OPERATING INSTRUCTIONS FOR SORB-AC® CARTRIDGE PUMPS

Revised March 1986
FM/AP/ps

1. INTRODUCTION

SORB-AC® Pumps are a new type of vacuum pump that sorb active gases by a non-evaporable getter material.
The available getter material are: St101® zirconium-aluminium alloy or St707 zirconium-vanadium-iron alloy (*). These getter alloys are incorporated in an interchangeable cartridge which provides the sorption surface.

The pumping process, different from the one used in sublimation pumps, does not involve the deposition of a film of gettering material.

In a non-evaporable getter, the active gases are sorbed on the surface of each particle of getter material. This surface becomes contamined progressively, but can be cleaned by diffusing the impurities into the bulk of the metal or alloy.
In practice, for the St101 alloy when heated at 700°C this diffusion process is sufficient to clean the surface in a few minutes.
At 400°C the diffusion speed is considerably reduced but is still epough to maintain an adequate pumping speed at pressures of the order of 10^{-6} torr.
When the St707 version is used, the above mentioned working temperatures could be reduced respectively to 400°C and 280°C.

The cartridge as received is passivated by a surface layer of absorbed gases and does not become active until it has been "activated" for a few minutes at 750°C for St101, at 450°C for St707 and under vacuum (see par. 6).

2. DESCRIPTION

A typical SORB-AC Cartridge pump is shown schematically in Fig. 1.

(*) St101: Zr 84% - Al 16%
St707: Zr 70% - V 24,6% - Fe 5,4%

2.1 GP-W series

The essential components of an "enclosed" pump are:

- the cartridge C containing the getter material
- the heater assembly H which includes the cartridge positioning and securing components
- the heater supporting flange F with the electrical feedthroughs to the heater (*)
- the removable flanged water jacket W.

Note: water cooling is not necessary for the pump to function efficiently. Its main function is to cool the pump casing to prevent excessive heating and degassing of the neighbouring elements of the vacuum system.
It also keeps the pump casing at a safe temperature during operation.

2.2 GP series

A "nude" pump is identical to the corresponding GP-W but without the flanged water jacket. These pumps should only be used in a clean, throughly degassed, UHV type system. Their pumping speed is no longer limited by the conductance of the pump casing. The total capacity however is not effected.

3. UNPACKING

The pump is contained in two packs: one for the pump body and the second for the corresponding SORB-AC cartridge sealed unde dry N2.

(*) The flange may be supplied with two extra feedthroughs with thermo-couple connection for temperature monitoring.

The pack which contains the pump may be opened immediately on arrival. It also contains copper gaskets for flange connections (one or two respectively for a nude or an enclosed pump).

Caution:

1) Do not open the cartridge pack, until final assembly.
   The getter material may be harmed by a long exposure to air, specially if stored for several days in a humid atmosphere.

2) All parts exposed to the "vacuum" atmosphere must be handled with lint-free gloves to minimize degassing.

Note: GP 500 4 FS are shipped with the cartridge already installed. The pump is contained in a tin sealed under dry N2, the tin is enclosed in a woodden box.

4. INSTALLATION

As for all UHV type equipment, clean lint-free gloves should be used for handling the parts of the pump exposed to vacuum. All operations should be conducted on a clean dust-free bench. All tools used for the assembly should be cleaned before use.

A) Ensure that the plastic protective cover is over the electrical feedthroughs.

B) (GP W only)disassemble the heater flange from the water jacket.

Caution:

The copper gasket already in this flange assembly has been used as a spacer for transport. As the flange assembly has not been tightened the gasket should be used for the final assembly.

C) Stand the pump vertically on the plastic protective cover with the heater to the top.

NOW REFER TO FIG. 2.

D) Remove the two 3 MA nuts and bolts (1) and take off the two halves of the split clamp (2)

E) Lift off the four bakeable spring washers (3)

F) GP 50 (W) and GP 100 (W) only. Lift off the ceramic insulating spacer (4)

G) Lift off the cartridge centering cap (5)

H) Open cartridge pack and place the cartridge over the heater, taking care not to damage the heater assembly and ensuring that the base of the cartridge goes over the lower centering ring (see N.3 in Fig. 3).

I) Replace the centering cap (5).

Caution

Ensure that the cap centres in the cartridge and that the side cut-out (6) clears the welded filament lead (7) to avoid earthing the filament.

J) GP 50 (W) and GP 100 (W)
Replace the ceramic spacer (4) ensuring that the narrow part is in the centering cap.

K) Replace the spring washers (3) with their cavities alternating (see cross-section inserted in Fig. 2).

L) Replace the split clamp (2) with its two 3 MA nuts and bolts (1), ensuring that it located on the relieved part (8) of the centre post.

Note: The spring washers should only be slightly pressed. If this requires excessive vertical pressure, one or more spring washers should be removed to achieve correct pressure. Any spare washers should be kept for possible future use.

M) Check that the cartridge is properly seated.

N) Check, with an ohmmeter, at the feedthroughs, that the heater shows continuity and is isolated from the flange.

Note: Flanges should be assembled according to normal UHV techniques taking into account that the heater flange specially may reach a high temperature during activation.

O) GP W only. Reassemble the heater flange to the water jacket, using one of the gaskets supplied.

Caution

The water cooled envelope W 50 of the GP 50 W is not symetrical (see Fig. 6). Care must be taken to reassemble the pump with the shorter neck next to the heater flange.

P) GP W only. Assemble the free flange of the water jacket to the vacuum system using the other gasket supplied.

Q) GP only. Assemble the heater flange to the vacuum system using the gasket supplied.

R) Connect the power supply to the electrical feedthroughs. For safety the pump should be earthed, an earthing tag (E in Fig. 1) is provided on the flange.

5. EXTERNAL SUPPLIES

5.1 Power Supply

A simple ac or dc power supply is all that is necessary. Two current levels are the minimum requirements, one for activation and one for operation. Power requirements are listed in par. 6 and 7).

A variable transformer connected through an ammeter to the pump heater has the advantage of allowing any intermediate current setting. An SCR power supply provides similar advantages. The pump is unaffected by mains failure so no automatic cut-out is needed.

Note: See caution in par. 6.A.

Further information on power supplies is available from your pump supplier.

5.2 Water cooling for GP-W series

For all pumps fitted with a water jacket, the minimum cooling water flow is 0.5l/min. The water should not be connected (e.g. after baking) until the pump body has cooled to below 100°C.

6. ACTIVATION

Every new cartridge must be submitted to an activation procedure.

A - Rough pump to 10^{-3} torr or better.

Caution

The maximum tolerable pressure at the pump, when the heater is energised, is 10^{-2} torr as higher pressures of active gases may corrode the heater wire. Pressures above 10^{-3} torr may allow r.f. discharges to develop, triggered by any r.f. components in the supply (e.g. from SCR power units).

B - Energise the pump heater according to the following table:

PUMP	ACTIVATION CURRENT		APPROX VOLTS		ACT. TIME	
	St 101	St 707	St 101	St 707	St 101	St 707
GP 50 (W)	4.5	2.6	50	18	15 MINUTES	45 MINUTES
GP 100 (W)	5.5	3.0	75	32		
GP 200 (W)	4.7	2.6	200	77		
GP 500 (W)	18	9.3	110	43		

Note: 1. To avoid excessive heater currents during activation, the current delivered by the power supply should never exceed the values shown above.

