Nov. 20, 1962 A. Y. DODGE 3,064,446

AIR CONDITIONING APPARATUS

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Fig. 1

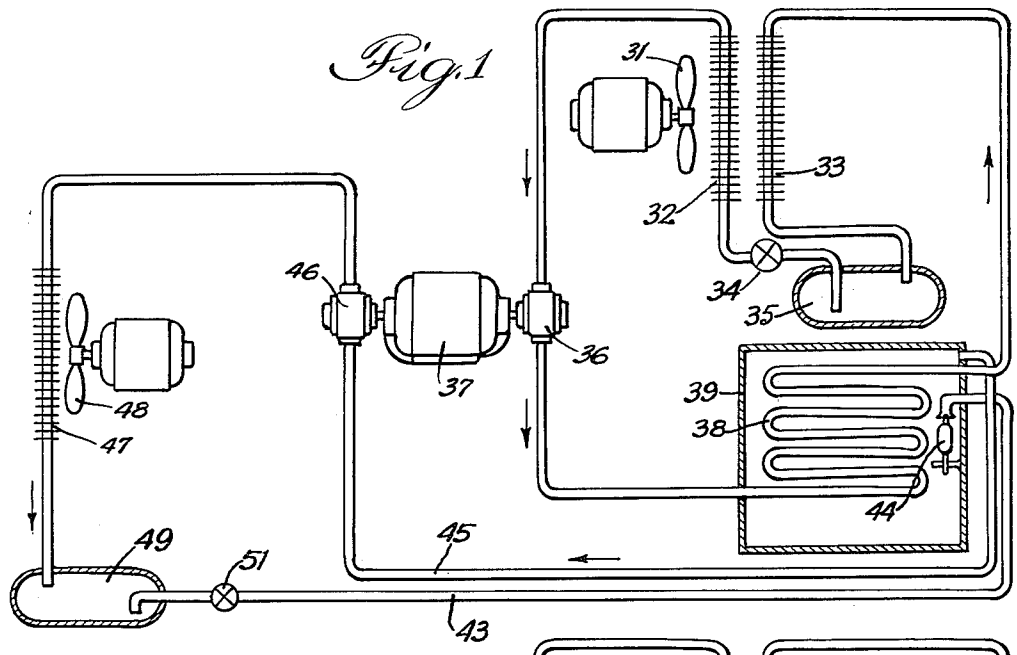
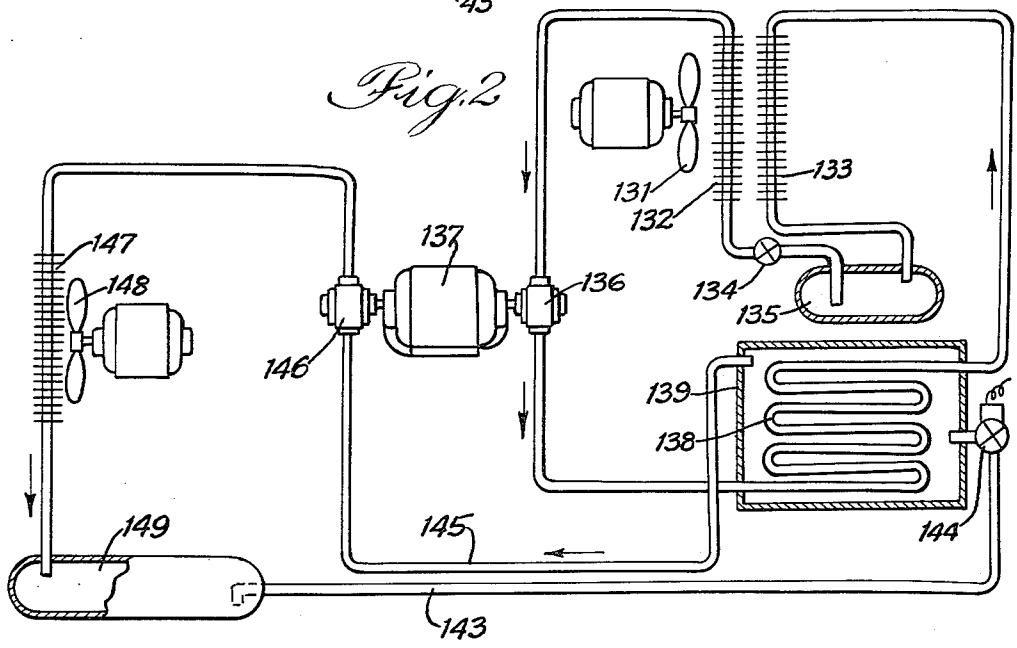


