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ORGANISATION MONDIALE DE LA SANTE

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ORIGINAL: ENGLISH

Expanded Programme on Immunization

DEVELOPMENT OF BETTER KEROSENE REFRIGERATORS FOR STORING VACCINES

Summary of Progress
May 1986

Table of Contents

INTRODUCTION

During the past 7 years a considerable amount of effort has been put into improving the standards of kerosene-operated refrigerators for storing vaccines. Before 1978 the small kerosene refrigerators available were known to be ineffective in ambient temperatures above 35°C. The need for some improvement in the technology of vaccine storage was urgent.

Most developing countries have at least some period of the year when the noon temperature is above 35°C, so cooling unit efficiency and the principles of cabinet design had to be improved. The vast majority of applications for kerosene-operated vaccine refrigerators were in small isolated health units which served small populations and hence needed small refrigerators. The more efficient top-opening type cabinets were not available for such applications.

Furthermore, there was a serious shortage of training and training materials available for the instruction and guidance of health personnel. Awareness of the special service and maintenance needs of kerosene-operated equipment was low and the responsibility for this task was not recognized. In-service training for this purpose was rarely available, and formal training courses and materials for new staff in the principles of vaccine care and handling were similarly lacking.

Finally, a survey of kerosene used in the cold chain in 7 countries showed that the kerosene in use in each country surveyed was of a low quality. In fact, the quality of this kerosene was so low that a normal domestic refrigerator of the type used in the EPI could not be expected to keep the correct temperature.

This combination of inefficient designs, inappropriate equipment, inadequate maintenance and poor quality fuel meant that it was rare to find a kerosene refrigerator at a health centre which was operating properly and which adequately protected the stocks of vaccine.

The purpose of this paper is to summarize the developments that have taken place since 1978. Sections 1 and 2 deal with developments on equipment and spare parts, and Section 3 describes the training materials available. Much work remains to be done, however, and the final part of the paper gives some directions for further developments which are needed on kerosene operated equipment.

1. IMPROVEMENT AND DEVELOPMENT OF EQUIPMENT

The most important changes in kerosene refrigerator design have been the development of two refrigerator/freezers especially for storing vaccine.

1.1 **Refrigerator/Freezer for Health Units:** The first of these new refrigerators was developed for the EPI by Electrolux AB, and is described in detail in Annex 1.

In summary, the advantages of this refrigerator over the previously available kerosene refrigerators of a similar size are:

- Low fuel consumption (Less than half a litre per day);
- Long "hold-over time" in case of flame failure (up to 12 hours);
- Top-opening cabinet of rust free plastic construction;
- Good internal temperature stability under varying ambient temperatures;
- Ability to operate with several fuel options;
- Rust-free plastic kerosene tank.

On the other hand this refrigerator also has some limitations:

- Limited icemaking ability (less than 250 grams at 43°C);
- Fragile lamp glass;
- Burner performance that varies greatly with kerosene quality and, even with acceptable quality fuel, flame adjustment is difficult;
- Higher capital cost per unit capacity than other models;
- Difficult regulation of internal temperature.

1.2 **Refrigerator/Freezer for District/Regional Use:** The second refrigerator also developed for the EPI, made by SIBIR, is described in detail in Annex 2.

Its advantages are, in summary:

- Automatically stabilized internal temperature;
- Long hold-over time (three times that of similar refrigerators);
- Large icemaking capability (up to 4.8 Kgs per day);
- Rust-free plastic kerosene tank;
- Lower capital cost than models previously available.

Its limitations are:

- It is not yet widely used and, as a result, spare parts may not be readily available in some countries;
- The refrigerator has to be moved when routine maintenance is performed (access is from the rear of the cabinet);
- Front opening cabinet.

These two refrigerators offer substantial benefits for vaccine storage in the range of up to 100 litres capacity compared with all models previously available.

2. IMPROVEMENT IN THE QUALITY OF SPARE PARTS.

2.1 Lamp glass

After some innovative work by M.S. Patternmaker of Dhacca, Bangladesh, the fragile lamp glass that was originally fitted to most kerosene refrigerators has largely disappeared. With the exception of the Electrolux RCW 42, all kerosene refrigerators are now fitted with lamp glasses that can safely be dropped from a height of about a metre. Some of these lamp "glasses" are actually made mainly of steel, and have only a small window of glass; others are made of thicker, heat-treated glass. Work is continuing to have the fragile lamp glass replaced on the Electrolux RCW 42, and to further improve the window in the metal lamp glasses by fitting a heat-proof glass window.

2.2 Kerosene Wicks

The Silver Trading Company, Osaka, Japan, have developed for EPI a series of wicks for kerosene refrigerators, made from fibreglass instead of the traditional cotton. These wicks are available in the four standard sizes commonly used in vaccine refrigerators, as follows:-

Burner type	Wick Number	Unit Wick Costs (US$)*	
		Fibreglass	Cotton
Kosmos 8"	SWM-001UF	0.47	0.67
Kosmos 10"	SWM-002UF	0.51	1.39
Aladdin 23E	SWI-231UF	1.03	2.96
Aladdin 32	SWI-141UF	0.94	1.45

* Prices based on manufacturer's quotation for f breglass wicks dated May 1985 and 1985 UNIPAC catalogue listing for cotton wicks.

Field and laboratory tests have been carried out on these new wicks and trials to establish their working life are continuing. Normal cotton wicks have a working life reported to range from 3 to 12 months, depending on the conditions of use. By comparison, the manufacturer of the fibreglass wicks claims a three year working life. At the time of writing (May 1986) the fibreglass wicks have been burning continuously for 16 months with no sign of any significant reduction in performance or length of the wick.