2. During activation the pressure usually rises, mainly due to hydrogen evolution from the zirconium alloy. This hydrogen is resorbed on cooling.

It is therefore preferable to keep the pressure in the $10^{-4} \div 10^{-5}$ torr range or better during activation; when necessary, activation may be also effected from 10^{-3} torr. A full explanation of hydrogen evolution is given in par. 11.

7. OPERATION

When activated, the SORB-AC Cartridge Pump can be operated at various temperatures according to the load of active gases.

After the activation step, reduce power to reach the required operating temperature. The operating pressure must be less than 10^{-3} torr.
For each particular requirement the best operating temperature is the following:

- Active gases, such as CO, CO2, O2, N2 to be pumped with a total pressure less than 10^{-5} torr
- Active gases to be pumped in the range 10^{-5} - 10^{-3} torr
- Hydrogen, when a high pumping speed is required and a residual background of active gas impurities (for example 1%) is present in the system
- Pure hydrogen when a high pumping speed and also a high capacity is required
- Pure hydrogen when the main requirement is a high capacity or a power supply for cartridge heating is not available

St 101	St 707
400°C	280°C
700°C	400°C
400°C	280°C
200°C	200°C
Room temperature	

The electrical characteristics for the various models at 200°C, 280°C and 400°C are listed below:

MODEL	APPROXIMATE CARTRIDGE TEMPERATURE		
	400°C	280°C	200°C
GP 50 (W)	2.2A (~16 V)	1.5A (~11V)	1.2 (~8.5V)
GP 100 (W)	2.6A (~26 V)	1.9A (~17V)	1.5 (~11.5V)
GP 200 (W)	2.2A (~65 V)	1.5A (~35V)	1.1 (~25 V)
GP 500 (W)	8.0A (~37 V)	5.2A (~21V)	3.5 (~16 V)

Note: A) During baking cycles the operating temperature of the cartridge may be maintained by the oven itself if it reaches a suitable temperature. No power supply connections are needed during such a bake.

B) Ensure that pump has cooled down before opening up to atmosphere.

8. REACTIVATION

When the cartridge is exposed to air or its surface becomes saturated and the pumping speed has decreased excessively with respect to its efficiency in the system, a further activation is required.
The reactivation may be shorter if the getter has not been exposed to air.

These activation and reactivation processes remove from the getter material surface any reaction products formed by exposure to atmosphere or by previous sorption. Gases sorbed on the getter surface are diffused into the bulk of the getter and, with the exception of hydrogen, are not released.

When the pumping speed no longer recovers sufficiently after reactivation, the cartridge must be changed as below (par. 9).

9. MAINTENANCE

9.1 Change of cartridge

A) Disconnect the power supply leads from the pump.

B) Let the system up to atmospheric pressure.

Note: As for all UHV systems, it is always recommended to use dry nitrogen for back-filling.

C) Fit the white plastic protective cover over the electrical feedthroughs.

D) Disassemble the heater flange from the vacuum system. It may be necessary after several baking cycles to use the tapped holes of the heater flange: insert screws and turn them slowly until flanges separate.

Caution

Withdraw the "nude" pump carefully and straight from the flange, holding it by the outside of the heater flange. Wait for pump internal assembly to cool before continuing.

E) Stand the pump vertically on the plastic protective cover with the heater to the top.

NOW REFER TO FIG. 2

F) Remove the two 3 MA nuts and bolts (1) and take off the two halves of the split clamp (2).

Note: if the 3 MA nuts and bolts have seized they may be sheared or cut. Replacement nuts and bolts must be of stainless steel.

G) Lift off the spring washers (3)

H) (GP 50 (W) and GP 100 (W) only). Lift off the ceramic insulation spacer (4).

I) Lift off the cartridge centering cap (5).

J) Lift off the saturated cartridge, taking care not to damage the heater assembly. Discard cartridge.

K) Examine heater wire; if it shows signs of damage or appreciable corrosion, the heater assembly should be changed as in par. 9.2

L) Open new cartridge pack and place the cartridge over the heater taking care not to damage heater assembly and ensuring that the base of the cartridge goes over the lower centering ring (see n°3 in Fig. 3).

Note: The change of cartridge in a GP 500 4 FS pump requires the following steps in addition to those described for 2 F pumps.

I1) Disconnect the thermocouple from the feedthroughs

J1) Lift off the thermocouple from the saturated cartridge

L1) Before placing the cartridge over the heater the following operation must be done

L2) Insert the thermocouple into the cartridge

L3) Connect the thermocouple to the feedthroughs

M) Replace the centering cap (5).

Caution

Ensure that the side cut-out (6) clears the welded filament lead (7) to avoid earthing the filament.

N) (GP 50 (W) and GP (W) only). Replace the ceramic spacer (4), ensuring that the narrow part is in the centering cap.

O) Replace the spring washers (3) with their cavities alternating (see cross section insert in Fig. 2).

Caution

Check that the spring washers are not flattened or damaged. For replacement use the following washers:

50 CV 4 UNI Ø 12 x 4.2 x0.5 for GP 50 (W) GP 100 (W) and GP 200 (W)

50 CV 4 UNI Ø 12.5 x 6.2 x 0.5 for GP 500 (W)

P) Replace the split clamp (2) with its two 3 MA nuts and bolts (1) ensuring that it locates on the relieved part (8) of the centre post.

Note: adjust the number of washers to achieve a light pressure over the cartridge assembly.

Q) Check that the cartridge is properly seated.

R) Check with an ohmmeter at the feedthroughs that the heater shows continuity and is isolated from the flange.

S) Reassemble the heater flange to the vacuum system, changing the copper gasket.

T) Reconnect the earth and power supply leads.

U) Activate the new cartridge as in par. 6 (activation).

9.2 Change of heater assembly

Heater assemblies (see Fig. 2 and 3) are available as spare parts from S.A.E.S. Getters S.p.A. through your pump supplier.

The base of heater assembly with the cartridge removed is shown in Fig.3. When the cartridge has been removed as in par. 9.1 above continue as follows:

a) Loosen the two 2MA screws (1) which clamp the heater terminals to the feedthroughs.

b) Remove the hexagonal-slotted screws (2).

Note: The GP 50 (W) and the GP 100 (W) have two 4 MA screws, the GP 200 (W) has four 4 MA screws and the GP 500 (W) four 5 MA screws.
All screws are stainless steel and have an axial bore to allow pumping of the blind hole.

c) Lift off the heater assembly taking care not to damage the feedthroughs.

d) Position the new heater assembly.

e) Replace the hexagonal-slotted screws (2).

f) Tighten the two 2 MA screws (1).

g) Replace the cartridge as in par. 9.1 above.

10. PUMPING SPEED AND CAPACITY

Speed and capacities for the most important gases are shown in the table of Fig. 4. and 4bis. Speeds for the enclosed pump are limited by the conductance of the waterjacket and flange and are therefore given at the mouth of the pump at 3.10^{-6} torr.

