May 15, 1962 R. C. COBLENTZ 3,034,315

AIR CONDITIONER

Filed May 5, 1958 4 Sheets-Sheet 1

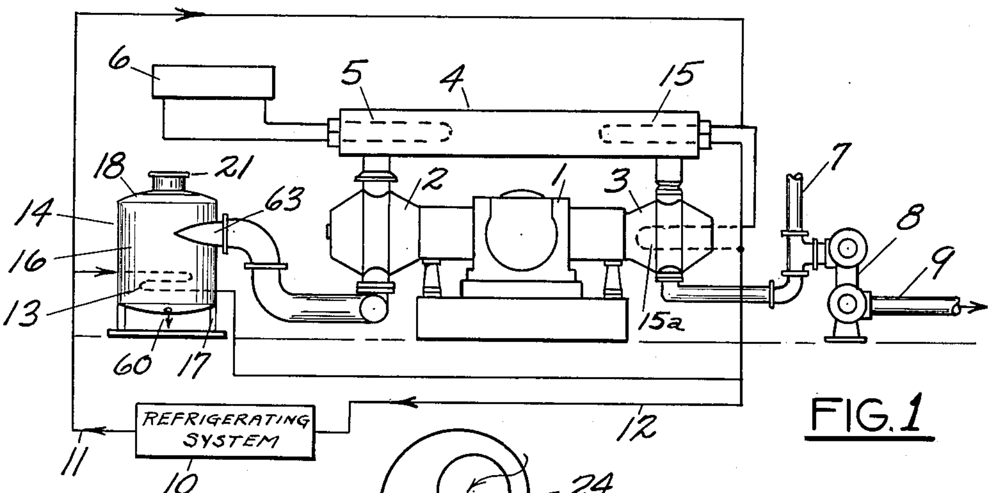

FIG. 1

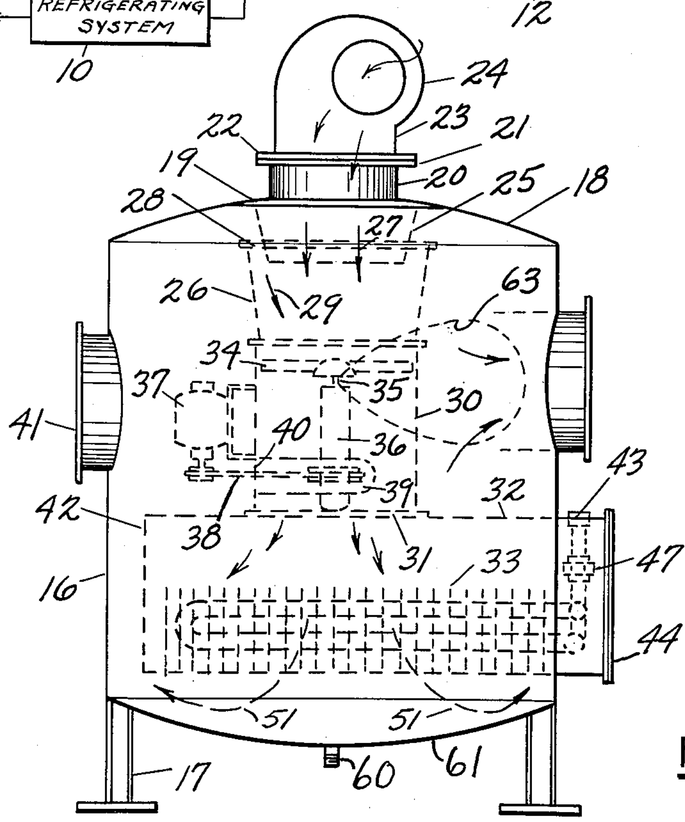

FIG. 2

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May 15, 1962 R. C. COBLENTZ 3,034,315

