Sept. 22, 1953 L. ROMANI 2,652,699

WINDMILL AND HEAT PUMP SET

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Fig. 1

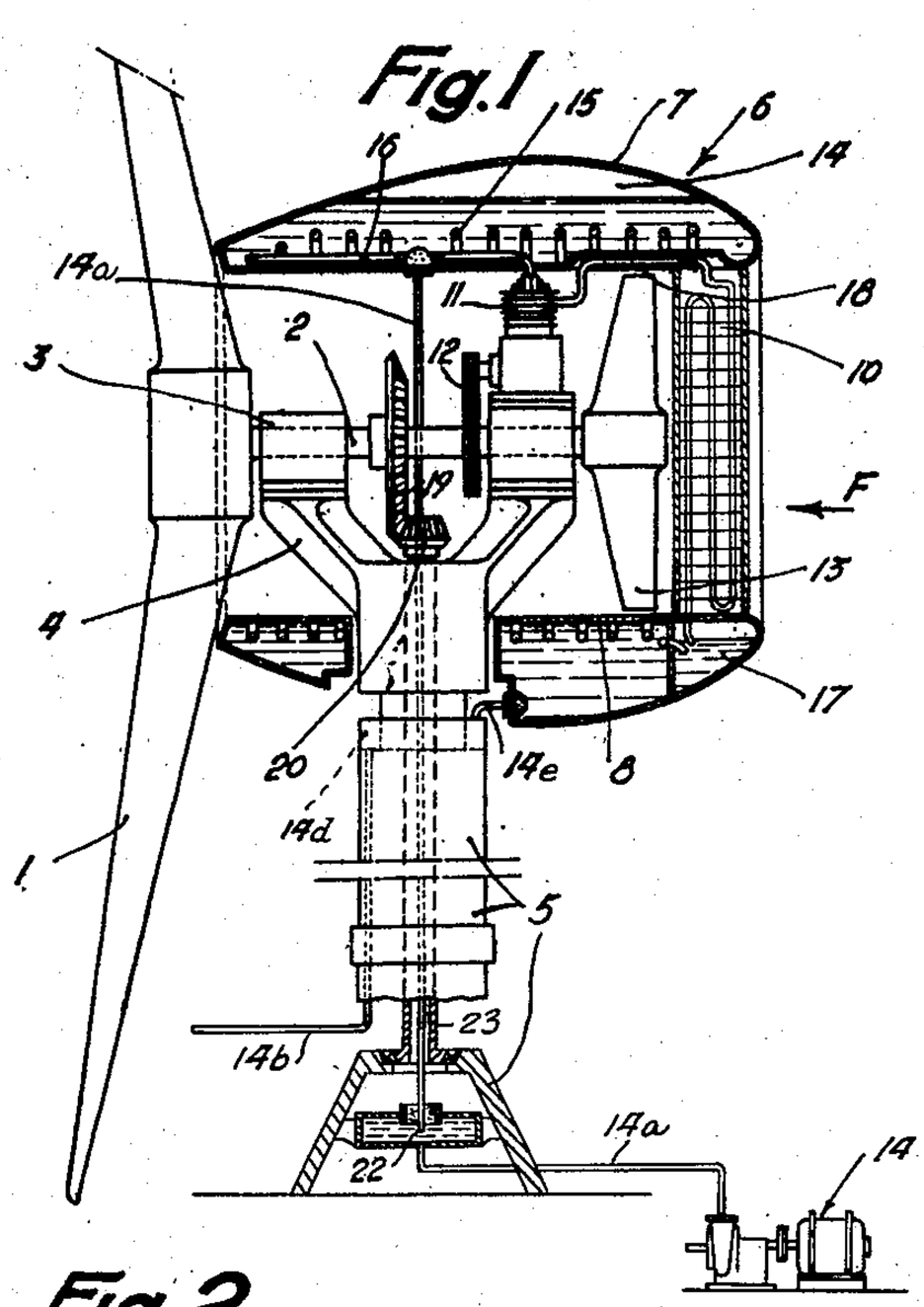
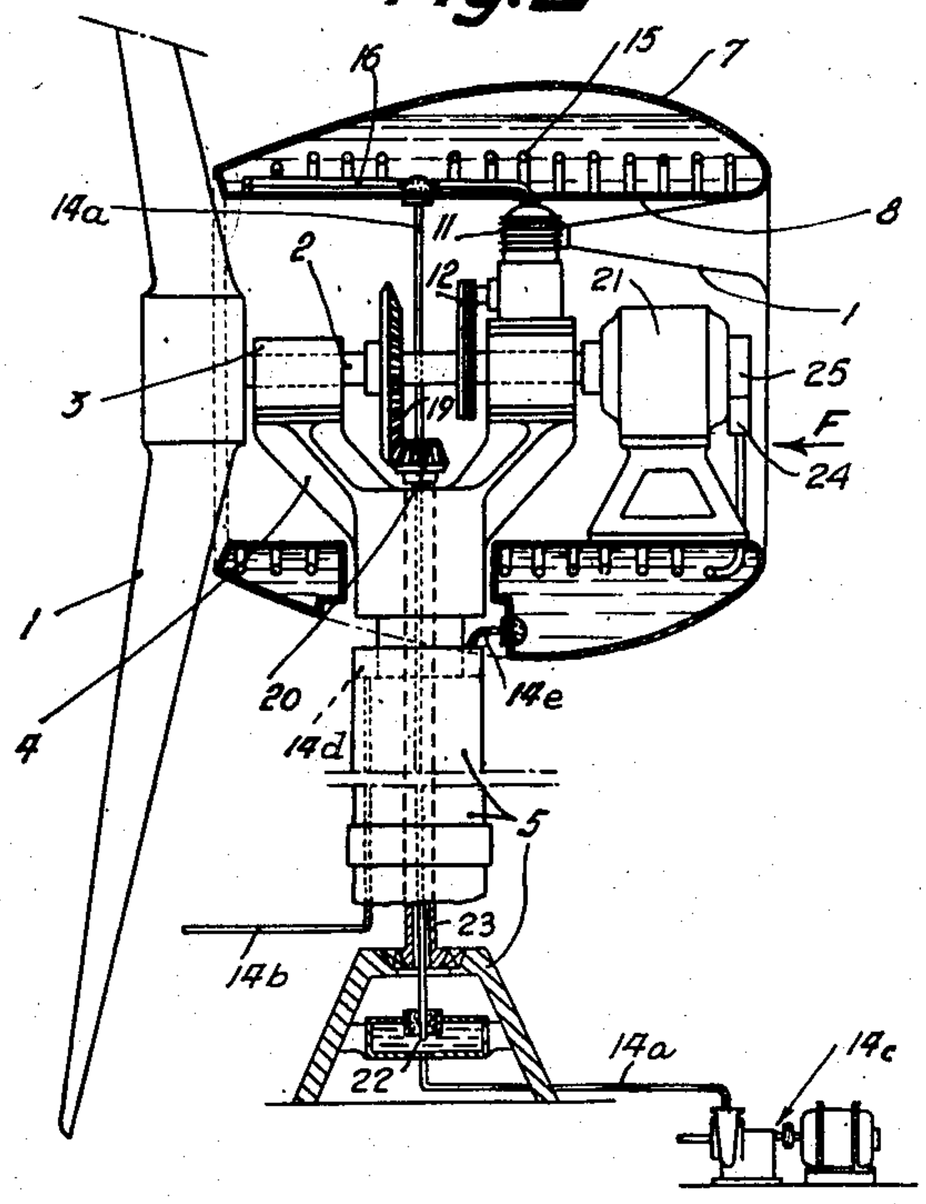


