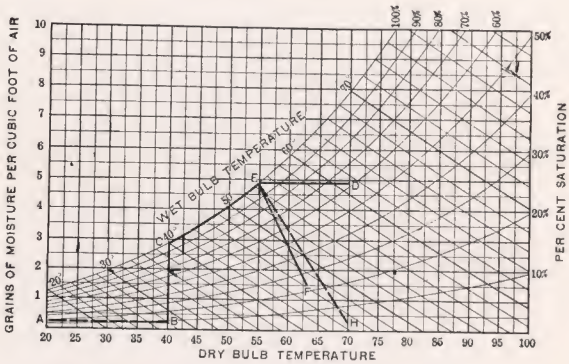
The amount of moisture in the entering air is 7.25 grains, while the amount of moisture in the air leaving the washer is 8.57 grains (dry bulb 81 deg., wet bulb 75 deg.). If the humidifier had continued to add moisture until saturation had been procured, the amount of moisture leaving the washer would have been 9.36 grains (saturated at 81 deg.). In other words, the amount of moisture deficiency from saturation in the entering air was $9.36 - 7.25 = 2.11$ grains, and the moisture added to the air in the washer was $8.57 - 7.25 = 1.32$. Therefore, the amount of moisture added was equal to $1.32 \div 2.11 =$ (approximately) 60 per cent of the amount required to procure complete saturation. Now this same percentage would hold good for this same washer regardless of the difference between the wet and dry bulb temperature of the entering air. That is, the amount of moisture added with *this* washer would always have been 60 per cent of the amount required to procure complete saturation, and the drop in dry bulb temperature of the air would be 60 per cent of the difference between the wet and dry bulb temperatures.

This factor (in this case 60 per cent) may properly be called the HUMIDIFYING EFFICIENCY of the washer.

The various commercial washers on the market vary in humidifying efficiency from 30 to about 90 per cent, and a fair average may be taken as 60 per cent.

The factors controlling the humidifying efficiency of any washer are:

1. The fineness with which the spray is atomized.
2. The length of spray chamber.
3. The impact with which the water and air meet and are mixed.
4. The relative quantities or weight of air and water used.



A Variable Water Temperature: In the regulation of constant humidity by maintaining a *constant saturated temperature leaving the air washer,* the tempering coils if automatically regulated should be controlled by thermostat placed in fresh air inlet, turning on steam to coils at a predetermined temperature of the outside fresh air. The humidifying efficiency of washer being 60 per cent; water temperature being varied by a thermostat placed in the path of the air leaving the washer.

The immediate effect of bringing air into contact with water at a higher temperature is that a portion of the water is immediately evaporated without a change in temperature of the air. Where the water is of sufficient temperature it furnishes the heat necessary for evaporation, bringing the air up to the point of saturation. After saturation has been reached, if the water is still sufficiently warm, the evaporation will continue to take place and the air heated at the same time.

Referring to curve, the air is shown entering at zero with a wet bulb of — 1½ deg. and containing ¼ grain of moisture per cubic foot, the air being heated by the tempering coil along the dotted line AB to a temperature of, say 40 deg., and the wet bulb to a temperature of 28 deg.

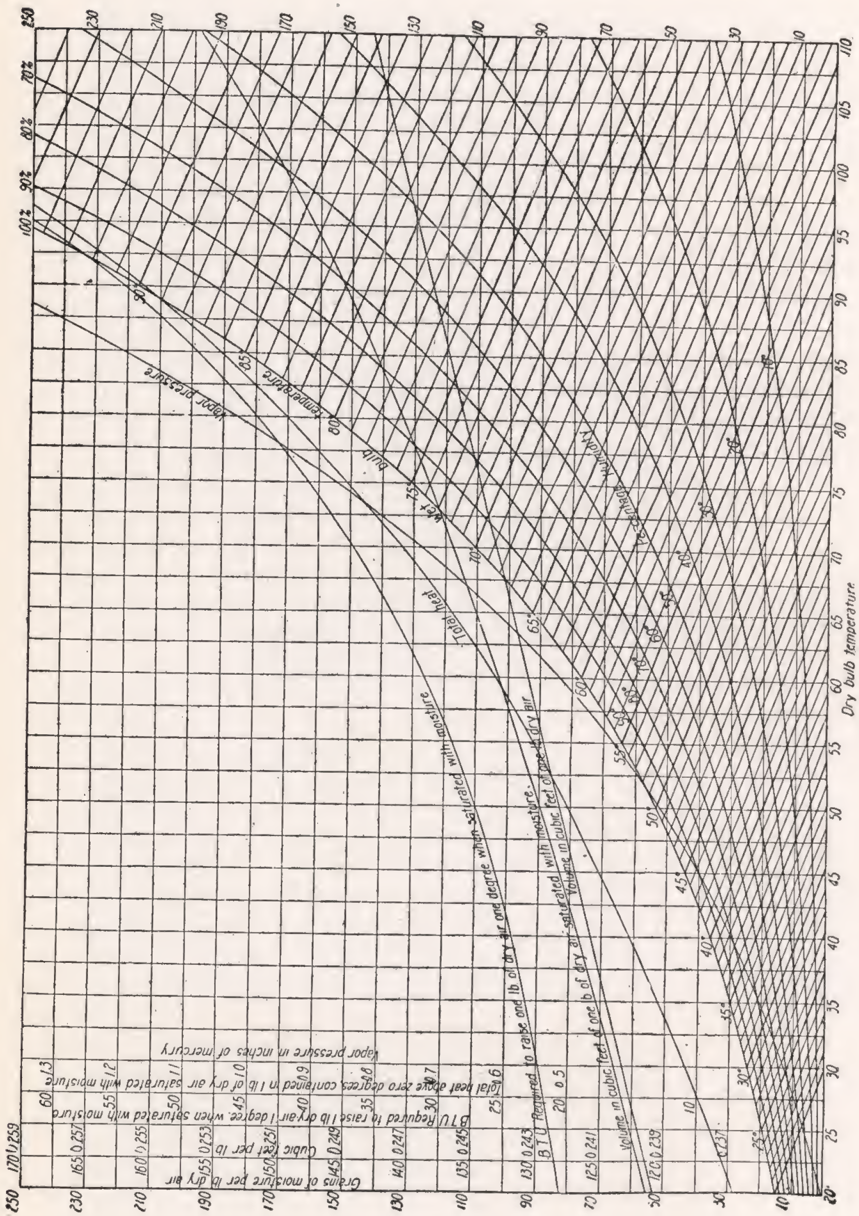
The thermostat at the washer outlet being set for 55 deg., turns on steam to heat the water, which in turn immediately furnishes the heat necessary for evaporation, raising at the same time the wet bulb temperature to the dry bulb temperature, when saturation is procured as shown by line BC, then further raising the temperature and increasing the evaporation until saturation at 55 deg. is procured along the curved line of saturation CE. If the air is then passed through the reheater it is raised in temperature, as shown by the line ED.

