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NEWS LETTER

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2.35 MW Type II Absorption Heat Pump in a Butadien Rubber Plant in Japan. This Waste Vapor source heat pump supplies regenerated steam to the distillation tower (see also page 9) Photograph JRAIA

Editorial by T. Okabe*

Market Penetration of Heat Pumps in Japan

The growing awareness of the importance of energy conservation caused by the oil crisis and the technology development, led to a wide market penetration of the heat pump as a means of air conditioning both in residential and commercial buildings.

In Japan nowadays the heat pump is becoming the main heat source for room air conditioners. From now on, as houses are made more airtight and heat-insulating, the application of heat-pump-type air conditioners in the residential sector is expected to increase more rapidly because of the advanced capacity control technology and still decreasing operating cost. The number of commercial air conditioning units shipped in 1983 totaled 354,000 units, including 234,000 heat pumps (66% of total shipment). Almost all (99%) of the heat-pump-type air conditioners for general purpose use air as a heat source because these units have advantages regarding installation space, maintenance, service etc. Water-source heat pumps are little used in Japan. Application of large heat pumps is expanding from use in commercial and industrial buildings to use for district heating/cooling, in sports centers, shopping centers, museums etc. Thus, construction and engineering companies are now taking an earnest interest in including heat pump systems in their business. So, industrial heat pump use is expected to increase sharply. Besides, when we realize higher output temperatures of heat pumps, they will have a huge market in industry.

As our task for the future growth of the heat pump market, I think that it is important to develop, besides the hardware, software technology such as utilization techniques for various application requirements, economic assessment, evaluation of energy conservation and so on.

Japan decided to take part in the IEA Heat Pump Center from 1984 onwards. As a research manager engaged in R&D for energy conservation technology, I hope that the activities of the Center will accelerate international exchanges of both hardware and software information, and that the penetration of the heat pump will contribute to energy conservation on a world-wide scale.

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Contents: **Page**

E. Podesser*

The Absorption Heat Pump — State of the Art and Prospects

The experience gathered from the absorption cooling technique can, almost completely, be used for the development and construction of absorption heat pumps (AHP) of different styles, because in principle — whether the plant is supposed to cool or heat — there is no basic difference in its design and construction. This is the case if there is little temperature difference between the level of the absorption heat pump devices and those for refrigeration. An example for such an application of an AHP with the working pair ammonia/water operated in a similar way as cooling machines was the heat pump plant of the city of Vienna which was built immediately after the Second World War in the "Theresien Public Baths" in order to heat the showers, baths and pools. (Heat capacity: 400 kW, thermal drive: district heating water at 140 °C, heat source: waste water, at 35 to 40 °C). Another AHP was used to heat the "Vienna Greenhouses", known as the "Wiener Städtischer Reservegarten Hirschstätten" (Heat capacity: 1200 kW at 45 °C, thermal drive: district heating water at 140 °C, heat source: ground water at 8 °C).

However, the beginning of the absorption cooling technology dates back to as early as the middle of the last century — more than 130 years ago. At that time, the brothers Ferdinand and Edmund Carré were building a periodical and, some years later, a continuously working absorption cooling machine for ice production. As a result, names such as E. Altenkirch, R. Planck, F. Merkel, F. Bošnjaković, W. Niebergall and some others are inseparably connected with the research and development of the absorption cooling machine. Altenkirch, in particular, made various suggestions for different methods and measures for the reduction of irreversible losses, and, as early as 1911, suggested a central heating system using AHP. In 1959, Niebergall gave a comprehensive presentation of absorption technology [1].

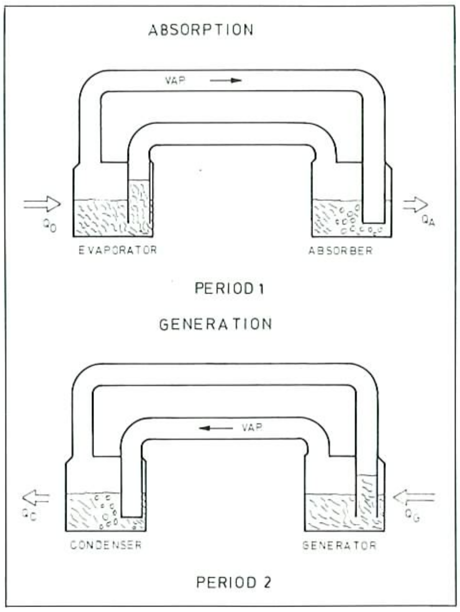

Fig. 2 Single-Stage periodically working AHP

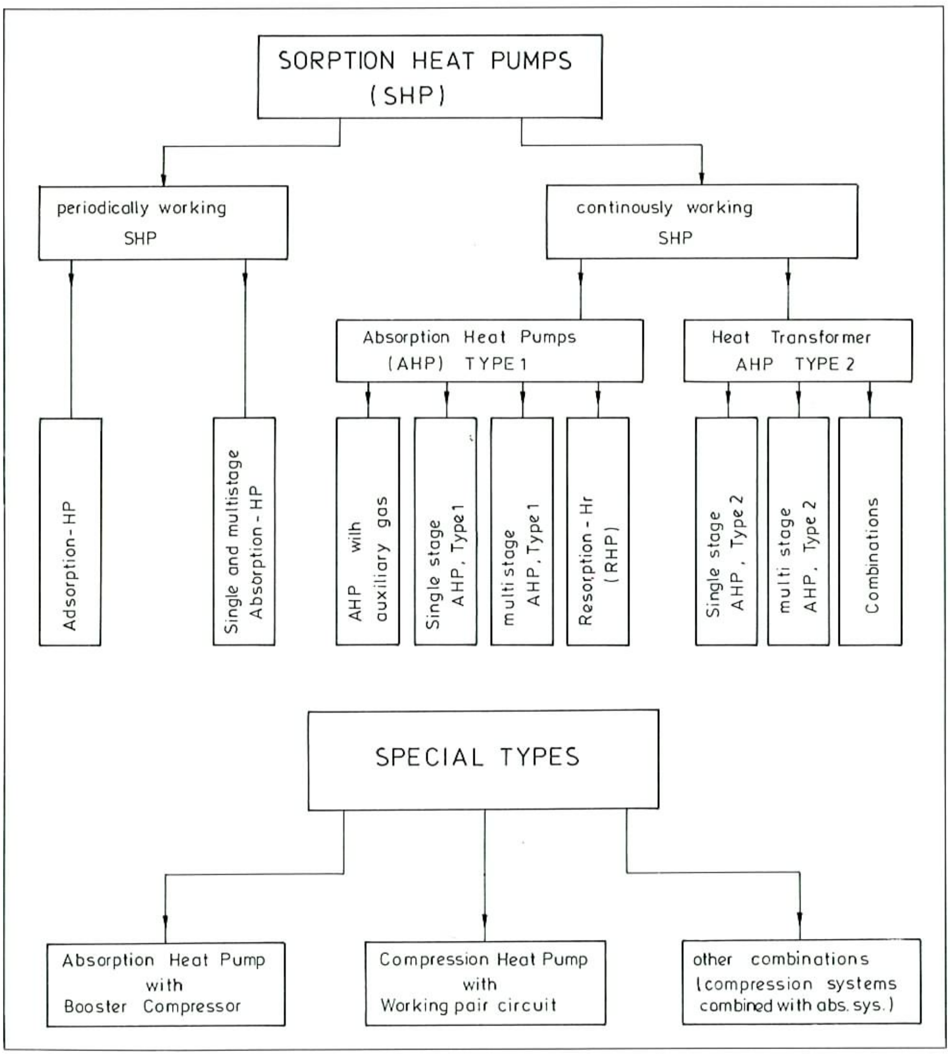

Fig. 1 Classification of Sorption Heat Pumps

The sorption heat pump process differs fundamentally from the compression heat pump process in that the mechanical compressor is replaced by a thermal compressor. The thermal compressor consists of expeller (generator), where the drive energy (heat) is supplied, solution heat exchanger, absorber, working fluid pump, and expansion valve. It is powered by heat. The entire group of possible heat pumps with thermal compressors is, according to Niebergall, called "Sorption Heat Pumps", because the procedure of "sucking in" can occur both through absorption into liquid or non-liquid substances and through adsorption from non-liquid substances.

Fig. 1 shows a possible categorization of the better known types of sorption machines.

Revival of the periodically-working Sorption Heat Pump

So far, only the periodically working absorption systems and, especially the periodical absorption heat pump systems with a liquid working pair, show significance. Basically, the single-stage periodical

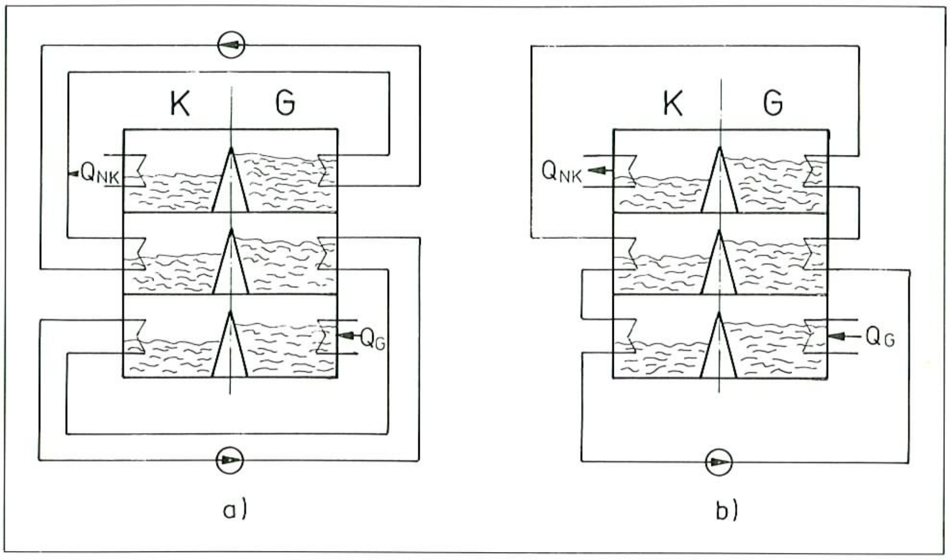

Fig. 3 Multi-Stage periodically working AHP

AHP consists of two parts, one of which acts both as evaporator and condenser, and the other as both expeller and absorber, but in a shift of time. Fig. 2 shows, in simplified form, both working phases of a periodical AHP with liquid working pair (e.g. $LiBr/CH_3OH$).

The single-stage periodically-working absorption system has been applied many times to cooling machines, but as an AHP has not become significant, up to now (Fig. 2). However, the elements of the single stage periodically working system (Fig. 2) have been used for the design and construction of the prototypes according to the principle of the multi-stage, periodically-working AHP of K. F. Knoche and D. Stehmayer [2].

The advantage of the multi-stage type in comparison to the single-stage type lies in the attainment of

- low evaporation temperatures or
- better heat ratio (the ratio between available heat and driving heat).