Fig. 2



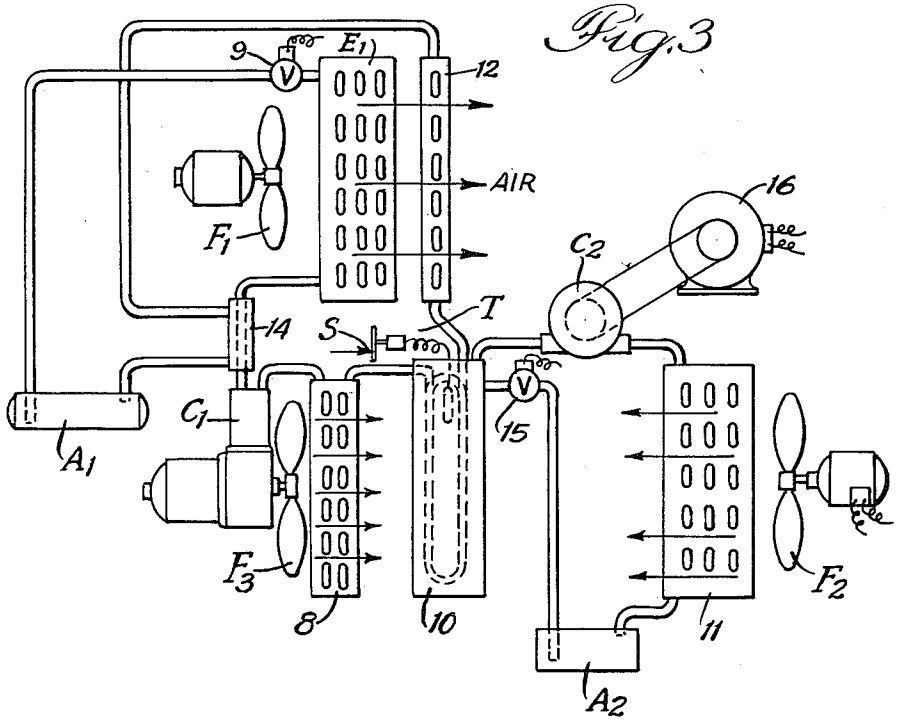
INVENTOR:
Adiel Y. Dodge,
BY
Bair, Freeman & Molinare
ATTORNEYS.

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Fig. 3



INVENTOR:
Adiel Y. Dodge,
BY
Fair Freeman & Molinare
ATTORNEYS.

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AIR CONDITIONING APPARATUS

Adiel Y. Dodge, 206 S. Main St., Rockford, Ill.

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3 Claims. (Cl. 62—175)

This application is a continuation-in-part of application S.N. 826,093, filed July 9, 1959, now abandoned, which related to air conditioning or air cooling apparatus.

The main object of this invention is to provide an apparatus employing a new cycle to more effectively produce refrigeration when using warm ambient air as the final means of dissipating heat.

An object of this invention is to provide means to cool a refrigerant condenser where adverse conditions make cooling difficult. Cooling systems in dry hot climates on occasions find inadequate cooling means to cool the condenser of the cooling system. Since present day refrigerants such as Freon 12 or 22 operate less efficiently at high temperatures, it is advisable to permit them to stay within the optimum temperatures.

This invention provides auxiliary means for cooling the condenser wherein such refrigerants are condensed by means of a refrigerant which has a much higher critical temperature or one which has no critical temperature such as H_2O.

Another object of this invention is to provide a compound cooling apparatus employing two different refrigerants, two different compressors, and two different evaporators. The secondary apparatus carries the refrigerant to higher temperatures to thereby better dissipate the heat into the warm ambient air.

Another object of this invention is to provide an apparatus which may be used for cooling air without consuming water under extreme adverse conditions.

Another object is to provide a refrigeration system by means of which ice or any other form of refrigeration may be produced economically without consuming cooling water, using warm or hot ambient air as the final cooling medium.

