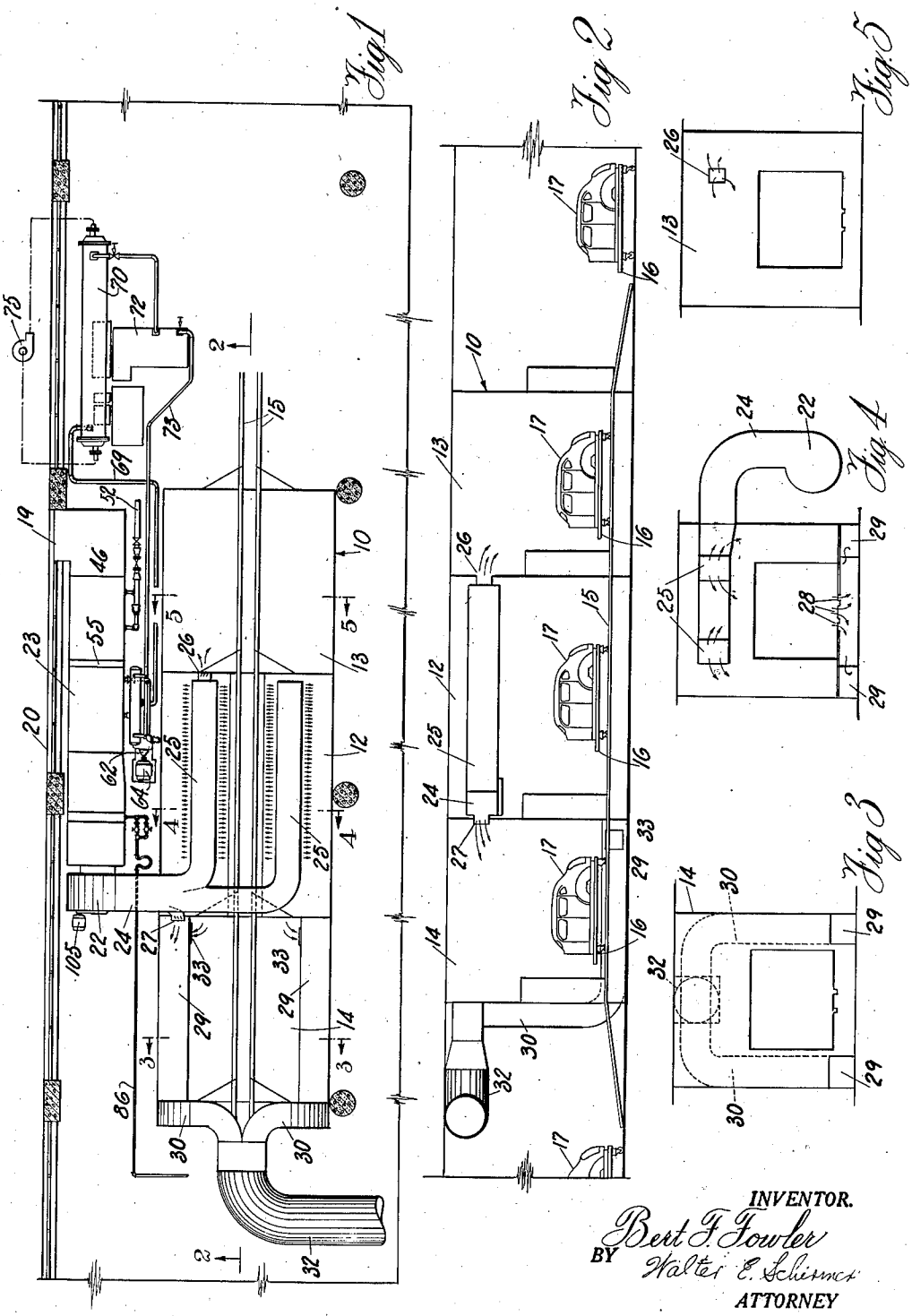
July 22, 1941. B. F. FOWLER 2,250,260

AIR CONDITIONING SYSTEM

Filed Feb. 17, 1939 2 Sheets-Sheet 1



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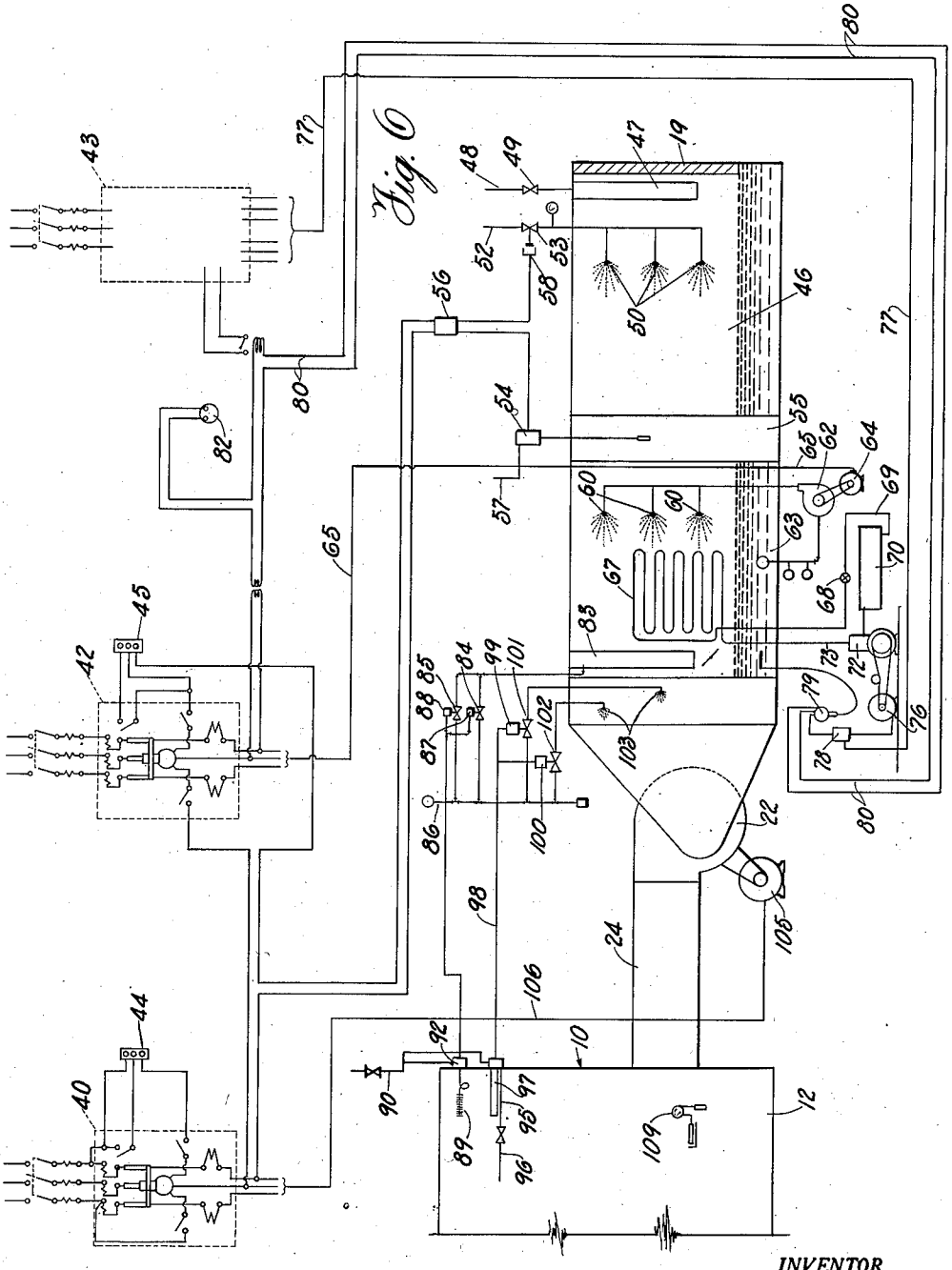


Fig. 6

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AIR CONDITIONING SYSTEM

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3 Claims. (Cl. 261—9)

This invention relates to an air conditioning system for conditioning air to be supplied to the spray painting booths utilized for the spraying of vehicle bodies and the like.