According to Knoche and Stehmayer, the theoretical heat ratio of the single-stage periodically working AHP with the working pair $LiBr/CH_3OH$ has the value of 1.61. In contrast, a three-stage arrangement, according to Fig. 3, can exceed a heat ratio of 2 at the same evaporation temperature. This proposed system is especially interesting because of the absence of working fluid pumps and the dual use of the systems' components.

Continuously Working AHPs

The majority of plants built to date fall into this group of AHPs. In most cases the experience from absorption refrigeration technology could be used in the design and construction.

In general, heat requirements of at least 15 kW up to several megawatts are required for the application of AHPs. In this connection a COP as high as possible for the capacity of the AHP should be aimed at. For this reason, AHPs with an auxiliary gas and no fluid pumps are scarcely used because of the low heat ratio of approximately 1.25, all in spite of the captivating simplicity of the system.

The continuously working, single stage AHP has become the most famous type of AHP through applications in experimental plants of small capacities (up to 50 kW) for heating homes or large capacities up to several megawatts. All the experience from absorption refrigeration technology can be adapted directly to the design of such AHPs up to output temperatures of about 60 °C. Mostly used working pairs are $LiBr/H_2O$, $LiBr/CH_3OH$ and H_2O/NH_3. The limitations to the application of the working pairs mentioned are determined by the danger of recrystalisation, of chemical decomposition, and of increased susceptibility to corrosion at high working temperatures.

At present, Sanyo produces single-stage, continuously working $LiBr/H_2O$ and $LiBr/CH_3OH$ AHPs for evaporation temperatures below zero in a range of several megawatts. The Sanyo AHPs are designed according to the well-known dual tank system like $LiBr/H_2O$ refrigeration machines using the same elements well proved in the low-pressure absorption refrigeration machines used in air-conditioning.

In [4] additional combinations of both types of heat pumps for summer cooling and winter heating are listed.

The three operation modes: absorption refrigeration machine, AHP (Type I), and heat transformer (Type II) are shown. In the above mentioned summer and winter operations a LiBr/water AHP and a $LiBr/CH_3OH$ AHP work together the only connection beeing by means of the external water circuits. In summer this system is used for ice (−13 °C) production and for supplying the air conditioning system (+6 °C) while in winter it works as a heat transformer with temperatures of +90 °C for space heating.

Waste heat with a temperature of 60 °C is used to drive the system. As an AHP (Type I), this plant achieves a heat ratio of 1.67, and as heat transformer (Type II), a heat ratio of 0.51 [4].

Besides the different types of excellent single stage continuously working AHP systems of the Sanyo company. There are others to be mentioned like: Carrier, Arkla, Yasaki and Eshel. These offer, in general $LiBr/H_2O$ AHPs, which can be used both for refrigeration and air conditioning.

On the European market, several continuously-working, single stage AHP plants with the working pair ammonia/water, mostly with heat capacities of more than 1 MW, have been constructed mainly by the firms Borsig and Linde. One of the AHP plants is operated by the Rudolf Otto Mayer company in Düsseldorf (Heat capacity: 1740 kW, at 45/57 °C, evaporator: −10 °C) and another AHP plant is operated by Deula in Bad Kreuznach (heat capacity: 390 kW, at 47/50 °C, evaporator: −10 °C). All main elements of these machines are taken directly from absorption refrigeration technology. The COP ranges from 1.45 to 1.55 for single-stage machines at design conditions, because of the irreversible losses caused by dephlegmation and rectification (increase of concentration of the expelled working vapors).

Also interesting to note is the single-stage, continuously-working AHP-plant for district heating [5] constructed by Borsig, with a heat capacity of 3.5 MW at 90 °C/110 °C.

With this AHP, the conventional application of the absorption refrigeration machine has been clearly abandoned. It is worth mentioning that the working pair NH_3/H_2O in the expeller is operated nearly at the limit temperature of about 180 °C,

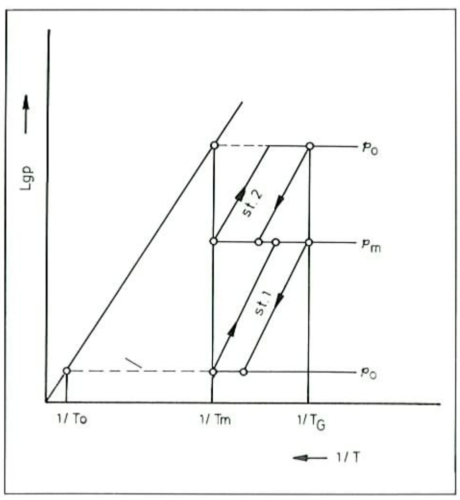

Fig. 5 1g p, 1/T-Diagram of a dual stage AHP where the pressure reaches almost 40 bar. The COP varies according to Malewski, between 1.45 and 1.79. The capital expenditure for a single-stage, continuously-working AHP with the working pair ammonia/water for the heat capacities up to several megawatts range from about AS 1400 to AS 2100 per kW heat capacity.

For capacities of 15 kW up to 50 kW gas AHP according to the continuously working, single stage principle with the working pair NH_3/H_2O have already reached market fitness (Ruckelshausen company, type Rekord GAWP). With COP stated at 1.3 the attempt to introduce such heat pumps into the market has been unsuccessful up till now. The main reasons are the high first cost, long pay-back period and the low economization of running cost compared with a conventional oil- or gasfired boiler.

Moreover, in recent years, much research and development work has been done whose aim was the small, continuously working, single-stage AHP for heating homes with working pairs barely known until now, even with three-substance-systems. Impressive success has not yet been recorded.

Multiple-Stage Continuously Working Absorption Heat Pump (Type I)

In contrast to the technique of compression heat pumps, where the limitations of the single-stage operation mode are given by economy at a pressure ratio of p/p_0 of 5, for AHPs, the limitations are given by the physics of the working pair. This, for example, occurs with AHP, when the type of heat source, for example the ambient air, requires an evaporating temperature of $-25\,°C$ at a given final expeller temperature of 140 °C and with a simultaneous demand for a high available temperature (60 °C). In this case the operational range of the working pair ammonia/water would be exceeded [1], and the desired heat pump effect could not be achieved.

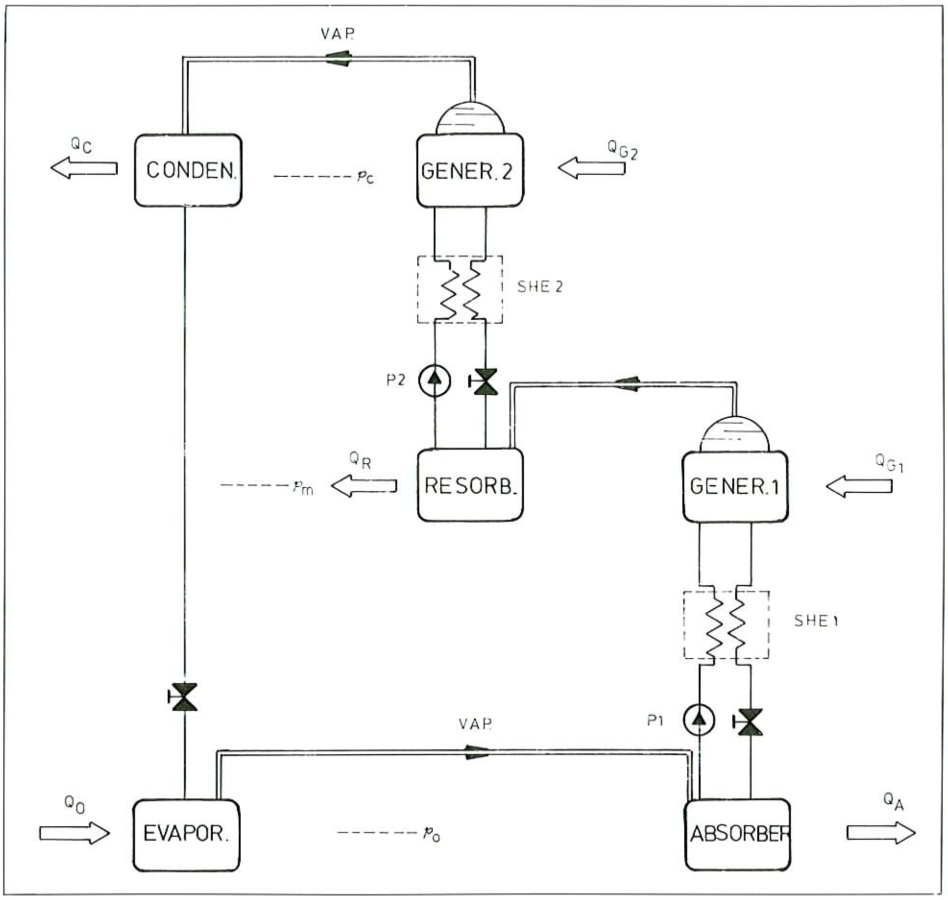

Fig. 4 Principle circuit of a dual stage AHP

Altenkirch discussed [6] this topic thoroughly and presented a variety of modifications for the solution of present problems. A complete discussion of the different variants of multiple-stage continuously working AHP can not be given because of space limitations. With the continuously working multi-stage AHPs at constant external temperatures, or with the multistage periodically-working AHP, higher heat ratios — even above 2 — or significantly lower evaporation temperatures compared with the single stage AHP can be reached.

Fig. 4 shows, an example of a dual-stage continuously — working AHP, a dual-stage system with two "thermal compressors", placed in series, which reaches low evaporation temperatures for refrigeration. The Lg P. vs. 1/T-diagram in Fig. 5 shows a dual-stage working process for the circuit shown in Fig. 4. From that follows that a dual-stage expulsion is needed because of the low evaporation temperature (T_0) and the relatively high condensor/absorber temperature (T) at a given expeller temperature.

