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Operating Instructions

The unit complies with the corresponding EC guidelines.

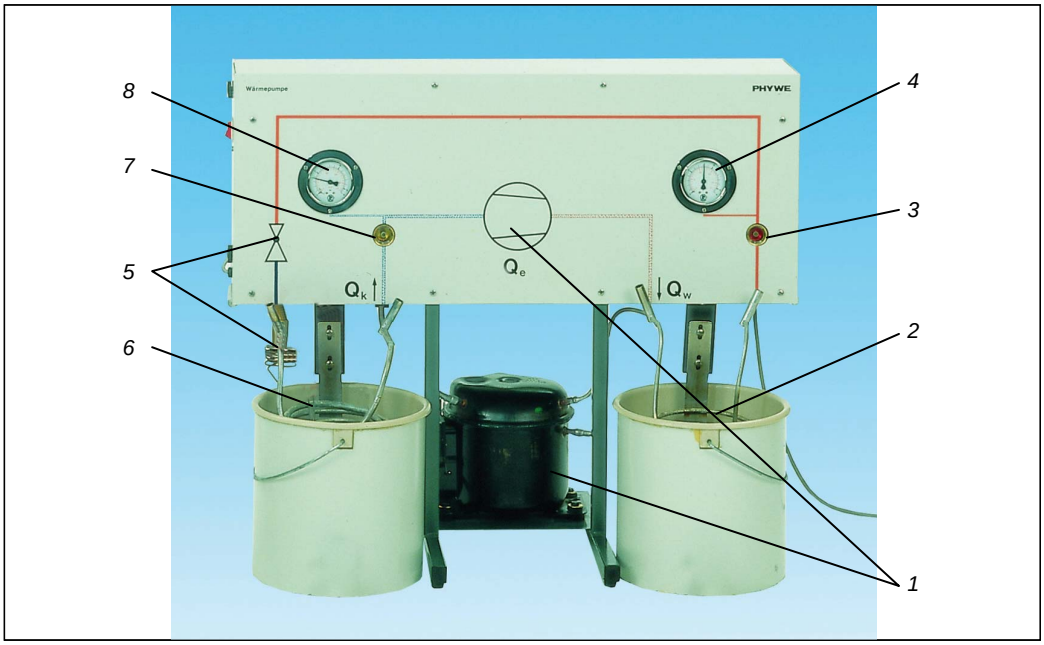

Fig. 1: Heat pump, compression principle 04370-88

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1 SAFETY PRECAUTIONS

Attention!

- Carefully read these operating instructions completely before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Check that your mains supply voltage corresponds to that given on the type plate fixed to the instrument.
- Install the instrument so that the on/off switch and the mains connecting plug are easily accessible. Do not cover the ventilation slits.
- Take care that no liquids or objects enter in through the ventilation slots.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Do not operate if there are visible signs of damage to the unit or the connection cord.
- Only use the instrument for the purpose for which it is intended.

2 PURPOSE AND CHARACTERISTICS

A heat pump extracts energy from a low temperature environment and adds this energy to an environment which has a higher temperature. The work required for this is performed by a compressor.

The heat pump 04370-88 is a symmetrical set-up demonstration model used to demonstrate that refrigerators and heat pumps operate according to the same principle. Pressure and temperature of the working medium can be measured and the state observed in viewing glasses.

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Two insulated water containers are supplied with the unit to determine the received or the removed energy.

3 FUNCTIONAL AND OPERATING ELEMENTS

In order to illustrate the cyclic process, several components have been integrated in a diagram on the front plate, with lines identified by colours.

1 The *compressor* compresses the gaseous working medium; the required energy is supplied in form of electric energy Q_e. Pressure and temperature of the working medium are increased due to the compression. For this reason, the line leading to the compressor is represented dotted and blue (gaseous and cold), whereas the lines leading away from the compressor are represented dotted and red (gaseous and warm).

2 On the *condenser* side, the working medium gives off thermal energy Q_w to the environment. During this process, the main part of this energy is released through liquification of the working medium, whereas only a small part is released through cooling of the working medium. Temperature in front of and behind the condenser can be controlled at two measuring points. The line behind the condenser is represented as a solid red line (liquid and warm).

3 During the operation of the heat pump, one can see liquid working medium containing a few gaseous bubbles in the *viewing glass* situated behind the condenser. This state may change.

4 The *manometer* displays the overpressure of the working medium on the condenser side in bar. Compared to the absolute pressures indicated in table 1, the atmospheric pressure of approximately 1 bar must be added (1 bar = 10^5 Pa).

5 The working medium flows through the *regulating valve* from the high pressure area to the lower pressure areas, cooling down during this process. The line situated after the regulating valve is represented solid and blue (liquid and cold).

6 On the *evaporator* side, the working medium takes up thermal energy Q_k from the environment. During this process, the main part of the energy is used to evaporate the working medium and only a small part is used to heat up the working medium. Temperature in front of and behind the evaporator can be controlled at two measuring points. A temperature sensor fixed directly to the spirals of the evaporator controls the regulating valve, as only vaporised working medium may enter the compressor.

7 During the operation of the heat pump, one can see gaseous working medium or just evaporating liquid working medium in the *viewing glass* situated behind the evaporator. This state may change.

8 The *manometer* displays the overpressure of the working medium on the evaporator side in bar. Compared to the absolute pressures indicated in table 1, the atmospheric pressure of approximately 1 bar must added (1 bar = 10^5 Pa).