Fig. 2



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WINDMILL AND HEAT PUMP SET

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The windmill is obviously a possible solution for the fulfillment of the requirements of small remote working plants such as farms, sawmills located in the hills, alluvial operations etc.

Difficulties unfortunately are encountered that arise above all from the limited productive capacity of the windmill when there is only a slight breeze blowing or there is no wind, taken together with the well known drawbacks of any power-storage system.

The windmill, as a general rule, is asked to convert mechanical power from the air into electrical energy. Now use is not made always of the whole of the power electrically. Cooking, heating, and many other purposes lead to dissipation of the electric power, which is not economical since one kilowatt-hour theoretically gives only 860 kilo heat units (in practice this is from 700 to 750). Furthermore, as electric storage is a very heavy item of expenditure, heat storage is called in when possible by means of water heating and storage radiators, but this equipment is fairly expensive.

One object of this invention is to provide an arrangement for making the best possible use of the power supplied by a windmill wheel and for this purpose plans to combine a windmill with a heat pump that is actuated by a portion of the power supplied by the windmill.

Another object of this invention is to provide for the best possible use simultaneously of the power and of the heat units of the wind. A further object of this invention is to benefit from the conditions prevailing at the top of a windmill tower for operating a heat pump.

Two embodiments of a windmill-heat pump set according to the invention have been shown in quite a diagrammatic way as examples that are not to be regarded in any way as restrictive.

In these drawings:

Fig. 1 is an elevational view of the upper portion of a windmill of which the fairing is illustrated in horizontal section and encloses a heat pump in closed circuit.

Fig. 2 is a view similar to Fig. 1 of a heat pump set in open circuit.

In the example illustrated in Fig. 1, the windmill wheel-heat pump set includes an ordinary windmill wheel of the "leeward" pattern of which the shaft **2** rests in bearings **3** of a support **4** carried by the upper end of a tower **5** and that may turn round the axis of this tower. In front of the wheel **1** is a hollow fairing or hub **6** with double wall **7**, **8**, of which the outer wall **7** is stream-lined. At the entry of this fairing **6** is

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arranged an evaporator **10** forming part of a heat pump of standard pattern of which the compressor **11** is fastened on the bearing **3** that is farthest away from the wheel **1** and connected through a transmission **12** to the shaft **2** of the windmill wheel. At the end of the latter shaft is keyed a fan **13** arranged to the rear of the evaporator **10**. The space **14** included between the two walls **7** and **8** of the fairing **6** encloses the condenser **15** of the heat pump, connected on the one hand, through a pipe **16** to the discharge of the compressor **11** and, on the other hand, to a chamber **17** arranged in the nose and in the lower part of the fairing **6**; a pipe **18** connects the outlet of the evaporator **10** to the compressor **11**. The space **14** contains, besides, the water to be heated and is connected through piping **14***a* and **14***b*, housed inside the tower **5**, on the one hand, to a supply **14***c* of water delivery and, on the other hand, to a delivery circuit of warm water. A turn joint **22** is arranged at a suitable point of the pipe system **14***a*. The actual piping **14***b* emerges into an annular tank **14***d* arranged at the upper portion of the tower and into which is admitted, so that it may turn round the axis of the tower, a pipe **14***e* coming from the lower portion of the space **14**.

The shaft **2** of the windmill wheel is connected furthermore, in the standard way, by bevel gears **19**, **20** to a rotating shaft **23** that is coaxial with the tower and that goes down to the foot of the tower. The pipe **14***a* goes inside this rotating shaft **23**.

The windmill works exactly in the customary way but its shaft **2** drives in addition the compressor **11** through the transmission gear **12** and the fan **13** that thus quickens the ventilation through the evaporator **10** and promotes the heat exchanges. The cold-producing fluid with low heat of vaporisation is contained in the chamber **17** and circulates in the evaporator **10**, the pipe **18**, the compressor **11**, the pipe **16**, the condenser **15** where it condenses in cooling and is thus heating the water contained in the space **14**, then returns to the chamber **17**. The heat pump thus formed is of the standard "closed circuit" pattern.

In the modified form of execution shown in Fig. 2, the only alteration is in the pattern of heat pump that in this case has an open circuit, that is to say that the air itself is used as intermediary fluid. On this drawing, the parts that remain unaltered are denoted by the same reference numbers as on Fig. 1. The pipe **18**

for feeding the compressor with cold-producing fluid is replaced by a combining-cone 18*a*, open towards the upflow side to the free air and with its axis parallel with that of the wheel 1 so as to face the actual oncoming wind shown by the arrow F; the coil 15 acts no longer as a condenser but merely as a heat exchanger and emerges no longer into a tank of cold-producing fluid but through the inlet 24 into an expansion engine 21 housed in the fairing 6 and linked up to the shaft 2, from which it escapes through the outlet 25 into the open atmosphere. The remaining energy of the compressed air after its cooling in the exchanger 15 will then be recovered. Such a heat pump may be of advantage in certain warm and dry climates, where the condensation of the water vapour is not to be feared on expansion.

The invention, of course, is in no way restricted to the details of execution as illustrated or disclosed that have been presented only as examples.

What I claim is:

1. In combination, a windmill including a tower having a vertical axis, a support rotatably mounted on said tower so as to be capable of rotating around the axis of said tower according to the direction of the wind, and a wind wheel rotatably mounted on said support so as to be capable of rotating under the action of the wind, a heat pump of the type which includes a structure embodying a conditioning passage for a fluid, means for circulating said fluid through the conditioning passage, a compressor operatively connected with said windmill so as to be actuated by a portion of the power supplied by the latter, a refrigerant circuit having at least a part mounted on said support so as to be permanently positioned on the path of the windstream which actuates said windmill and including a heat exchanger positioned in said conditioning passage in heat transferring relation to the fluid therein, means for transferring heat from said windstream to said refrigerant circuit, and circuit connection for connecting the compressor with said refrigerant circuit.