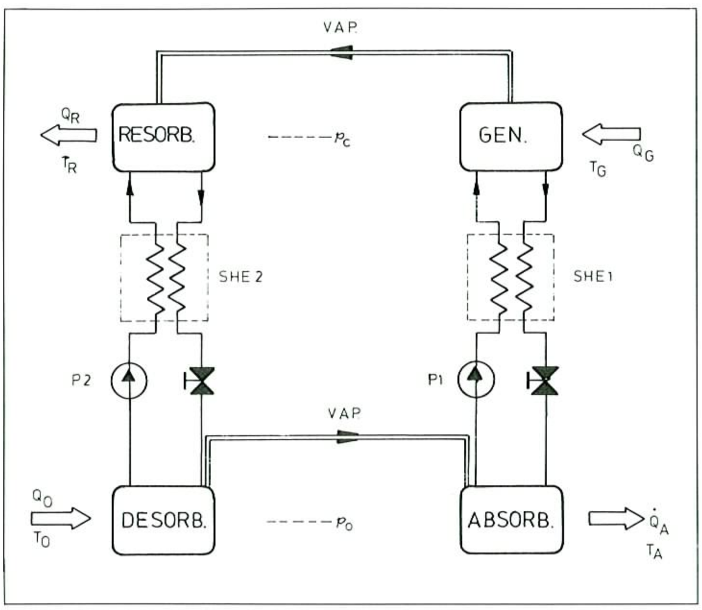

Fig. 6 Principle circuit of a Resorption Heat Pump

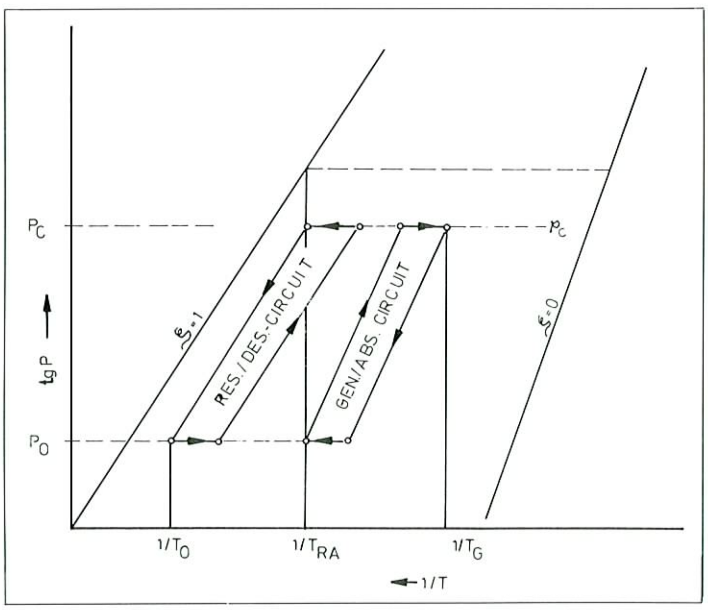

Fig. 7 lg p, 1/T-Diagram of the Resorption Heat Pump, Type I

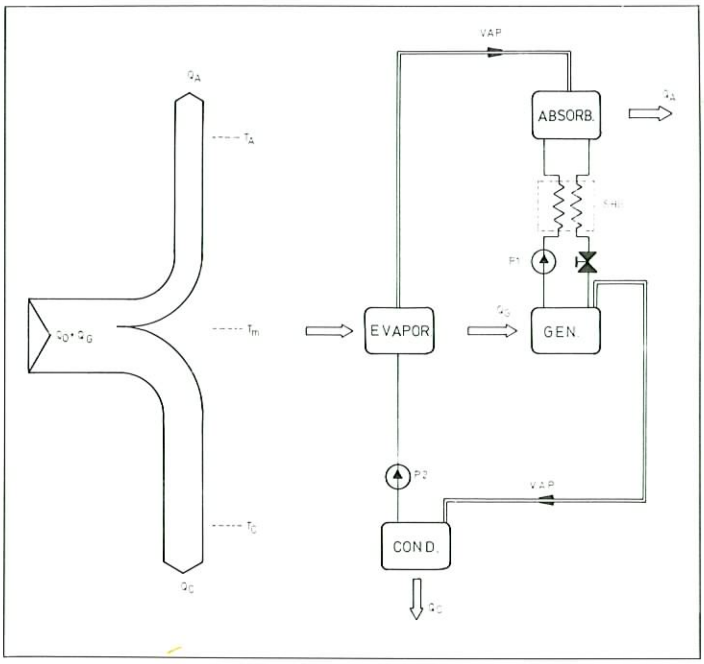

Fig. 8 Principal flow sheet of an Absorption Heat Transformer (AHP, Type II)

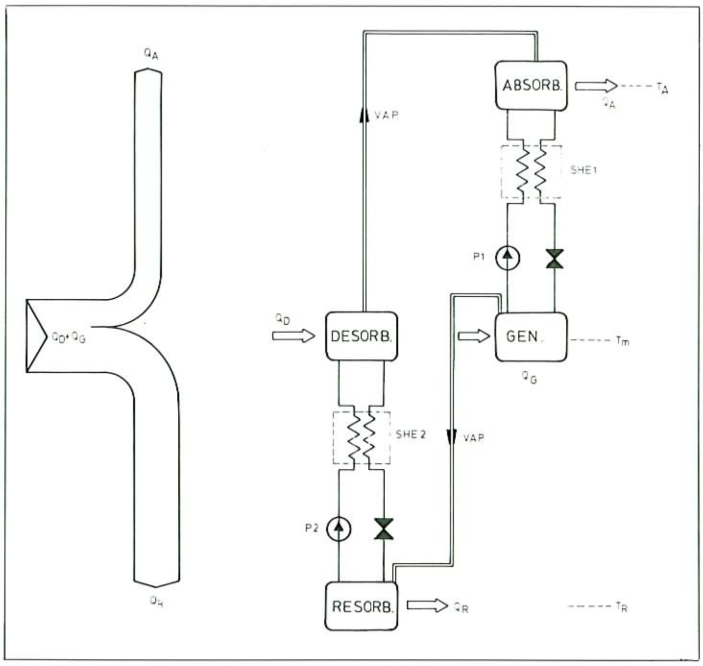

Fig. 10 Principal flow sheet of the Resorption Heat Transformer

Resorption Heat Pumps

The temperature of cooling water in the condenser of cold vapor machines — in this category we have compression and absorption heat pumps of conventional type and style — is usually about 5 to 10 °C lower than the constant condensation temperature, and in the evaporator the temperature of the incoming heat source is higher than the constant temperature of the boiling refrigerant. This results in irreversibilities, because the absorber has to take in the cold vapor from a temperature which is lower than the heat source temperature. Similarly, the refrigerant in the expeller is expelled at a higher temperature than the corresponding heat sink temperature. These losses can be avoided in part if, according to a recommendation of Altenkirch, the condensation and the evaporation do not proceed at a constant temperature, but within a given temperature range. This can be obtained by substituting the branch condenser, refrigerant injection valve and evaporator by a second working fluid circuit with resorber (instead of condenser) and desorber (instead of evaporator) in an absorption heat pump.

In the resorber a suitable weak solution absorbs the refrigerant set free in the expeller. The solution temperature in the resorber varies according to the concentration of the solution. The resorption of the refrigerant vapor does not take place at a constant temperature as in the condenser, but within a temperature range. The same applies to the desorber which substitutes the evaporator.

Fig. 6 shows the principle arrangement of a resorption machine and Fig. 7 the position of the operating points in the lgp, vs. 1/T-diagram.

The advantages of resorption heat pumps compared with common absorption heat pumps are:

- no rectification unit (e.g. ammonia/water),
- lower pressure difference,
- reduced losses and increased heat ratio.

However, a high premium has to be paid for the above mentioned advantages by the higher first cost (eg. an additional working fluid pump).

Heat Transformer (AHP, Type II)

The heat transformer is also known as the reverse absorption heat pump process or absorption heat pump Type II. The objective of such an AHP is to convert waste heat of medium temperature (from 60 to 80 °C) to useful heat at high temperature.

Fig. 8 shows a flow diagram of a single stage unit which is suitable for this purpose. According to P. Franzen [7] the heat ratios — measured at a 50 kW test plant with NH_3/H_2O as a working pair — reached about 0.37 at a condensator temperature of 15 °C and a drive temperature of 90 °C for an available temperature of 130 °C and about 0.31 for an output temperature of 145 °C. The lgp, vs. 1/T-diagram for this simplified circuit is given in Fig. 9.

The working pair ammonia/water can be used, up to about 190 °C. NH_3/H_2O AHPs have the disadvantage of high pressures, when high output temperatures are necesary, which means that substantially more electric power is required for the working fluid pumps compared with low pressure working pairs (e.g. $LiBr/H_2O$ or $LiBr/CH_3OH$). Systems with low pressure working pairs use the simple dual tank system, well-known from absorption refrigeration technology and thus have lower first cost compared with NH_3/H_2O plants.

A wide spectrum of applications is possible for AHP, Type II, as well as for the AHP, Type I. But only the most basic types for the different configurations are mentioned below.

The first stage of a dual tank cascade connection is powered by waste heat of medium temperature. The output heat of stage 1 is used to heat the expeller and the evaporator of stage 2.

Useful temperatures up to 150 °C can be reached in stage 2 for an actual heat ratio of about 0.15. The pressures in stage 2 of an NH_3/H_2O system exceed 40 bar. Theoretically temperatures of about 190 °C can be reached by means of a three stage heat transformer cascade. The available temperatures which can actually be reached, are determined by the physi-

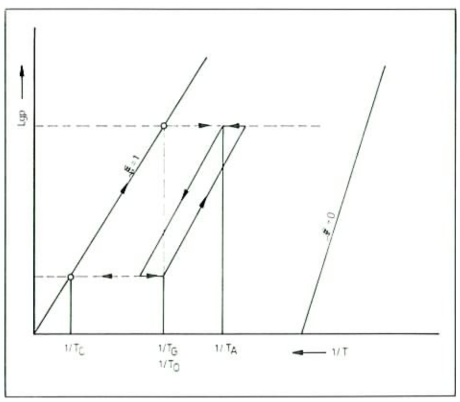

Fig. 9 lg p, 1/T-Diagram of the Absorption Heat Transformer (AHP, Type II)

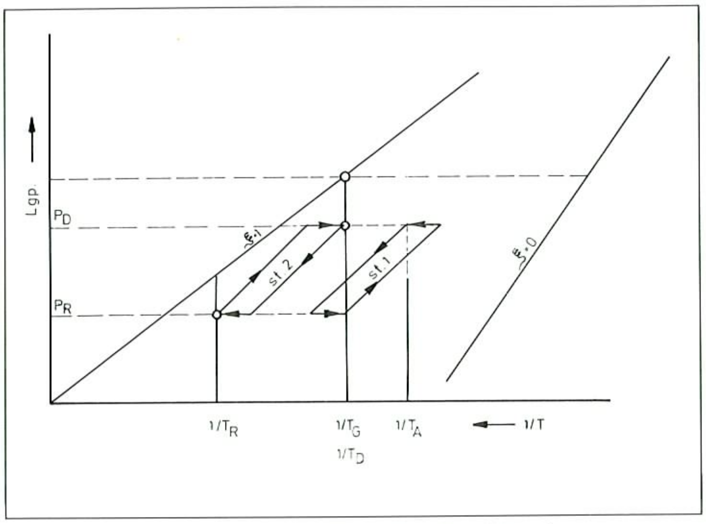

Fig. 11 lg p, 1/t-Diagram of the Resorption Heat Transformer (RHP, Type II)

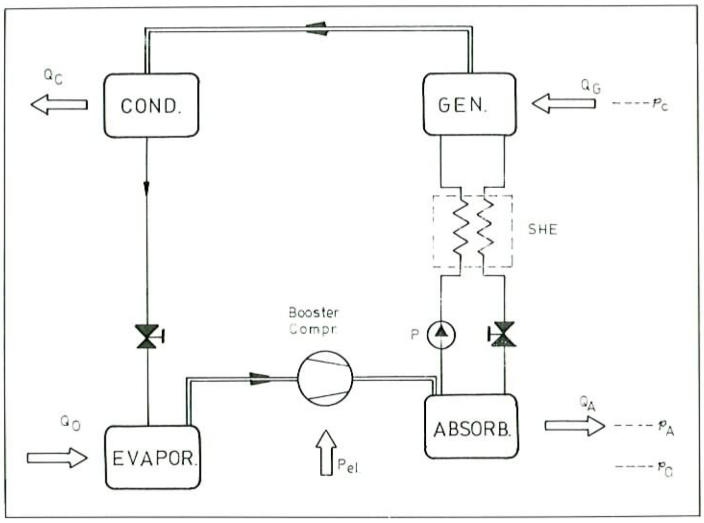

Fig. 12 AHP with Booster Compressor

cal properties of the working pair. Therefore in practice the heat ratio is below 0.1.