Heretofore considerable difficulty has been experienced in body painting, even in modern types of spray booths having cleaned force feed air supply thereto, since variations in characteristic conditions of the air, caused by weather variations, produced undesirable results in the appearance of the vehicle. Various attempts to solve this problem have been attempted, such as varying the paint composition in accordance with weather changes, but no satisfactory solution whereby this could be accomplished automatically has thus far been devised, so far as I am aware.

The two main objections which have arisen in spray painting of vehicles are the occurrence of conditions on the paint job of what is known in the trade as "orange peel" and "blushing." The first of these conditions results in a pitted uneven surface and is caused, so far as I can determine, by the fact that the solvent employed for carrying the lacquer from the spray gun to the surface being painted is too volatile, or atmospheric conditions are such that it evaporates at a rate which does not allow the lacquer particles to flow into a smooth continuous film when deposited on the surface being sprayed. As a result these particles flow only partially together, and form uneven contact surfaces which prevents the production of a smooth glossy finish such as is desired.

The second condition results from condensation of moisture on the surface, which prevents the paint from flowing thereover in a smooth film, and produces dull or granulated-appearing surfaces. Also, with the fast drying lacquers employed any overspray on a painted surface was very apparent, and consequently required that a very highly skilled operator be employed for spraying such articles.

In considering this problem, I first conceived that if the rate of evaporation of the solvent was slowed down, the lacquer particles would remain in a liquid state for a longer period of time, and would produce the desired smooth continuous film. However, changes in atmospheric conditions might retard evaporation still further, and too slow a drying time on vertical surfaces would cause sagging or running of the paint.

To overcome this I experimented with a condition in which a very low spray booth temperature, about 50° F. was employed, with the lacquer chilled and the compressed air for the gun both chilled and dehydrated. A relative humidity of around 55% to 65% was maintained in the booth. Test jobs under such conditions showed remarkable results, with entire elimination of any orange-peel effect.

However, certain disadvantages became apparent. Such conditions required a large expenditure for cooling equipment, and were unsatisfactory so far as the comfort of the spray gun operator was concerned. Further, the jobs developed some tendency toward blushing, due probably to condensation on the surfaces when moved into a cooled booth. This latter difficulty was overcome by having preconditioning lockers to bring the temperature of the bodies to that of the booth before spraying. This, however, still did not eliminate the expense and discomfort involved.

In further studying the problem, I found what appeared to be the recondite cause of the previous failures to eliminate orange peel, and which would allow such elimination without the disadvantages of revising the paint or lacquer composition or the chilling which I had found effective.

The rate of evaporation of any given solvent is a function of its boiling point and also of the condition of the atmosphere into which it is discharged. This could therefore be controlled by controlling the humidity of the air in the booth, maintaining it within a range such as to give the desired rate of evaporation of the solvent that would prevent the orange peel effect. Another factor present, however, was the time involved in getting the spray from the gun to the receiving surface, and the breaking up or atomization of the lacquer particles into very minute globules. I found that by materially increasing the pressure of the air supplied to the gun a dense spray of finely atomized lacquer particles could be produced which would travel at high speed to the surface to be painted. This allows less time for evaporation of the solvent during travel of the spray and consequently allows the dense spray to be applied to the surface in a condition such that adjacent particles flow together in a smooth continuous film.

The present invention therefore contemplates the provision of a spray booth in which air can be introduced under such conditions of temperature and humidity as to provide the proper rate of evaporation of the particular lacquer being used that will prevent too quick drying of the lacquer when balanced against the increased air pressure which decreases the time during

which the lacquer travels from the gun to the surface to be painted and thereby allows a more dense and finely atomized application of spray particles to this surface. This control of temperature and humidity can be effected so that the spray booth temperature can be maintained within a comfortable range, varying from 70° to 80° F. with the relative humidity running from a possible low of 55% up to 70% with the most efficient range being from 60% to 65%. Coupled with this the air pressure on the spray gun has been increased very materially over pressures formally thought advisable In experimentation I have found that pressures from 150 pounds per square inch upward to 200 pounds per square Inch, as compared with a previous pressure of 60 pounds per square inch normally used, provide a marked increase in efficiency of paint application, limit the fringe or overspray to an appreciable extent and produce a more concentrated, dense and more finely atomized spray which adequately covers the surface and which has the particles so closely spaced together that they may flow into a continuous smooth film before the solvent has had an opportunity to evaporate. This eliminates entirely any tendency for an orange peel type of finish and due to the use of more or less normal room temperatures within the booth any possibility of brushing caused by condensation or the like on the body or other surface to be painted is also eliminated.