With any incoming amounts of vapor and any temperature of 55 deg. or less, the action is always the same; that is, to evaporate the water until saturation is procured and then simultaneously evaporate and heat the air along the saturation curve until the same final result is procured; viz., saturation at 55 deg.

With temperatures higher than 55 deg., but containing less than the required amount of vapor, the action would be slightly different; that is, heat necessary for evaporation is procured both from the air and from the water. With an entering temperature of 63 deg. and 1½ grains of vapor per cubic foot, as shown at F, the air would tend to cool 60 per cent of the wet bulb depression, that is, to 52 deg., as shown by dotted line FG, and the water would supply the heat to increase the evaporation to the required point. The heat given up by the air and water produces a change, as shown by the full line FE.

For a Carrier washer the limits for the incoming air conditions which will result in giving the required 60% relative humidity at 70° F are shown by the dotted line EH. Any combination of temperature and humidity of the incoming air which are to the left of this line will give correct regulation.

No other method will meet such wide variations without resetting or readjusting the system.



Psychrometer Chart
Compiled by Willis H. Carrier

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

WET BULB DEPRESSION

Dry Bulb Temp.	Grains at Saturation	1			2			3			4			5			6			7			8			9		
		%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
0	.48	67	−7	.32	33	−20	.16																					
2	.53	70	−5	.37	39	−15	.21	9	−40	.05																		
4	.58	72	−2	.42	44	−11	.26	17	−28	.10																		
6	.64	74	0	.47	49	−8	.32	23	−21	.15																		
8	.70	76	3	.54	53	−5	.37	29	−15	.20	6	−42	.04															
10	.78	78	5	.61	56	−2	.44	34	−10	.26	13	−27	.11															
12	.86	80	7	.69	59	2	.51	39	−6	.33	19	−19	.16															
14	.94	81	10	.76	62	5	.58	44	−2	.41	26	−12	.25	8	−33	.08												
16	1.03	82	12	.85	65	7	.65	48	+1	.50	31	−7	.32	14	−20	.15												
18	1.13	84	14	.95	68	10	.72	52	5	.59	36	−2	.41	20	−13	.23	5	−37	.06									
20	1.24	85	16	1.1	70	12	.86	55	8	.68	40	+2	.49	26	−7	32	12	−21	.15									
22	1.36	86	19	1.17	71	15	.96	58	11	.79	44	5	.60	31	−2	.42	17	−12	.23	4	−36	.05						
24	1.48	87	21	1.30	73	17	1.1	60	13	.89	47	9	.70	35	+2	.52	22	−6	.33	10	−20	.15						
26	1.62	87	23	1.41	75	20	1.22	63	16	1.02	51	12	.83	39	7	.63	27	−1	.44	16	−11	.26	4	−32	.07			
28	1.77	88	25	1.56	76	22	1.37	65	19	1.15	54	15	.96	43	10	.76	32	+4	.52	21	−4	.37	10	−17	.18			
30	1.94	89	27	1.72	78	25	1.5	67	21	1.30	56	18	1.08	46	14	.89	36	8	.70	26	+2	.50	16	−7	.31	6	−25	.12
32	2.11	89	30	1.88	79	27	1.67	69	24	1.46	59	21	1.25	49	17	1.03	39	12	0.82	30	7	0.63	20	−1	0.42	11	−12	0.23
34	2.28	90	32	2.05	81	29	1.85	71	26	1.62	62	23	1.41	52	20	1.19	43	16	0.98	34	11	0.78	25	5	0.57	16	−3	0.42
36	2.46	91	34	2.24	82	31	2.02	73	29	1.79	64	26	1.57	55	23	1.35	46	19	1.13	38	15	0.93	29	10	0.71	21	3	0.52
38	2.65	91	36	2.41	83	33	2.20	75	31	1.98	66	28	1.74	58	25	1.54	50	22	1.32	42	18	1.11	33	14	0.87	25	8	0.66
40	2.85	92	38	2.62	83	35	2.36	75	33	2.14	68	30	1.94	60	28	1.71	52	25	1.48	45	21	1.28	37	18	1.06	29	13	0.83
42	3.06	92	40	2.82	85	38	2.61	77	35	2.36	69	33	2.12	62	30	1.90	55	27	1.69	47	24	1.44	40	21	1.23	33	17	1.01
44	3.29	93	42	3.06	85	40	2.80	78	37	2.57	71	35	2.34	63	32	2.08	56	30	1.85	49	27	1.61	43	24	1.42	36	20	1.19
46	3.54	93	44	3.29	86	42	3.04	79	40	2.80	72	37	2.54	65	35	2.30	58	32	2.05	52	29	1.84	45	27	1.59	39	23	1.38
48	3.80	93	46	3.53	86	44	3.27	79	42	3.00	73	40	2.77	66	37	2.51	60	35	2.28	54	32	2.05	47	29	1.79	41	26	1.56
50	4.08	93	48	3.79	87	46	3.55	80	44	3.26	74	42	3.02	67	40	2.73	61	37	2.49	55	34	2.24	49	32	1.20	43	29	1.75
52	4.37	94	50	4.11	87	48	3.80	81	46	3.54	75	44	3.28	69	42	3.02	63	40	2.75	57	37	2.49	51	34	2.23	46	32	2.01
54	4.69	94	52	4.40	88	50	4.13	82	48	3.84	76	46	3.56	70	44	3.28	64	42	3.00	59	40	2.77	53	37	2.48	48	34	2.25
56	5.02	94	54	4.71	88	53	4.41	82	51	4.11	76	49	3.81	71	47	3.61	65	44	3.26	60	42	3.01	55	40	2.76	50	37	2.51
58	5.37	94	56	5.05	88	55	4.73	83	53	4.46	77	51	4.14	72	49	3.87	66	47	3 55	61	45	3.28	56	42	3.01	51	40	2.74
59	5.56	94	57	5.22	89	56	4.95	83	54	4.61	78	52	4.33	72	50	4.00	67	48	3.72	62	46	3.44	57	44	3.17	52	41	2.89
60	5.75	94	58	5.40	89	57	5.11	83	55	4.77	78	53	4.48	73	51	4.19	68	49	3.91	63	47	3.62	58	45	3.33	53	43	3.04
61	5.94	94	59	5.58	89	58	5.29	84	56	4.99	78	54	4.64	73	52	4.34	68	50	4.04	63	48	3.74	58	46	3.45	54	44	3.21
62	6.14	94	60	5.77	89	59	5.46	84	57	5.16	79	55	4.85	74	53	4.54	69	52	4.24	64	50	3.93	59	47	3.62	54	45	3.32
63	6.35	95	61	6.03	89	60	5.65	84	58	5.23	79	56	5.01	74	55	4.71	69	53	4.38	64	51	4.07	60	49	3.81	55	47	3.49
64	6.56	95	62	6.24	90	61	5.91	84	59	5.51	79	57	5.19	74	56	4.86	70	54	4.59	65	52	4.27	60	50	3.94	56	48	3.68