2. In the combination as in claim 1, further, a central annular fairing mounted on said support coaxially with said wind wheel and adapted to form part of said conditioning passage.

3. In the combination as in claim 2, further, an annular tank mounted underneath said conditioning passage at the upper part of the tower and coaxially with said tower, a supply conduit for delivering fluid to said passage and axially arranged inside said tower, an exhaust conduit for said fluid from said conditioning passage, said exhaust conduit having its outlet above said annular tank, and a delivery piping for said fluid from said tank.

4. In combination, a windmill including a tower having a vertical axis, a support rotatably mounted on said tower so as to be capable of rotating around the axis of said tower according to the direction of the wind, and a wind wheel rotatably mounted on said support so as to be capable of rotating under the action of the wind, a heat pump of the type which includes a structure embodying a conditioning passage for a fluid, means for circulating said fluid through the conditioning passage, a compressor mounted on said support and connected with said windwheel so as to be actuated thereby, a refrigerant circuit having at least a part mounted on said support so as to be permanently positioned on

the path of the windstream which actuates said windmill and including a heat exchanger positioned in said conditioning passage in heat transferring relation to the fluid therein, means for transferring heat from said windstream to said refrigerant circuit and circuit connection for connecting the compressor with said refrigerant circuit.

5. In combination, a windmill including a tower having a vertical axis, a support rotatably mounted on said tower so as to be capable of rotating around the axis of said tower according to the direction of the wind, and a wind wheel rotatably mounted on said support so as to be capable of rotating under the action of the wind, a heat pump of the type which includes a structure embodying a conditioning passage for a fluid, means for circulating said fluid through the conditioning passage, a compressor operatively connected with said windmill so as to be actuated by a portion of the power supplied by the latter, a refrigerant circuit including a heat exchanger positioned in said conditioning passage in heat transferring relation to the fluid therein and another heat exchanger mounted on said support so as to be permanently positioned in the passage of the windstream which actuates said windmill and circuit connection for connecting the compressor with said circuit.

6. In the combination as in claim 5 further a fan mounted on said support and connected with said windwheel so as to be actuated thereby and positioned to force said windstream through said last heat exchanger.

7. In combination, a windmill including a tower having a vertical axis, a support rotatably mounted on said tower so as to be capable of rotating around the axis of said tower according to the direction of the wind, and a windwheel rotatably mounted on said support so as to be capable of rotating under the action of the wind, a heat pump of the type which includes a structure embodying a conditioning passage for a fluid, means for circulating said fluid through the conditioning passage, a compressor operatively connected with said windmill so as to be actuated by a portion of the power supplied by the latter, a refrigerant circuit including a structure mounted on said support and forming an entrance through which an amount of windstream actuating said windmill is introduced into the circuit connection at a point ahead of the compressor and a heat exchanger positioned in said conditioning passage in heat transferring relation to the fluid therein and circuit connection for connecting the compressor with said circuit.

8. In the combination as in claim 7 further an expansion engine operatively connected with said windwheel and conduit means by which the expansion engine is incorporated in the refrigerant circuit at the outlet of the heat exchanger.

9. In combination, a windmill including a tower having a vertical axis, a support rotatably mounted on said tower so as to be capable of rotating around the axis of said tower according to the direction of the wind, and a windwheel rotatably mounted on said support so as to be capable of rotating under the action of the wind, a heat pump of the type which includes a circuit for fluid including a conditioning passage, a supply conduit for delivering fluid to the conditioning passage, an exhaust conduit for said fluid from said conditioning passage, means for circulating said fluid through said conditioning passage, a

compressor operatively connected with said windmill so as to be actuated by a portion of the power supplied by the latter, a refrigerant circuit including a structure mounted on said support and forming an entrance through which an amount of windstream actuating said windmill is introduced into the circuit connection at a point ahead of the compressor, a heat exchanger positioned in said conditioning passage in heat transferring relation to the fluid therein and circuit connection for connecting the compressor with said circuit, a pipe system for compressed air connected with the refrigerant circuit at the outlet of the heat exchanger, said compressed air piping being coaxial with the fluid supply conduit to the conditioning passage.

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