Another object of this invention is to use water vapor as the secondary refrigerant.

Still another object of the invention is to provide air cooling apparatus in which the primary condensing function is accomplished by evaporating a medium having a high vaporizing temperature, preferably water, to effect cooling of the primary refrigerant.

According to a feature of the invention, water vapor utilized in the condenser cooling operation may be condensed and returned to the system to be reused to conserve water where this is important.

The above and other objects and features of the invention will be more readily apparent from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a diagrammatical view of an air cooler embodying the invention;

FIGURE 2 is a diagram like FIGURE 1 in which an expansion valve has been substituted for float valve;

FIGURE 3 is a diagrammatical view showing another form of apparatus embodying the invention.

As illustrated in FIGURE 1, a suitable low temperature refrigerant flows from receiver 35 through expansion valve 34 into evaporator 32. Air is blown through the evaporator 32 by fan 31 to cool the air passing therethrough. Compressor 36 compresses the refrigerant vapor which is cooled by passing through coil 38. Chamber 39 in which coil 38 is contained is partly filled with cold water and cold water vapor as will presently be described.

The part of FIGURE 1 so far described might be almost any refrigeration cooling system using almost any conventional refrigerant.

There is a special feature, however, which consists of auxiliary condenser 33 placed so that it is cooled by the air which is chilled while passing through evaporator 32. In this way, condenser 33 acts as an air temperer to take the unnecessary chill out of the air and to further chill the refrigerant, as more fully described in my copending application S.N. 826,093.

This auxiliary condenser 33, however, is incidental to and not fundamentally necessary to the compound cooling I am about to describe.

The cold water and cold water vapor previously mentioned in chamber 39 is produced by evaporation. The evaporation is caused by the partial vacuum being created in the chamber 39 by a suction pump and compressor 46 connected to chamber 39 by means of pipe 45. Low pressure is maintained in chamber 39 to evaporate the water. Said water vapor is compressed in compressor 46 and passes through condenser 47.

Warm ambient air is blown through condenser 47 by fan 48. The temperature of the compressed water vapor may be several degrees higher than it is desirable to compress other refrigerants. Due to this increased temperature, energy is dissipated to the ambient air more readily.

After the compressed refrigerant is reduced in temperature by the air passing through 47, it becomes condensed and is accumulated in accumulator 49 in the form of liquid or water. As accumulator 49 becomes more full of water, chamber 39 becomes less full.

Eventually, float valve 44 opens its valve portion to admit a charge of water from accumulator 49 through check valve 51 and conduit 43. When sufficient water has been admitted, float valve 44 again closes so that subatmospheric pressure may be maintained in chamber 39 by the suction of compressor 46.

By charging the secondary system with the correct amount of fluid, intermittent operation by float valve 44 will take place. It will alternately close the valve to permit a partial vacuum to be created in chamber 39 until sufficient water has been evaporated so that valve 44 opens to admit fluid from accumulator 49 where it has been accumulated.

The air to be conditioned is forced by a fan or blower 31 over the evaporator 32 and then over condenser 33 before returning to the space to be conditioned. Low temperature refrigerant is supplied to the evaporator 32 past a restriction 34 from a receiver 35 containing condensed refrigerant. The refrigerant vaporized in the evaporator 32 is compressed by a compressor 36 driven by a motor 37 and flows through coil 38 to be condensed. From the coil 38, the refrigerant flows through the condenser 33 and back to the receiver 35.

In this apparatus, the primary condensing of the main refrigerant is performed in the heat exchanger 38—39 by heat exchanging contact of the refrigerant coil 38 with the water or water vapor. The condenser 33 in the conditioned air stream functions to temper the conditioned air; however, it insures that the refrigerant is fully condensed before it is returned to the receiver 35. The water vapor withdrawn from the chamber 39 is compressed in compressor 46 and recondensed in air cooled condenser 47 and returned to the accumulator 49 so that no water is consumed in the operation.

FIGURE 2 is very similar to FIGURE 1. Like parts are designated by similar characters with the prefix 1; i.e., motor 37 of FIGURE 1 becomes motor 137 in FIGURE 2.