Pumping speeds for CO2 and oxygen are of the same order as those for CO. All speeds given are for pure gases, but mixtures of gases are pumped at speeds of the same order.
Hydrocarbons are pumped at about one hundredth of the speed for CO when the pump is operated at 400°C.
This does not enable the pump to act as a contamination trap in an oily system but the pump will not contaminate a clean system and is suitable for UHV applications. On the other hand, its function is not impaired by the presence of large amounts of oil or mercury vapours; it is therefore suitable for use in conjunction with trapped or untrapped diffusion pumps.

11. REVERSIBLE PUMPING OF HYDROGEN

Hydrogen does not form a stable combination with the getter alloy and consequently it diffuses much more rapidly into the bulk of each particle of active material. A given concentration of hydrogen inside the getter alloy corresponds to an equilibrium pressure for hydrogen which is strongly dependant on temperature. This equilibrium pressure for a given concentration can vary between 10^{-11} torr or below at °C to over 10^{-2} torr at °C. This makes it possible to use the getter material as a heat-controlled reversible pump which can pump hydrogen at low pressures and releases it at high pressure.

Figure 5 shows equilibrium partial pressures versus sorbed quantities at various pressures.
For practical purposes a SORB-AC getter pump can be cyclically saturated and regenerated in the range of 200°C and 700°C.

During sorption the H2 equilibrium pressure continuosly rises until the maximum pressure in the system (normally in the range of 10^{-5} - 10^{-6} torr) is reached.
If a maximum pressure is not a limitation, then sorption of H2 can be continued until just before embrittlement of the getter material starts to take place.

During the subsequent regeneration, the cartridge should be heated to a temperature slightly below the "Activation temperature" while pumping the hydrogen out of the system. The quantity of hydrogen removed depends on the temperature of the cartridge and the ultimate vacuum of the system. For example, a trapped two-stage rotary pump used during normal activation will remove from 80 to 90% of the maximum sorbed quantity as defined above.

To use the pump at UHV pressures the hydrogen equilibrium pressure can be easily decreased by lowering the temperature of the cartridge.

The importance of hydrogen as a contaminant determines the value that has to be adopted for the saturation pressure and is obviously arbitrary as it depends on the nature of the processes taking place in the vacuum system.

The frequency of reactivations depends therefore on:

- the maximum equilibrium pressure which can be tolerated
- the temperature of the getter
- the gas load between two reactivations

12. WATER VAPOUR

When the pump is operated at a high temperature (400°C for St101 version, 280°C for St707 version) a good sorption activity with H_2O is also possible.

Water vapour is pumped as hydrogen and oxygen and its pumping speed is limited by the rate of dissociation of H2O molecules. The pumping capacity is equal to the capacity for hydrogen under the prevailing conditions (see hydrogen above). If the released hydrogen is pumped away at each reactivation however, the total capacity is only limited by the total capacity for oxygen allowing as many as 20 or 30 pumping cycles.

13. INERT GASES

No inert gases are pumped and the pump can be used to pump active gases in a rare gas atmosphere.

14. LEAK DETETION

When an air leak is present in the vacuum system it shows as a steady increase in the partial pressure of argon due to the high pumping speed for active gases. Leak detection cannot be carried out with hydrogen.

15. SPECIAL APPLICATIONS

For further information on special application of SORB-AC pumps please contact your pump supplier.

16. DIMENSIONS

Detailed drawings of each of the four GP-W series pumps are to be found in Fig. 6, 7, 8 and 9.

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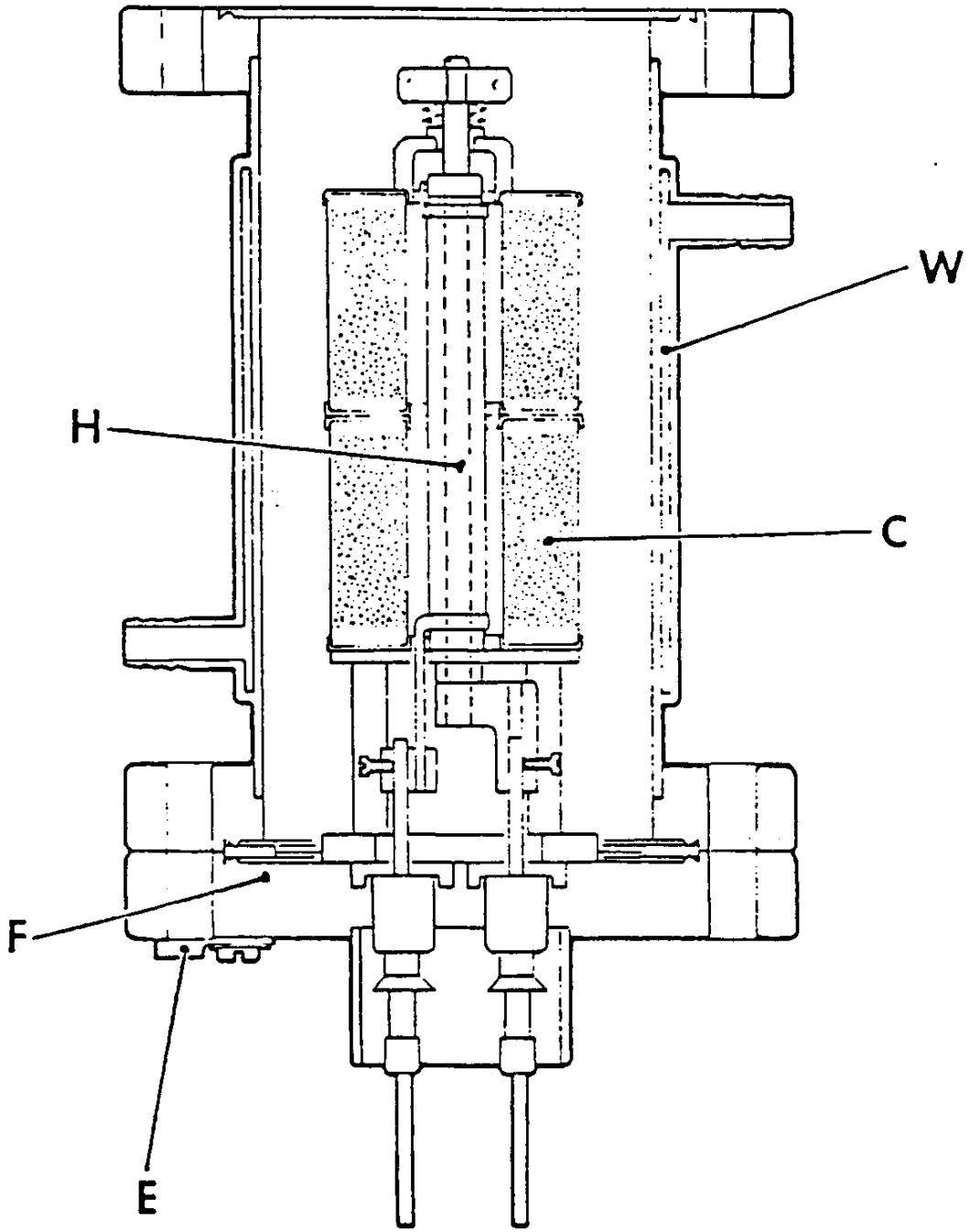
SAES GETTERS