The single stage resorption heat transformer (RHP, Type II) should be mentioned as the fundamental configuration (Fig. 10 and Fig. 11) from which a large number of variations can be developed. The condenser is replaced by the resorber and the evaporator by the desorber, similar to the resorption heat pump this requires the addition of a second solution circuit. This design permits heat transfer at varying temperature differences. Thereby lower exergy losses and reduced consumption of cooling water are attained. Higher heat ratios in comparison with the Type I AHP, and lower electric power consumption are possible for the resorption heat transformer.

Choosing $LiBr/H_2O$ as the working pair instead of NH_3/H_2O will result lower first and operation cost.

Special Types of AHP

In this group we find different systems, combining vapor compression with absorption heat pump elements.

In refrigeration technology, designs of absorption refrigeration machines using a booster compressor are known. These are used to achieve the features of dual and multi-stage absorption plants by means of single stage, continuously-working absorption machines. A booster compressor as shown in Fig. 12 is connected either between the expeller and the condenser [9] or between the evaporator and the absorber [1].

Good performance figures can be attained, by a compression heat pump that includes a sorption circuit (Fig. 13). This can be achieved by designing the resorber and desorber in such a way that the irreversible losses can be kept low by operation according to the Lorenz process. (large temperature differences between the outlet and inlet of the mass flow and comparatively small temperature differences between both mass flows). A further advantage is the lower pressure difference compared to compression heat pumps, resulting in a reduced required drive power.

A comparison of COPs shows that an adapted compression heat pump with a solution circuit brings slight improvements over a compression heat pump with a non-azeotropic working fluid mixture. When used instead of a compression heat pump with a one-substance refrigerant (e. g R22) it brings marked improvements. An application of this HP type has been set up by "Stadtwerke Mannheim" (municipal administration of Mannheim).

This category of heat pump has interesting application possibilities. However, before reaching market fitness, considerable development work has still to be carried out.

Conclusion

Many attempts have already been made to estimate the market potential for the various absorption heat pump systems. It has become evident that their competitive position is very much dependent on size, type and application.

— Small AHP units for home heating:
Among the most significant disadvantages of the small AHPs for home heating systems are only little increase in COP for the high first cost in comparison to an efficient oil- or gas-fired boiler. As a consequence of the low savings compared with conventional oil- and gas-fired boilers, the pay back period for small AHPs, the design of which is based on the existing know-how, is too long. At present, the main obstacle, according to Steimle [11], is the lack of a working pair well suited for this application.

— AHPs and Heat Transformers for industrial applications:
In the MW heat capacity range the utilization of industrial waste heat offers good chances for cost-effective plants. The application of low-pressure working pairs is of particular interest. In this form a variety of different system designs and operating methods for AHPs, working as Type I or II, are profitable. It is worth mentioning that the waste heat of stationary gas and diesel engines is of great importance as drive energy for AHPs.

— Special Types of AHP:
Special types of AHP like combinations of elements originating from the compression and absorption cycle promise competitive solutions. Test plants of systems with a compressor-solution-circuit show that at high output temperatures comparatively low process pressures can be achieved compared with one-substance compression heat pumps.

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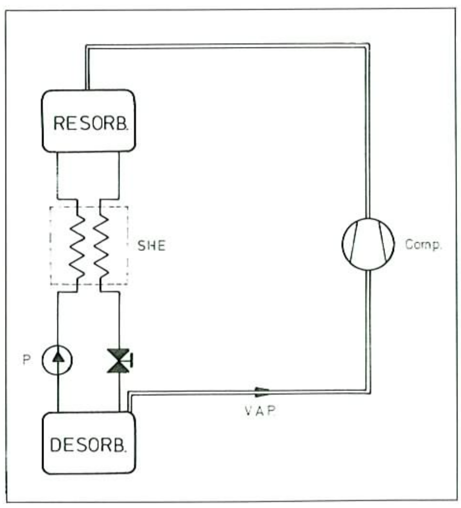

Fig. 13 Compression Heat Pump with solution circuit

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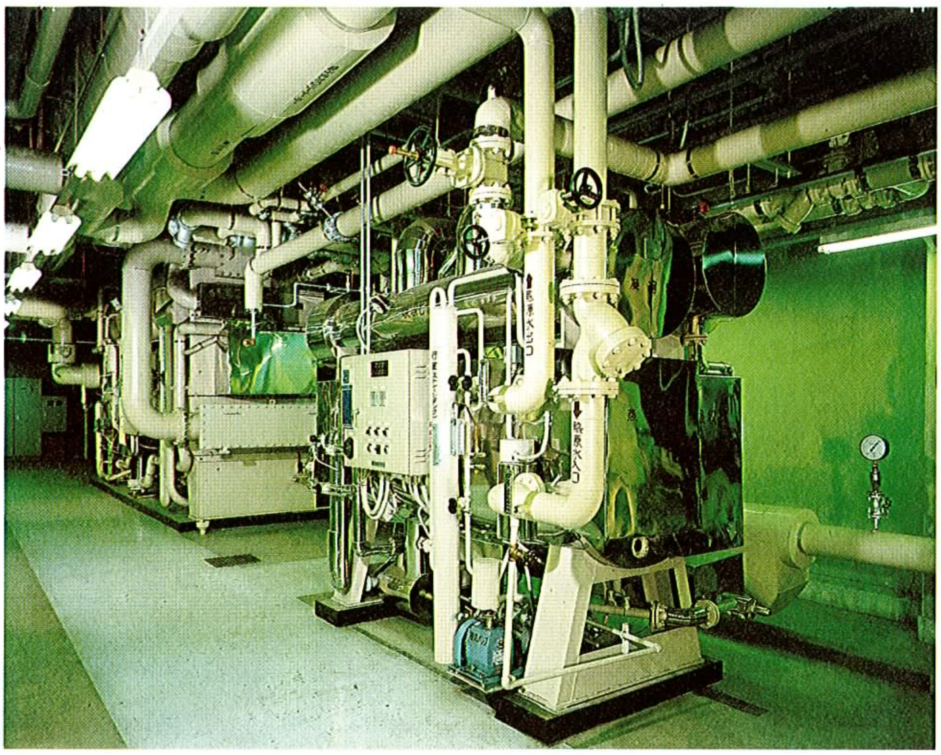
Y. Okamoto*

Utilization of Absorption Heat Pumps in Japan



Picture 1 Absorption Heat Pump for Computer Center, Tokyo Gas Co., Tokyo — Heating capacity 350,000 kcal/h

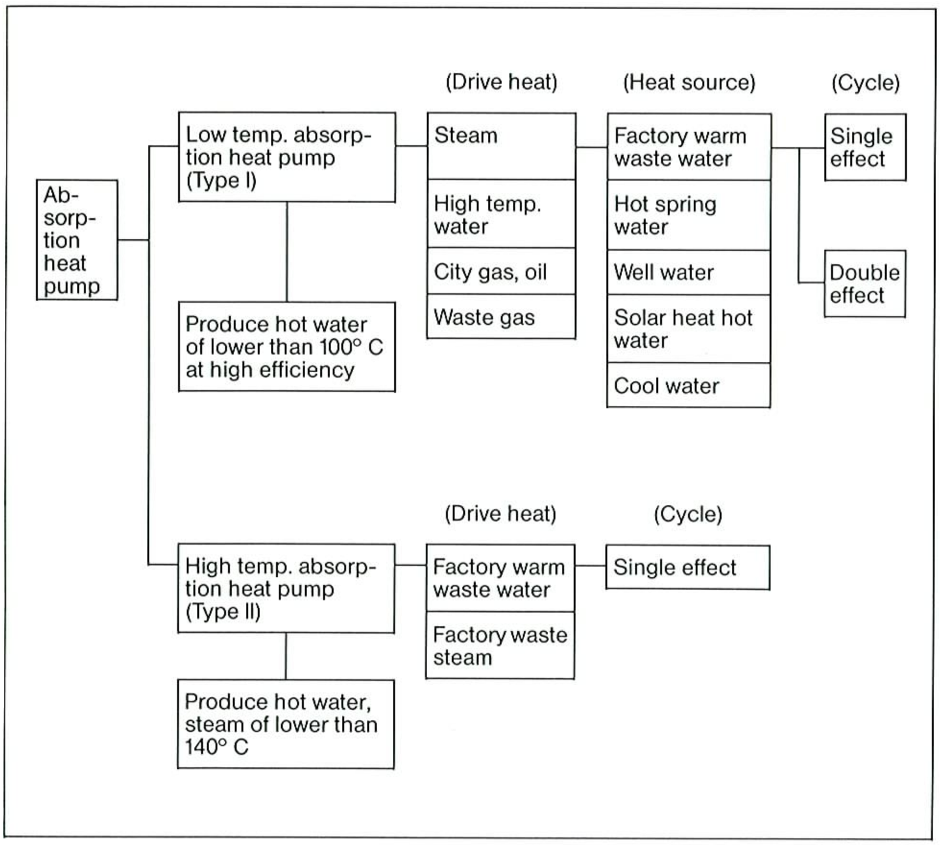


Fig. 1 Classification of Absorption Heat Pumps

In Japan, absorption refrigerating machines are used in a large number of buildings and plants, all using a combination of water and lithium bromide. Lithium bromide used as working fluid is chemically stable, while water as refrigerant gas has a large latent heat of vaporization, and the process runs in vacuum. Thus, absorption refrigerating machines have excellent features, such as energy conservation, safety, ease of operation and maintenance, low noise and low vibrations.

The absorption heat pump was developed based on the absorption refrigeration machinery technology. As shown in fig. 1, absorption heat pumps are broadly classified into type I absorption heat pump of low-temperature type, and type II absorption heat pump of high-temperature type (heat transformer).

In terms of COP, its efficiency is over 1.4 times as high as that of a conventional boiler, so that type I units are being diffused rapidly.