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

WET BULB DEPRESSION

Dry Bulb Temp.	Grains at Saturation	1			2			3			4			5			6			7			8			9		
		%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
65	6.78	95	63	6.44	90	62	6.10	85	60	5.77	80	59	5.43	75	57	5.09	70	55	4.75	66	53	4.48	61	51	4.14	56	49	3.80
66	7.01	95	64	6.66	90	63	6.31	85	61	5.96	80	60	5.61	75	58	5.26	71	56	4.98	66	54	4.63	61	52	4.28	57	50	3.99
67	7.24	95	65	6.88	90	64	6.52	85	62	6.16	80	61	5.79	75	59	5.43	71	57	5.14	66	55	4.78	62	53	4.49	58	52	4.20
68	7.48	95	67	7.10	90	65	6.73	85	63	6.36	80	62	5.98	76	60	5.69	71	58	5.31	67	57	5.01	62	55	4.64	58	53	4.34
69	7.73	95	68	7.34	90	66	6.95	85	64	6.57	81	63	6.26	76	61	5.87	72	59	5.56	67	58	5.18	63	56	4.87	59	54	4.56
70	7.98	95	69	7.58	90	67	7.18	86	65	6.86	81	64	6.46	77	62	6.15	72	61	5.75	68	59	5.43	64	57	5.11	59	55	4.71
71	8.24	95	70	7.83	90	68	7.42	86	67	7.09	81	65	6.67	77	63	6.35	72	62	5.93	68	60	5.60	64	58	5.27	60	56	4.94
72	8.51	95	71	8.08	91	69	7.74	86	68	7.31	82	66	6.97	77	64	6.55	73	63	6.21	69	61	5.87	65	59	5.53	61	58	5.19
73	8.78	95	72	8.34	91	70	7.99	86	69	7.55	82	67	7.20	78	66	6.85	73	64	6.41	69	62	6.06	65	60	5.71	61	59	5.36
74	9.07	95	73	8.61	91	71	8.25	86	70	7.80	82	68	7.43	78	67	7.07	74	65	6.71	69	63	6.26	65	62	5.89	61	60	5.53
75	9.36	96	74	8.89	91	72	8.51	86	71	8.05	82	69	7.67	78	68	7.30	74	66	6.92	70	64	6.59	66	63	6.18	62	61	5.80
76	9.66	96	75	9.27	91	73	8.79	87	72	8.40	82	70	7.92	78	69	7.53	74	67	7.14	70	66	6.76	66	64	6.37	62	62	5.99
77	9.96	96	76	9.56	91	74	9.02	87	73	8.67	83	71	8.27	79	70	7.87	74	68	7.37	71	67	7.07	67	65	6.67	63	63	6.28
78	10.28	96	77	9.87	91	75	9.35	87	74	8.94	83	72	8.53	79	71	8.12	75	69	7.71	71	68	7.30	67	66	6.89	63	64	6.47
79	10.60	96	78	10.18	91	76	9.65	87	75	9.21	83	73	8.80	79	72	8.38	75	70	7.95	71	69	7.53	68	67	7.21	64	66	6.79
80	10.93	96	79	10.50	91	77	9.95	87	76	9.51	83	74	9.08	79	73	8.64	75	72	8.20	72	70	7.87	68	68	7.44	64	67	7.00
81	11.28	96	80	10.82	92	78	10.37	88	77	9.92	84	75	9.47	80	74	9.02	76	73	8.57	72	71	8.12	69	70	7.78	65	68	7.33
82	11.63	96	81	11.16	92	79	10.70	88	78	10.23	84	77	9.77	80	75	9.30	76	74	8.84	72	72	8.37	69	71	8.02	65	69	7.56