TYPICAL SORB-AC CARTRIDGE PUMP

Fig. 1



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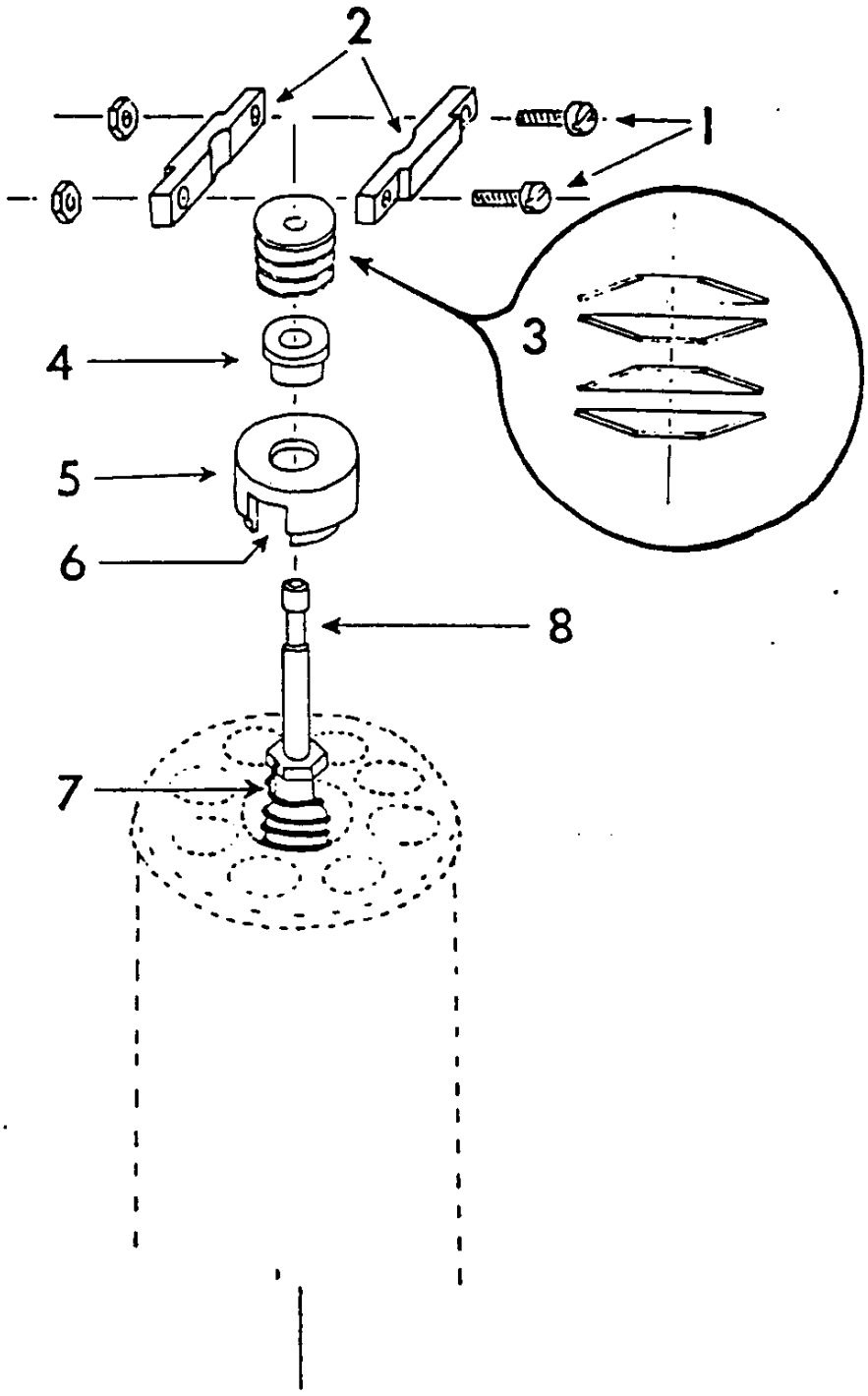
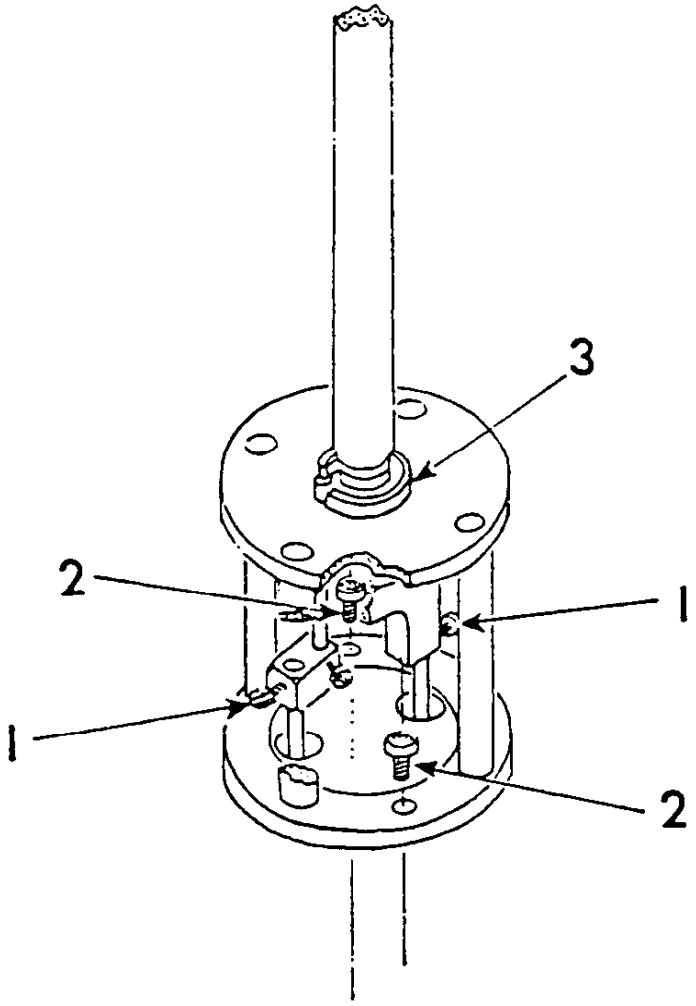
SAES GETTERS	GETTER CARTRIDGE RETAINING COMPONENTS	Fig.2