Further, the use of the very high air pressure at the spray gun prevents the spray from spreading and thereby provides a more concentrated and more easily directed spray which eliminates any tendency toward overspraying of the surface already painted, which has been a disadvantage of previous systems.

It is essential, in order to accomplish all these advantages, that all three of these factors be accurately balanced for the particular type of lacquer composition employed. Further, this balance must be maintained automatically regardless of variations in atmospheric conditions or weather conditions affecting the air drawn into the conditioning means leading to the spray booth. For commercial lacquer of the type now universally employed in spraying automobile bodies I have found that the most desirable results so far as elimination of orange peel or blushing is concerned have been attained with an air pressure from within 150 to 200 pounds per square inch, a dry bulb temperature in the booth of from 70° to 80° F. and a relative humidity of from 60% to 70%.

It will be at once apparent that under such conditions there is no great refrigerating load required for the system except on extremely hot days when the air must be cooled down. Except for such hot days, the air may either be heated or cooled if taken directly from the outside, depending on weather conditions.

It is therefore a primary object of the present invention to provide a method of and means for spraying articles of this type which will insure the application of a smooth continuous film over the surface being painted and which will eliminate any tendency toward orange peel, sagging or blushing.

Other objects, advantages and economies afforded by the present invention will appear more fully from the following detailed description which, taken in conjunction with the accompanying drawings, will disclose to those skilled in the art the particular construction and operation of a preferred form of the present invention.

In the drawings:

Figure 1 is a top plan view of a spray booth assembly, with the roof removed and the air conditioning means therefor;

Figure 2 is a side view taken substantially on line 2—2 of Figure 1;

Figures 3, 4 and 5 are transverse sectional views taken respectively on lines 3—3, 4—4, and 5—5 of Figure 1; and

Figure 6 is a schematic diagram of the air conditioning system and controls therefor.

Referring now in detail to the drawings, the spray booth is indicated generally at 10 and includes the spray chamber 12, the preconditioning chamber 13 and the discharge chamber 14. Extending through these chambers is a raised track 15 adapted to receive the trucks 16 upon which the car bodies or similar articles 17 are mounted. These trucks may be pushed along the tracks 15 by hand or may be mounted on an intermittently operated conveyor or the like, if desired.

The dividing walls between the chambers 12, 13 and 14 are provided with doors which may be closed during the spraying operation, if so desired. The chamber 13 is employed mainly for the purpose of insuring that the temperature of the article, such as the car body 17, will be substantially the same as the temperature within the spray booth 12 when the body is moved into the booth. The chamber 14 is provided to prevent too rapid change of the temperature of the body from the temperature of chamber 12 to the outside normal room temperature. The spray booth was originally designed in this manner due to the chilled conditions which were at first thought necessary for the successful operation of the invention. However, this design is effective for the present system of operation in that it is additional assurance against the possibility of blushing or the like.

The air circulation system comprises an air inlet 19 opening to the outside of the building wall 20 through which fresh air is drawn by a suitable blower or motor 22 mounted in the opposite end of an air conditioning chamber 23. The conditioned air drawn into the blower 22 is forced through the duct 24 into two overhead ducts 25 extending within the spray chamber 12 and provided on their lateral walls with openings, as indicated in Figure 4, for discharging the air downwardly into the booth and about the surface of the car body 17.

At the end of one of the ducts 25 there is provided an additional outlet 26 which allows a certain minor portion of the conditioned air to be discharged into the pretempering chamber 13 through the outlet in the transverse wall therebetween. Similarly, the duct 24 has a restricted opening 27 for discharging a certain amount of air into the chamber 14.