As heat sources for the evaporator industrial waste water, well water, solar heated water, and hot spring water is used. Thus, in addition to industrial applications such as spinning mill, pulp works, paper mill,

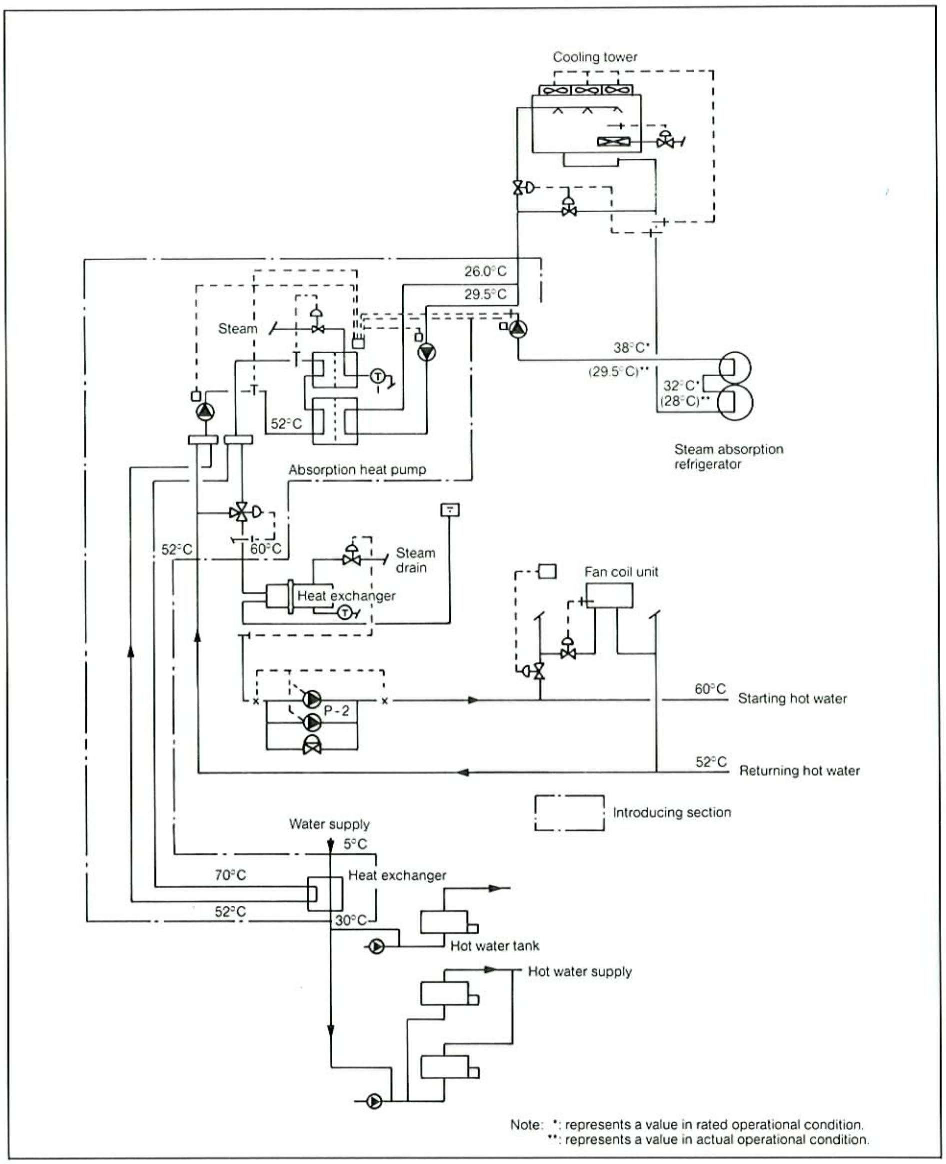


Fig. 2 System-Flow

steel mill, chemical plant, semiconductor plant, photo film plant and dye works, type I is also widely used in buildings where large quantities of warm waste water are available.

As to air conditioning, waste heat usually lost in cooling towers during cooling mode can be recovered for parallel heat demand, in particular for tap water heating. The type I unit using waste heat of about 35° C as an evaporator heat source can raise the temperature of supplied water from 10° C up to 60—70° C for use in hotels, sauna bathhouses, etc. Fig. 2 shows a flow sheet of type I unit which is actually in use in order to utilize waste heat from cooling of a computer center for sanitary hot water supply and heating for office segments of the same building. Picture 1 shows the steam absorption refrigeration machine and the heat pump. For these cases of application, COP in a single-stage cycle is about 1.75, provided that COP = (Qa + Qc) / Qg*.

In cases where cooling load exists even in winter, such as computer room air conditioning, there is a system that utilizes waste heat from the cooling service for heating within the same building. In this case, the standard temperature condition is 7° C for chilled water, and 45° C for warm water. The COP in single-stage cycle is of about 2.5, while that in a dual-stage cycle is of about 3.4, provided that COP = (Qe + Qa + Qc) / Qg*.

Additionally, there is a system in which with a shell and tube condenser of the two-bundle-type, warm water recovered from the condenser is used as a heat source for sanitary hot water supply. This system can be used for preheating of sanitary hot water at offices, or humidity control at public halls. The COP differs depending on sanitary hot water demand varying from 1.2—2.1, provided that the COP = (Qa + Qc) / Qg*.

Absorption cycle is either single-, double-, or multi-stage. Normally used heat pumps are of single-stage type. When the heat source temperature is low and when high temperature is required, the dual-stage cycle is advantageous with COP improving by about 35% over the single-stage cycle.

So far, the number of type I absorption heat pump deliveries has totaled 107 units between 1980 and 1983 of which 2 units were exported.

Fig. 3 shows an example in an alcohol distillation plant, and fig. 4 shows an example in a butadiene rubber plant. See also picture on front page.

Described above are water-lithium bromide absorption heat pumps and their uses. Apart from them research is being conducted on absorption heat pump using Flon as working fluid. Its COP during cooling is reduced by about 50% compared to the water-lithium bromide type, being as low as 0.5 while the COP during heating is as high as 1.2, somewhat higher than that of a conventional boiler. Therefore, the air source absorption heat pump using Flon can be effectively utilized for residential use if annual heating and hot tap water demand is high, or for hot water supply.

* Qe: input to evaporator
Qg: input to generator
Qa: output from absorber
Qc: output from condenser

* Yozo Okamoto, Manager, Heating and Cooling Division Tokyo Gas Co. Ltd.

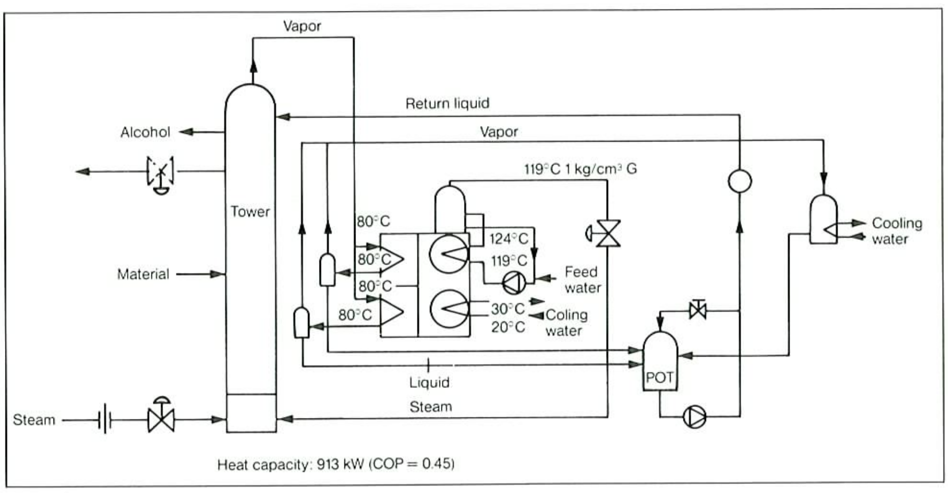
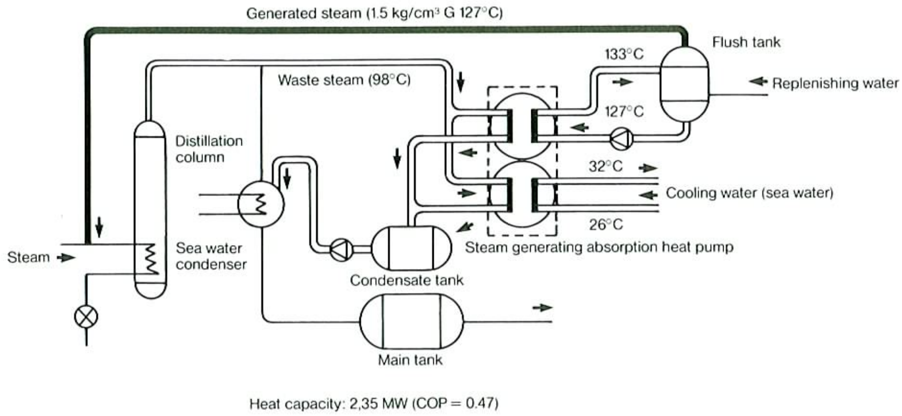


Fig. 3 Ethylalcohol Distillation Plant, Kagoshima, Japan



a) GENERAL			
Heat pump cycle:	Type II		
Location:	Chiba, JAPAN		
Owner:	Butadiene Rubber Plant		
Manufacturer:	Tokyo Sanyo Electric Co., Ltd.		
Purpose:	Steam generation for process heating by heat recovery of waste steam		
Start of operation:	December, 1981		
Load factor:	8000 h/year		
b) TYPE			
Working pair:	H_2O + LiBr		
Drive heat:	Waste steam		
Process output condition:	Low pressure steam		
c) OPERATIONAL CONDITIONS			
Drive heat source:	Evaporator & generator inlet temp.	98 °C	
	Drain temp.	88 °C	
	Drive heat capacity (QE + QG)	5 MW	
Cooling water:	Flow rate	380 ton/h	
	Condenser inlet temp.	26 °C	
	Condenser outlet temp.	32 °C	
Process output:	Absorber inlet temp.	127 °C	
	Absorber outlet temp.	133 °C	
	Useful heat capacity (QA)	2.35 MW	
COP:	QA/(QE + QG)	0.47	

Fig. 4 Butadiene Rubber Plant, Chiba, Japan

W. Lorch*

What are the Reasons for the Decline of German Heat Pump Sales?

In principle, there are three main advantages arising from the use of heat pump heating systems.

- for heating single-family buildings it is an environmentally safe heating technique which does, in contrast to oil heating, not produce dangerous emissions,
- the efficiency of the input of electric energy is about tripled and thus losses occuring in generation of electric power in thermal plants are balanced,
- the kind of energy savings achieved are economically advantageous for the house owner as well as for the national economy.

These advantages are enough reasons to use heating systems with heat pumps to a far greater extent. As this heat pump breakthrough has not yet taken place it is important to realize what the reasons are in order to overcome the problems. The distribution of the roles should be seen correctly: the house owner or builder-owner is the one who pays for all measures and therefore decides about their kind and realization. The architect is the consultant who, in most cases, has not yet demonstrated much interest for the energy balance of a house and still remains concentrated only on the routine work of designing the house. The installer of the heating system generally has no occasion of making proposals but tries only to secure contract by placing a low-priced bid.