AUTHOR	Gerber	Date Sept. 14, 1987	Sheet

SAES GETTERS	SOLID-AC CARTRIDGE PUMP HEATER ASSEMBLY	Fig. 3



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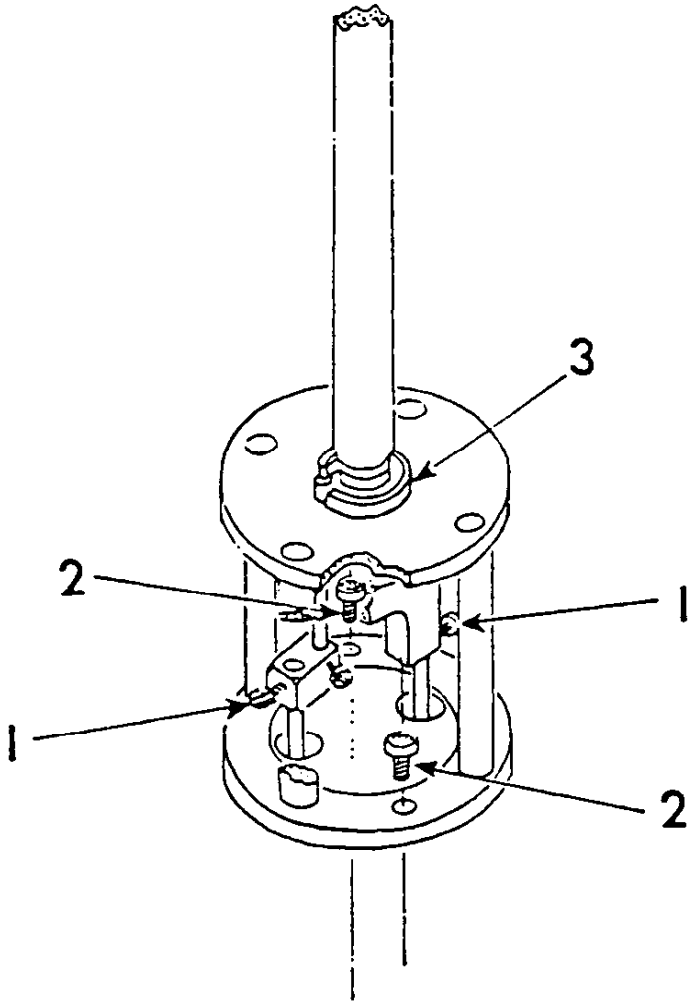
SAES GETTERS	[illegible]	Fig. 3



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SORB-AC Cartridge performances St 101 Version

Cartridge		C 50			C 100			C 200			C 500		
Active gases		CO		N_2	CO		N_2	CO		N_2	CO		N_2
Pumping (*) speed (litres/sec)	Nude	100		35	300		110	350		160	750		320
	Enclosed	50		25	100		50	200		120	500		250
Sorption (*) capacity (litres Torr)	For the first activation	15		15	55		55	100		100	280		280
	Total pratical	50		50	165		165	300		300	840		840
Hydrogen		25°C	200°C	400°C	25°C	200°C	400°C	25°C	200°C	400°C	25°C	200°C	400°C
Pumping speed (litres/sec)	Nude	130	200	200	450	650	650	620	850	850	1500	2000	2000
	Enclosed	(100)	100	100	(280)	280	280	(470)	470	470	(1400)	1400	1400
Reversible sorption capacity (litres Torr)	$3x10^{-6}$ torr equil. press.	–	–	45	–	–	135	–	–	230	–	–	670
	$1x10^{-4}$ torr equil. press.	–	–	250	–	–	780	–	–	1350	–	–	4000
Maximum reversible sorption capacity (before danger of embrittlement of the coated getter material begins) (litres Torr)		500		–	1550		–	2700		–	8000		–

(*) At the standard operation condition of 400 °C in presence of a pressure less than 3×10^{-5} torr.

Fig. 4

SORB-AC Cartridge performances St 707 Version

Cartridge		C 50			C 100			C 200			C 500		
Active gases		CO		N_2	CO		N_2	CO		N_2	CO		N_2
Pumping (*) speed (litre/sec)	Nude	50		20	150		55	180		80	370		160
	Enclosed	20		15	75		35	130		60	300		130
Sorption (*) capacity (litre Torr)	For the first activation	15		15	65		65	110		110	330		330
	Total pratical	270		270	900		900	1500		1500	4500		4500
Hydrogen		25°C	200°C	280°C	25°C	200°C	280°C	25°C	200°C	280°C	25°C	200°C	280°C
Pumping speed (litre/sec)	Nude	70	100	100	220	330	330	310	430	430	850	1000	1000
	Enclosed	(50)	50	50	(200)	200	200	(300)	300	300	(800)	800	800
Reversible sorption capacity (litre Torr)	$3x10^{-6}$ torr equil. press.	—	—	70	—	—	230	—	—	400	—	—	1150
	$1x10^{-4}$ torr equil. press.	—	—	400	—	—	1350	—	—	2300	—	—	6700
Maximum reversible sorption capacity (before danger of embrittlement of the coated getter material begins) (litre Torr)		600		—	2000		—	3400		—	10000		—

(*) At the standard operation condition of 280°C in presence of a pressure less than 3×10^{-6} torr.