3. DEVELOPMENT OF TRAINING COURSES AND MATERIALS

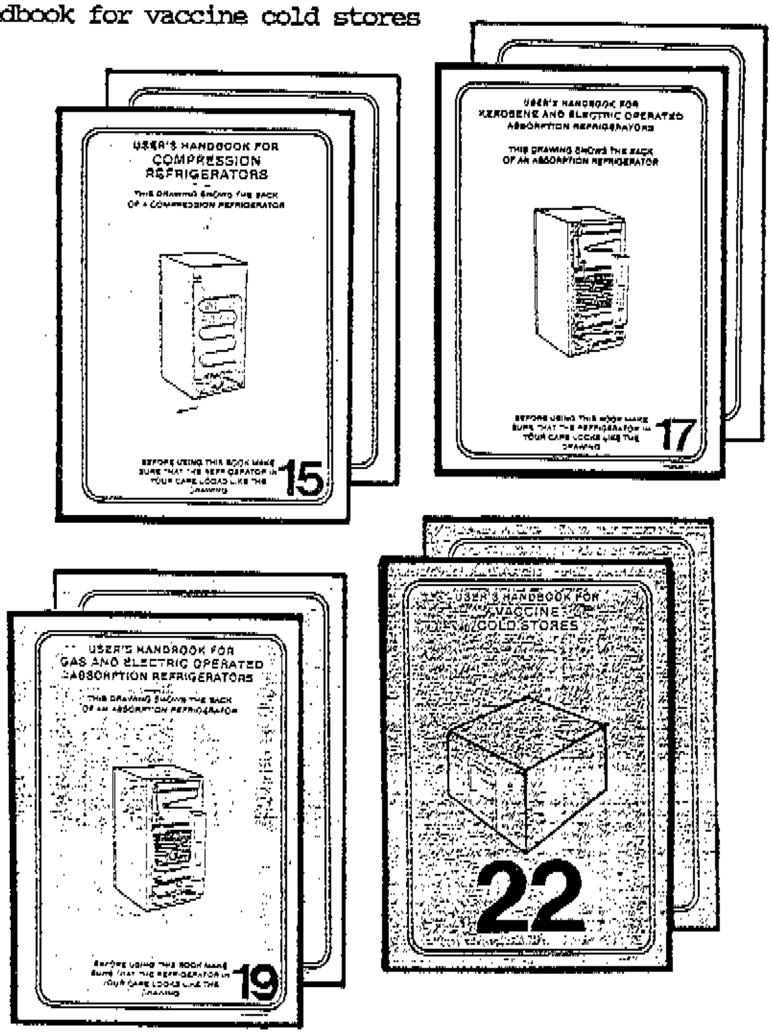
In addition to the general cold chain training materials available, specific materials have been developed which cover the principles of care and operation of all types of kerosene-operated refrigerators for vaccine storage. Unless otherwise indicated, the materials listed below are available free of charge for limited quantities from EPI, World Health Organization, Geneva or Regional Offices.

3.1 Refrigerator Use, Maintenance and Repair Booklets in a modular, 15 book series provide material for courses designed to improve the standards of refrigerator and cold room maintenance and repair. The series is grouped into two sub-sets:

(a) User and Maintenance Handbooks

Each of the following pairs of handbooks form a one-day course for people who use compression, kerosene or gas refrigerators, or cold rooms:-

Module Number[1]	Title
14	How to look after a compression refrigerator
15	Users' handbook for compression refrigerators
16	How to look after a kerosene refrigerator
17	Users' handbook for kerosene and electric refrigerators
18	How to look after a gas refrigerator
19	Users handbook for gas and electric refrigerators
21	How to look after a cold store
22	Users' handbook for vaccine cold stores

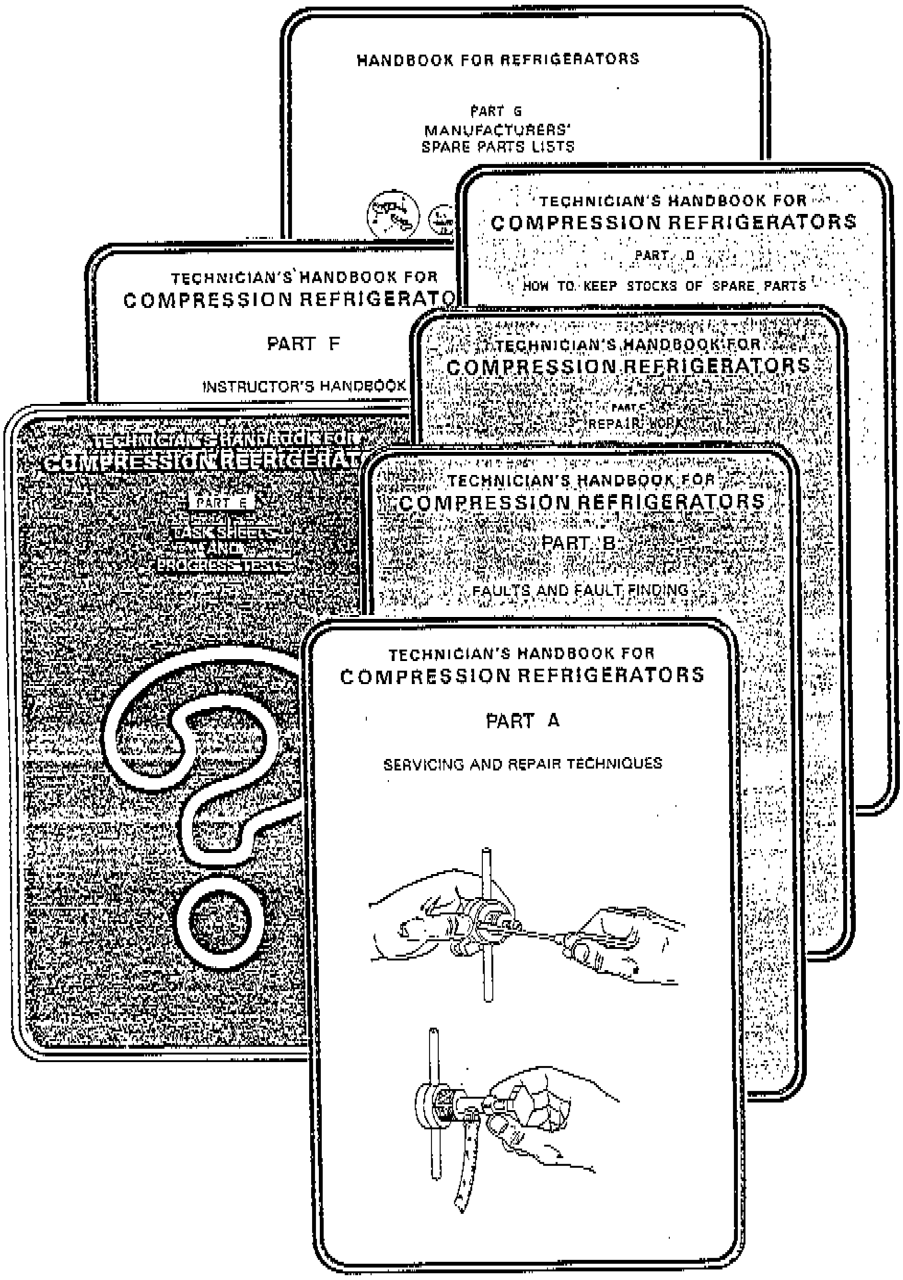


[1]These handbooks are also part of the Logistics and Cold Chain for Primary Health Care modules and the numbers below indicate where they fall within that series.