In FIGURE 2, the float valve 44 of FIGURE 1 is replaced by a conventional expansion valve 144. The accumulator 149 is similar to the old accumulator except enlarged in size so that it may accumulate a greater portion of the fluid in the system when called upon to do so.

The functioning of the apparatus diagrammatically

shown in FIGURE 2 is very similar to that of FIGURE 1. Parts **131** through **138**, inclusive, function in like manner to those described in FIGURE 1. However, the auxiliary cooling portion functions slightly differently as follows:

Water vapor or other refrigerants not having a high critical heat are compressed in compressor **146**, cooled in condenser **147** by ambient air being blown therethrough by fan **148**. Fluid and fluid vapor is accumulated in accumulator **149**. Liquid is expanded in expansion valve **144** and enters chamber **139** as a mist, flashing immediately into steam due to the low pressure being maintained in chamber **139** by the suction side of compressor **146**.

In this way, the condenser for the primary cooling system is cooled by the evaporator of the secondary system as previously described. However, in this case, the secondary cooling system functions more as a closed mechanical refrigeration system.

FIGURE 3 diagrammatically illustrates another and in some ways preferred form of compound refrigeration apparatus. If used for air cooling, main evaporator E1 cools the air "Air" entering the dwelling space. The circulation of air is caused by fan F1. Refrigerant flows through expansion valve 9 into main evaporator E1 and is returned to compressor C1. From compressor C1, the refrigerant passes through condenser **8** and also condenser **10**, which is in series. It then passes through an auxiliary condenser **12** in the stream of air to be conditioned downstream from evaporator E1 as more fully described in the forepart of this specification and also in my copending application S.N. 826,093.

Auxiliary condenser **12** may or may not be used as a component in this form of the invention. Refrigerant is returned to accumulator A1 and may pass through heat exchanger **14** enroute. Heat exchanger **14** may be omitted, if desired.

The secondary cooling portion comprises a second refrigerating system connected in series with the first. The second refrigerating system cools condenser **10** and dissipates the heat at an elevated temperature through air cooled condenser **11** to the ambient air. The elements that go to make up the secondary cooling system comprises accumulator A2, expansion valve **15**, and combined evaporator, and heat exchanger **10** which forms a steam cooled condenser.

Compressor C2 is driven by motor **16**. The compressor delivers a suitable refrigerant such as H_2O to air cooled condenser **11**. Air is circulated through condenser **11** by fan F2. Refrigerant after passing through condenser **11** is returned to accumulator A2.

The foregoing parts comprise two closed refrigeration systems connected in series. The second system cools the condenser of the first system. The secondary cooling system may remain inoperative and alternately become operative when called upon by increased heat load. If the temperature in condenser **10** rises above a predetermined degree, thermostatic switch S will be closed thereby starting motor **16** for compressor C2 and starting fan F2 to bring the secondary cooling system into play.

Secondary condenser **11**, which is air cooled, may operate at temperatures in the neighborhood of 125° F. up to 150° F., if desired.

When high ambient temperatures are confronted too high to permit the main cooling system to function efficiently, the higher temperatures created in heat exchanger **10** cause the thermostatic control indicated at T to close electric switch S to set the auxiliary cooling system into motion. This cools the compressed gas of the primary system by means of the conversion of water into steam in heat exchanger **10**. Valve **15** provides the necessary resistance so that low pressure may be maintained in heat exchanger **10**.

Heat exchanger **10** is kept under a low pressure in the neighborhood of .4 to 1. p.s.i. absolute by suction from compressor C2. Water vapor flashes into steam and is later compresser by compressor C2 into heat exchanger **11** which may be operated at some desired higher temperature such as 150° F. air cooled. This calls for a pressure of 3.72 pounds square inch pressure absolute. An auxiliary cooling system is thus provided.

It is apparent that this system may be operated as a compound system under continuous conditions or may be set up so that the secondary cooling system functions only as a booster when most needed.

Secondary condenser **12** may be employed to act as an air temperer when desired as fully described in my copending application S.N. 826,093.

The following calculations pertain to ideal performance of one form of my compound refrigerating cycle. Of course, other temperature ranges may be used to advantage under various other conditions.