Fig. 4 bis

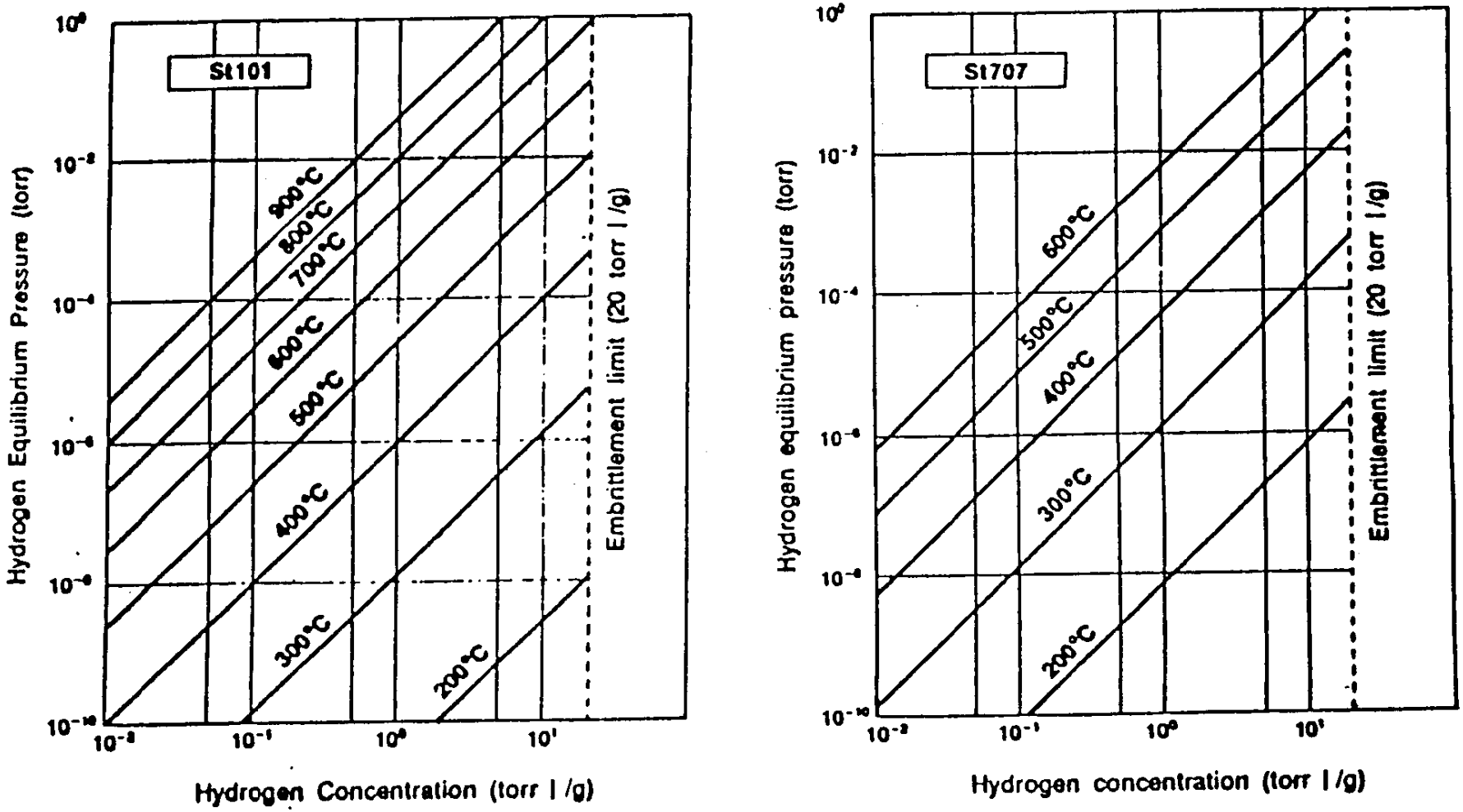
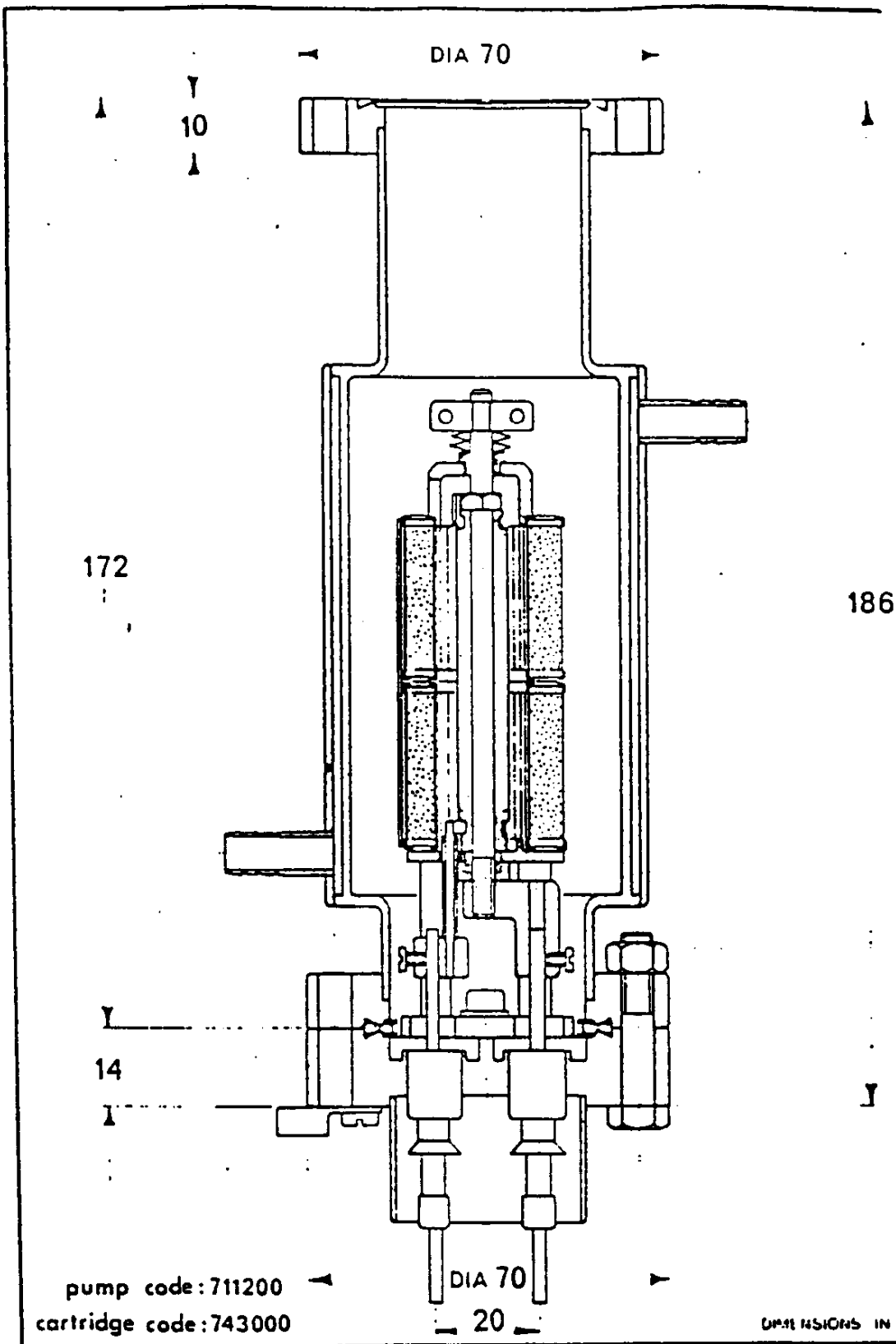


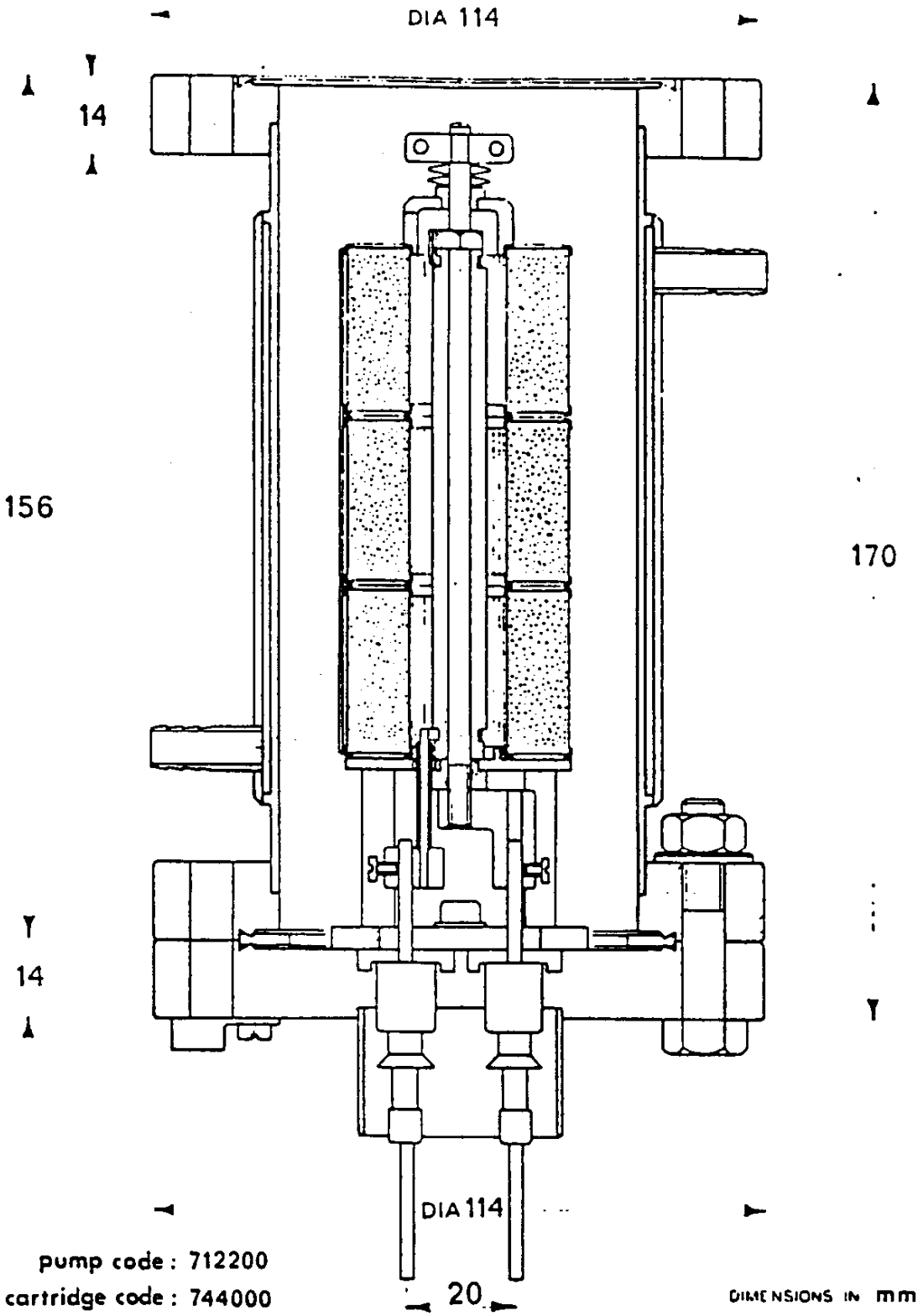
Fig. 5 - Hydrogen Equilibrium Curves
on St 101 and St 707 alloys