83	11.99	96	82	11.51	92	80	11.03	88	79	10.55	84	78	10.07	80	76	9.59	76	75	9.11	73	73	8.75	69	72	8.27	66	70	7.91
84	12.36	96	83	11.86	92	81	11.37	88	80	10.87	84	79	10.38	80	77	9.89	76	76	9.39	73	74	9.02	69	73	8.53	66	71	8.16
85	12.74	96	84	12.22	92	82	11.72	88	81	11.21	84	80	10.70	81	78	10.32	77	77	9.81	73	75	9.30	70	74	8.92	66	72	8.41
86	13.13	96	85	12.60	92	83	12.08	88	82	11.55	84	81	11.03	81	79	10.63	77	78	10.11	73	76	9.58	70	75	9.19	66	73	8.67
87	13.53	96	86	12.99	92	84	12.44	88	83	11.90	85	82	11.50	81	80	10.96	77	79	10.42	74	78	10.01	70	76	9.47	67	75	9.06
88	13.94	96	87	13.38	92	85	12.82	88	84	12.26	85	83	11.85	81	81	11.29	77	80	10.73	74	79	10.31	70	77	9.76	67	76	9.34
89	14.36	96	88	13.99	92	86	13.21	88	85	12.64	85	84	12.21	81	82	11.63	78	81	11.20	74	80	10.63	71	78	10.19	68	77	9.76
90	14.79	96	89	14.20	92	87	13.61	89	86	13.16	85	85	12.57	81	83	11.98	78	82	11.54	74	81	10.94	71	79	10.50	68	78	10.06
92	15.69	96	91	15.06	92	89	14.44	89	88	13.96	85	87	13.34	82	86	12.87	78	84	12.24	75	83	11.77	72	81	11.30	68	80	10.67
94	16.63	96	93	15.97	93	92	15.47	89	90	14.81	85	89	14.14	82	88	13.64	79	86	13.14	75	85	12.48	72	84	11.98	69	82	11.48
96	17.63	96	95	16.92	93	94	16.39	89	92	15.69	86	91	15.16	82	90	14.45	79	88	13.93	76	87	13.40	73	86	12.87	69	84	12.16
98	18.67	96	97	17.92	93	96	17.36	89	94	16.62	86	93	16.06	83	92	15.50	79	90	14.75	76	89	14.19	73	88	13.63	70	87	13.07
100	19.77	96	99	18.98	93	98	18.38	89	96	17.59	86	95	17.00	83	94	16.41	80	93	15.81	77	91	15.22	73	90	14.43	70	89	13.84
104	22.13	97	103	21.46	93	102	20.58	90	100	19.91	87	99	19.25	83	98	18.36	80	97	17.70	77	95	17.04	74	94	16.37	71	93	15.71
108	24.72	97	107	23.98	93	106	22.99	90	104	22.25	87	103	21.51	84	102	20.77	81	101	20.02	78	100	19.28	75	98	18.54	72	97	17.80
112	27.88	97	111	27.02	94	110	26.19	90	109	25.07	87	107	24.24	84	106	23.40	81	105	22.57	79	104	21.60	76	103	20.90	73	101	20.34
116	30.10	97	115	29.20	94	114	28.29	91	113	27.39	88	111	27.21	85	110	26.31	82	109	25.40	79	108	24.50	76	107	23.60	74	105	22.99
120	34.80	97	119	33.76	94	118	32.71	91	117	31.67	88	115	30.62	85	114	29.58	82	113	28.88	80	112	27.84	77	111	26.78	74	110	25.71