(b) Repair Technicians Handbooks

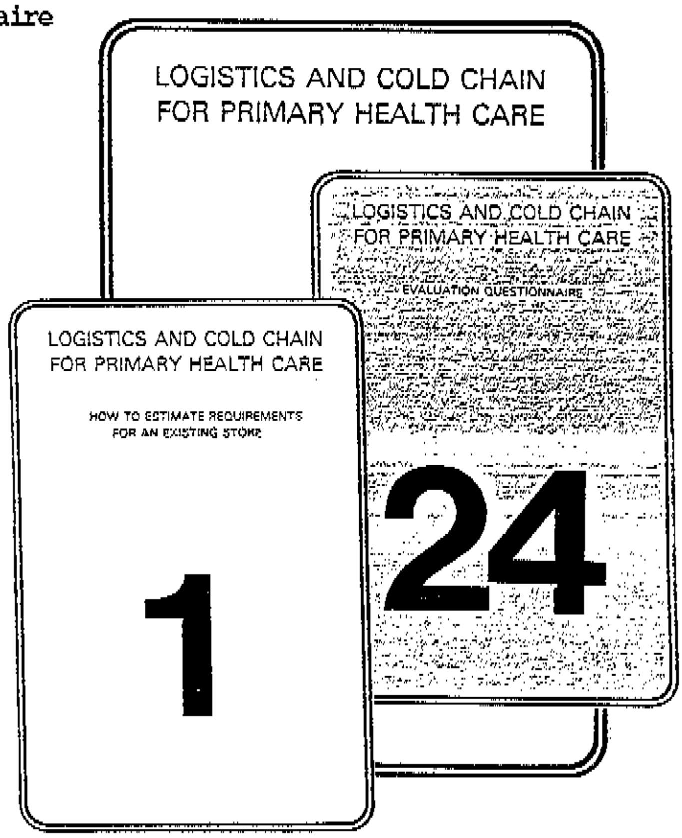
The following booklets are the basic materials for a 10-day course for refrigerator repair technicians:-

Module Number	Title
A	Servicing and repair techniques
B	Faults and fault-finding
C	Repair work
D	How to keep stocks of spare parts
E	Task sheets and progress tests
F	Instructors handbook
G	Manufacturers spare parts lists



3.2 Logistics and Cold Chain for Primary Health Care Booklets comprise a series of 24 handbooks which are designed to teach the skills needed to estimate the demand for supplies, to store and distribute the supplies properly, and to maintain the equipment required for storage. This series comprises the following titles (some of which also appear in the list in paragraph 3.1(a) above):

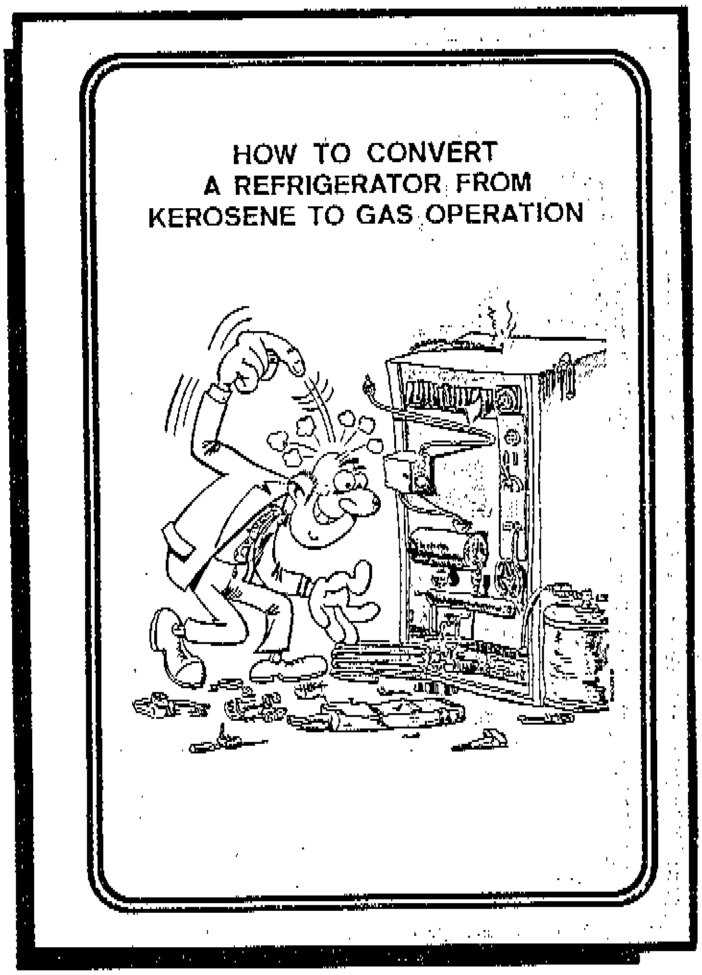
Module Number	Title
1.	How to estimate requirements for an existing store
2.	How to store supplies
3.	How to distribute supplies
4.	How to keep records and calculate wastage
5.	How to control quality of stocks
6.	How to estimate requirements for the first time
7.	How to estimate chloroquine requirements for the first time
8.	How to estimate ORS packet requirements for the first time
9.	How to estimate vaccine requirements for the first time
10.	How to estimate contraceptive requirements for the first time
11.	How to estimate essential drug requirements for the first time
12.	The cold chain game
13.	How to improve communication (& Annex)
14.	How to look after a compression refrigerator
15.	Users handbook for compression refrigerators
16.	How to look after a kerosene refrigerator
17.	Users handbook for kerosene and electric refrigerators
18.	How to look after a gas refrigerator
19.	Users handbook for gas and electric refrigerators
20.	How to keep stocks of spare parts
21.	How to look after a cold store
22.	Users handbook for vaccine cold stores
23.	Instructors guide
24.	Evaluation questionnaire



3.3 Conversion from Kerosene to Gas Operation is a booklet explaining the detailed steps necessary to convert an existing kerosene refrigerator to gas operation. The booklet deals specifically with two common refrigerator models:

Electrolux RAK 100, and
Sibir K230T

Generalized instructions are also included to enable conversion of any other kerosene refrigerator to gas operation. The spare parts needed for the conversion of the Sibir model K230T are available in kit form from the manufacturer, but for the Electrolux model RAK 100, individual items as detailed in the booklet, must be specified with any order. This booklet is available only in English.



3.4 Modules for the installation, maintenance and repair of solar refrigerators are currently being prepared. The maintenance and repair modules are expected to be ready by late 1986 and the installation module shortly thereafter.

3.5 Slide Sets showing how to care for and maintain kerosene equipment, how to handle and pack vaccines, and how to recognize the six EPI diseases. These sets comprise 48 slides, and are intended for use in instructing health staff at all levels in these important principles. The slides are available from Teaching Aids at Low Cost (TALC) UK, at a cost of 6.50 pounds sterling per set, inclusive of an explanatory text which may be used as the basis for a technical presentation.

3.6 A Fold-Out Wall Chart for kerosene refrigerators was developed, based on the points of care and maintenance explained in the slide set. This chart is intended for use at all locations where refrigerators are used, and is available from WHO/EPI in English, French or Portuguese language.

4. FUTURE DEVELOPMENTS

Although progress has been made in a number of areas, much work remains to be done. Some of the important issues which are currently receiving attention are the following:

4.1 Management of Fuel Supplies

One of the most critical problems which faces operators of kerosene powered refrigerators is the provision of regular and reliable supplies of high quality fuel. This problem is usually closely related to country economies and thus it may not be within the power of EPI programme managers, or even ministries of health, to ensure continuous and adequate supplies of kerosene.