The following reasons can be given for the totally insufficient application of new heating technologies, ordered according to their importance:

1. Standstill of oil prices

During the past few years, the price for oil has remained at about the same level, as the oil is traded according to the market: demand and offer determine the price. Since there was no price increase, there was no necessity to look for alternative heating possibilities. It is almost a historical fact that man gets active only when an accute danger is present. Long-term rational decisions are mostly forgotten due to short-term influences or to commodity.

2. Simple System Designs

System Technology had not yet matured as no technically simple solutions were aimed at or stressed which could have been installed easily by any installation firm. So, for example "energy roofs", from the point of view of the installer, are a mis-development. They require extensive work on the roof (later on possibly repair work) and special sealings against condensation humidity. In the meantime, simple and easily installable heat pump systems have been developed and these were simplified further by the introduction of modular systems. These solutions, however, are not yet widely known.

3. Information by the Media

The media preferred to report about failures of the new technology, as for the reporter the presentation of the negative is much more interesting. There are, however, thousands of heat pump systems working without any troubles, thus not offering any sensations for the reporter.

4. Builder-Owners and House Owners

Both had not been convinced of the functioning of this new technology. Media made them reluctant and excessively critical, and the over enthusiastic sales literature of the new products puzzled them. The new comprehensive sales and information brochures of the individual firms addressed to this party represent the second step already, while the first step, a general, neutral and not too technical information for builder-owners and house owners has never been released. For this, a supervisory, neutral institution is necessary which already "sifts the chaff from the wheat", i.e. gives samples for simple systems design.

5. Lack of Interest from the Architects

As for the introduction of new heating technology, the architect has not been helpful, but rather reluctant. He wanted to avoid eventual problems and additional work. In the near future, there is scarcely a chance for more assistance. Including a small heating room in the basement and a chimney, is a solution that causes no troubles for the architect because the rest of the work is done by the installer, as usual. Another generation of architects will have to come about that is willing to become familiar with ventilation systems, with heat recovery, hot-air heating systems and heat pump heating systems.

6. Environmental Pollution

The public is becoming more and more aware of the environmental damage of sulfur dioxide and NO_x emission but the demand for remedies is until now, aimed at the coal-fired power plants. Millions of residential heating systems are forgotten which use heating oil and thus produce dangerous emissions. Therefore, architects and house owners, too, have to realize that residential heating systems must also be non-polluting.

To end with, a by-effect of the application of electric heat pumps for residential heating should be mentioned and not be under estimated. The foreign exchange saved by the reduced need for heating oil will stimulate consumption and investments, thus having a positive impact upon our economy. The industry branch of heat pumps and accessories as well as the installing branch could create many new jobs. Our national economy would thus be stimulated.

* Walter Lorch, Ing. Büro f. Solartechnik, Landgraben 107, D-5100 Aachen

Schedule of Conferences and Trade Fairs

May 14—16, 1984, Budapest (Hungary), 10th Conference on Heating, Ventilation and Air-Conditioning, Contact: Scientific Society for Building; 6—8 Kossuth Lajster, H-1055 Budapest (Hungary)

May 22—25, 1984, Graz (Austria), IEA Heat Pump Conference: Current Situation and Future Prospects, Contact: W. Hochegger, IEA Heat Pump Center, Analysis Center Graz, Petersgasse 45, A-8010 Graz (Austria)

Jun 4—7, 1984, Amsterdam (Netherlands), Gas Turbine Exhibition, Contact: American Society of Mechanical Engineers, Gas Turbine Division, International Gas Turbine Center, 6065 Barfield Rd. Atlanta GA 30328 (USA)

Jun 13—17, 1984, Genova (Italy), 6th International Exhibition and Congress on Solar, Renewable and Alternative Energy Sources, Contact: Mrs. Mirando Cinzia; Fiera Internazionale di Genova; P.le J. F. Kennedy, 1, I-16129 Genova (Italy)

Jun 17—20, 1984, Kansas City MO (USA), Annual meeting of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Contact: R. S. Burkowshy, Manager of Meetings and Conferences, ASHRAE, 1791 Tullie Circle, N. E., Atlanta, GA 30329 (USA)

Aug 20—24, 1984, Stockholm (Sweden), 3rd International Conference on Indoor Air Quality and Climate (Indoor Air 3), Contact: Indoor Air '84 c/o RESO Congress Service, S-10524 Stockholm (Sweden)

Sep 10—12, 1984, Zürich, (Switzerland), International Seminar 'ORC-Technology', New Working Fluid for Energy Engineering, Contact: ETH Zuerich (Switzerland)

Sep 10—13, 1984, Washington D.C. (USA), International Gas Research Conference: Natural gas production, substitution, utilization, Contact: 1984 Gas Research Conference c/o Gas Research Institute, Att. Dr. L. Hirsch, 8600 W. Bryn Mawr Ave, Chicago Jll. 60631 (USA)

Sep 11—15, 1984, Berlin (German Federal Republic), 5. Internationales Sonnenforum, Contact: Prof. Dr. A. Goetzberger, Fraunhofer-Institut für Solare Energiesysteme, Oltmannstr. 22, D-7800 Freiburg (FRG)

Sep 25—27, 1984, York (UK), 2nd BHRA International Symposium: Large Scale Applications of Heat Pumps, Contact: Conference Organizer 2nd Heat Pump Symposium, BHRA, The Fluid Engineering Centre, Cranfield, Bedford MK430AJ (UK)

Oct 4—6, 1984, Nuernberg (German Federal Republic), 5. Internationale Fachmesse Kaelte-Klimatechnik, Contact: Nuernberger Messe- und Ausstellungsgesellschaft mbH, Messezentrum, D-8500 Nuernberg 50 (FRG)

Oct 15—16, 1984, Tulsa, OK (USA), 7th Heat Pump Technology Conference, Contact: Dr. Jerald Parker, Professor School of Mechanical and Aerospace Engineering, 218 Engineering North, Oklahoma State University, Stillwater OK 74078 (USA)

Nov 12—17, 1984, Lyon (France), Expotherm, Contact: Foire Internationale de Lyon, Quai Achille Lignon, F-69459 Lyon Cedex 3 (France)

Call for Papers: Heat Pump Technology Conference

This conference is to serve as a forum for exchange of information among the users, manufacturers, component suppliers, and designers concerned with heat pumps in order to encourage the discussion of ideas and mutual problems of manufacturers and users. Some recent trends in heat pump design and use will be discussed.

Call for Papers:
Topics covered will emphasize unique applications as well as developments in new systems and components, economics, reliability, service programs, storage systems, and impact on utilities. Speakers on the conference have an ideal forum to reach many influential people in the field of Heat Pump Technology. It will be publicized in many technical publications and periodicals, and descriptive information will be sent to persons in industry, government agencies, universities, utilities, and to consulting and architectural firms.

Please, use plain white bond paper to submit your abstract or outline, printed or typed, discussing the pertinent topics to be included (100 words or less).

Please, send the abstract or outline along with a cover letter identifying the authors before June 1, 1984, to:

Dr. Gerald Parker, Professor
School of Mechanical and Aerospace Engineering
218 Engineering North
Oklahoma State University
Stillwater, OK 74078, U.S.A.

One author or presenter per paper will be admitted to the conference free of charge. All other authors/presenters will be charged with full registration fee.

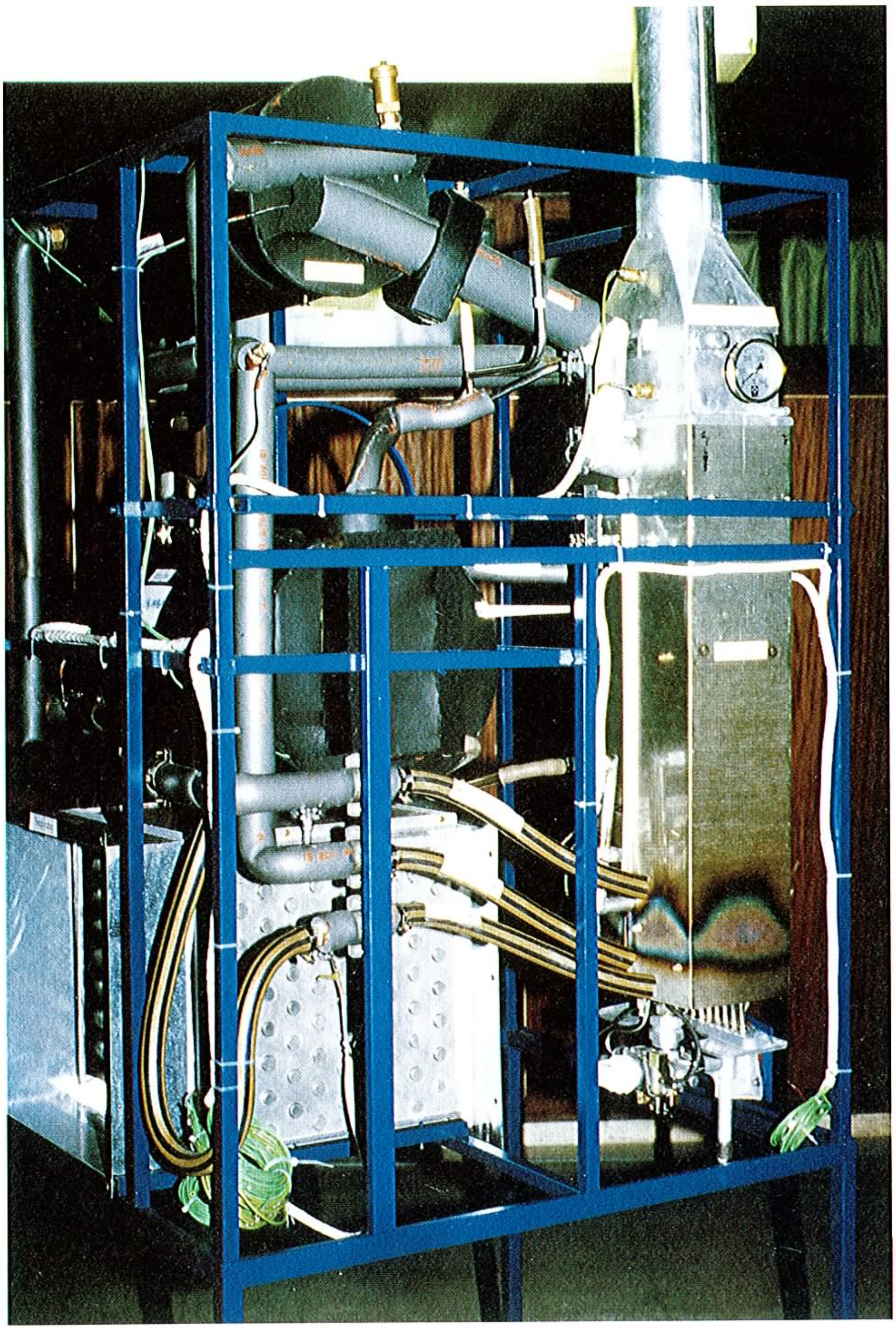
Schedule:
June 1, 1984: Abstractor outline due
June 15, 1984: Authors notified of acceptance or rejection of paper
September 1, 1984: Final form of paper following guide-lines in the OSU Preparation of Papers Guide

J. A. Knobbout*

"Energy Saving in Buildings International Seminar of the Commission of the European Communities and the Dutch Ministry of Economic Affairs"

In the framework of the R&D and demonstration programs of the European Commission the results of a number of projects concerning energy savings in buildings were presented. In total, eighty projects were discussed in three days, supported by a poster session for the direct contact between the project leaders and the visitors. An important session of this seminar was devoted to the heat pump for heating residential and commercial buildings. In this sector, 28 projects were presented by 2 reporters and a number of authors.