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

WET BULB DEPRESSION

Dry Bulb Temp.	10			11			12			13			14			15			16			17			18		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
32	2	-42	0.04																								
34	8	-17	0.18	0																							
36	13	-6	0.32	5	-25	0.12																					
38	17	1	0.45	10	-10	0.27	2	-36	0.05																		
40	22	7	0.63	15	-1	0.43	7	-14	0.20	0																	
42	26	12	0.80	19	6	0.58	12	-3	0.37	5	-18	0.15															
44	30	16	0.99	23	11	0.76	16	4	0.53	10	-5	0.33	4	-24	0.13												
46	32	20	1.13	26	15	0.92	20	10	0.71	14	3	0.50	8	-7	0.28	2	-30	0.07									
48	35	23	1.33	29	19	1.11	23	14	0.88	18	9	0.68	12	1	0.46	7	-10	0.27	1	-41	0.04						
50	38	26	1.55	32	22	1.30	27	18	1.10	21	13	0.86	16	8	0.65	10	0	0.41	5	-13	0.20	0					
52	40	29	1.75	35	26	1.53	29	22	1.27	24	18	1.05	19	13	0.83	14	7	0.61	9	-2	0.39	4	-17	0.18			
54	42	32	1.97	37	29	1.73	32	25	1.49	27	22	1.27	22	18	1.03	17	12	0.80	12	6	0.56	8	-4	0.38	3	-20	0.14
56	44	34	2.21	39	32	1.96	34	29	1.71	30	25	1.51	25	22	1.25	20	17	1.00	16	12	0.80	11	5	0.55	7	-5	0.35
58	46	37	2.47	41	35	2.20	37	32	1.99	32	29	1.72	27	25	1.45	23	21	1.24	18	17	0.97	14	11	0.75	10	4	0.54
59	47	39	2.61	42	36	2.33	38	33	2.11	33	30	1.83	29	27	1.61	24	23	1.33	20	19	1.11	16	14	0.89	11	8	0.61
60	48	40	2.76	43	38	2.47	39	35	2.25	34	32	1.95	30	29	1.72	26	25	1.50	21	21	1.21	17	17	0.98	13	11	0.75
61	49	42	2.97	44	39	2.61	40	36	2.38	35	33	2.08	31	30	1.84	27	27	1.60	22	23	1.31	18	19	1.07	14	14	0.83
62	50	43	3.07	45	40	2.76	41	38	2.52	36	35	2.21	32	32	1.97	28	29	1.72	24	25	1.47	20	21	1.23	16	16	0.98
63	50	44	3.28	46	42	2.92	42	39	2.67	37	36	2.34	33	34	2.17	29	30	1.84	25	27	1.59	21	23	1.33	17	19	1.08
64	51	46	3.35	47	43	3.09	43	41	2.82	38	38	2.49	34	35	2.23	30	32	1.97	26	29	1.71	22	25	1.44	18	21	1.18
65	52	47	3.53	48	45	3.26	44	42	2.98	39	40	2.65	35	37	2.37	31	34	2.10	27	31	1.83	24	27	1.63	20	24	1.36
66	53	48	3.71	48	46	3.36	44	44	3.08	40	41	2.80	36	38	2.52	32	35	2.24	29	32	2.03	25	29	1.75	21	26	1.47
67	53	49	3.84	49	47	3.55	45	45	3.19	41	43	2.97	37	40	2.68	33	37	2.39	30	34	2.17	26	31	1.88	22	28	1.59
68	54	51	4.04	50	49	3.74	46	46	3.44	42	44	3.14	38	42	2.84	34	39	2.54	31	36	2.32	27	33	2.00	23	29	1.72
69	55	52	4.25	51	50	3.94	47	48	3.63	43	45	3.32	39	43	3.01	35	40	2.70	32	37	2.47	28	34	2.16	24	31	1.85
70	55	53	4.39	51	51	4.07	48	49	3.83	44	47	3.51	40	44	3.19	36	42	2.87	33	39	2.63	29	36	2.31	25	33	2.00
71	56	54	4.62	52	52	4.29	48	50	3.96	45	48	3.71	41	46	3.38	37	43	3.05	33	41	2.72	30	38	2.47	27	35	2.23
72	57	56	4.86	53	54	4.51	49	52	4.17	45	50	3.83	42	47	3.57	38	45	3.23	34	42	2.89	31	40	2.64	28	37	2.38
73	57	57	5.01	53	55	4.65	50	53	4.39	46	51	4.04	42	49	3.69	39	46	3.43	35	44	3.07	32	41	2.81	29	38	2.55
74	58	58	5.26	54	56	4.90	50	54	4.53	47	52	4.26	43	50	3.90	39	48	3.54	36	45	3.26	33	43	2.99	29	40	2.63
75	58	59	5.43	54	57	5.05	51	55	4.77	47	54	4.40	44	51	4.12	40	49	3.74	37	47	3.46	34	44	3.18	30	42	2.81
76	59	60	5.70	55	59	5.31	51	57	4.92	48	55	4.64	44	53	4.25	41	51	3.96	38	48	3.67	34	46	3.28	31	43	2.99
77	59	62	5.88	56	60	5.58	52	58	5.18	48	56	4.78	45	54	4.48	42	52	4.18	39	50	3.89	35	48	3.49	32	45	3.19
78	60	63	6.17	56	61	5.76	53	59	5.45	49	57	5.04	46	55	4.73	43	53	4.42	39	51	4.01	36	49	3.70	33	46	3.39
79	60	64	6.36	57	62	6.04	53	60	5.62	50	59	5.30	46	57	4.88	43	55	4.56	40	53	4.24	37	50	3.92	34	48	3.60