There are, however, several strategies that have been employed with varying degrees of success to alleviate this problem.

(a) **External funding** of recurrent costs (such as kerosene, petrol or diesel fuel) is now recognized by some agencies as an essential component of programme assistance. This is sometimes only funded by the donor agency for a limited period and, thereafter, recurrent costs are expected to be covered by the national government. However, during periods of economic difficulty, special provisions for external funding of this vital programme element may have to be considered.

(b) **Revolving funds** to cover fuel costs are being considered (notably by Mozambique), and this system also offers possibilities for other countries. Typically, a fund of foreign currency is established to buy high grade fuel on the international market and this fuel is then available for purchase by the country using local currency. The agency that established the fund then uses the local currency to fund other projects in that country. In this way the country can be assured of a continuous supply of high grade fuel and the donor can be assured that they are not spending their money on recurrent costs.

(c) **Sub-Contracting** the supply of fuel to the private sector (as used for gas supplies in Zimbabwe) relieves the programme of the problems involved with managing the fuel supply. However, the question of adequate finance and fuel stocks remain unchanged.

(d) **Special Storage Tanks** are used in Tanzania to provide large stocks of kerosene exclusively for EPI use. This system may be applied on a national, regional, district or health centre basis, as appropriate. Such buffer stocks help to avoid short term fluctuations in supply. However, national stocks and the programme fueul budget still determine programme viability.

(e) **Deliveries of kerosene in sealed drums** together with vaccines and other supplies is another method of ensuring regular stocks of fuel. This system helps to avoid the difficulties of contaminated fuel found in many countries. This system is currently being used in Fiji.

While these various strategies have been helpful in ensuring regular fuel supplies, there is, as yet, no method of guaranteeing availability. Further attention to this critical problem is needed.

4.2 Fuel Quality

Contamination of fuel supplies takes two main forms:
(i) impurities (dirt, water etc.) that have been mixed with the kerosene, and
(ii) non-kerosene components that remain in the fuel after the refining process. This results in a low-grade product.

The first problem may be solved by attention to the handling of the fuel (as with the sealed drum system mentioned above), but the second problem causes kerosene to burn with a smokey flame when the wick is turned up. The more impurities in the fuel, the more easily the flame will smoke, and the harder it becomes to adjust the refrigerator to the required storage temperature.

Chemical additives have been tried which reduce the amount of smoke produced when the fuel is burned. However, the tests conducted have not proved successful, and further investigation of this possibility is needed.

4.3 Fuel Burners

Another approach to the problems caused by low-grade fuel is to try to design a refrigerator and burner which can tolerate low grade fuels. One manufacturer has produced a design for a low-grade kerosene burner but, so far, this is not available in a size small enough to be used in vaccine refrigerators. Further development of this idea is clearly needed.

Other attempts have been made to avoid the use of kerosene entirely by trying to design a diesel fuel burner for refrigerator use, but to date this has not proved successful either, and this is an area where additional study and development are needed.

ANNEX 1

HEALTH CENTRE REFRIGERATOR
ELECTROLUX RCW42[2]

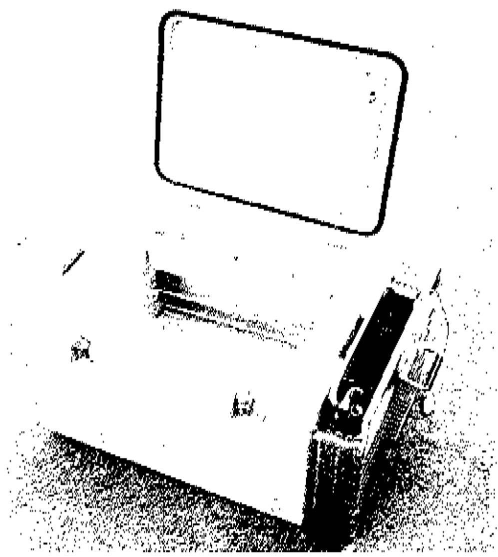
The RCW42 refrigerator was developed by Electrolux* on the basis of a WHO/EPI specification for storing vaccine in health centres. The appliance consists of a cold box known as an RCW25 which has been fitted with a cooling unit. One RCW42 refrigerator is sufficient to store vaccine in a health centre covering an area with a population of 100,000 on the basis of a one month vaccine supply interval. The RCW42 refrigerators are available in 5 models:

a) Absorption types:

1. EK (Electric 220/110V, 12V DC and Kerosene)
2. EG (Electric 220/110V, 12V DC and Gas)
3. EKG (Electric 220V/110V, 12V DC, 24V DC, Kerosene and Gas)

b) Compression types:

1. AC (110/220V)
2. DC (12/24V)



RCW 42 EG

The objective of the present paper is to summarise the results of the field and laboratory trials carried out on the EK and EG models of the RCW42 refrigerators.

a. Field Trial
b. Laboratory Tests
   1. Maintenance of safe temperature for vaccine.
   2. Ability to maintain an acceptable internal temperature with partial and with no electrical supply.
   3. Ability to freeze ice.
   4. Hold over time.
   5. The effect of day/night temperature.
   6. Energy consumption.
   7. Unit price of RCW 42 models.
   8. Shortcomings of RCW 42, EG and EK models.
c. Summary

* Development costs were borne by the Government of Luxemburg and 359 units were donated for the purpose of these field trials.

[2] This annex also exists separately as document EPI/CCIS/83.10.

a. Field Trial

During 1982 and 1983 field trials were carried out on a total of 359 RCW42, EK and EG models in 77 developing countries within 5 WHO regions.

The users of RCW42 refrigerators in EPIs in different countries submitted a number of temperature record forms, together with their comments regarding the performance and the condition of the units in field trials. The forms constitute a daily record of internal refrigerator and external temperatures. So far, reports have been received from 15 countries and are summarised in Figure 1.

Figure 1. Summary of field trial for EK and EG models

Region	Number of countries participating in trial	Number of units tested	Number of countries from which report received	Refrigerators running days on E	G	K	?	Total number of running days
Africa	42	100	7	344	-	57	373	744
Americas	17	70	4	356	-	-	156	512
Eastern Mediterranean	5	50	2	137	177	30	-	344
South East Asia	9	70	2	83	-	-	-	83
Western Pacific	4	69	-	-	-	-	-	-
Total: 5	77	359	15	845	177	87	529	1713

EG models 76 units
EK models 283 units
Total units of RCW42: 359

The collected data from the field trial have been examined quantitatively and qualitatively. The total running time for EK and EG models together in this trial was 1713 days (see Figure 1).

b. Laboratory tests

The standard EPI protocol for testing refrigerators in laboratories has been applied to the RCW42 models. The summary of the tests has been shown in Figure 2.

