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High Efficiency Compressor-Condenser in a Single Hermetic Component for Heat Pumps

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HIGH EFFICIENCY COMPRESSOR-CONDENSER IN A SINGLE HERMETIC COMPONENT FOR HEAT PUMPS

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ABSTRACT

A unit that encloses a motor-compressor and a condenser of refrigerant fluid in a single hermetic casing is presented.

After a description of the general advantages of the component compared with the traditional solution, as far as weight, size, cost and very low noise emission are concerned, experimental test results are presented.

COP values in different working conditions show that a good energy performance is achieved making this component utilization attractive in the heat-pump field.

INTRODUCTION

In a vapor compression cycle the four basic operations (compression, condensation, isoentropic expansion, evaporation) are carried out by devices that, in most of systems, are single parts connected with each other in a loop on assembly lines.

We have considered it could be of interest to make a single hermetic component containing both the compressor and the condenser of working fluid.

Therefore, we have made a component which, in a cross section, appears as shown in Fig. 1.

Between the two casings (see Fig. 1) we have put a formed coil working as condenser.

Cooling of condenser is done by water flowing inside the coil.

This integrated component should offer

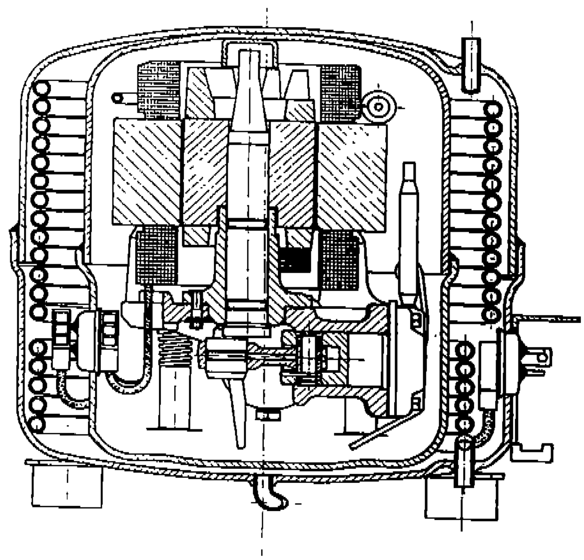

Fig.1 First prototype

the following advantages in comparison with the traditional solution (compressor plus separate condenser).

- Good use of material in assembly.
  This comes from the fact that the external surface of the compressor works also as casing surface of the heat-exchanger (copper tube casing).
- Reduction in weight
  This is an obvious consequence of the reduction in material usage.
- Reduction in dimensions
  This solution is of course more compact in comparison with two separate components.
- Easier assembling and handling
  From the final user's point of view, the connections necessary to set up a system

in assembly lines are reduced and the handling involves a single component only, instead of two.

The above-mentioned general features give to the component an interest from a potential savings point of view, but the most important aim of this prototype realization was to achieve better energy performances.

The better energy performances due to:

- Heat recovery from compressor
  With the integrated compressor condenser, all the heat usually lost from compressor can be recovered. In fact, compressor cooling is guaranteed by the water flowing inside the heat-exchanger and the external casing can be thermally insulated.
  The heat usually lost from this size of compressor in normal working conditions can be evaluated and experimentally tested in 70/90 watts.
  The heat recovery in this way gives a gain thermal capacity and then of COP of 6-12%.

- Less superheating of suction gas
  This is due to a reduction of inner surface temperature of the compressor casing. The temperature of the compressor casing decreases approaching values near to condensing temperature due to the presence of liquid refrigerant and the cold wall of the heat-exchanger.

  The suction gas, during its passage through the compressor, reduces its final superheating, so improving the compression efficiency.
  With a lower superheating of 6-7°C, a 3-4% improvement on COP can be reached.

TEST RESULTS - FIRST PROTOTYPE

The above evaluated performances have been confirmed by tests carried out on the first prototype.
Following diagrams (fig.2-5) show an improvement of 10-15% on COP and about 10% on thermal capacity (W_t).