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

WET BULB DEPRESSION

Dry Bulb Temp.	10			11			12			13			14		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
80	61	65	6.67	57	63	6.23	54	62	5.90	50	60	5.47	47	58	5.14
81	61	66	6.88	58	65	6.54	55	63	6.20	51	61	5.75	48	59	5.41
82	61	67	7.09	58	66	6.74	55	64	6.39	51	62	5.93	48	60	5.58
83	62	69	7.43	59	67	7.07	56	65	6.71	52	64	6.23	49	62	5.87
84	62	70	7.66	59	68	7.29	56	66	6.92	52	65	6.43	49	63	6.06
85	63	71	8.02	60	69	7.64	57	68	7.26	53	66	6.75	50	64	6.37
86	63	72	8.27	60	70	7.88	57	69	7.48	53	67	6.96	50	65	6.56
87	64	73	8.66	61	72	8.25	57	70	7.71	54	68	7.17	51	67	6.90
88	64	74	8.92	61	73	8.50	57	71	7.94	54	69	7.53	51	68	7.11
89	65	75	9.33	61	74	8.76	58	72	8.33	55	71	7.90	52	69	7.47
90	65	76	9.61	61	75	9.09	58	73	8.58	55	72	8.13	52	70	7.69
92	65	79	10.20	62	77	9.73	59	76	9.26	56	74	8.79	53	73	8.32
94	66	81	10.98	63	79	10.48	60	78	9.98	57	76	9.48	54	75	8.98
96	66	83	11.63	63	82	11.11	61	80	10.75	58	79	10.22	55	77	9.69
98	67	85	12.51	64	84	11.95	61	82	11.39	58	81	10.83	56	79	10.46
100	68	87	13.44	65	86	12.85	62	85	12.26	59	83	11.66	56	82	11.07
104	69	92	15.27	66	90	14.60	63	89	13.94	60	88	13.28	58	86	12.83
108	70	96	17.30	67	95	16.56	64	93	15.82	62	92	15.33	59	91	14.59
112	70	100	19.50	68	99	18.94	65	98	18.11	63	96	17.55	60	95	16.72
116	71	104	22.05	69	103	21.45	66	102	20.55	64	101	19.95	61	99	19.05
120	72	108	25.01	69	107	23.95	67	106	23.24	65	105	22.40	62	104	21.46

Dry Bulb Temp.	15			16			17			18		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
80	44	56	4.81	41	54	4.48	38	52	4.16	35	50	3.83
81	45	57	5.07	42	55	4.74	39	53	4.40	36	51	4.06
82	45	59	5.23	42	57	4.88	39	55	4.53	36	52	4.19
83	46	60	5.52	43	58	5.01	40	56	4.65	37	54	4.44
84	46	61	5.68	43	59	5.31	40	57	4.94	37	55	4.57
85	47	62	5.99	44	61	5.60	41	59	5.22	38	57	4.84
86	47	64	6.17	44	62	5.78	42	60	5.52	39	58	5.12
87	48	65	6.49	46	63	6.22	43	61	5.82	40	59	5.41
88	48	66	6.69	46	64	6.41	43	62	5.99	40	61	5.58
89	49	67	7.04	47	66	6.75	44	64	6.32	41	62	5.89
90	49	69	7.25	47	67	6.95	44	65	6.51	41	63	6.06
92	50	71	7.84	48	69	7.53	45	68	7.06	42	66	6.59
94	51	73	8.48	49	72	8.15	46	70	7.65	43	68	7.15
96	52	76	9.17	50	74	8.81	47	72	8.28	44	71	7.76
98	53	78	9.90	50	76	9.34	48	75	8.96	45	73	8.40
100	54	80	10.67	51	79	10.08	49	77	9.69	46	76	9.09
104	55	85	12.17	53	83	11.73	50	82	11.06	48	80	10.62
108	57	89	14.09	54	88	13.35	52	86	12.85	49	85	12.11
112	58	94	16.16	55	92	15.39	53	91	14.84	51	90	14.28
116	59	98	18.45	57	97	17.85	54	95	16.87	52	94	16.21
120	60	102	20.75	58	101	20.07	55	100	19.05	53	98	18.37

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

WET BULB DEPRESSION

Dry Bulb Temp.	19			20			21		
	%	Dew Point	No. cf Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
56	2	-25	0.10						
58	6	-6	0.32	1	-30	0.05			
60	9	4	0.52	5	-8	0.29	1	-36	0.06
62	12	11	0.74	8	3	0.49	4	-9	0.25
64	15	17	0.98	11	11	0.72	7	3	0.46
66	17	22	1.19	14	17	0.98	10	11	0.70
68	20	26	1.50	16	22	1.20	13	17	0.97
70	22	30	1.76	19	26	1.52	15	22	1.20
72	24	33	2.04	21	30	1.79	18	26	1.53
74	26	37	2.36	23	34	2.09	20	30	1.81
75	27	39	2.53	24	36	2.25	21	32	1.96
76	28	41	2.70	25	38	2.41	22	34	2.12
77	29	42	2.89	26	39	2.59	23	36	2.29
78	30	44	3.08	27	41	2.78	24	38	2.47
79	31	46	3.29	28	43	2.97	25	40	2.65
80	32	47	3.50	29	44	3.17	26	42	2.74
81	33	49	3.72	30	46	3.38	27	43	3.04
82	33	50	3.84	30	48	3.49	28	45	3.26
83	34	52	4.08	31	49	3.72	29	47	3.48
84	35	53	4.33	32	51	3.95	29	48	3.58
85	36	54	4.59	33	52	4.20	30	50	3.82
86	36	56	4.73	33	54	4.33	31	52	4.07
87	37	57	5.00	34	55	4.60	32	53	4.33
88	37	59	5.16	35	57	4.88	32	55	4.46
89	38	60	5.46	36	58	5.17	33	56	4.74
90	39	61	5.77	36	59	5.33	34	57	5.03
92	40	64	6.28	37	62	5.81	35	60	5.49
94	41	67	6.82	38	65	6.32	36	63	5.99
96	42	69	7.40	39	67	6.87	37	66	6.52
98	43	72	8.03	40	70	7.47	38	68	7.10
100	44	74	8.70	41	72	8.10	39	71	7.71
104	46	79	10.18	43	77	9.51	41	76	9.07
108	47	84	11.62	45	82	11.12	43	81	10.63
112	49	88	13.70	47	87	13.12	44	85	12.26
116	50	93	15.62	48	91	14.98	46	90	14.33
120	51	97	17.69	49	96	16.96	47	94	16.28