A.Y.D. COMPOUND COOLING IDEAL PERFORMANCE CALCULATIONS

Freon #12 ambient temperature=95° F. Figures per ton or 200 B.t.u. per minute

First Stage Working Alone

Refrigerant in evaporator E1 at 35° F.=82 B.t.u.
Referigerant in condenser #8 at 105° F.=32 B.t.u.
(Difference 50 B.t.u.)
200 B.t.u./50 B.t.u.=4 lbs. of refrigerant (F12) required.

	T. ° F.	Vcu. ft.	P.s.i.a.	B.t.u.
	105 35	.30 .877	141.1 47.7	89 82
Diff.	DX4	.577 2.308	93.4	7 28

Work=$W=Jw(hgl-hf2=778\times4\times7=21,800$ ft. lbs.)

H.P.=21,800/33,000=.66 H.P. C.o.p. 200×778/21,800=7.1 2.308 × 93.3/1.4×144/33,000=.69 H.P.
Compression ratio=2.95:1

Performance of First Stage While Working With Second Stage

Refrigerant in evaporator E1 at 35° F.=82 B.t.u.
Referigerant in condenser #**10** at 80° F.=26 B.t.u.
(Difference 56 B.t.u.)
200 B.t.u./56 B.t.u.=3.575 lbs. required

	T. ° F.	V	P	B.t.u.
	80 35	.42 .877	100 47.7	86 82
Diff.	DX3.6	.457 1.65	52.3	4 14.5

778×3.6×4=11,200=.34 H.P. .66 H.P.—.34 H.P.=.32 H.P. less 200×778/11,200=13.9 c.o.p. 52.3/1.4×144×1.65/33,000=8880/33000=.27 H.P. Compression ratio=2.13:1

Performance of Second Stage While Boosting First Stage

Water vapor used full 200 B.t.u. extracted. Vapor in #**11** at 128° F.=1117 B.t.u. Water in #**10** at 76°=44 B.t.u. Difference=1073 B.t.u. 200/1073=.186 lbs., say .2 lb. required.

	T. ° F.	V	P	B.t.u.
	128 76	165.5 717	2.1 .44	1,117 1,051
Diff.	DX.2	551.5 110.4	1.66	66 13

778×13 B.t.u.=10,120=.307 H.P. 200×778/10,120=15.3 c.o.p. .66 H.P.—(.307+.340)—.013 H.P.
Final saving=2% and heat dissipated at 128° vs. 105° F.

110.4 cu. ft.×144×1.66/2÷33,000=13,200/33,000=.4 H.P. Compression ratio=4.77:1. If desired, higher T may be employed in final condenser. For instance, the compression ratio is only 6½:1 when going to 140° F. from 76° F.

Comparable and perhaps somewhat better results may be achieved by using a secondary refrigerant for cooling the primary condenser which will vaporize at a lower temperature than water and adjusting the pressure in the secondary system for most effective use of the secondary refrigerant use. I have found that various hydrocarbons are suitable for this purpose such as benzene, naphtha, naphthalene, or carbon tetrachloride or mixtures thereof. To reduce fire hazard carbon tetrachloride or chlorinated hydrocarbons or mixtures thereof are preferable. It is also preferred to add mineral oil in an amount up to 10% by volume as a lubricant for the secondary compressor.

While several embodiments of the invention have been shown and described in detail it will be understood that they are illustrative only and are not to be taken as a definition of the scope of the invention, reference being had for this purpose to the appended claims.

What is claimed is:

1. In an air conditioning apparatus including a compressor, an air cooled condenser connected to the compressor outlet, an evaporator connected to the compressor inlet, and a connection between the condenser and the evaporator, the improvement which comprises a heat exchanger having separated closed spaces one of which is connected in series in said connection, means to maintain water in the other of said spaces, a pump having its inlet connected to the upper part of the other of said spaces to produce a subatmospheric pressure therein to vaporize the water therein and to pump water vapor therefrom and compress the water vapor, an air cooled condenser connected to the pump outlet to receive compressed water vapor therefrom and condense it, and a connection from the last named condenser to said other of the spaces to return the condensed water vapor to said other of the spaces.

2. The air conditioning apparatus of claim 1 including control means responsive to the temperature of the water in said other of the spaces to control operation of the pump.

3. The air conditioning apparatus of claim 2 including a float valve in said other of the spaces responsive to the level of water therein to control the return of condensate through said last named connection.

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