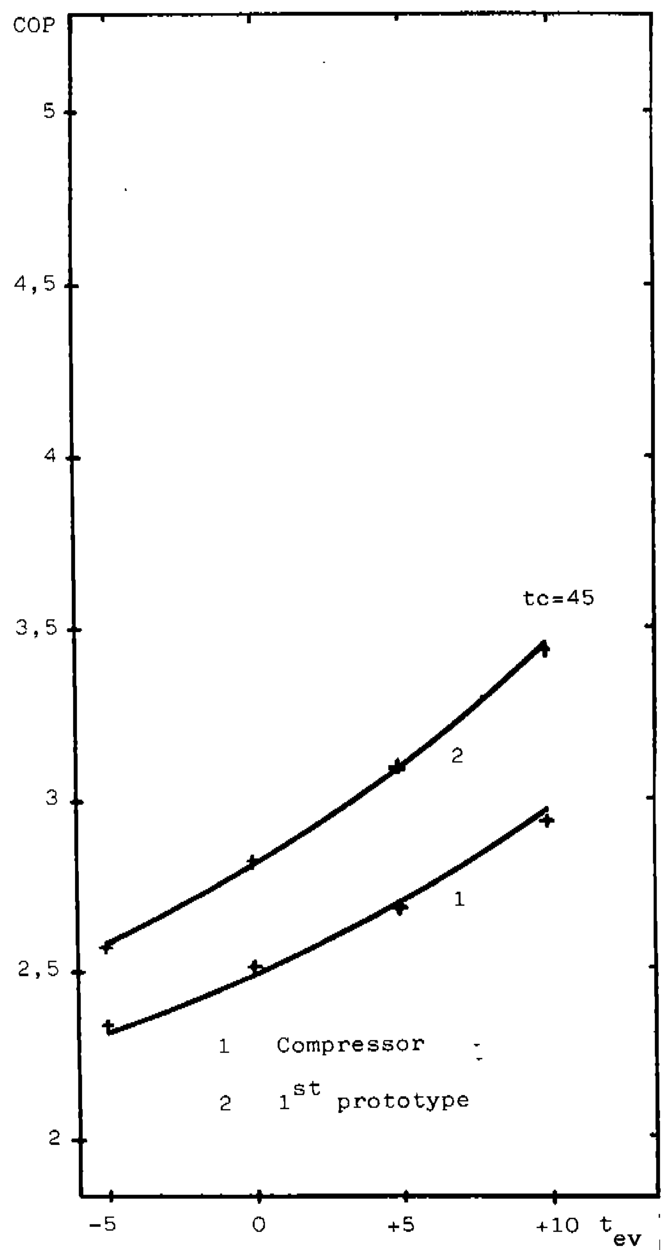

Fig.2 COP Comparison

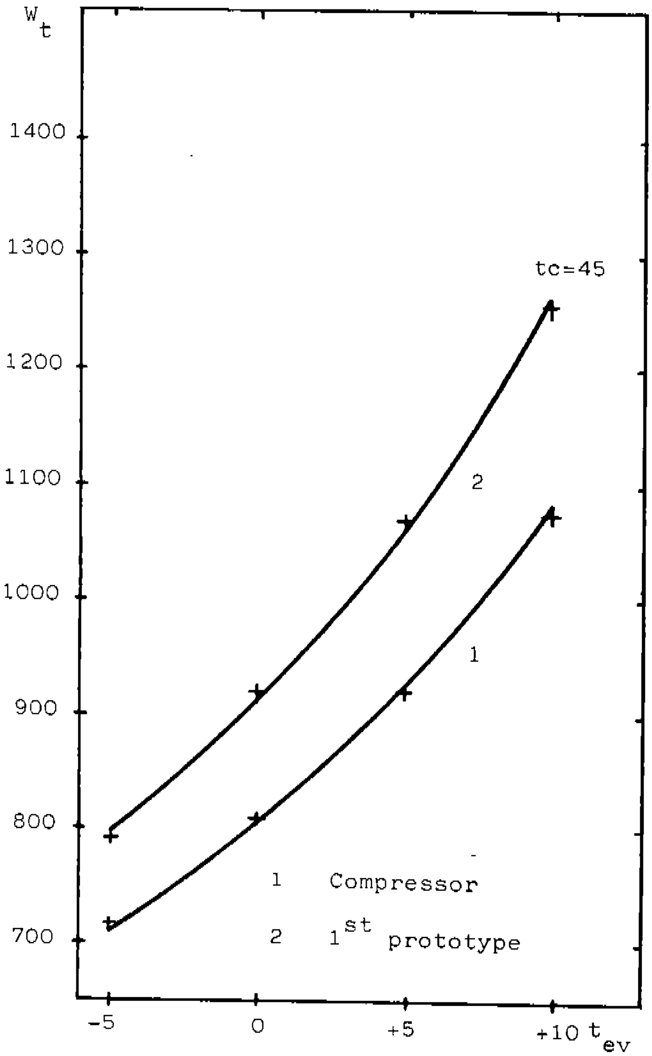

Fig.3 Thermal output comparison

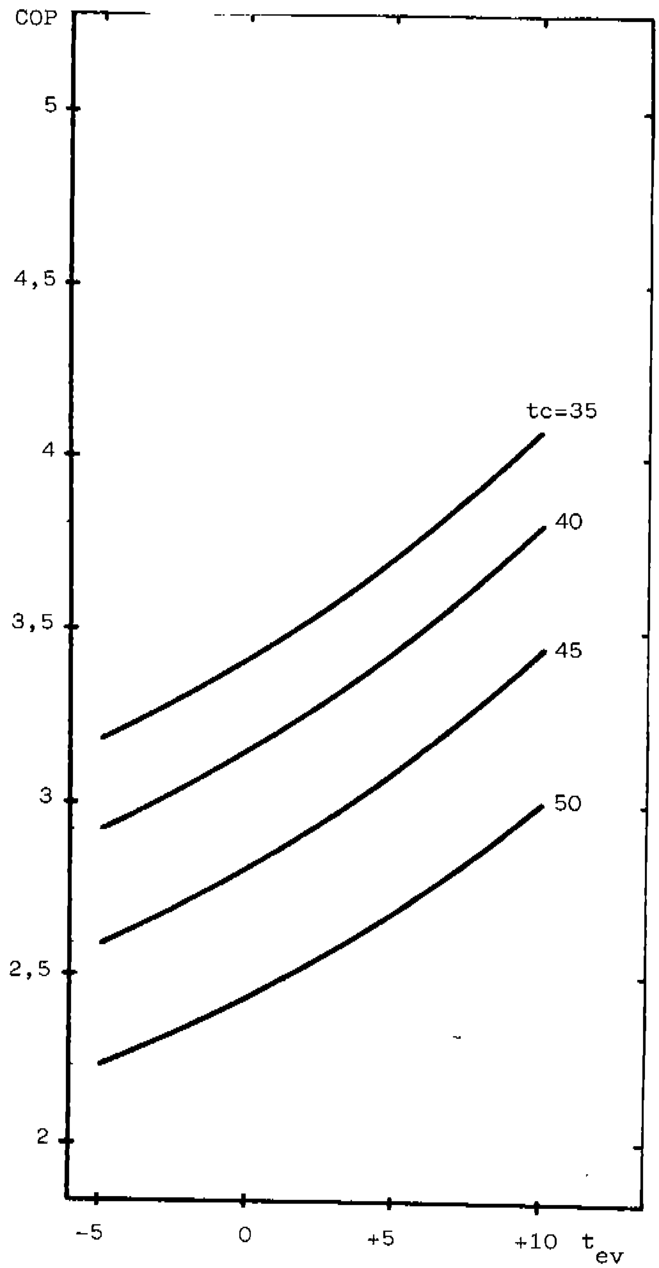

Fig.4 First prototype COP

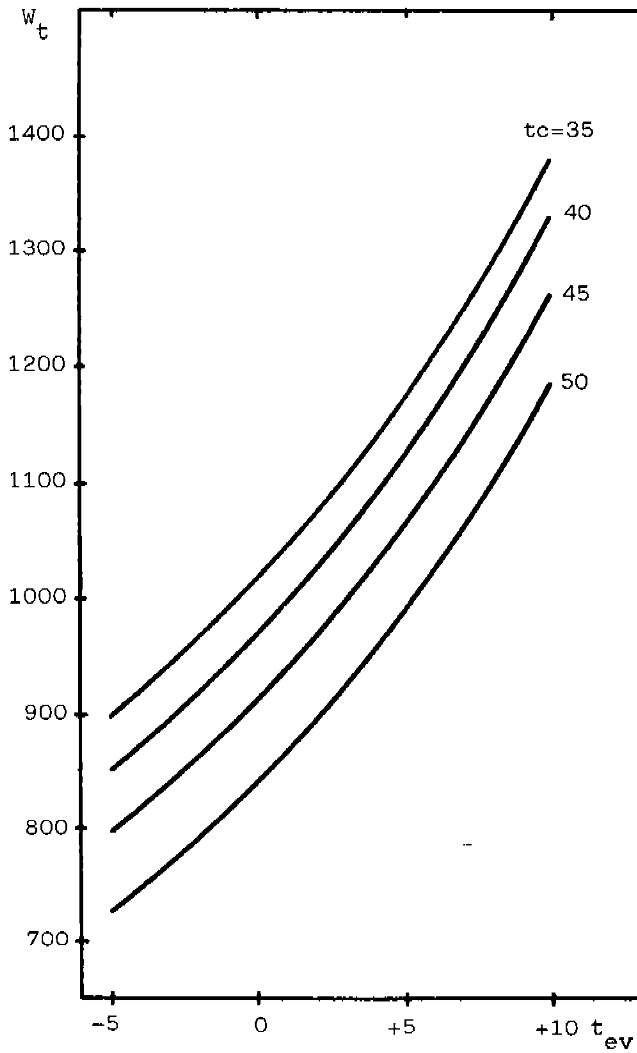