Dry Bulb Temp.	22			23			24		
	%	Dew Point	No. of Gr'ins	%	Dew Poinf	No. of Gr'ins	%	Dew Point	No. of Gr'ins
56									
58									
60									
62	1	-45	0.06						
64	4	-10	0.26	0					
66	7	2	0.49	3	-11	0.21	0		
68	10	11	0.75	6	2	0.45	3	-11	0.22
70	12	17	0.96	9	11	0.72	6	2	0.48
72	15	22	1.28	12	17	1.02	9	11	0.77
74	17	27	1.54	14	23	1.27	11	18	1.00
75	18	29	1.68	15	25	1.40	12	21	1.12
76	19	31	1.84	16	27	1.55	13	23	1.26
77	20	33	1.99	17	29	1.69	14	26	1.39
78	21	35	2.16	18	31	1.85	16	28	1.64
79	22	37	2.33	19	34	2.01	17	30	1.80
80	23	39	2.52	20	36	2.19	18	32	1.97
81	24	41	2.71	21	38	2.37	19	34	2.14
82	25	42	2.91	22	39	2.56	20	36	2.33
83	26	44	3.12	23	41	2.76	21	38	2.52
84	26	46	3.31	24	43	2.97	21	40	2.59
85	27	48	3.44	25	45	3.18	22	42	2.80
86	28	49	3.68	26	47	3.41	23	44	3.02
87	29	51	3.92	26	48	3.52	24	46	3.25
88	30	52	4.18	27	50	3.76	25	47	3.48
89	31	54	4.45	28	51	4.02	26	49	3.73
90	31	55	4.59	29	53	4.29	26	51	3.85
92	32	58	5.02	30	56	4.71	28	54	4.39
94	33	61	5.49	31	59	5.16	29	57	4.82
96	35	64	6.17	32	62	5.64	30	60	5.29
98	36	66	6.72	34	64	6.35	32	63	5.98
100	37	69	7.31	35	67	6.92	33	65	6.52
104	39	74	8.63	37	72	8.19	35	71	7.75
108	41	79	10.14	39	77	9.64	37	76	9.15
112	42	84	11.68	40	82	11.10	38	81	10.54
116	44	88	13.69	42	87	13.04	40	86	12.40
120	45	93	15.60	43	92	14.92	41	90	14.24

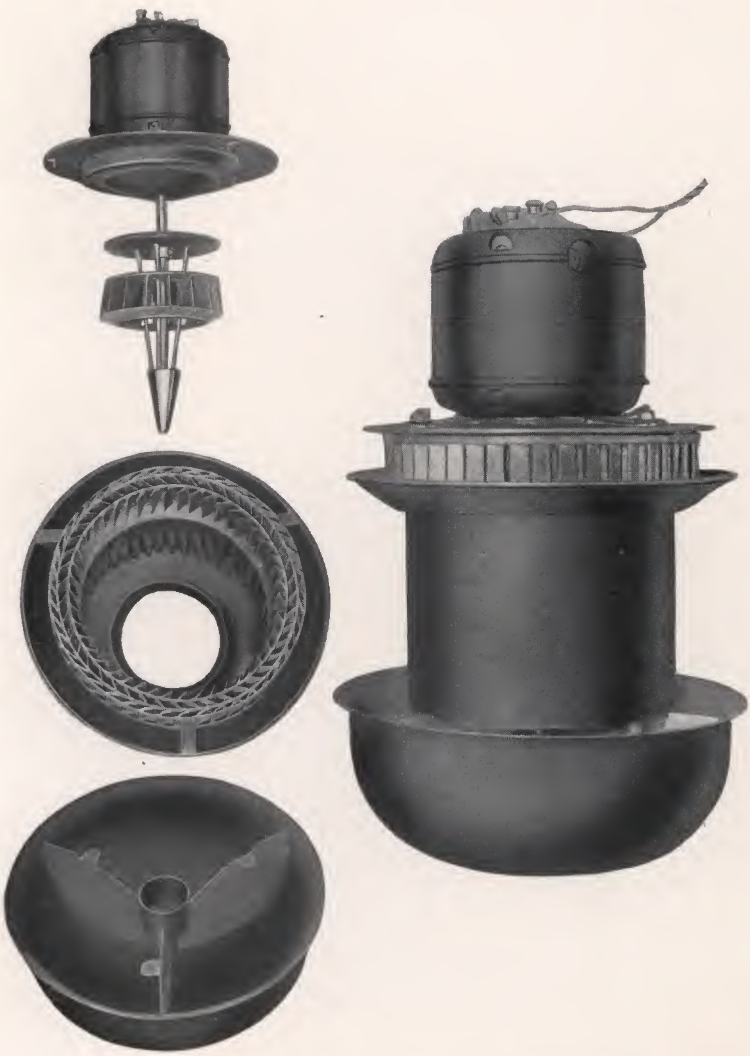
Dry Bulb Temp.	25			26			27		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
56									
58									
60									
62									
64									
66									
68									
70	3	-11	0.24						
72	6	3	0.51	3	-11	0.26			
74	8	12	0.73	5	3	0.45	3	-10	0.27
75	9	15	0.84	7	8	0.66	4	-2	0.37
76	11	18	1.06	8	12	0.77	5	4	0.48
77	12	21	1.20	9	16	0.90	6	9	0.60
78	13	24	1.34	10	19	1.03	8	13	0.82
79	14	26	1.48	11	22	1.17	9	16	0.95
80	15	28	1.64	12	24	1.31	10	20	1.09
81	16	31	1.80	13	27	1.47	11	22	1.24
82	17	33	1.98	14	29	1.63	12	25	1.40
83	18	35	2.16	15	31	1.80	13	27	1.56
84	19	37	2.35	16	34	1.98	14	30	1.73
85	20	39	2.55	17	36	2.17	15	32	1.91
86	21	41	2.76	18	38	2.36	16	34	2.10
87	22	43	2.98	19	40	2.57	17	36	2.30
88	22	45	3.07	20	42	2.79	18	38	2.51
89	23	46	3.30	21	44	3.02	19	41	2.73
90	24	48	3.55	22	45	3.25	19	43	2.81
92	25	51	3.92	23	49	3.61	21	46	3.30
94	27	55	4.49	24	52	3.99	22	50	3.66
96	28	58	4.94	26	55	4.58	24	53	4.23
98	29	61	5.41	27	58	5.04	25	56	4.67
100	30	63	5.93	28	61	5.54	26	59	5.14
104	33	69	7.30	31	67	6.86	29	65	6.42
108	35	74	8.65	33	72	8.16	31	71	7.66
112	36	79	9.98	35	78	9.42	33	76	8.86
116	38	84	11.78	36	83	11.16	34	81	10.56
120	40	89	13.90	38	87	13.20	36	86	12.49