A few other components which are visible after removing the back panel fixed by means of four knurled screws are not important to explain the function of the heat pump, but for its unhindered operation:

- a collector with a reserve of working medium to compensate for losses,
- a dryer to remove possibly present residual water from the working medium,
- a high and a low pressure controller to protect the heat pump against overheating or undercooling. The pressure controller temporarily switches off the compressor if pressure raises above or drops below definite pressure values set at the factory.

4 NOTES ON OPERATION

This high-quality instrument fulfils all of the technical requirements that are compiled in current EC guidelines. The characteristics of this product qualify it for the CE mark.
This instrument is only to be put into operation under specialist supervision in a controlled electromagnetic environment in research, educational and training facilities (schools, universities, institutes and laboratories).

5 HANDLING

The heat pump is connected to the mains grid using the fixed connecting cable. The main switch is situated on the side of the housing.

Attention!

After delivery, or if the unit was transported over a longer distance, a waiting period of one hour must be adhered to before switching on the compressor, in order to protect it, as the distribution of the working medium in the system may be disrupted due to shaking or because the unit was not standing horizontally.
In general, the evaporator and the condenser are set into the insulated water container to carry out the experiment. For this, the unit must be lifted or displaced in such a way that the heat exchangers hang successively over the side of the table and the containers may be pushed under them.
A weighed amount of water must be filled into the container in order to determine the energy balance. The provided temperature probes are fitted into the temperature measuring points, using a little thermal conducting paste. No further support is required. The temperature of the water container should also be measured.
Once in a while, the lime coating should be removed from the heat exchangers. This can be done using diluted acetic acid (about 5 %).

6 TECHNICAL DATA

Working medium	R134a Tetrafluorethan CH_2FCF_3
Working volume	5.08 cm³
Rotational speed	1450 min^{-1}
Performance number ε	approx. 2.2
Efficiency η	approx. 80 %
Connecting voltage (+6 % / −10 %)	see type plate
Mains frequency	50 Hz
Power consumption	approx. 120 VA
Housing dimensions (mm³)	750 x 350 x 630
Weight	34 kg

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7 WORKING MEDIUM SPECIFICATIONS R134a

Specific thermal capacity (liquid, 25 °C)	1.4189 J/gK
Specific thermal capacity (gaseous, 25 °C)	0.8323 J/gK
Specific evaporating heat (25 °C)	177.33 J/g

Table 1:

T temperature
p pressure (absolute)
V specific volume of saturated vapour
h' specific enthalpy of the liquid
h'' specific enthalpy of the vapour

T	p	V	h'	h''
°C	MPa	m^3/kg	kJ/kg	kJ/kg
−30	0.08436	0.22596	161.10	380.45
−20	0.13268	0.14744	173.82	386.66
−10	0.20052	0.09963	186.78	392.75
−8	0.21684	0.09246	189.40	393.95
−6	0.23418	0.08591	192.03	395.15
−4	0.25257	0.07991	194.68	396.33
−2	0.27206	0.07440	197.33	397.51
0	0.29269	0.06935	200.00	398.68
2	0.31450	0.06470	202.68	399.84
4	0.33755	0.06042	205.37	401.00
6	0.36186	0.05648	208.08	402.14
8	0.38749	0.05238	210.80	403.27
10	0.41449	0.04948	213.53	404.40
12	0.44289	0.04636	216.27	405.51
14	0.47276	0.04348	219.03	406.61
16	0.50413	0.04081	221.80	407.70
18	0.53706	0.03833	224.59	408.78
20	0.57159	0.03603	227.40	409.84
22	0.60777	0.03388	230.21	410.89
24	0.64566	0.03189	233.05	411.93
26	0.68531	0.03003	235.90	412.95
28	0.72676	0.02829	238.77	413.95
30	0.77008	0.02667	241.65	414.94
32	0.81530	0.02516	244.55	415.90
34	0.86250	0.02374	247.47	416.85
36	0.91172	0.02241	250.41	417.78
38	0.96301	0.02116	253.37	418.69
40	1.01650	0.01999	256.35	419.58
42	1.07210	0.01890	259.35	420.44
44	1.13000	0.01786	262.38	421.28
46	1.19010	0.01689	265.42	422.09
48	1.25270	0.01598	268.49	422.88
50	1.31770	0.01511	271.59	423.63
60	1.68150	0.01146	287.49	426.86
70	2.11650	0.00867	304.29	428.89

8 EXPERIMENTAL LITERATURE

Handbook Laboratory Experiments Physics
Experiment P2360200 Heat pump 16502-32

9 ACCESSORIES

- Heat pump, compression principle 04370-88

for measuring temperature:

- Thermometer −10 °C…+100 °C (up to 6x) 38056-00

or

- Temperature meter digital, 4-2 13617-93

- Temp. probe, immers. type, Pt100 (up to 4x) 11759-01
- Heat-conductive paste, 50 g 03747-00

for measuring compressor power output:

- Work and power meter 13715-93

10 WARRANTY

We give a warranty of 24 months for units supplied by us inside the EU, and a warranty of 12 months outside the EU. The following is excluded from the warranty: Damage that is due to non-compliance with the operating instructions, improper use, or natural wear.

The manufacturer can only be held liable for the function and safety-relevant properties of the unit, if the maintenance, service, and modifications of the unit are performed by the manufacturer or by an institution that is expressly authorised by the manufacturer.

11 WASTE DISPOSAL

The packaging mainly consists of environmentally-friendly materials that should be returned to the local recycling stations.

Do not dispose of this product with normal household waste. If this unit needs to be disposed of, please return it to the address that is stated below for proper disposal.

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