Fig.5 Thermal output 1st prototype

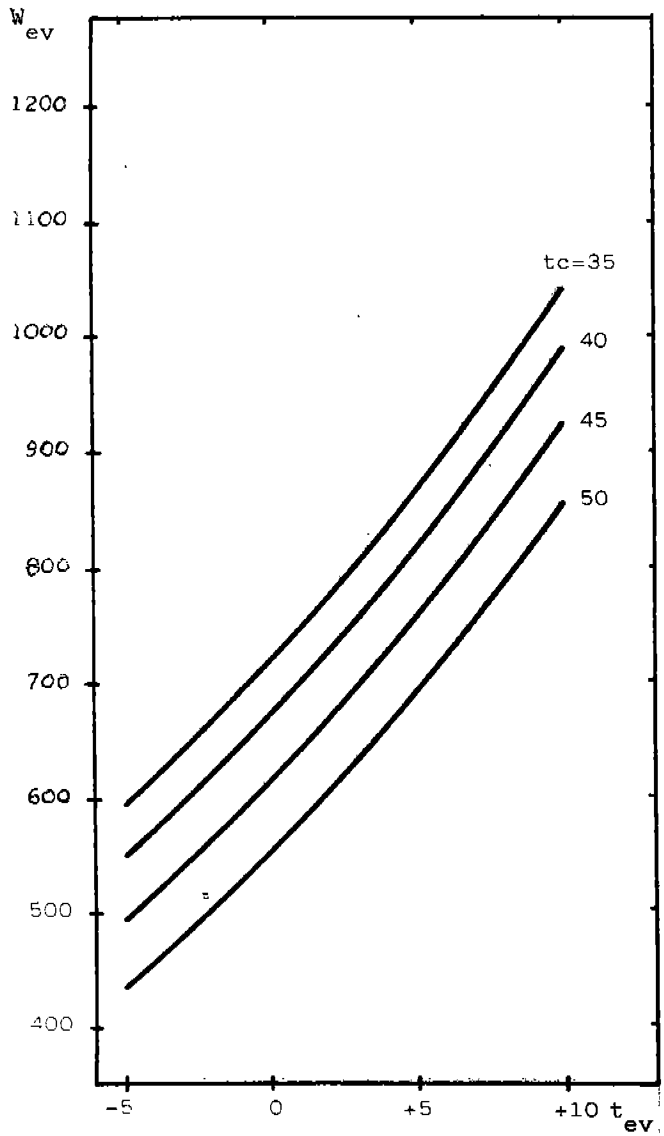

Fig.6 1st Prototype evaporator thermal input

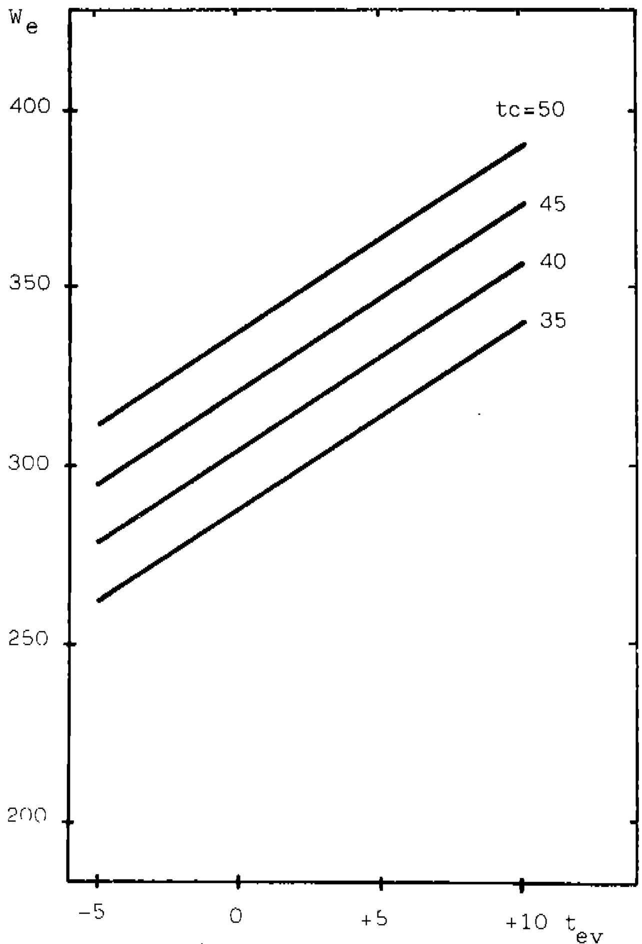

Fig. 7 1st Prototype electric input

Furthermore, the tests carried out on the first prototype have pointed out the following:

- low noise level (29 dbA) due to the screen effect of the heat-exchanger and the external casing
- good cooling of motor and compressor surfaces due to the improved radiation heat transmission with the compressor casing (10°C - 20°C lower).