Relative Humidity, Dew Points and Grains of Moisture per Cubic Foot for various Dry and Wet Bulb Temperatures of the Sling Psychrometer—Barometric Pressure, 30 Inches

WET BULB DEPRESSION

Dry Bulb Temp.	28			29			30			31		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
75	1	−23	0.09									
76	3	10	0.29									
77	4	−2	0.40	1	−21	0.10						
78	5	5	0.51	3	−9	0.31						
79	6	10	0.64	4	−1	0.42	1	−20	0.11			
80	7	13	0.77	5	6	0.55	3	−7	0.33			
81	9	17	1.02	6	10	0.68	4	0	0.45	1	−18	0.11
82	10	20	1.16	7	14	0.81	5	7	0.58	2	−6	0.23
83	11	23	1.32	8	18	0.96	6	11	0.72	3	2	0.36
84	12	26	1.48	9	21	1.11	7	15	0.87	5	8	0.62
85	13	28	1.66	10	24	1.27	8	19	1.02	6	12	0.77
86	14	31	1.84	11	27	1.44	9	22	1.18	7	16	0.92
87	15	33	2.03	12	29	1.62	10	25	1.35	8	20	1.08
88	15	35	2.09	13	31	1.81	11	27	1.53	9	22	1.26
89	16	37	2.30	14	34	2.01	12	30	1.72	10	26	1.44
90	17	39	2.52	15	36	2.22	13	32	1.92	11	28	1.63
92	19	43	2.98	17	40	2.67	15	37	2.35	13	33	2.04
94	20	47	3.33	18	44	2.99	16	41	2.66	14	38	2.33
96	22	51	3.88	20	48	3.53	18	45	3.17	16	42	2.82
98	23	54	4.29	21	52	3.92	19	49	3.55	17	46	3.17
100	24	57	4.74	22	55	4.35	21	52	4.15	19	50	3.76
104	27	63	5.98	25	61	5.53	23	59	5.09	21	57	4.65
108	29	69	7.17	27	67	6.67	25	65	6.18	24	63	5.93
112	31	74	8.58	29	72	8.03	27	71	7.49	26	69	7.22
116	33	79	10.25	31	78	9.61	29	76	8.99	28	74	8.68
120	34	84	11.79	33	83	11.44	31	81	10.73	29	80	10.04

Dry Bulb Temp.	32			33			34			35		
	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins	%	Dew Point	No. of Gr'ins
75												
76												
77												
78												
79												
80												
81												
82	0											
83	2	−15	0.24									
84	3	−4	0.37	0								
85	4	3	0.51	2	−12	0.26						
86	5	9	0.66	3	−2	0.39	1	−27	0.13			
87	6	13	0.81	4	5	0.54	2	−10	0.27			
88	7	17	0.98	5	10	0.70	3	0	0.42	1	−22	0.14
89	8	21	1.15	6	15	0.86	4	6	0.57	2	−7	0.29
90	9	24	1.33	7	19	1.04	5	11	0.74	3	1	0.44
92	11	29	1.73	9	25	1.41	7	20	1.10	5	13	0.78
94	12	34	2.00	10	30	1.66	9	26	1.50	7	21	1.16
96	14	39	2.47	12	35	2.12	10	31	1.76	8	27	1.41
98	15	43	2.80	14	40	2.61	12	36	2.24	10	32	1.87
100	17	47	3.36	15	44	2.97	13	41	2.57	12	37	2.37
104	20	54	4.43	18	52	3.98	16	49	3.54	14	46	3.10
108	22	61	5.44	20	59	4.94	19	56	4.70	17	54	4.20
112	24	67	6.68	23	65	6.41	21	63	5.87	19	61	5.33
116	26	73	8.06	25	71	7.78	23	69	7.17	22	67	6.86
120	28	78	9.70	26	76	9.02	25	75	8.68	23	73	7.99



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