AIR CONDITIONER

Filed May 5, 1958 4 Sheets-Sheet 2

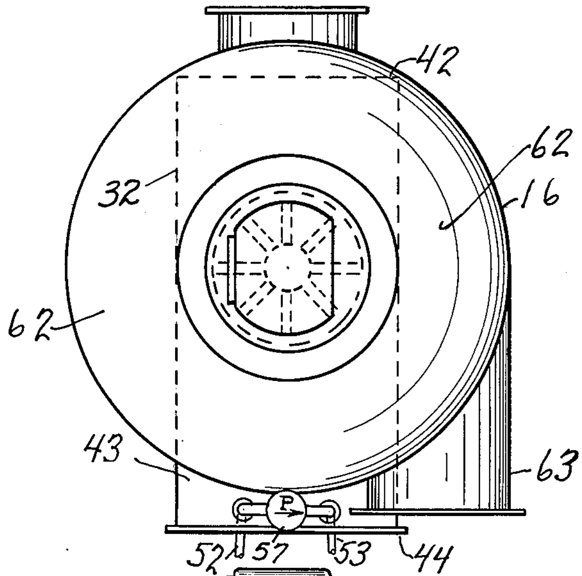

FIG. 4

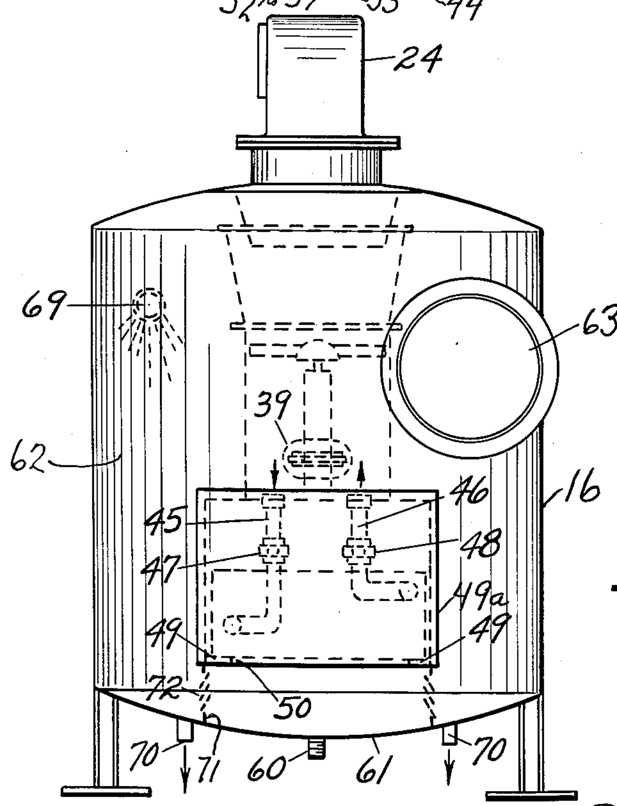

FIG. 3

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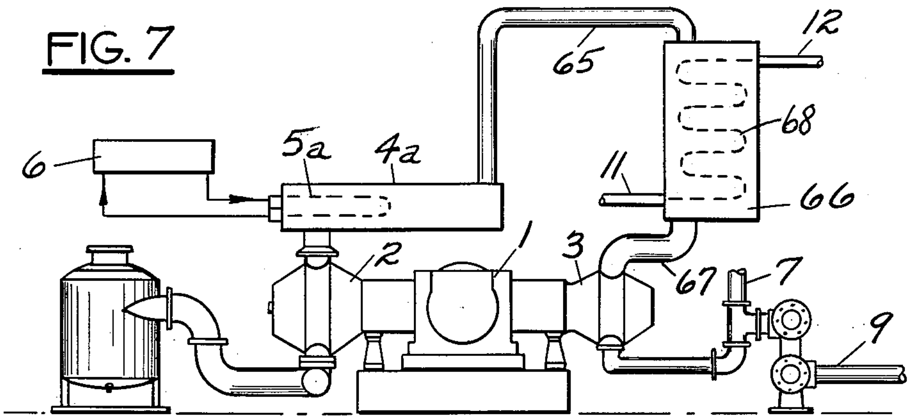
AIR CONDITIONER

Filed May 5, 1958 4 Sheets-Sheet 3

FIG. 7



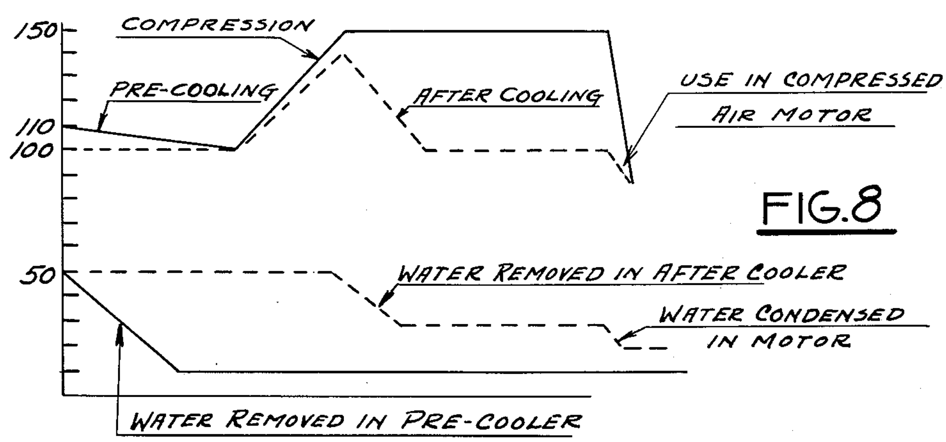
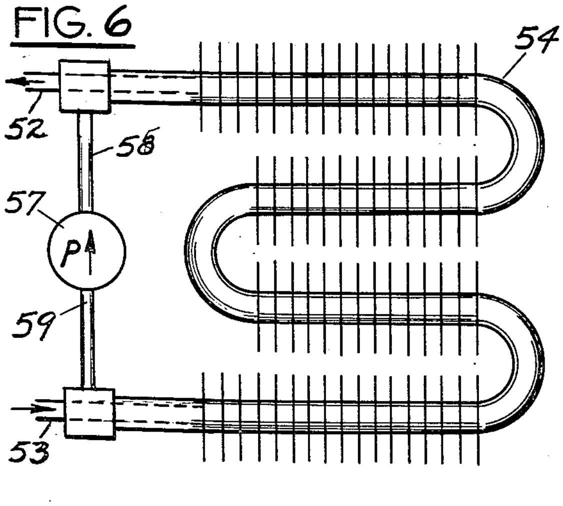


FIG. 8

FIG. 6



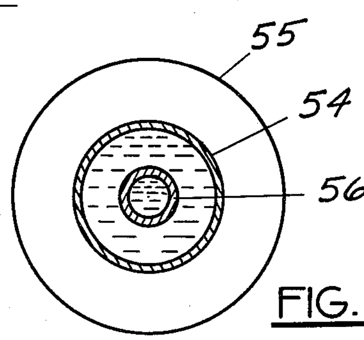


FIG. 5

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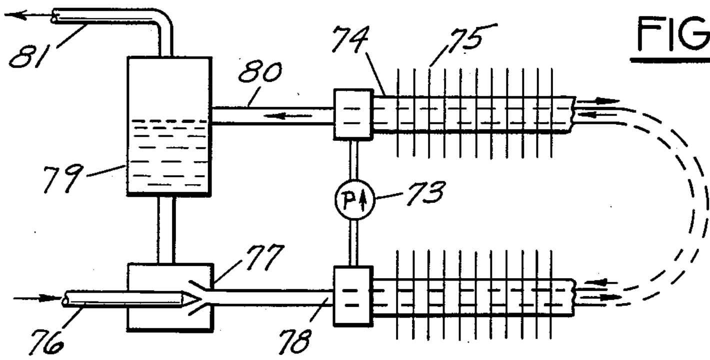