From the above test remarks, it has been possible to make the following modifications:

- to adopt straighter gas flow to reduce pressure losses without noticeably increasing the noise level
- to adopt a more directed suction gas flow without the risk of dangerously increasing the inner temperatures
- to adopt a better performing electric motor to reduce electrical losses coherently with be above fluodynamic and thermodynamic reduced losses.

Consequently, we have made a second prototype as per figg. 8-9.

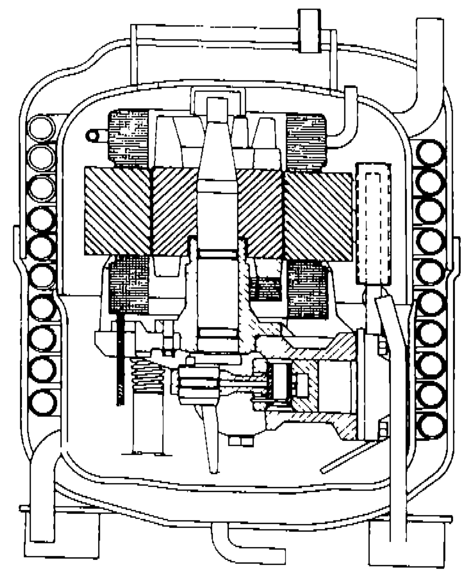

Fig.8 Second prototype

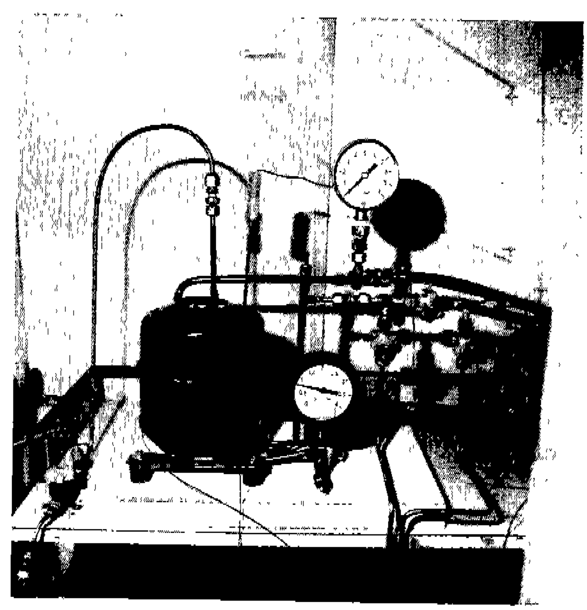

Fig. 9 Second prototype

The expected COP improvements have been evaluated of this order of magnitude:
- 2-3% for reduced pressure losses
- 7-8% for reduced superheating (12°C-15°C)
- 10% for better electrical efficiency.

TEST RESULTS - 2nd PROTOTYPE

The test results are shown in fig.10-15. In some test conditions, COP increase has overcome the foreseen 19-21%. Noise level tested : 31 dbA.