Figure 2. Summary of the laboratory tests on RCW42 models

Models	Tested on E (220V)	Tested on K or G
EK	UV CA	UV CA*
EG	SP	SP CA
EKG	CA**	-

* only ice freezing capacity and operation on polluted kerosene
** tested with 2 absorption units operating simultaneously
UV: Univalle Laboratories, Cali, Colombia
CA: Consumers' Association, Harpenden, U.K.
SP: Staten Provningsanstalt, Sweden

1. Maintenance of safe temperature for vaccine storage

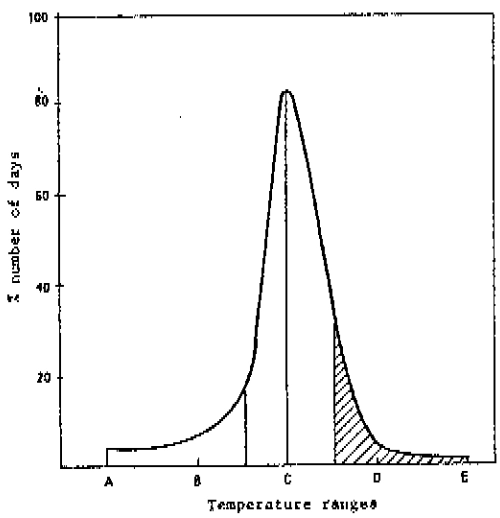
Figure 3 and Figure 4 show the percentage of time that various internal temperature ranges were maintained. Since the field trials were carried out in 77 countries, the inference can be made that the appliances were exposed to a wide spectrum of climatic conditions. The mean ambient temperature was approximately 29°C with a range between 9 and 42°C.

Figure 3. Internal temperature distribution based on field trials

Temperature Range	Internal temperature °C	Number of days	Percentage of total
A	-20 to -5	81	5
B	-4 to 0	113	7
C	1 to 8	1439	83
D	9 to 20	72	4
E	21 to 43	8	1
Total		1713	100%

It can be seen that 83% of internal temperature records fall into the acceptable temperature range for vaccine storage.

Figure 4. Internal temperature distribution based on field trials



The 17% internal temperature records which do not fall within the acceptable temperature range may be caused by the following:

a) 5% of temperature records which fall between 9 to 43°C (the shaded area on the right side of the curve, Fig. 4) are accounted for by long periods of power cuts (more than 13 hours in 24 hours) and lack of kerosene or gas.

b) 12% of temperature records which fall between -20 to 0°C (the left side of the curve, Fig 4.) are due to wrong adjustment of the flame length when EK models were on kerosene operation. There have been reports of difficulties in adjusting the flame length and consequently in stabilizing the internal temperature in EK models. However, this is mainly attributed to the poor quality of kerosene in many developing countries.

Results of the laboratory tests show that the acceptable internal temperature for vaccine storage can be maintained in both EK and EG models under 32 and 43°C external temperatures. One laboratory test shows that when an EG model is operated on an electrical supply, in 32 and 43°C external temperature, an acceptable internal temperature is obtained without changing the thermostat setting (thermostat on 5). This might be because of the well sealed lid and effective insulation of the box.

The results of laboratory tests for the EK model when operated on kerosene are comparable to the results of the field trial and confirm the difficulties in adjusting the flame to stabilise the internal temperatures. A test has been conducted in the laboratory on the EK model operating with polluted kerosene at 32°C external temperature. The result indicates that routine maintenance (cleaning the burner and trimming the wick) approximately every 3 days should be carried out to maintain a stable internal temperature. The same test concludes that, in higher external temperatures, when a higher flame is required the burner should be examined more frequently.

The RCW42, EK and EG models, are capable of bringing the internal temperature to 10°C with external conditions of 32°C in approximately 3.5 hours (based on laboratory tests).

2. Ability to maintain an acceptable internal temperature with partial and with no electrical supply

EK and EG models can both be run on electricity and each with kerosene and bottled gas respectively so they are suitable for areas with limited or no electrical supply.

In the range of small and low vaccine storage capacity refrigerators, RCW42 models are the only appliances which can be operated on electricity and one other fuel source.

3. Ability to freeze ice

The present evaporator of the RCW42 is not designed specifically to freeze ice packs. The freezing capacity of the units have been laboratory tested by using ice trays. Figure 5 shows the summary of the results.

Figure 5. Ice freezing capacity of RCW42 models in kg in 24 hours

Models	External temperature °C	
	at 32	at 43
EK	1.1	Not tested
EG	1.35	0.5
EKG*	2.40	1.5
AC	2.40	Not tested

*Two absorption units operating simultaneously

The laboratory tests on RCW42 models indicate that when an acceptable internal temperature is obtained, the temperature difference between the coldest and the warmest points within the internal space of the refrigerator is very small as shown in Figure 6.

Figure 6. The temperature difference (in °C) between the warmest and the coldest points within the internal space

Models	External Temperature; °C		Mean internal temperature °C
	32	43	
EK	Not available	1.2	6.5
EG	1.5	1.2	4.25

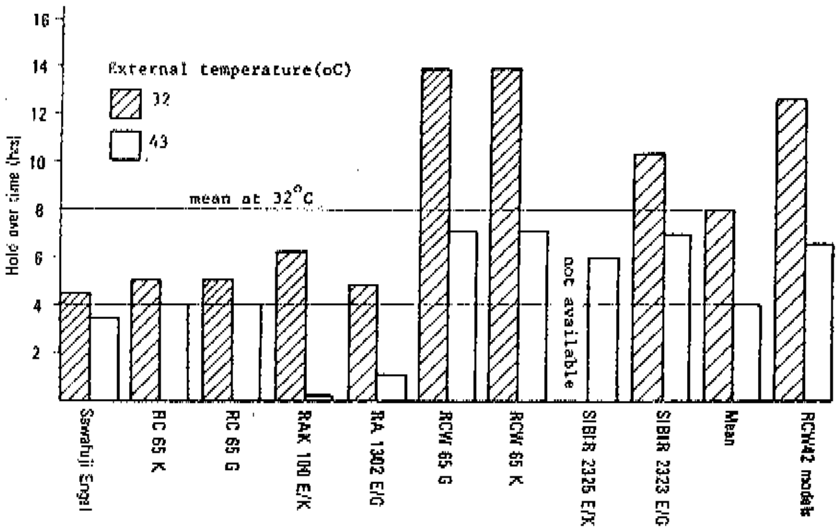
This in turn, shows that the thermostat should be accurately set to freeze ice in an optimum period of time without exposing the vaccine to a freezing temperature.

New evaporators have been developed to enable the RCW42 models to freeze 4 standard ice packs (1.3 lit.) in 24 hours at 32°C ambient temperature. The RCW42 refrigerators produced from 1984 onwards will all be equipped with these new evaporators. Conversion kits will be offered to enable the users to change the evaporators of currently existing units so that they can freeze ice packs.

4. Holdover time

Figure 7 compares the holdover time of several different refrigerators.