FIG. 9

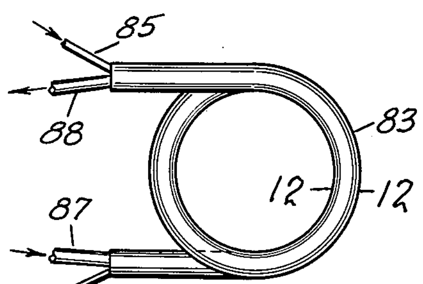


FIG. 11

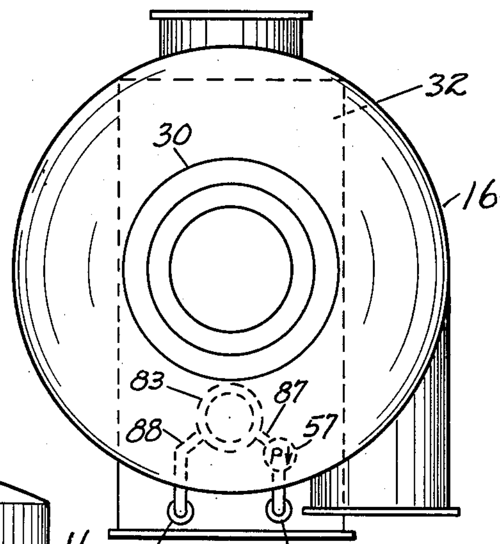
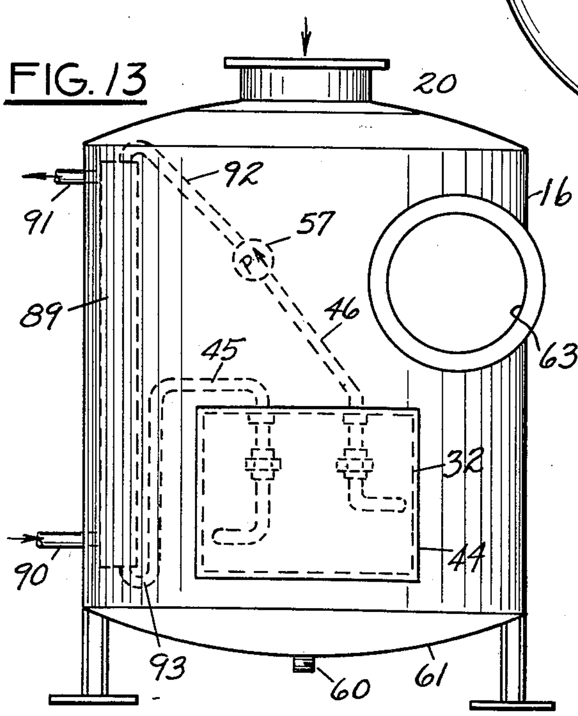


FIG. 10

FIG. 13



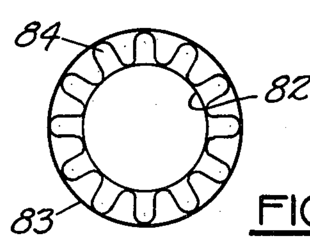


FIG. 12

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3,034,315
AIR CONDITIONER
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Filed May 5, 1958, Ser. No. 733,122
20 Claims. (Cl. 62—272)

In compressed air systems, moisture is harmful. It condenses in air operated motors washing the oil off lubricated surfaces and forming a sludge. It collects in the compressed air lines and may be discharged as slugs of water. Heretofore, the moisture problem has been attacked primarily by aftercoolers and afterdryers. According to this invention, the moisture is removed primarily by precooling or predrying so the compressor and the air lines handle dry air, resulting in up to 50% increase in air volume and in substantial savings in power and water. Precooling requires low temperatures for adequate moisture removal introducing the problem of frosting. There is also a pulsation of the compressor intake which causes unwanted vibration or noise. These are some of the problem overcome by the present invention.

In the drawing, FIG. 1 is a system diagram; FIG. 2 is a side elevation of the precooler; FIG. 3 is a front elevation of the precooler; FIG. 4 is a top plan view of the precooler; FIG. 5 is a section through the cooling coil; FIG. 6 is a flow diagram of the cooling coil; FIG. 7 is a diagram of an alternative intercooler for existing two-stage compressor installations; FIG. 8 is a moisture-volume diagram of the present system compared to the conventional aftercooler system; FIG. 9 is a diagrammatic view of another cooling coil; FIG. 10 is a top plan view of another precooler; FIG. 11 is a diagrammatic top view of the cooling coil used in FIG. 10; FIG. 12 is a section on line 12—12 of FIG. 11; and FIG. 13 is a diagrammatic side elevation of another precooler.

The invention is shown applied to a compressed air system having a motor **1** driving a two-stage compressor having a first stage **2** and a second stage **3**. Between the first and second stages the compressed air is cooled by an intercooler **4** having a cooling coil **5** supplied by a cooling tower **6**. From the second stage **3** the compressed air is discharged alternatively to an insulated compressed air line **7** which maintains the compressed air in a heated condition so that the air does not shrink in volume. This line is primarily for supplying compressed air devices which can use the air hot and thereby take advantage of the greater efficiency. The air from the second stage **3** of the compressor is also fed to an aftercooler **8** feeding a low temperature uninsulated air line **9** which, for example, might be a shop air line for supplying hand tools. The parts so far described are or may be of conventional construction.