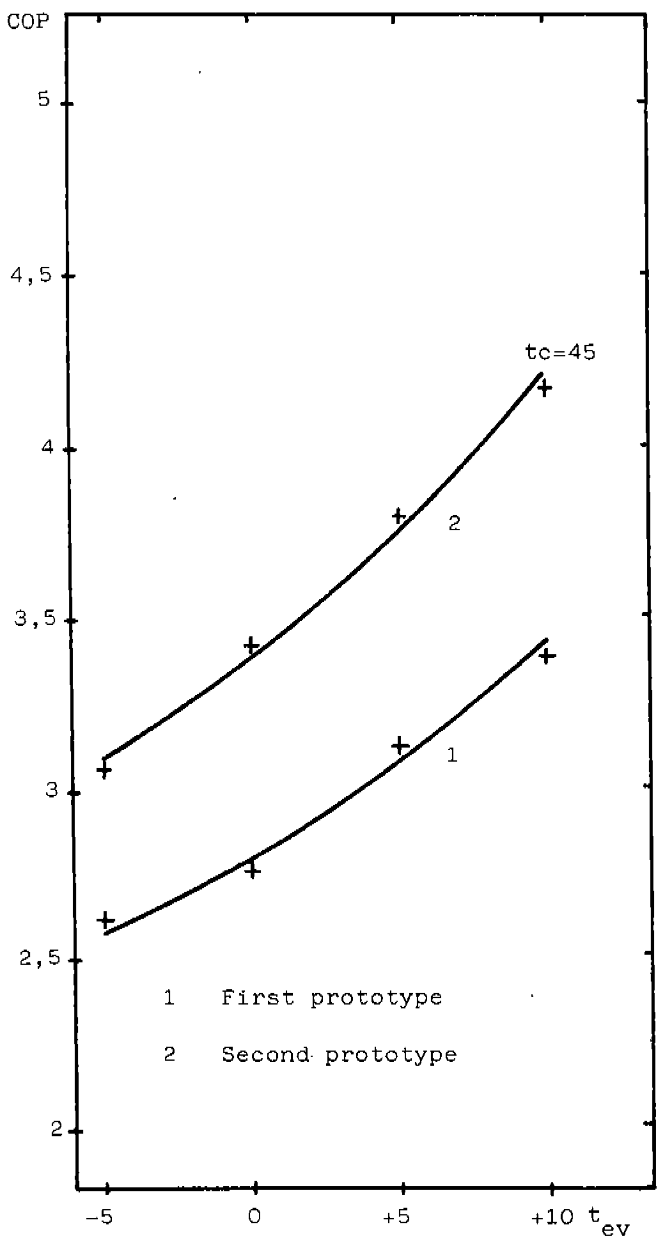

Fig.10 COP Comparison

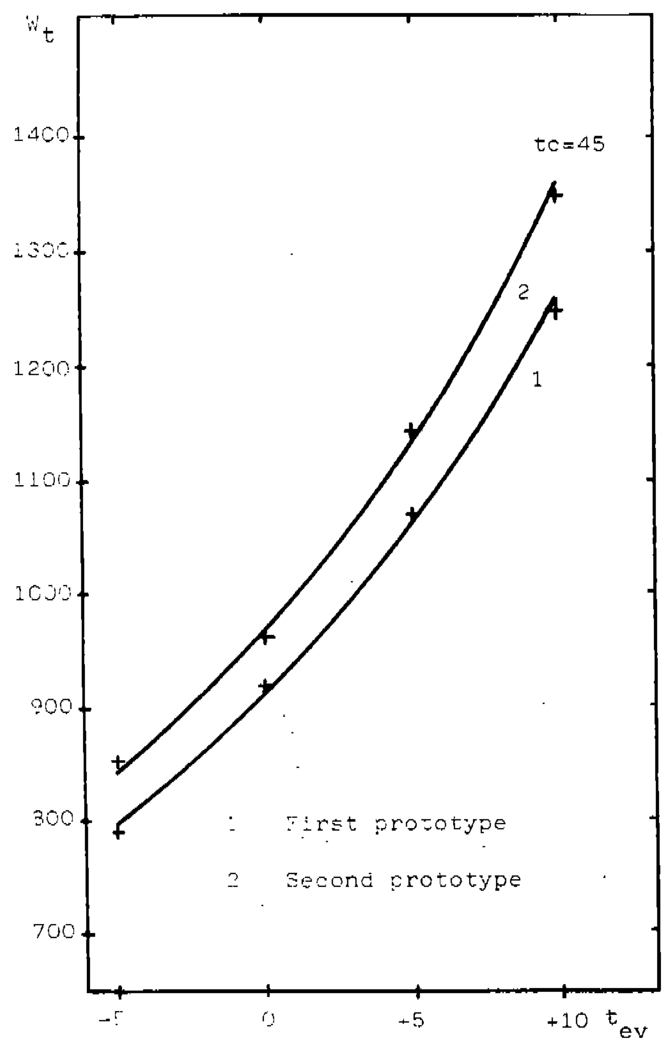

Fig.11 Thermal output comparison

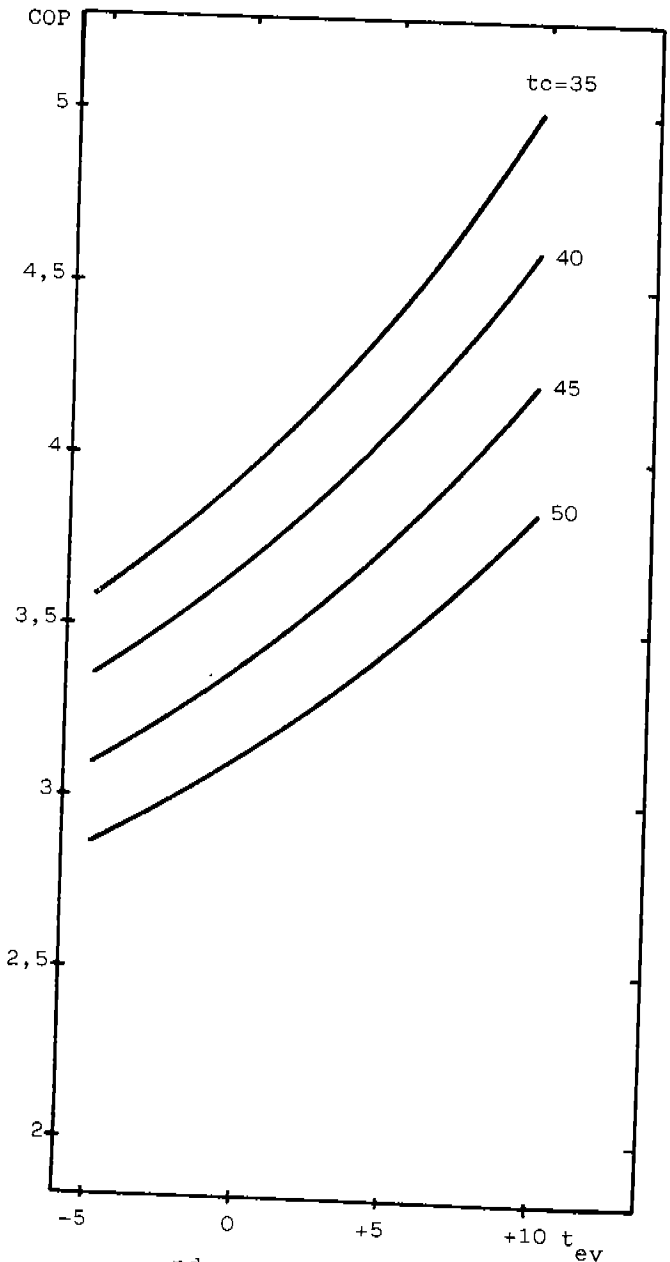

Fig.12 2^{nd} prototype COP

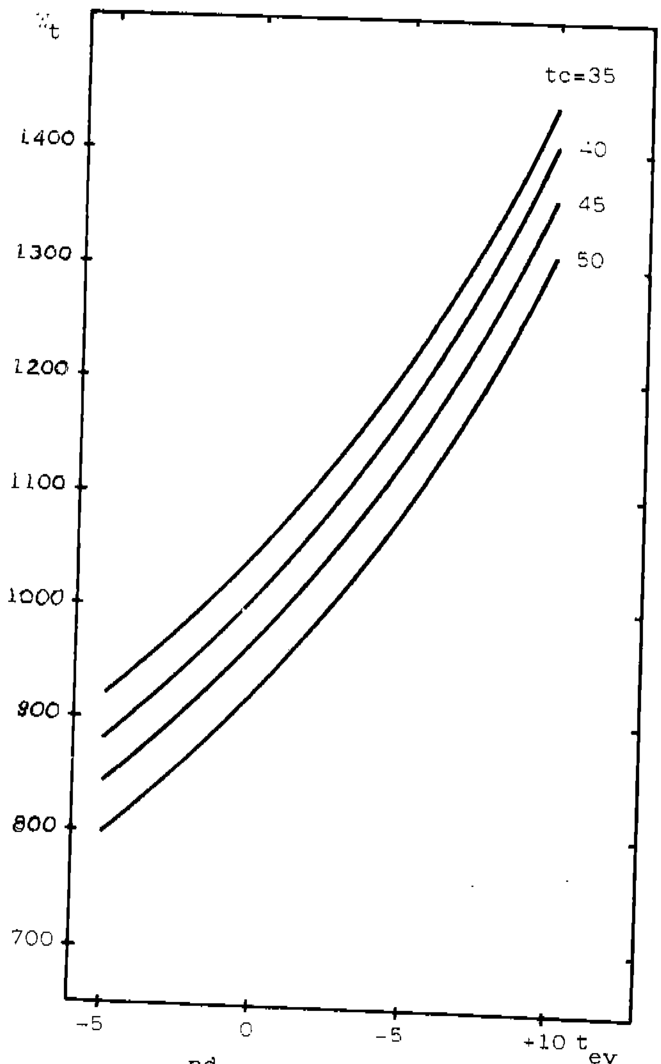

Fig.13 2^{nd} prototype thermal output

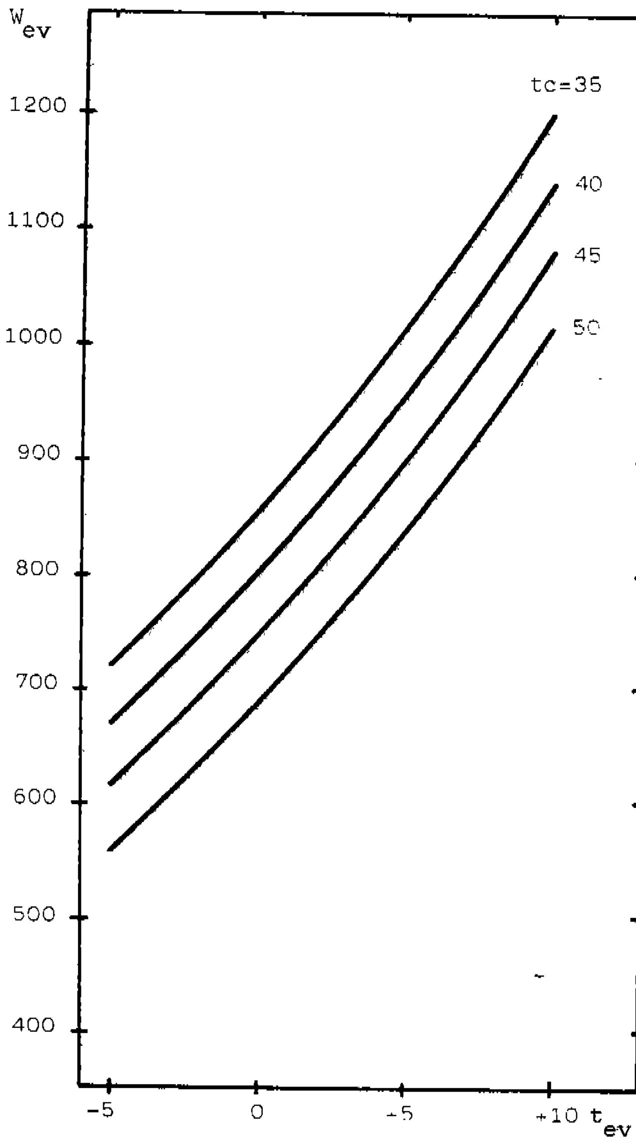

Fig.14 2nd Prototype evaporator thermal input

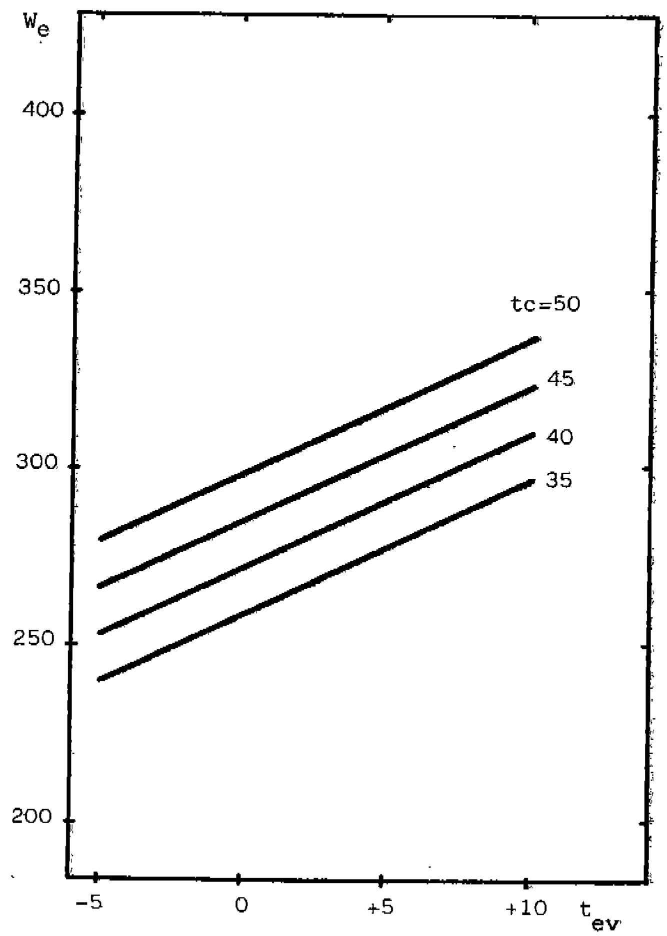

Fig.15 2nd Prototype electric input

CONCLUSIONS

The compressor-condenser in a single hermetic component seems to give a performance which is of interest as far as its application to small size water-to-water or air-to-water heat pump is concerned.

Its use at low evaporating temperatures (refrigeration) can be developed not only because it allows a good discharge heat recovery, but also because it could increase the COP at the same condensing temperature.

The calculation of possible heat recovery and of working condensing temperatures depends on the system hardware and working energy flows.

In the refrigeration field, the very low noise level would be highly appreciated.

LIST OF SYMBOL (UNITS)

W_t = Thermal power output from condenser (Watt)

W_e = Electric power input to compressor (Watt)

W_{ev} = Thermal power input to Evaporator (Watt)

$COP = \frac{W_t}{W_e}$ Coefficient or Performance

t_{ev} = Evaporating temperature (°C)

t_c = Condensing temperature (°C)

NOTE

All tests have been carried out keeping liquid subcooling temperature = gas superheating temperature = ambient temperature = = 32°C.

BIBLIOGRAPY

U.S. patent application N° 393 888

"Motor-driven compressor-condenser group for cooling cycles".