At the level of the track within the spray chamber 12 floor ducts indicated generally at 28 in Figure 4 are provided, through which air is forced through the floor of the chamber and distributed laterally into the longitudinally extending outlet ducts 29, which transmit this air through the ducts 30 to the exhaust duct 32. The ducts 29 also have lateral openings 33 therein for taking some of the air from the chamber 14 outwardly through the exhaust duct 32. It will thus be seen that a maximum distribution of conditioned air is provided within the cham-

ber 12 and the air is forced down about the surface of the body being sprayed and is removed at the floor level, together with the vapors which may have been imparted to the air by the spraying process, and which are withdrawn from the chamber along with the air. This provides for adequate circulation of clean conditioned air about the body during the spraying operation and insures that no dust or the like will be allowed to enter the spray chamber assembly. This latter feature is accomplished by having the air within the chamber under a slight pressure so as to prevent any possible infiltration of air from other sources.

Considering now the control system to be employed for conditioning the air, this is schematically shown in Figure 6 with parts of the mechanism being shown in plan view in Figure 1. Three control boxes, 40, 42 and 43, are provided, each connected to a source of three-phase alternating current. These controls are so arranged that operation of the push button control 44 at the control box will set in operation all of the equipment controlled from box 40 while operation of the push button 45 at control box 42 will set into operation the equipment controlled thereby. However, when the control box 40 is deenergized through the push button control switch 44 the entire system is disconnected since this control mechanism also controls the same motor for the blower 22.

Considering now in detail the operation of this system in conjunction with controls therefor, the outside air enters a first conditioning chamber 46 and if it is at too low a temperature for the conditions desired within the spray chamber it may be initially heated by a preheater 47 connected through the steam line 48 and valve 49 to any suitable source of steam supply. From the heater 47 the air is passed into the sprays 50 which constitute water sprays supplied from the water supply line 52 under the control of a valve 53. This valve in turn is controlled by means of an air thermostat 54 disposed within a series of baffles or filters 55 through which the air must pass and which in turn controls the air drawn through the pneumatic valve 56 connected to the control system between the boxes 40 and 42. The pneumatic valve 56 controls the air pressure from the air supply line 57 to the diaphragm or small control valve 58 which operates to control the water supply valve 53. Consequently the thermostat 54, responsive to the temperature of the air leaving the sprays 50, controls the amount of water supplied to the sprays through the valve 53.

From the baffles, eliminators or filters 55 the air passes into contact with a series of brine sprays 60 and is there subjected to contact with a brine solution which tends to remove moisture from the air and cools the air to an appreciably reduced temperature. The brine sprays are controlled from a circulating pump 62 which has its inlet connected to a sump 63 for collecting the sprayed brine and forcing it upwardly to the sprays 60. The pump 62 is controlled by a motor 64 of the three-phase type which is connected through the lines 65 to the control box 42 and consequently is controlled by the switch 45. The air is also cooled by passing over an ammonia coil 67 wherein a further cooling and dehumidification of the air is effected so as to remove all moisture therefrom that it is possible to remove at the particular temperature at which the air is maintained.

The ammonia coils are supplied with ammonia from the expansion valve 68 which is in the line 69 leading from an ammonia receiver 70 having its inlet side connected to the high pressure side of a compressor 72. The return line from the coils 67, indicated at 73, communicates with the low pressure side of the compressor 72. The receiver 70, as more clearly shown in Figure 1, is adapted to have water circulated therethrough by means of the water circulating pump 75. The compressor 72 is driven from an electric motor 76, which motor is actuated from the motor control box 43 through the supply lines indicated diagrammatically at 77, which connect with an automatic starter 78, this starter being under the control of an electric thermostat 79. The thermostat 79 is responsive to temperatures within the sump 63 and is energized through a suitable winding leading from the control box 42 through the connections 80. A suitable high pressure cutout or safety control 82 is provided in this line to prevent too great an ammonia pressure and is responsive to the pressure of the ammonia gas for shutting off the control circuit to the thermostat 79, thereby shutting off the control through the starter 78 to the motor 76.