As air is compressed and cooled, it loses its ability to retain moisture with the result that the moisture tends to condense out in the compresed air lines and in any motors or other devices operated by compressed air. Condensation is in the form of drops of slugs of water which are not only objectionable in themselves but are also objectionable because the water washes the oil off lubricated surfaces and forms a troublesome sludge with the lubricant. In the present invention the moisture removal is by precooling or predrying air which increases the efficiency of compression and results in a saving of both power and water. The precooling is by a refrigerating system **10** discharging refrigerant to a supply line **11** and receiving the returned refrigerant from a return line **12**. The refrigerating system is supplied with the usual controls for the refrigerant line output. For example, the refrigerant line might contain chilled water with a suitable

anti-freeze at a temperature of 30 degrees F. in which case the usual controls would operate to maintain the 30 degrees F. chilled water output temperature. It is preferable, however, that the refrigerant line **11** be supplied with the liquified refrigerant which is led to the point or points of use and there expanded to absorb heat after which it is returned through the line **12** to the refrigerating system. When the lines **11** and **12** carry refrigerant rather than chilled water, the piping is greatly reduced in size which results in a lower initial cost of the equipment. Whether the refrigerant is supplied in the form of chilled water or in the form of a refrigerant for direct expansion, the refrigerating system runs when there is a demand for cooling and shuts down when the cooling load has been satisfied. Conventional controls are available for this purpose and need not be illustrated for the purposes of this invention.

The refrigerant line supplies a cooling coil **13** in an intake air cooler **14** and a cooling coil **15** in the intercooler 4. The purpose of the cooling coil **13** is to drop the air intake temperature from outside air temperature, for example from summer heat of 95 degrees F. down to 35 degrees F. The purpose of the cooling coil **15** in the intercooler is to drop the intercooler air temperature down from its normal temperature of, for example, 100 degrees F. to 40 degrees F. By these temperature drops, enough moisture is removed so that the dew point of the compressed air never drops below the ambient temperature with the result that moisture does not condense either in the compressed air lines or in any compressed air operated device. This is a matter of great importance because the damage caused by drops of water is a large element in the maintenance costs of compressed air tools. The preliminary removal of moisture by the coil **13** reduces the amount of moisture removed by the coil **15** and decreases the danger of water entering the second stage cylinder and damaging the compressor by washing the lubricant off the cylinder walls. The moisture removal by precooling (and intercooling) is such that it is possible to circulate refrigerant through the cylinder jackets as indicated at **15***a* in the second stage **3**. Without the predrying of the air, the compressor jacket water temperature must always be kept above the dew point to prevent injury to the compressor by condensation on the cylinder walls. Predrying permits lower jacket water temperatures with resultant increase in compressor efficiency.

The intake air cooler has an upright cylindrical casing **16** supported on a base **17**. On the upper header **18** of the casing is fixed a removable cap **19** having at its center an intake air coupling **20**. The coupling **20** has a flange **21** which may be suitably secured to a flange **22** on the discharge **23** of a super charger **24**. The super charger is used to improve the efficiency and gives the incoming air a precompression of up to two pounds per square inch. If the increase in efficiency is not desired, the super charger may be omitted. Depending from the intake air coupling **20** is a converging discharge **25** extending within a converging fan inlet cone **26** to form a venturi. The inlet air from the coupling **20** is discharged into the center of the fan inlet section as indicated by the arrows **27** while other air is drawn by venturi action through the annular space **28** between the sections **25** and **26** as indicated by the arrow **29**. At the lower end the converging fan inlet section **26** is fixed to a fan casing or duct **30** discharging through an opening **31** in a casing **32** for the cooling coil 33. The fan **34** is fixed to a shaft **35** journaled in a structure **36** at the center of the duct **30** and is driven by a motor **37** through a belt drive **38** extending through a re-entrant housing **39** sealed to a side wall of the duct **30**. The re-entrant section **39** prevents escape of air from the opening **40** through which the belt extends. Access to the motor 37 and the belt drive 38 for repair and maintenance is through a bolted access plate 41 opposite the motor.

The coil housing 32 extends diametrally or chordwise across the lower part of the casing 16 and has its back end 42 welded or otherwise supported to the inside of the casing and its front end 43 projecting outside the casing and closed by a bolted plate 44. The front end extension of the casing 32 has fixed therein the inlet and outlet piping 46 for connection with the cooling coil 13. Upon removing the plate 44 and breaking the unions 47 and 48, the cooling coil can be slid out through the front end of the casing. When in place, the cooling coil is supported by inwardly extending flanges 49 at the lower edges of side walls 49*a* of the casing which define the bottom opening 50 through which the cooled air is discharged to the bottom of the casing as indicated by the arrows 51. The cooling coil has a drawer like support which permits ready removal for service. The coil housing 32 provides a structural support for the fan housing and acts as a cross brace for the casing 16.

In some installations, the cooling coil will be supplied with chilled water containing a suitable anti-freeze at a temperature of 30 degrees. For this installation, only the inlet and outlet pipes 45 and 46 will be used. In other installations, the cooling coil is supplied with liquid refrigerant and for this purpose there is mounted in the front end 43 of the casing a refrigerant inlet pipe 52 and a refrigerant outlet pipe 53. For this type of installation, the cooling coil may be of the structure shown in FIGS. 5 and 6 where there is an outer coil 54 to which are attached fins 55 and an inner coil 56 at the center of the coil 54. The coil 54 contains water mixed with antifreeze while the coil 56 contains liquified refrigerant which is expanded to absorb heat from the water within the coil 54. In order to prevent local cold spots within the coil 54 a continuous circulation of the water and antifreeze mixture is maintained by a pump 57 having an inlet 58 and a discharge 59 connected to opposite ends of the coil. The circulation of the water and anti-freeze mixture is counter to the circulation of the liquid refrigerant, the inlet pipe 52 for the liquid refrigerant being connected to the outlet end of the coil 54 while the outlet pipe 53 for the expanded refrigerant is connected to the inlet end of the coil 54.