pump code: 711200
cartridge code: 743000

DIMENSIONS IN mm

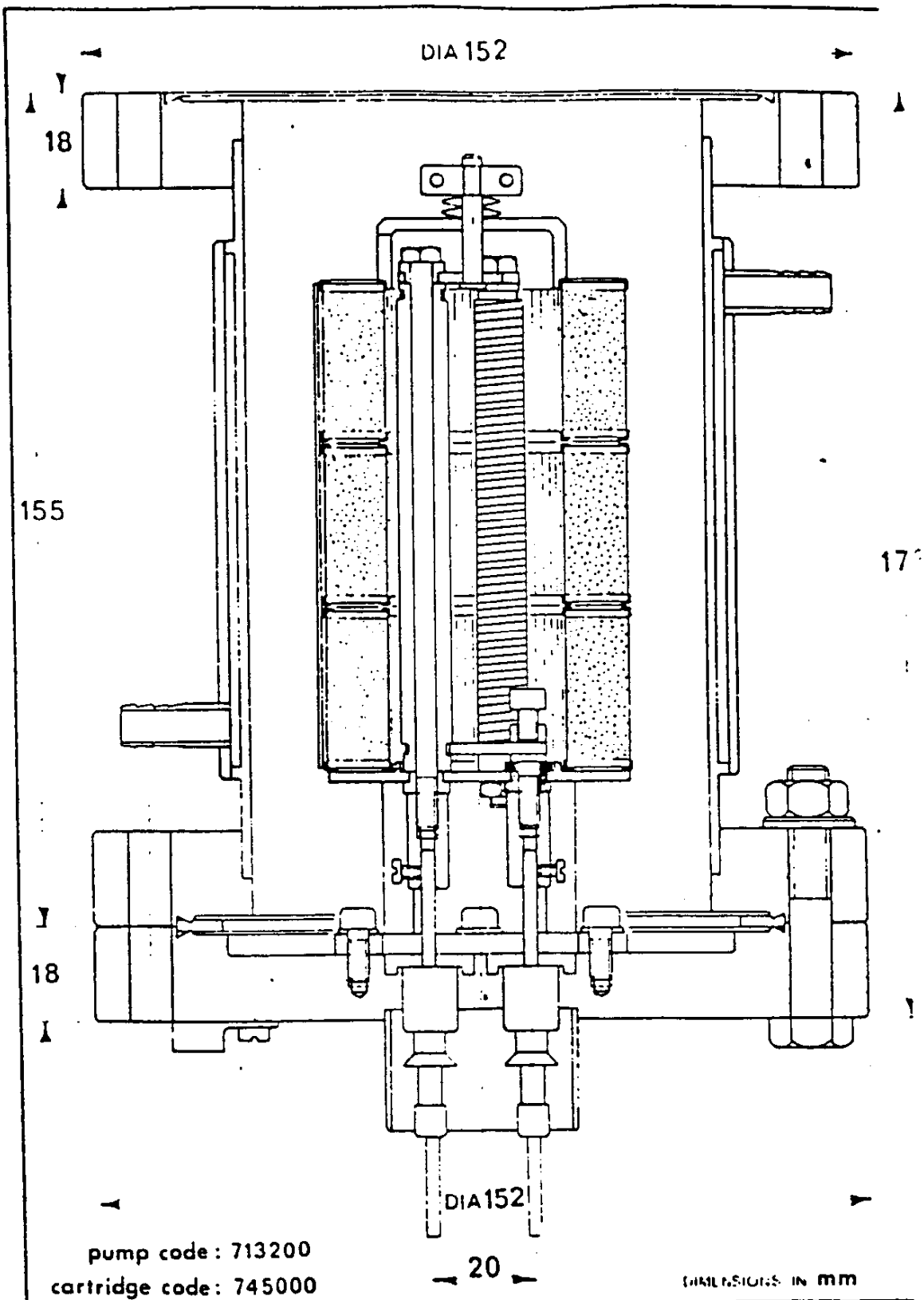
SAES GETTERS	SORB-AC cartridge pump TYPE GP 50 W	Fig. 6
		851.014