It will thus be seen that the air has now been completely dehumidified, washed and cleaned and is now ready for conditioning to the desired temperature and humidity. For this purpose a heating coil 83 is provided which is supplied through automatic steam valves 84 and 85 with steam from a supply line 86. The valves 84 and 85 are controlled through suitable diaphragms or the like indicated at 87 and 88, respectively, responsive to a thermostat 89 disposed within the spray chamber 12 and connected to the air supply line 90. The air thermostat 89 is connected through a control valve 92 to the control valves 87 and 88 so that variations in the air supply to the control valves 87 and 88 will in turn control the steam valves 84 and 85 to admit varying quantities of steam to the heating coil for imparting to the air a predetermined temperature.

In order to humidify the air a humidity regulator 95 is provided within the spray booth 12 and comprises a water feed line 96 and a wet bulb thermostat 97 also connected to the air supply line 90 and through the conduit 98 to the control valves 99 and 100 of the high and low pressure steam valves 101 and 102. This provides for varying amounts of steam being delivered to the steam sprays 103 to introduce into the air a predetermined amount of moisture in accordance with the humidity existing within the spray booth 12. As a result, the air which is introduced into the spray booth has a certain predetermined temperature, controlled by the heating coil, and a certain predetermined humidity, controlled by the steam sprays 103, providing the desired conditions within the booth.

A suitable motor 105 drives the fan 22 and is connected through the line 106 to the control box 40. The light control switch 44 controls the starting and stopping of this motor and also controls the opening or closing of the circuit between the control box 40 and the control box 42 so that cutting out of the fan motor immediately deenergizes the entire remaining part of the system.

As stated heretofore, a large part of the time it will not be necessary to use the brine spray or the preheating coil 47 due to the fact that the air may be at or about the desired temperature and need only be cleaned, washed and brought to the desired humidity before introduction into the spray booth. However, with the

system as set up the control is automatic so that regardless of variations in conditions occurring in the air being supplied to the system, the conditioning system itself will insure the predetermined temperature and relative humidity for the air which is introduced into the spray booth. This, as stated before, preferably is arranged to produce 70° F. air and from 60% to 65% relative humidity.

Preferably a recording humidity and temperature instrument indicated at 109 is disposed within the booth itself to insure that proper conditions are being maintained therein so that if such conditions should vary corresponding regulation can be made in the air conditioning system.

It will be apparent that with the present system, no matter what may be the temperature or humidity conditions existing in the outside air which is being supplied to the booth, the proper temperature and humidity conditions are imparted thereto to secure the best conditions for operation of the spray equipment. These two factors of temperature and humidity are correlated with the air pressure of the spray gun to produce the desired smooth, continuous glossy coating to the articles being painted, and to eliminate any tendency toward orange peel, blushing or the like.

I am aware that a number of changes can be made in details of arrangement, construction and relationship of the parts of the present invention and therefore do not intend to be limited except as defined by the scope and spirit of the appended claims.

I claim:

1. In an air conditioning system for supplying conditioned air under predetermined temperature and humidity conditions to a paint spray booth, the method of conditioning said air which comprises spraying said air with water, passing said air through baffles for eliminating any unvaporized water carried in the air, controlling the amount of water sprayed into said air in accordance with the temperature of the air passing through said baffles, spraying said air after it leaves said baffles with a dehumidifying solution to cool the same and reduce the moisture content thereof, further cooling said air to completely dehumidify the same in accordance with the temperature of the discharged solution, reheating the air to a predetermined temperature, rehumidifying the air in accordance with the humidity existing in the spray booth, and then discharging the conditioned air into said booth.

2. In a method of conditioning air for a paint spray booth, the novel steps which comprise washing fresh air, controlling the washing of the air in accordance with the temperature of the washed air, spraying the washed air with a brine solution, passing the sprayed air through a cooler, controlling the operation of the cooler in accordance with the temperature of the discharged brine spray, reheating the cooled air to a predetermined temperature, and introducing a controlled quantity of steam into the reheated air to produce a predetermined humidity therein at said predetermined temperature.

3. In a method of conditioning air in which incoming air is washed, unevaporated moisture removed, and then dehumidified, reheated and rehumidified to predetermined conditions, the novel steps which comprise dehumidifying the washed air by first adiabatically removing moisture therefrom and then by reducing the temperature of said air, and controlling the reduction in temperature of the air in accordance with the temperature of the adiabatically removed moisture.

BERT F. FOWLER.