Due to the rapid circulation maintained by the water circulating pump 57, a very uniform temperature of, for example, 30 degrees F. is maintained throughout the coil. The volume of water and anti-freeze mixture required is very small being only the capacity of the coil 54 and of the pump 57 and its inlet and outlet connections 58 and 59. The heat exchange from the liquified refrigerant to the water takes place right at the point of use, namely within the cooling coil 54 in contact with the air to be cooled. The need for a separate heat exchanger and for piping to conduct the chilled water to the cooling coil 54 is eliminated. The chilled water provides more efficient transfer than as though the coil 54 were supplied directly with liquified refrigerant. In direct expansion of liquified refrigerant, cold spots are produced at which ice formation starts. Since the coefficient of heat transfer from ice to air is very much less than from metal fins to air, the ice formation once started proceeds rapidly and the cooling efficiency of the coil drops off rapidly at the point of ice formation causing cumulative icing. This is eliminated in the chilled water cooling coil where cold spots are effectively eliminated.

As the air flows downward over the cooling coil, moisture condenses on the surface of the coil and is blown off the coil by the air toward a drain 60 in the lowermost or center part of the domed lower header 61 of the casing 16. The air discharge from the bottom of the cooling coil flows upward through the spaces 62 on either side of the cooling coil casing 32 and part of the air enters a tangential inlet 63 leading to the first stage 2 of the compressor. The greater part of the upwardly flowing air enters the annular space 28 between the cones 25 and 26 and repasses over the cooling coil for further cooling. While it would be expected that the maximum moisture removal would be limited by the temperature of the cooling coil, namely 30 degrees F. in the example given, in actual practice it has been observed that the moisture removal is greater than expected. The dew point of the cooled air is appreciably lower than the temperature of the cooling coil. For a 30 degree cooling coil temperature and a 35 degree temperature of the cooled air leaving the cooling coil, the 35 degree cooled air will have a relative humidity of 70% corresponding to a dew point of 27 degrees. With a straight through or single pass cooling coil without the repassing or recirculation, the cooled air would be at a relative humidity of 100% so the air temperature would correspond to the dew point.

In a specific example where the outdoor air temperature is 95 degrees F., the temperature of the mixture of air entering the the fan 34 will be 55 degrees F. and the temperature of the air leaving the cooling coil or the temperature of the air entering the tangential outlet 63 will be 35 degrees F. Although the air flow can be very large, the mixing effect of the fan 34 prevents stratification which would impair the cooling efficiency.

The tangential outlet 63 prevents vibration due to surging at the compressor intake. Air surges at the compressor intake do not impinge directly upon the fan entrance cone 26 but are dissipated in circumferential movements of the pulsating air about the inner surface of the casing 16.

FIG. 7 diagrammatically shows an application of the pre-cooling to an existing installation of a two-stage compressor. In this system corresponding parts are designated by the same reference numerals as in the previously described construction.

In this installation the intercooler 4*a* would normally receive the output of the first stage 2 of the compressor and the air in the intercooler would be cooled by a coil 5*a* fed from a cooling tower 6. The output of air from the intercooler 4*a* would normally flow directly to the second stage 3 of the air compressor. In order to improve the performance by further removal of moisture, the output of the intercooler 4*a* instead of being fed indirectly to the second stage 3 of the compressor is fed through a line 65 to an aftercooler 66 and after flowing through the aftercooler the cooled air which now has the temperature of approximately 35 degrees is fed through a line 67 to the second stage 3 of the air compressor. The cooling within the aftercooler 66 is accomplished by a coil 68 connected to the refrigerant inlet 11 and outlet 12. The lower temperature of the intercooled air still further increases the compressor efficiency as well as removes additional moisture. In order to convert an existing installation to my invention, it is necessary to add only the refrigerating system 10 and the intake air precooler 14. The existing aftercooler 66 is connected to aid the intercooler 4*a*.

For application requiring extremely dry air, the intake air precooler 14 may be supplemented by a spray of a desiccant such as glycerol. The desiccant spray or other gas and liquid contact apparatus 69 is located in the space 62 above the coil housing 32 where the air is moving at a relatively low velocity. As the upwardly moving air comes in contact with the glycol, moisture is absorbed and the glycol together with the absorbed moisture falls into the bottom header 61 and flows out through a drain 70. The glycol with the absorbed water is then led to the usual still where the moisture is removed and the dry glycol returned to the device 69. Because the great bulk of the moisture removal takes place in the cooling coil and is withdrawn through the drain 60, only a relatively small amount of moisture need be taken out by the glycol. This reduces the capacity requirement for the still for removing the absorbed water from the glycol. A baffle 71 keeps the glycol with the absorbed water from flowing to the center drain 60. If desired, louvres 72 may be added to keep the glycol out of the drain 60, although these ordinarily will not be necessary because of the high air velocity adjacent the louvres 72. The glycol spray is preferably located remote from the tangential outlet 63 to the compressor air intake so that carry over of particles of glycol into the compressed air will be minimized.

The advantages of the precooling of compressed air are illustrated in FIG. 8. In the conventional compressed air system using an aftercooler the incoming air fed directly to the compressor is expanded about 40% during compression and then is shrunk 40% by the aftercooler. At the point of use, there is a still further shrinking of the air which takes place, for example, in a compressed air hand tool. In the same conventional compressed air system, there is no water removal until the compressed air enters the aftercooler. At this point approximately 50% of the water is removed. This leaves up to 20% additional moisture which condenses in the compressed air tool at the point of use. In the present invention, the precooling of the incoming air increases the density so that it corresponds initially to approximately 10% greater volume than atmospheric air. During compression, the heat of compression expands the air until it has nearly 50% greater volume than atmospheric air. There is no aftercooling so that this expanded volume may be used directly as high temperature compressed air in many forms of compressed air machinery. Even in cases where the compressed air cannot be used hot, there is an effectively greater volume of air delivered to the line. In many cases, the dryness of the air is more important than the increase in efficiency or in delivered volume. The precooling as shown in FIG. 8 on a comparable basis removes 80% moisture instead of 50% so that at the point of use there is no condensation of moisture because the air is already dry enough.