The papers are to be published in the Proceedings, which will be presented in the first quarter of 1984. For the readers of this "Newsletter" it is of importance to take notice of the views of the authors and the conclusions based on the presentation.



The most important aims for the development of the mechanically driven heat pump are increasing the COP and lowering the costs of the installed heat pump.

One of the conclusions is that the use of non-azeotropic mixtures is a very successful means to increase the capacity. The soil as a heat source seems particularly attractive in many countries.

Special attention should be given to reducing the cost for installation and maintenance.

Attention will also have to be paid to the noise production of heat pumps and the two-phase flow in the system.

The absorption heat pump is not so well developed as a mechanically driven heat pump, and this is the reason why in this program priority is given to the development of this type of heat pump.
The choice of the fluid pair for an absorption heat pump is crucial and much attention is given to this aspect.

As the absorption heat pump will bear a greater resemblance to a heating boiler than the mechanical heat pump, its implementation can be easier.

Much attention in the R&D should be given to the absorber in the absorption heat pump as a component in which heat and mass transfer occurs.

For the low-capacity absorption heat pump the circulation pump should be cost-effective and have a controllable flow. It is expected that future R&D and demonstration programs will reflect these views and conclusions.

The general impression is that the seminar was very successful and has resulted in many contacts and a clear view of future activities in this field of R&D and demonstrations.

* J. A. Knobbout, TNO—MT, Laan v. Westenenk 501, 7300 AH Apeldoorn

Experimental Prototype of an periodically operating AHP presented by Knoche/Stehmeier/Grabenhenrich, Aachen at the EC Seminar in Den Haag, NL

H. van der Ree*

Energy Conservation in Industry

Seminar of the European Commission, Düsseldorf

From 13—15 February 1984, the European Commission presented in an International Seminar the results of the 1979 to 1983 Research and Developmant Program on Energy Conservation in Industry.

The aim of this seminar was to present to industry, as well as to manufacturers and consumers, the results of R&D-projects as an active step to the implementation of the results in practice.

The items were presented along two lines: first reporters summarized clusters of projects, which could then be individually discussed with the projectleaders, allowing the establishment of contacts and commercial follow-up.

One section of the program was dedicated to the development of industrial heat pumps in which attention was given to the following systems:

- Design of a high-temperature (170° C) Brayton cycle heat pump.
- Development of a dual-stage absorption heat pump to produce steam for paper drying.
- Search for new fluids in absorption heat pumps.
- Development of a NH_3/H_2O heat transformer.
- Testing of a small engine-driven heat pump (~15 kW output) for grain drying.

* H. van der Ree, TNO—MT, Laan v. Westenenk 501, 7300 AH Apeldoorn

VW Thermodiesel Produced in Austria

Under exclusive, world-wide licence of the Volkswagen AG Wolfsburg, the Thermo-Energiesysteme GmbH of Austria will start production of the VW Thermodiesel in April 1984. This is a bivalent or monovalent air-to-water heat pump of 25 kW thermal output, driven by the famous VW four-cylinder diesel-engine, of which half a million units have been produced in the VW works in Germany.

The Thermo-Energiesysteme GmbH is located in Berndorf near Vienna. It is owned by VMW, the Vereinigte Metallwerke Ranshofen-Berndorf AG (51%) and by ÖIAG, the government-owned Österreichische Industrieverwaltungs AG (49%).

Carrier And The French National Electric Utility Conduct Joint Heat Pump Research

Results demonstrate energy-saving of residential heat pumps

A unique, two-year research program by Carrier's Research Division and Electricité de France (EDF), the national electric utility, has shown that savings in fuel oil use of up to 72% and seasonal coefficients of performance (COP) of up to 2.8 can be attained with residential air-to-water heat pumps.

These were the most significant results of the research on the design, performance and energy-saving potential of dual-fuel heat pump systems in French single-family houses.

"In France, as well as in the United States, increasing concern about rising costs and a secure supply of imported oil, natural gas and other non-renewable energy sources has focused attention on energy conservation", said Gerald C. Groff, director of Carrier's Research Division.

Axel Dietrichson, manager of Carrier International's consumer products marketing department, said the results of this research program will help to make the next generation of Carrier heat pumps even more efficient than current models. The program consisted of four related studies.

Field Monitoring

The field monitoring of three residences in Paris suburbs established a base of information for investigation of residential heat pumps, explained Dr. Charles Bullock, Head of the Systems Analysis Group for Carrier's Research Division and program manager for this project. The data gathered for the 1980—81 and 1981—82 heating seasons, also helped to validate a computer model that was developed as another phase of the program.

The Choffe residence's heating equipment consists of an air-to-water heat pump that operates alone during mild outdoor temperatures and simultaneously with an oil-fired boiler at temperatures down to freezing. The boiler operates alone during colder weather.

"This dual system saved about 4000 litres or approximately 1000 gallons of fuel oil each season", reported Donald Wroblewski, a Carrier research engineer who analyzed the data. That is more than 72% of the heating oil that would have been used by the boiler alone. The heat pump achieved seasonal COPs of 2.7 and 2.8 for the two heating seasons.

"These results confirm the effectiveness of heat pumps applied as retrofit installations in older homes", Mr. Dietrichson pointed out.

The air-to-air heat pump in the Cailleau house saved about 3000 kWh of electrical energy during the first heating season, compared to direct electric heating and an estimated 4250 kWh in the second season. The greater savings in the second year resulted from improvements in the system, based on the first year's experience. The Cailleau residence is a new home, representative of current design and construction practices in France.

In the Richard home, an electric boiler heated the house at temperatures down to freezing with an oil-fired boiler operating below that point. For 1980—81 heating season, the electric boiler provided about half of the heating during the coldest months and nearly 100% during the milder months. The system with the electric boiler used approximately 1200 litres (317 gallons) of fuel oil each season compared to about 4200 litres (1100 gallons) which would have been used if the oil-fired boiler had provided all of the heat, a savings of 72%. Electricity consumption increased proportionately, however, and resulted in a much higher operating cost than for the heat pump dual-fuel system approach.

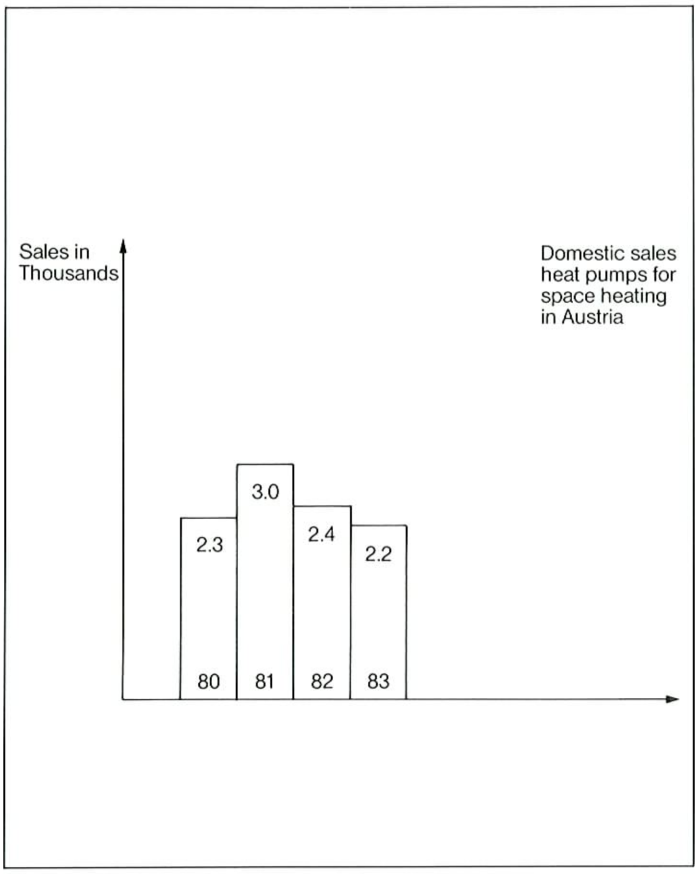
Other studies

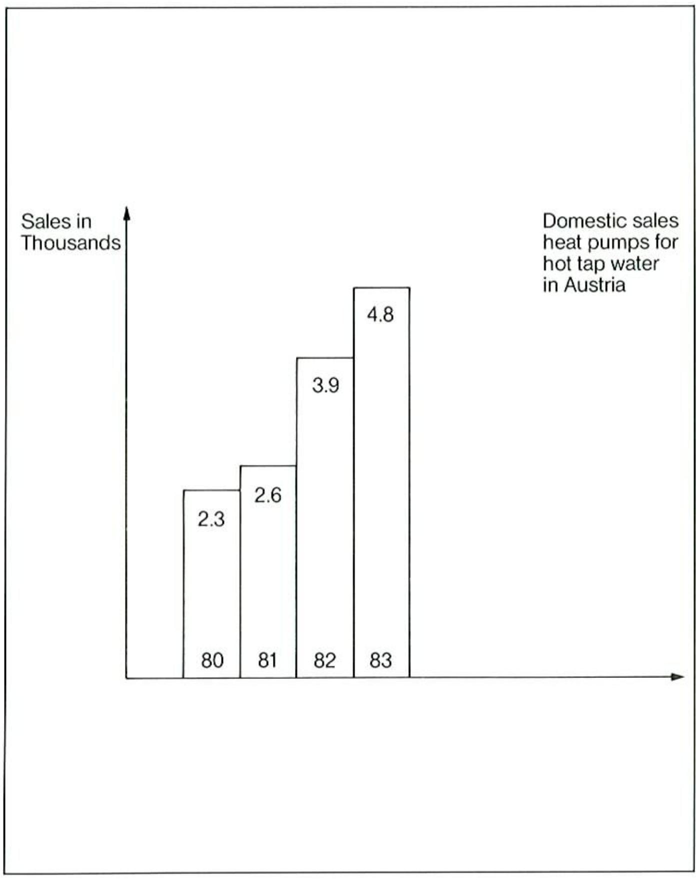
Laboratory tests were conducted on a number of European radiation elements and a fan coil terminal unit. "We wanted to investigate the performance of conventional radiation elements at water temperatures below those of typical hydronic heating systems", explained Kevin Dunshee, a Carrier project engineer who headed this part of the studies. Results of the test were incorporated into the computer model.