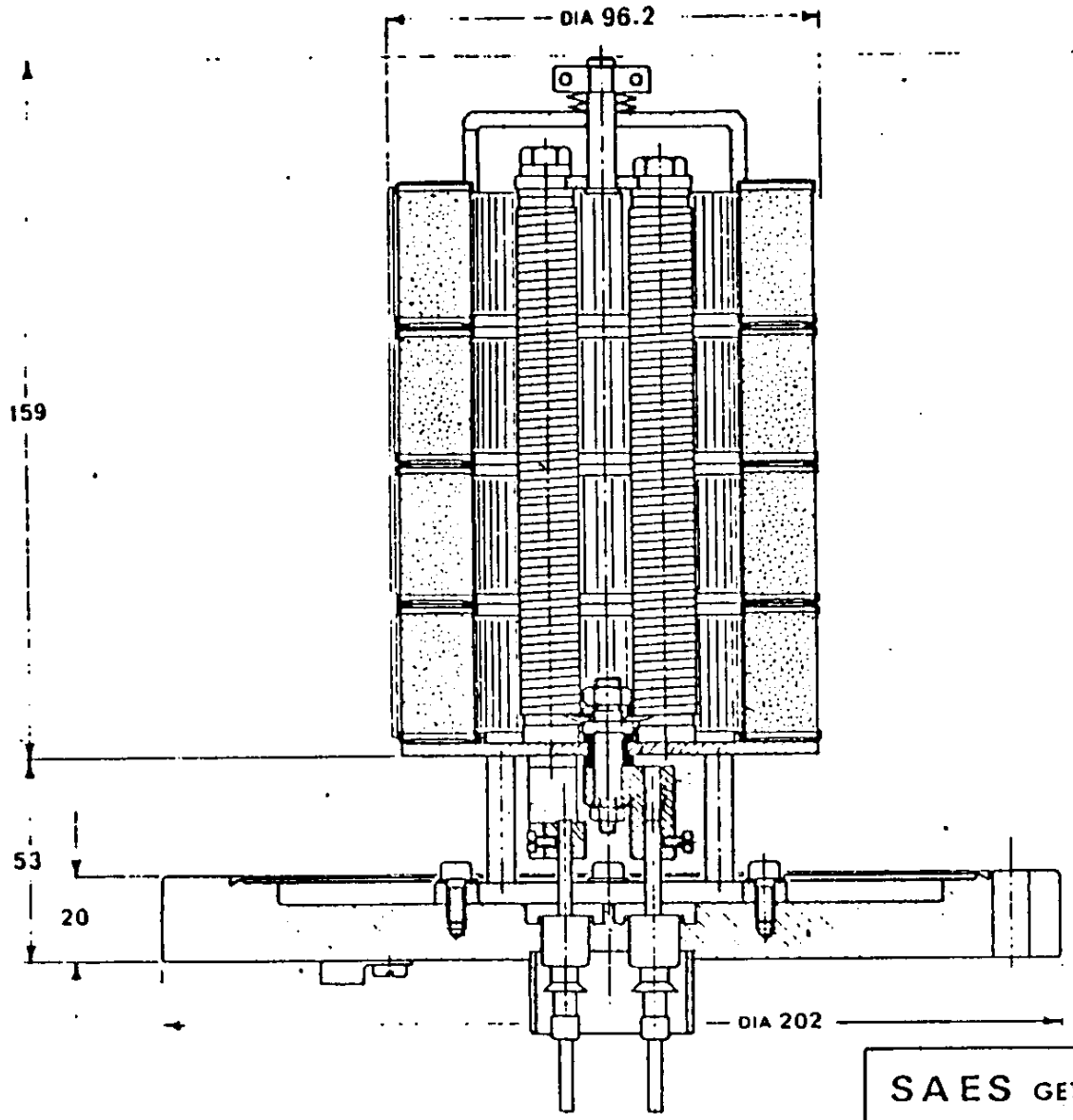
pump code : 712200
cartridge code : 744000

DIMENSIONS IN mm

SAES GETTERS	SORB-AC cartridge pump TYPE GP 100 W	Fig. 7 861.014

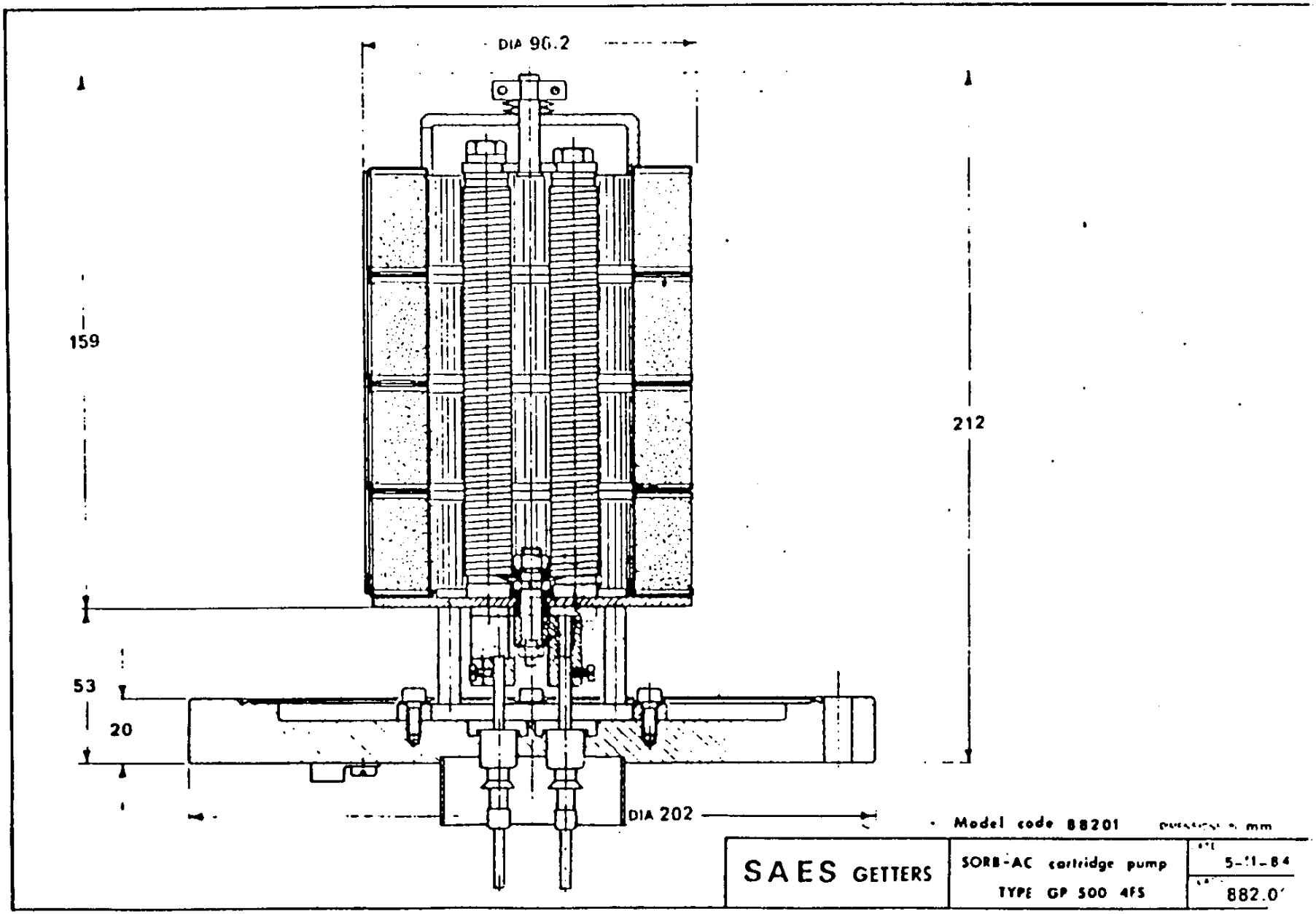


SAES GETTERS	SORB-AC cartridge pump TYPE GP 200 W	Fig. 8 871.017



Model code 88001 mm

SAES GETTERS	SORB-AC cartridge pump TYPE GP 500 2F	18 - 1 - 1971 880.005



Model code 88201

SAES GETTERS	SORB-AC cartridge pump TYPE GP 500 4FS	5-11-84 882.0