In FIG. 9 is shown a modification of the FIG. 6 cooling coil where the water is chilled at the point of use so as to avoid the necessity for large diameter chilled water lines. The chilled water is circulated by a pump 73 and flows through large diameter outer tubes 74 to be mounted within the cooling coil casing 32 as shown in FIG. 2. Heat exchange fins 75 are mounted on the tubing 74. The refrigerant is led to the exchanger through a small diameter tube 76 discharging into a venturi 77 leading to a concentric inner tube 78 which causes the liquid refrigerant to counter flow to the chilled water. The venturi 77 sucks liquid refrigerant from a chamber 79 fed by an outlet line 80. The venturi 77 maintains a circulation of liquid refrigerant which has a high rate of heat transfer to the surrounding chilled water and is able to maintain more nearly constant temperature of the chilled water throughout the finned tube 74. This avoids cold spots at which frost might build up. The lower part of the chamber 79 is filled with liquid refrigerant. The upper part of the chamber 79 is connected to the refrigerant suction line 81.

In FIGS. 10, 11 and 12 is shown another arrangement for making the chilled water at the point of use and using a concentric coil heat exchanger. Whereas in FIGS. 6 and 9 the refrigerant was on the inside of the concentric coil heat exchanger, in FIGS. 10, 11 and 12 the chilled water flows through the inner coil 82 and the refrigerant flows through the annular space between the inner coil 82 and outer coil 83. Heat transfer fins 84 connect the inner and outer coils 82 and 83 to increase the rate of transfer. Because the refrigerant is on the outside of the chilled water, the outer surface of the coil 83 is below freezing and collects frost. The build up of frost, however, has no effect upon the heat transfer between the refrigerant and the chilled water in the inner tube 82. The frost has the effect of removing additional moisture from the cooled air.

When substituted in the precooler of FIGS. 2, 3 and 4, the refrigerant inlet pipe 52 is connected at 85 and the refrigerant outlet pipe 53 is connected at 86. The water outlet 46 from the cooling coil will be connected to pump 47 which discharges to the heat exchanger at 87. The outlet from the heat exchanger at 88 is fed to the inlet 45 for the cooling coil 33. By this connection, chilled water for the cooling coil 33 is made within the precooler casing 16 so that insulated pipe lines for chilled water are not necessary. This materially reduces the installation cost.

While it would be thought that icing of the heat exchanger coil 83 would be objectionable, it in fact is an advantage. The icing, as explained before, has no effect upon the heat exchange from the refrigerant to the chilled water other than perhaps to slightly improve the efficiency of heat exchange because ice on the outer surface of the coil 83 would act as an insulator. The supply of chilled water to the cooling coil 33 is accordingly essentially independent of the presence or absence of the ice on the heat exchanger coil 83. The presence of ice on the coil 83 does indicate the removal of additional moisture from the air and in this sense improves the efficiency of the compressor. Ice on the coil 83 does not interfere with the circulation of air within the cooler casing 16 because the heat exchanger occupies only a small part of the space between the fan casing 30 and the inside wall of the precooler casing 16. No matter how great the build up of ice on the heat exchanger 83, the circulation of air in the casing 16 will not be affected. In a preferred location of the heat exchanger 83, namely on top of the cooling coil casing 32, whenever the refrigerator shuts down because the demand for cooling has been satisfied, the continued circuation of cooling water through the inner coil 82 of the heat exchanger quickly melts the ice and causes it to fall on the top of the cooling coil casing 32. The temperature of the cooling coil casing 32 is always substantially above freezing so that the ice melts and flows out the drain 60. There is accordingly a built in automatic defrosting for the heat exchanger 83.

In FIG. 13 is shown another structure in which the chilled water is made within the precooler chamber 16. In this construction, a cylindrical heat exchanger 89 of the type used in water chillers is mounted vertically in the space at one side of the cooling coil housing 32. The refrigerant inlet line is connected to the bottom of the heat exchanger at 90 and the refrigerant suction line is connected to the top of the heat exchanger at 91. The pump 57 connected to the coil outlet 46 pumps the water to be cooled to the top of the heat exchanger at 92 and the cooled water flows out the bottom of the heat exchanger at 93 into the coil inlet 45. The heat exchanger can be of simple circular cross section with any of the customary heat exchange passages used in the cooling field. If the outside of the heat exchanger 89 should frost, it would not block the circulation of air and would only increase the moisture removal further drying the compressed air. During the down periods of the refrigeration system, the heat exchanger would be quickly defrosted and the ice would fall down into the bottom of the precooler chamber 16 where it would melt and flow out the drain 60.

In air compressors it is essential that there be no condensation in the cylinders which would wash the oil off the cylinder walls. This has led to the industry-wide requirement that the cylinder jacket water temperature be 20 degrees above the temperature of entering air. In my system, the entering air is cooled to 35 degrees F. not only before entering the first stage but before entering the second and any succeeding stages with the result that the cylinder can be refrigerated with increased compressor efficiency. In multi stage compressors, the cooling between stages is far below that heretofore considered safe practice because of the increase in moisture removal.

The precooler 16 could be used as part of the intercooler between compressor stages and could even be used as an aftercooler in cases where extremely dry air was required. When used as an aftercooler, the compressed air should be reheated to restore the volume. The heat of compression dissipated in the refrigerator system condenser is a convenient source of heat for reheating the air. Reheating would not be used at the compressor intake or between compressor stages. When used as an aftercooler, the cooler **16** could also serve as a storage tank and the recirculation of the air could be obtained from the venturi action alone without the fan **34**.