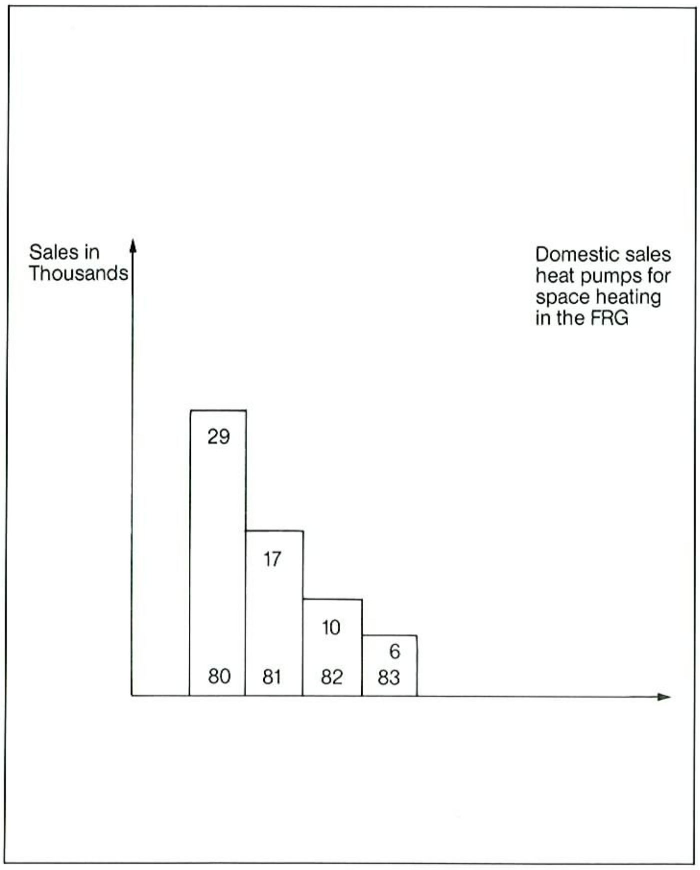
Carrier's Research Division also conducted heating system studies using the computer model. These involved two different house models based on the "new" Cailleau residence and the "old" Choffe house.

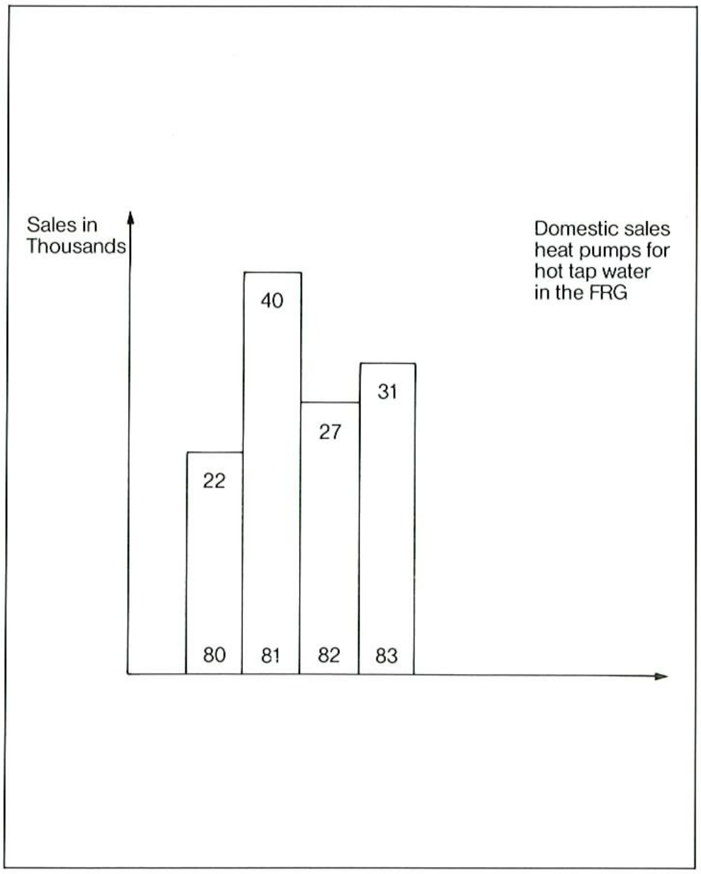
"These computer studies showed that the heat pump systems provide the best performance in terms of a reduction in fuel consumption and operating costs", revealed Dr. Bullock. The air-to-water heat pump system reduced heating oil consumption by more than 80%. That is the kind of results, the French government wants in its energy conservation program.

Heat Pump Sales for Space Heating and Hot Tap Water in Austria and the Federal Republik of Germany









Sources: CCI / Arbeitsgemeinschaft Technik u. Nutzung der Umweltenergie

DEAR READER!

Our NEWSLETTER is designed to become an international information forum for whoever is concerned with heat pumps - in research, development, installation, production and marketing. Our Readers' Column will be an important section for exchange of opinions, collection of new ideas, or criticism of present procedures.

We need your cooperation!

Please send in your drafts (contributions in the languages of participating countries will also be accepted) - together with a photograph if you like - up to half page DIN A 4 to:

IEA Heat Pump Center
c/o Fachinformationszentrum GmbH
D-7514 Eggenstein-Leopoldshafen 2

Our next topic will be: "What is your experience with Absorption Heat Pumps?"

Deadline for your contributions: Jun 30, 1984

Readers' Column

E. Piantoni*

What are the obstacles for a broad utilization of heat pumps in the residential sector?

The main obstacles for a broad utilization of heat pumps in residential sector may be summarized as follows:

— climatic conditions
In Italy the climatic conditions involve a relatively long heating period (from 600 to ~3000 degree days) and a short period of cooling requirements. For this reason, heating-cooling plants find a market only in the tertiary sector (office, shops, etc.) and a small percentage in the residential sector. Therefore reversible heat pumps in the next few years can only be sold in this part of the market while the broad utilization is concerned with space or water heating.

— building factor
According to law n. 373 April 30, 1976, for the reduction of energy consumption in the residential sector, the design of new buildings must take in account interventions to increase thermal insulation that diminish the demand for heating.

Low energy consumption buildings improve the competitiveness of heating systems with low investment cost versus operational costs. Therefore the broad distribution of heat pumps requires low-cost equipment and low-cost primary energy.

Another variable is the type of heat distribution medium which for the residential sector in Italy usually is water at high temperatures (70—80 °C) fed in conventional radiators. Although the heat pump could work in a bivalent way, jointly with a boiler, the overall economic balance in general is so far not attractive for the users.

— competitiveness of heating systems for buildings
The competitiveness of the heat pump usually is very high when only a low temperature level is required for heat distribution and the demand for cooling of the building is significant. As mentioned above these two conditions together are not often found in the residential sector in Italy. Moreover, for buildings with low-temperature heat distribution media (floor heating, convector heating, etc.) high-efficiency boilers (pulse combustion, condensing boiler) are usually more convenient than heat pumps, in terms of investment and operational costs.

— energy policy
In Italy, the efficiency of electricity production in low-tension, sold to the user, is equal to 2500 kcal/kWh; therefore in terms of primary energy the equivalence between electric heat pumps and conventional oil or gas boilers with efficiency $\eta = 0.85$ is reached when COP (including auxiliaries) equal to 2.47.

From an energetic point of view, this means that the possible utilization of heat pumps for heating purposes requires high-efficiency heat pumps and adequate heating plants.

As an energy saving equipment, heat pumps could be used for water heating as a substitute for conventional and less efficient electric boilers (10 Million electric boilers are installed in Italy).

In Italy, however, there exists a plan for the broad utilization of natural gas which will lead to a movement from oil towards gas in the future. This will increase the installation of gas heating systems including gas-engine driven heat pumps and absorption heat pumps. It is well-known that these kinds of heat pumps are energy saving equipment by definition.

— economic aspects
The electricity cost in Italy for domestic use is about 130 L/kWh against 500 L/Nm^3 for natural gas and 580 L/l for light oil. This means that from an economic point of view electric heat pumps are

competitive against oil boilers (η = 0.85) for COP higher than 1.8 and gas boiler (η = 0.85) for COP >2.1.

Electric heat pumps are therefore more attractive if installed as a substitute for oil boilers.

As to investment costs, heat pumps are more expensive than the equivalent boilers and consequently the pay-back periods for the extra-costs are generally less attractive for the user.

The availability of financial subsidies in the frame of law No. 308 of May 29, 1982, up to 15 Million Lire* improves the possibilities for heat pump application in the residential sector within the limits described in the previous items.

In addition, significant first cost reduction for heat pumps is impossible in Italy without increasing their production level at least by one order of magnitude.

Conclusion

To increase heat pump application in Italy it is necessary:

- to utilize the subsidy offered by law 308
- to quality installers and technicians to optimize utilization of heat pumps
- to intensify marketing provisions.

* For installation in residential sector and with certain limitation on the energy requirements.

* E. Piantoni, repr. CNR Progetto Finalizzato Energetica 2, clo CISE P. O. Box 12081, J-20100 Milano

Selected Book and Report Reviews

**Lorch, W.; Erprobte Heizungssysteme mit Waermepumpen, ISBN 3-9800893-0-4. Walter Lorch Buchvertrieb und Energieberatung, Landgraben 107, D-5100 Aachen (FRG); Proven Heating Systems with Heat Pumps; Presentation of up to date Heating Systems, Description of Components and Function, Applicability and Costs; 1983 (in German)
168 p.**

The main objective of this book is to provide the house owner and building contractor with a reference with regard to Solar and Heat Pump Heating Systems. From the commercially available equipment types, four main system configurations for low-temperature heating are described in detail. Chapters are devoted to Energy Costs, Solar Energy, Power Generation, Environmental Impact. Economical Hot Water Production, Ground Source Heat Pumps and other related subjects.

Grossmann, G.; Childs, K. W.; Oak Ridge National Lab. TN (USA) ASHRAE Semi-Annual Meeting; Atlantic City, NJ, USA; 23. Jan 1983. Development of a Computerized Simulation Program for Performance Prediction of a Lithium Bromide Absorption Heat Pump; 1983 (in English)

A computer-simulation model has been developed to predict the performance of an absorption heat pump for temperature boosting of low-grade heat (heat transformer). The model simulated a single-stage, lithium bromide-water system currently being constructed. The effects of waste-heat temperature, cooling-water temperature, and solution circulation rate were investigated. The temperature boost and delivered capacity increased almost linearly with an increase in the waste-heat temperature of a decrease in the cooling-water temperature. The system's coefficient of performance (COP) increases slightly under either of these conditions.

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IEA heat pump center

In our next issue you will find contributions to the following topics:

1. Editorial: Trends in Heat Pump Technology
2. Heat Pump Sales in Member Countries
3. IEA Heat Pump Conference, Graz — a Report
4. The IEA HPC's Working Program
5. Schedule of Conferences and Trade Fairs
6. Recent Performance Investigations on Heat Pumps
7. Trends in Heat Pump Installations
8. Heat Pumps in the Netherlands

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Date Signature

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