Figure 7. Holdover time in hours

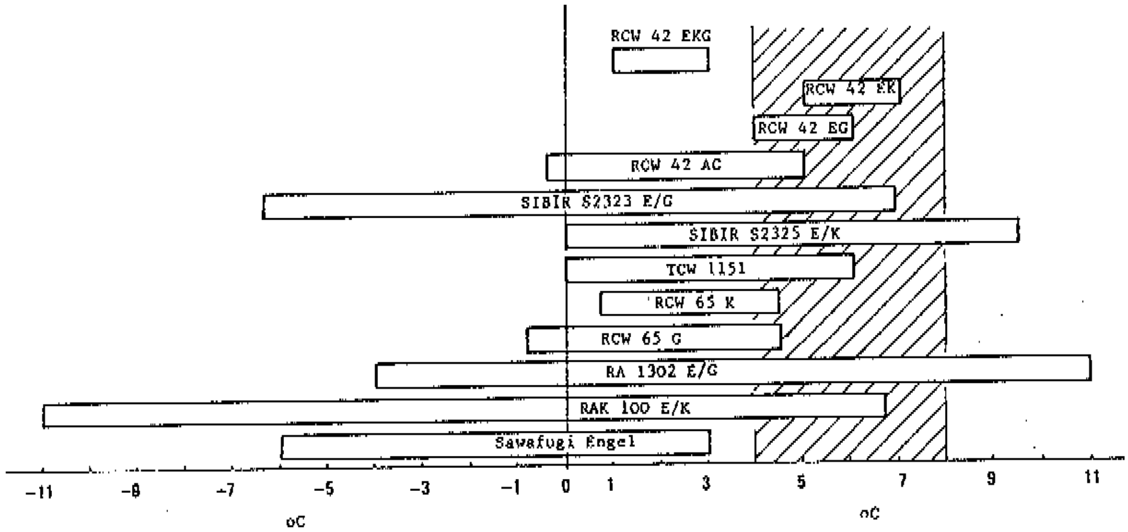


It can be seen that the holdover time for RCW42 (12.5 hours and 6.5 hours at 32 and 43°C external temperatures respectively) is comparable with that of other refrigerators in spite of the RCW42 low internal capacity.

5. The effect of day/night temperatures

Laboratory tests indicate that the acceptable internal temperatures for vaccine storage in all RCW42 models are exceptionally well maintained when subjected to varying external conditions, such as would occur when exposed to outside day and night temperatures in a desert area. Figure 8 shows the effect of such condition on different refrigerators.

Figure 8. Min./Max. internal temperature for day time 43°C night time 15°C



However, the laboratory test indicates that, when the EK model is operating on kerosene, the internal temperature is not as stable as it is with electricity. The flame height needs to be readjusted for day and night time temperatures.

6. Energy consumption

Figure 9 shows the energy consumption for RCW42 models based on laboratory tests.

Figure 9. Energy Consumption

Model	Source of Energy	External Temperature °C		Unit
		32	43	
EK	E K	2.2 0.3	2.2 0.4	Kwh/24 hrs lit./24 hrs
EG	E G	- 0.13	- 0.2	- Kg/24 hrs
EKG*	E K G	2.4 - -	3.1 - -	Kwh/24 hrs - -

*when two cooling units operating simultaneously.

Figure 10 shows the comparison of energy consumption between RCW42 models and other similar refrigerators. The last column on the table shows the fuel consumption per 10 litres of net vaccine storage in 24 hours at 43°C external temperature. It can be seen that both EK and EG models have a lower fuel consumption than other absorption refrigerators.

Figure 10. Comparison of energy consumption

Refrigerators	Net vaccine storage capacity lit.	Power option	Consumption in 24 hrs at 32°C	43°C	Consumption per 10 lits of net vaccine storage in 24 hrs at 43°C
RAK 100	70	E/K	0.8 lit.	1.0 lit.	0.143
SIBIR 2325	60	E/K	0.9 lit.	1.0 lit.	0.166
RCW 65 K	142	K	1.81 lit.	2.5 lit.	0.176
RCW 42 EK	24	E/K	-	0.3 lit.	0.125
RA 1302	70	E/G	-	-	-
SIBIR 2323	60	E/G	0.45 kg.	0.6 kg.	0.1
RC 65	142	G	0.9 kg.	1.5 kg.	0.105
RCW 42 EG	24	E/G	0.13 kg.	0.2 kg.	0.08

The kerosene consumption per 10 litres of net vaccines storage for EK models is 22% lower than average consumption of the other 3 kerosene refrigerators. Similarly, the gas consumption per 10 litres of net vaccine storage for EG models is 24% lower than the average gas consumption of the other 2 gas refrigerators.

7. Unit price of RCW 42 models

Figure 11 shows the unit price for different absorption refrigerators with 2 power source options. The unit price per net vaccine storage (UP/NVS) is shown on the last column. It can be seen that UP/NVS of the other refrigerators are all lower than those for RCW 42 models. The UP/NVS are 2.36 and 2.00 times larger than the average UP/NVS of the other refrigerators respectively for EK and EG models. However, for health centres covering an area with a population of 100,000 (on the basis of a one month vaccine supply interval), where one unit of RCW 42 is sufficient, the low running cost of the appliance will compensate the high UP/NVS in the long run.

Figure 11. Unit price (prices are for May 1983)

Absorption refrigerators	NVS lit.	Ice making capacity kg/day at 32°C	at 43°C	Power Option	Price per unit (US$)	Capital Cost per net vaccine storage capacity
EL RAK 100	70	1.9	1.4	E/K	602	8.6
SIBIR 2325	60	2.9	3.4	E/K	580	9.6
RA 1302	70	3.0	1.4	E/G	589	8.4
SIBIR 2323	60	2.7	2.7	E/G	390	6.5
Mean					540.25	8.275
RCW 42 EK	24	1.1	-	E/K	470	19.58
RCW 42 EG	24	1.35	0.5	E/G	398	16.58
RCW 42 EKG	21			E/K/G	597	28.43

For EK: 19.58 : 8.275 = 2.37
For EG: 16.58 : 8.275 = 2.00

8. Shortcomings of the RCW 42, EG and EK models (based on field and laboratory tests)

a) General in 2 models

- The present form of the evaporator is not capable of freezing ice packs efficiently.

- The thermostat display is not easily understood in a number of developing countries. Sometimes the divisional numbers on the thermostat scale are taken for internal temperatures.

- No baskets have been provided with the appliances. Therefore, some of the vaccine load must be removed to enable the ice trays to be loaded and unloaded.

b) For EK model

- The performance of the burner varies greatly with the quality of kerosene used.

- Even with a relatively acceptable quality of kerosene, flame adjustment is not easy.

- The rate at which the glass chimneys break is high. The number of spare glass chimneys that are supplied with the units is not sufficient.

c. Summary

Based on the results of the field and laboratory trials the performance of the RCW 42, EK and EG models, is acceptable for storing vaccine. They are unique in the range of low vaccine storage capacity refrigerators in that they offer two power source options on one unit.