In some cases, the coil housing will extend clear through the casing **16** so that both ends will be accessible rather than only one end. This would make the cooling coil even more accessible for service. The coil housing need not be rectangular as illustrated. A tubular shape of circular or oval or other cross section with the coil **33** at the center can be used and would be a stronger structure less susceptible to vibration due to pulsation of the air. The fan casing **30** or other parts within the casing **16** can be mounted on a tubular housing just as well as on a rectangular housing. The entire bottom of the coil housing need not be open as illustrated. It is sufficient that the coil housing have an outlet for cooled air below the cooling coil. So long as this outlet were provided, the bottom of the coil housing could be entirely closed and could be slanted to drain to the outside of the housing **16** through an extension such as shown at **43**. This would cut down the chance of moisture pickup from water in the bottom of the casing **16**. The tubular shape of fan housing with circular cross section and with the cooling coil chordwise at the center would be ideal for draining water from the fan housing because there would inherently be space below the cooling coil for an air outlet for cooled air above the bottom of the coil housing which would serve as a drain trough for conducting the condensed moisture to the outside of the casing.

My system does not increase the operating cost. On the contrary, it decreases the operating cost and in addition gives dry air. The improvement in compressor efficiency more than offsets the operating cost of the cooling equipment.

What is claimed as new is:

1. A compressor air cooler comprising a cylindrical casing having top and bottom headers, a central air inlet in the top header, a drain in the bottom header for condensed moisture, a tangential outlet for cooled air at the top of the casing radially outside the air inlet, a cooling coil housing extending from outside the casing into and across the lower part of the casing and having a bottom discharge spaced above the bottom header, said housing having a top wall and having side walls extending chordwise of the casing to provide passageways for upward flow of cooled air from the bottom of the casing, an access cover on the outside of the casing and closing one end of the coil housing, a cooling coil within its housing slidable out through said one end of the coil housing upon removal of the access cover, a fan housing at the center of the casing supported on the coil housing and having its upper end receiving air from the air inlet and its lower end discharging into the cooling coil, said fan housing having side walls spaced inward from the casing to provide an annular space for upward flow of cooled air, a fan in said housing for forcing air into said inlet and means providing a passageway from said annular space in the casing into the fan housing for recycling part of the cooled air back over the cooling coil.

2. An air cooler comprising a casing having an air inlet and a cooled air outlet and including means for forcing air to be cooled into said inlet, a coil housing extending across the casing with the outer end of the housing outside the casing, a closure for the outer end of the coil housing, an air inlet duct supported by and discharging into the top of the housing, a cooling coil slidable into the housing through the outer end of the housing upon opening the closure, said coil comprising inner and outer tubes in separate fluid circuits, the space between the inner and outer tubes being filled with a heat exchange liquid, a refrigerating system connected to the inner tube for supplying refrigerant, and a pump mounted on the outer end of the housing and connected to the outer tube for circulating the heat exchange liquid through the space between the inner and outer tubes.

3. A compressor intake air cooler comprising a casing, an air inlet having a discharge at one end of the casing extending within and directed toward the opposite end of the casing, means for forcing air to be cooled into said inlet, a cooling coil in the path of the air flow from the air inlet and having a discharge spaced from said opposite end of the casing and having sides spaced from the side walls of the casing to provide a passageway for return flow of air from the coil, a duct for directing air from the inlet through the cooling coil, said duct having an end surrounding and spaced from the discharge of the air inlet and from said one end of the casing and forming a venturi in which the incoming air produces a suction drawing cooled air into said duct, and an outlet from the casing to the compressor.

4. A compressor intake air cooler comprising a cylindrical casing having headers at each end, a central air inlet in one header, an outlet for cooled air radially outside the air inlet, a cooling coil housing extending from outside the casing into and across the casing and having a discharge spaced from the other header, said housing having side walls extending chordwise of the casing to provide passageways for return flow of cooled air from the cooling coil housing back toward the air inlet, a fan housing at the center of the casing receiving air from the air inlet and discharging into the cooling coil housing, a fan in said housing, said fan housing having side walls spaced inward from the casing to provide space for said return flow of cooled air, and means providing a passageway from the casing into the fan housing for recycling part of the cooled air back over the cooling coil.

5. A compressor intake cooler comprising a casing, an air inlet at one end of the casing, an outlet for cooled air at said one end of the casing, a cooling coil housing discharging toward the other end of the casing and spaced to provide a return passage for cooled air back to said outlet, an inlet air duct discharging into said cooling coil housing, means for forcing air to be cooled into said inlet, said inlet air duct occupying a minor part of the cross sectional area of the casing, a refrigerator evaporator in said return passage, and means for circulating a cooling liquid through the cooling coil and in heat exchange relation to the evaporator.

6. The cooler of claim 5 in which the refrigerant evaporator is the outer of two concentric tubes and the cooling liquid is cooled by flowing through the inner of said two concentric tubes.

7. An air cooler having a cooling coil in the path of the air flowing to a compressor intake, a refrigerator evaporator downstream of the cooling coil and upstream of the compressor intake, and means circulating a cooling liquid through the cooling coil and in heat exchange relation to the evaporator.

8. An air cooling coil, concentric inner and outer tubes, means for connecting a refrigerator to the outer tube in closed circuit to circulate refrigerant through the outer tube, means connecting a pump to the coil and to the inner tube in closed circuit for circulating a heat transfer liquid through the inner tube and cooling coil, and means for passing air to be cooled over the cooling coil and the outer tube.

9. A compressor intake air cooler comprising an upright cylindrical casing, an air inlet duct occupying a relatively small part of the cross section area of the casing, an outlet for cooled air at the top of the casing, a cooling coil housing spaced above the bottom of the casing and from

the inside of the casing to provide between the coil housing and inside of the casing a return passageway for the flow of cooled air toward the top of the casing, a fan housing at the center of the casing having its lower end discharging downward through the cooling coil and having its upper end surrounding and spaced from the discharge duct for the air inlet and from the top of the casing to provide therewith a passageway for recycling of cooled air back over the cooling coil, a fan in said housing for forcing air into said inlet, a refrigerant evaporator occupying a minor part of the return passageway and in contact with the cooled air, and means for circulating a heat transfer liquid through the cooling coil and in heat transfer relation to the evaporator.

10. A compressor air cooler comprising a casing, an air inlet extending within one end of the casing, means for forcing air to be cooled into said inlet, a cooling coil housing extending across the casing and having an outlet spaced from the other end of the casing and having its inlet connected to said air inlet, said air inlet and said coil housing occupying only part of the cross sectional area of the casing to provide a return passage for the cooled air back toward said one end of the casing around said air inlet and coil housing, an outlet from the casing at said one end, a refrigerator evaporator in said return passage, and means for circulating a cooling liquid through the cooling coil and in heat exchange relation to the evaporator, said evaporator occupying only part of said return passage whereby icing of the evaporator removes moisture from the air without blocking the flow to the outlet from the casing.

11. A compressor air cooler for removing moisture from air to be compressed comprising a casing having an inlet for air to be cooled and an outlet for cooled air leading to an air compressor, a cooling coil, a housing surrounding the cooling coil and directing air over the coil, a fan for forcing through the coil housing a greater volume of air than the volume of air flowing through said inlet and outlet, said cooling coil housing being spaced from the walls of the casing to provide a return passage between the cooling coil housing and the casing through which part of the air leaving the cooling coil housing is returned for repassage over the coil for further cooling whereby moisture is removed prior to compression and the compressed air may be used without an after cooler.

12. The construction of claim 11 in which the casing is cylindrical and the cooling coil housing extends chordwise of the casing to provide the return passage.

13. The construction of claim 11 in which the cooler is connected as an inter cooler between two stages of a multi-stage compressor to remove moisture prior to final compression.

14. The construction of claim 11 in which the casing is upright and the inlet and outlet are in the upper part of the casing and the fan directs the air downward through the coil housing which is spaced above the bottom of the casing to provide a drain and in which the air in the return passage flows upwardly and a liquid desiccant is discharged downwardly through the upwardly moving air into a separate drain for the desiccant with absorbed moisture.

15. A compressor air cooler for removing moisture from air to be compressed comprising a casing having an inlet for air to be cooled and an outlet for cooled air leading to an air compressor, a cooling coil, said coil comprising inner and outer tubes in separate fluid circuits, the space between the inner and outer tubes being filled with a heat exchange liquid, a refrigerating system connected to the inner tube for supplying refrigerant, a pump connected to the outer tube for circulating the heat exchange liquid through the space between the inner and outer tubes, a housing surrounding the cooling coil and directing air over the coil, a fan for forcing through the coil housing a greater volume of air than the volume of air flowing through said inlet and outlet, said cooling coil housing being spaced from the walls of the casing to provide a return passage between the cooling coil housing and the casing through which part of the air leaving the cooling coil housing is returned for repassage over the coil for further cooling whereby moisture is removed prior to compression and the compressed air may be used without an after cooler.

16. The construction of claim 15 in which the cooling coil housing has a part projecting outside the casing and the pump is mounted on the projecting part of the coil housing.

17. A compressor air cooler for removing moisture from air to be compressed comprising a casing having an inlet for air to be cooled and an outlet for cooled air leading to an air compressor, a cooling coil, a housing surrounding the cooling coil and directing air over the coil, a fan for forcing through the coil housing a greater volume of air than the volume of air flowing through said inlet and outlet, said cooling coil housing being spaced from the walls of the casing to provide a return passage between the cooling coil housing and the casing through which part of the air leaving the cooling coil housing is returned for repassage over the coil for further cooling whereby moisture is removed prior to compression and the compressed air may be used without an after cooler, and means supplying the cooling coil by a heat exchange liquid cooled by a refrigerator evaporator, said evaporator being located within the casing in said return passage.

18. The construction of claim 17 in which the refrigerant evaporator is the outer of two concentric tubes and the heat exchange liquid is cooled by flowing through the inner of said two concentric tubes.

19. An air cooler and dryer comprising a casing having an inlet for air to be cooled and dried and an outlet for cooled and dried air, a cooling coil within the casing, a housing within said casing surrounding a cooling coil and directing air over the coil, a fan for forcing a greater volume of air through the coil housing than the total volume of air flowing through said inlet and outlet, said cooling coil housing being spaced from the walls of the casing to provide a return passage between the cooling coil housing and the casing through which part of the air leaving the cooling coil housing is returned for repassage over the coil for further cooling, a drain below the cooling coil, means discharging a liquid desiccant into said return passage, a drain for the desiccant with absorbed moisture, and a dam between the drains for preventing mixing of moisture condensed by the cooling coil with the desiccant with its absorbed moisture.

20. A compressor air cooler for removing moisture from air to be compressed comprising a casing having an inlet for air to be cooled and an outlet for cooled air leading to an air compressor, a supercharger for forcing air to be cooled into said inlet, a cooling coil, a housing surrounding the cooling coil and directing air over the coil, a fan for forcing through the coil housing a greater volume of air than the volume of air flowing through said inlet and outlet, said cooling coil housing being spaced from the walls of the casing to provide a return passage between the cooling coil housing and the casing through which part of the air leaving the cooling coil housing is returned for repassage over the coil for further cooling whereby moisture is removed prior to compression and the compressed air may be used without an after cooler.

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