The units are suitable for areas with limited and/or no electricity. Due to their low energy consumption, EK and EG models are recommended for outlying health centres where fuel is supplied at regular intervals.

The units have the ability to keep a safe temperature in areas where day and night temperature differences are very high.

The EK and EG models are highly economic to run.

ANNEX 2
COMPARISON BETWEEN SIBIR AND ELECTROLUX GAS OR KEROSENE REFRIGERATORS[3]

During the past 2-3 years there have been important developments in the design of front-opening kerosene and gas operated refrigerators for the vaccine cold chain.

For many years, one manufacturer - Electrolux AB of Sweden - has dominated the supply of vaccine refrigerators for vaccine storage. Recently, another manufacturer - SIBIR Kühlapparate of Switzerland - has been working with WHO/Geneva to produce specially modified kerosene and gas refrigerators for vaccine storage. Sibir has produced four models that compete directly with two equivalent Electrolux models.

The purpose of this paper is to compare these six front-opening refrigerators and to clarify their strengths and weaknesses to help the purchaser in making a choice.

On the surface, these six refrigerators have several features in common (see photographs reproduced overleaf):

- they are all approximately the same size;
- they are all front opening;
- they all have two doors - one for freezer compartment;
  - one for the refrigerator compartment.

The table on page 2 summarizes the differences.

CONCLUSIONS

<u>Kerosene operated refrigerators:</u>

The choice between these three refrigerators depends on the price, the fuel options needed, the icemaking capability and the need for an automatic temperature controller. This device - which has been especially designed for EPI - controls the internal temperature when there are wide fluctuations in outside temperatures. This controller also gives the refrigerator a longer "holdover time" in case of flame failure (6 hours).

Where cost is important:	Select SIBIR model S 2325 PV1 at US$ 458.
Where a dual fuel option is needed:	Select SIBIR model S 2325 PV1 with electric heater option at US$ 31.00. Total cost: US$ 489.
Where better temperature control is needed:	Select SIBIR model S 2325 PEV 1ST at US$ 585.
Where icemaking is important:	Select Electrolux model RAK 1302 at US$ 641.

<u>Gas operated refrigerators:</u>

The choice between these three models depends on the price and the quantity of ice needed.

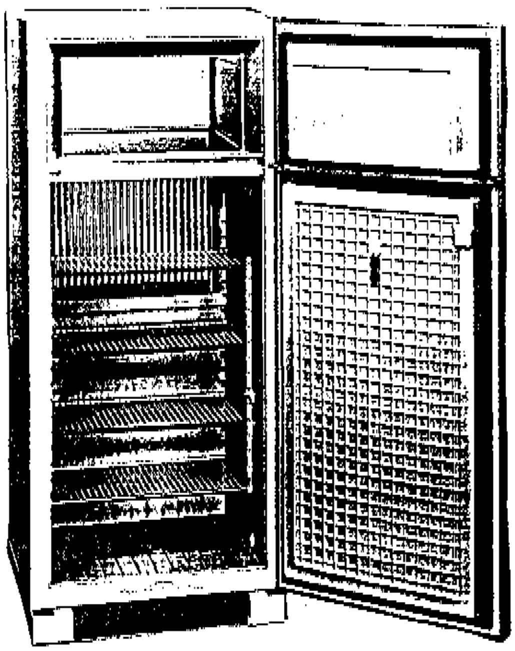
Where cost is important:	Select SIBIR model S 2323 2WV1 at US$ 456.
Where icemaking capacity is important:	Select SIBIR model S 2723-2WV1 that makes 6.3 kgs of ice in 24 hours and costs US$ 510.

[3]This annex also exists separately as document EPI/CCIS/85.3/Rev.1.

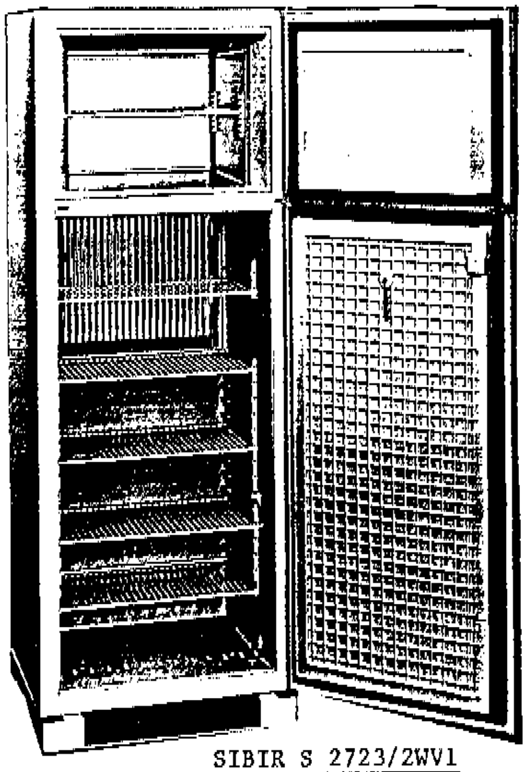
	Kerosene Refrigerators			Gas Refrigerators		
	ELECTROLUX RAK 1302	SIBIR S2325/PV1	SIBIR S2325/PEV 1ST	ELECTROLUX RA 1302	SIBIR S2323/2WV1	SIBIR S2723/2WV1
Freezer capacity	44 litres	30 litres	30 litres	44 litres	30 litres	52 litres
Vaccine volume/litres	70 litres	68 litres	68 litres	70 litres	68 litres	80 litres
Icemaking at 32°ambient	1.5 kg	4.8 kg ★	4.8 kg ★	3.0 kg	2.7 kg	6.3 kg ★
Holdover time at 43°ambient	3.5 hours	1.5 hours	6 hours ★	1 hour	3.5 hours	4.3 hours ★
Min./max. temp. at 32°ambient	0.4 to 7.5°C	0.4 to 5.3°C ★	0 to 6°C	-1.8 to 5.1°C	0.4 to 3.0°C ★	1.7 to 8.0°C
Fuel consumption at 32°C ambient	1.32 litres	0.7 litre ★	0.7 litre ★	0.63 kg*	0.45 kg ★	0.5 kg ★
Rust free kerosene tank	No	Yes ★	Yes ★	Not applicable	Not applicable	Not applicable
Strong burner glass	Yes ★	No	No	Not applicable	Not applicable	Not applicable
External thermometre	No	Yes ★	Yes ★	No	Yes ★	Yes ★
Level indicator	No	Yes ★	Yes ★	No	Yes ★	Yes ★
Removable door seal	No	Yes ★	Yes ★	No	Yes ★	Yes ★
External Fuel Indicator	No	Yes ★	Yes ★	No	No	No
Temperature stabilizer	No	No	Yes ★	No	No	No
Specially modified door	No	Yes ★	Yes ★	No	Yes ★	Yes ★
Dual fuel system	Yes ★	No**	Yes ★	Yes ★	Yes ★	Yes ★
Price per unit in US$	641	458 ★	585 ★	548	456 ★	510 ★

★ Indicates the "best buy" for each of the different items listed.

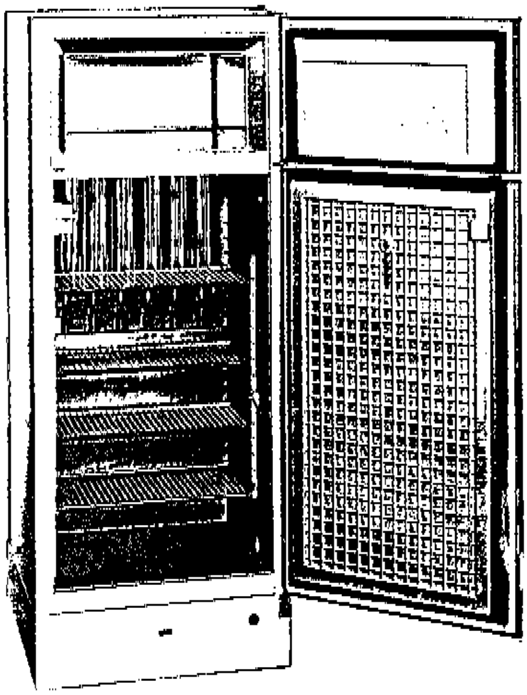
* Measured at 25°C ambient temperature.
** Electric conversion kit available at US$ 31.00.



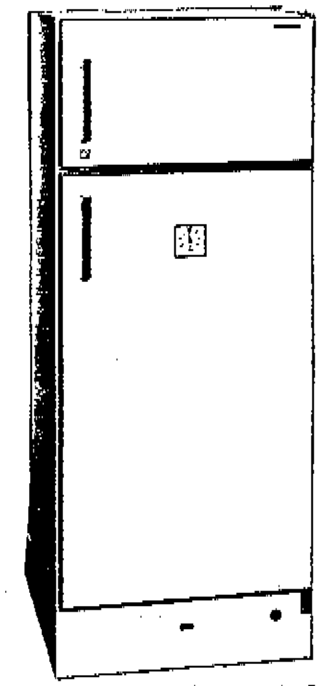
SIBIR S 2323/2WV1



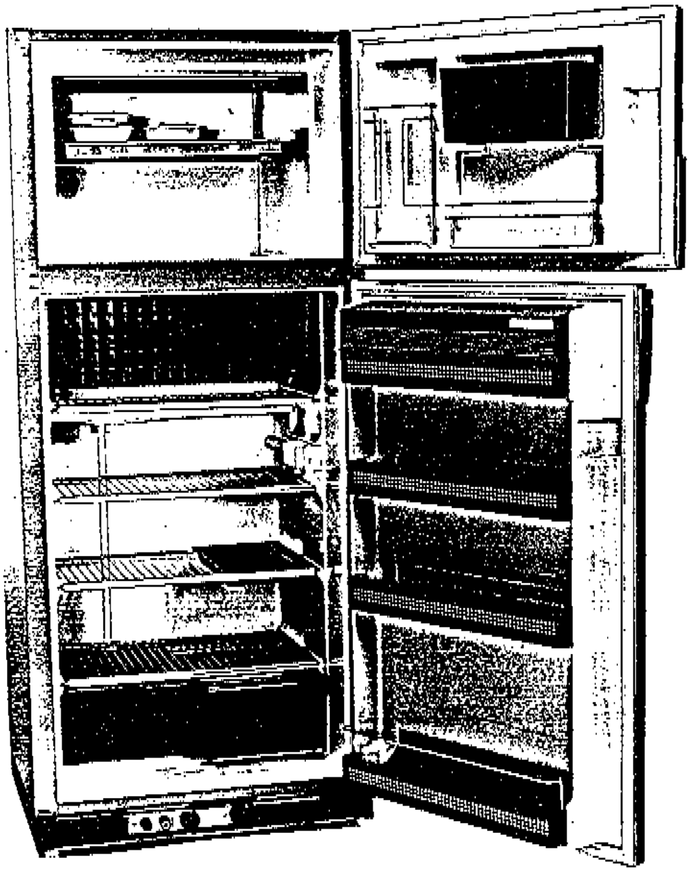
SIBIR S 2723/2WV1



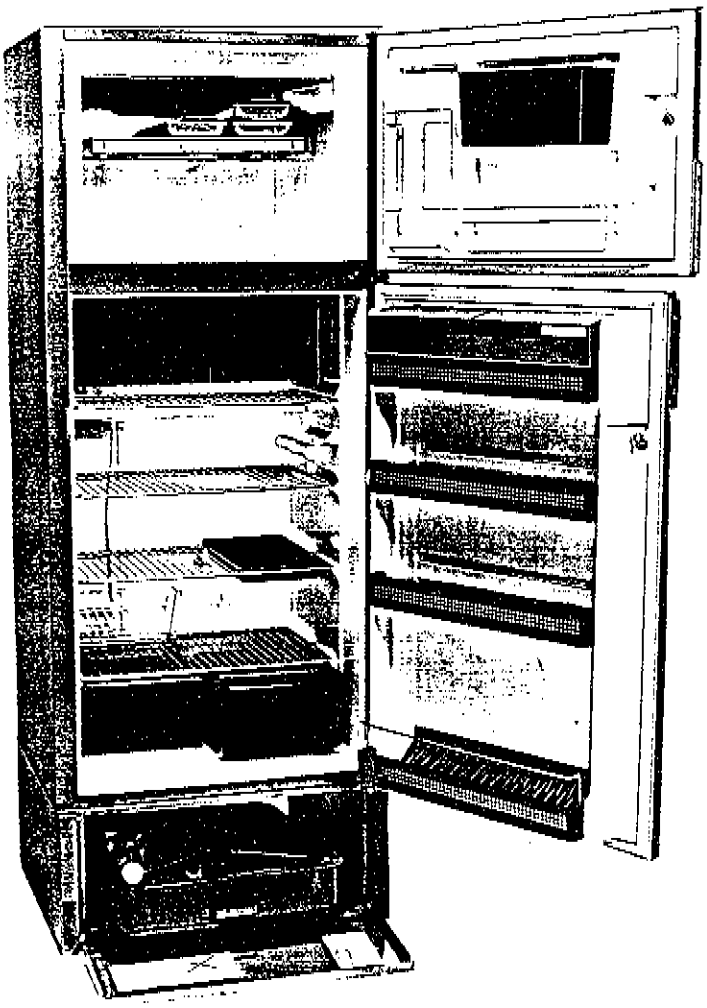
SIBIR S 2323/PEV1ST



SIBIR S 2325/PV1



ELECTROLUX RA 1302



ELECTROLUX RAK 1302

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