OPERATION MANUAL CS – 2000
from serial number 1501xxxxxx

1 INSTALLATION

1.1 Setting up

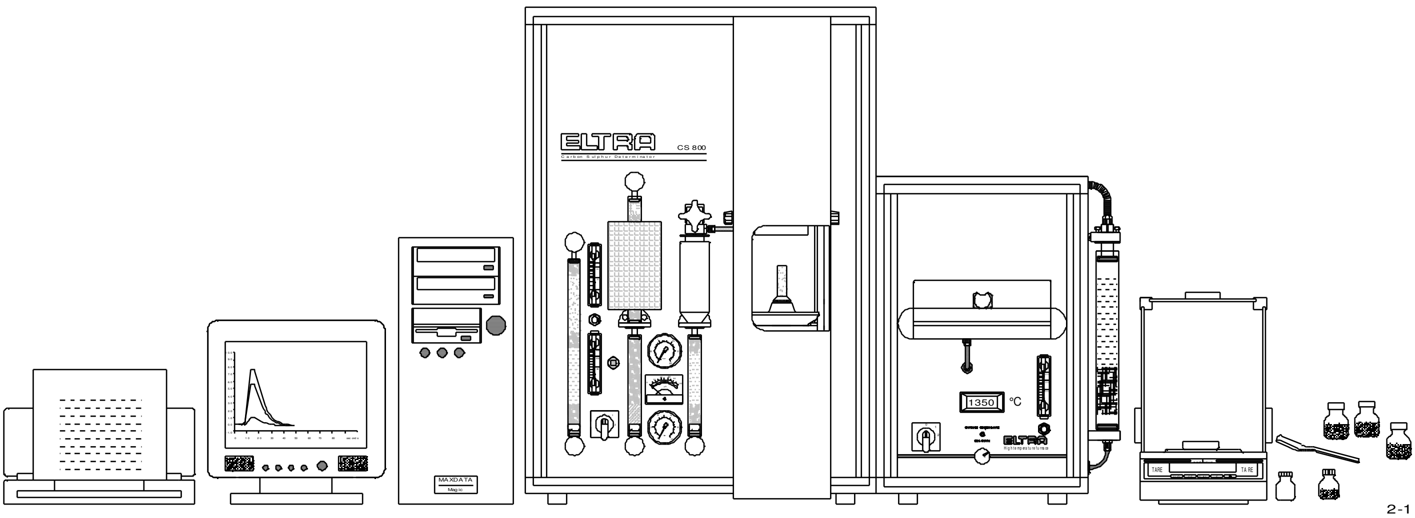
The analyser weighs about **110 kg** and the resistance furnace **36 kg**, they should be placed on a suitably stable surface. The balance should be placed in a position so that it is free of vibration.

The balance can be placed in any position, although positioning it to the right of the analyser has proved to be best suited.

The balance can of course also be placed on a weighing table next to the analyser.

There are no special requirements for setting up the printer and computer; they can be placed on a normal desk.

Below is an example of installation:



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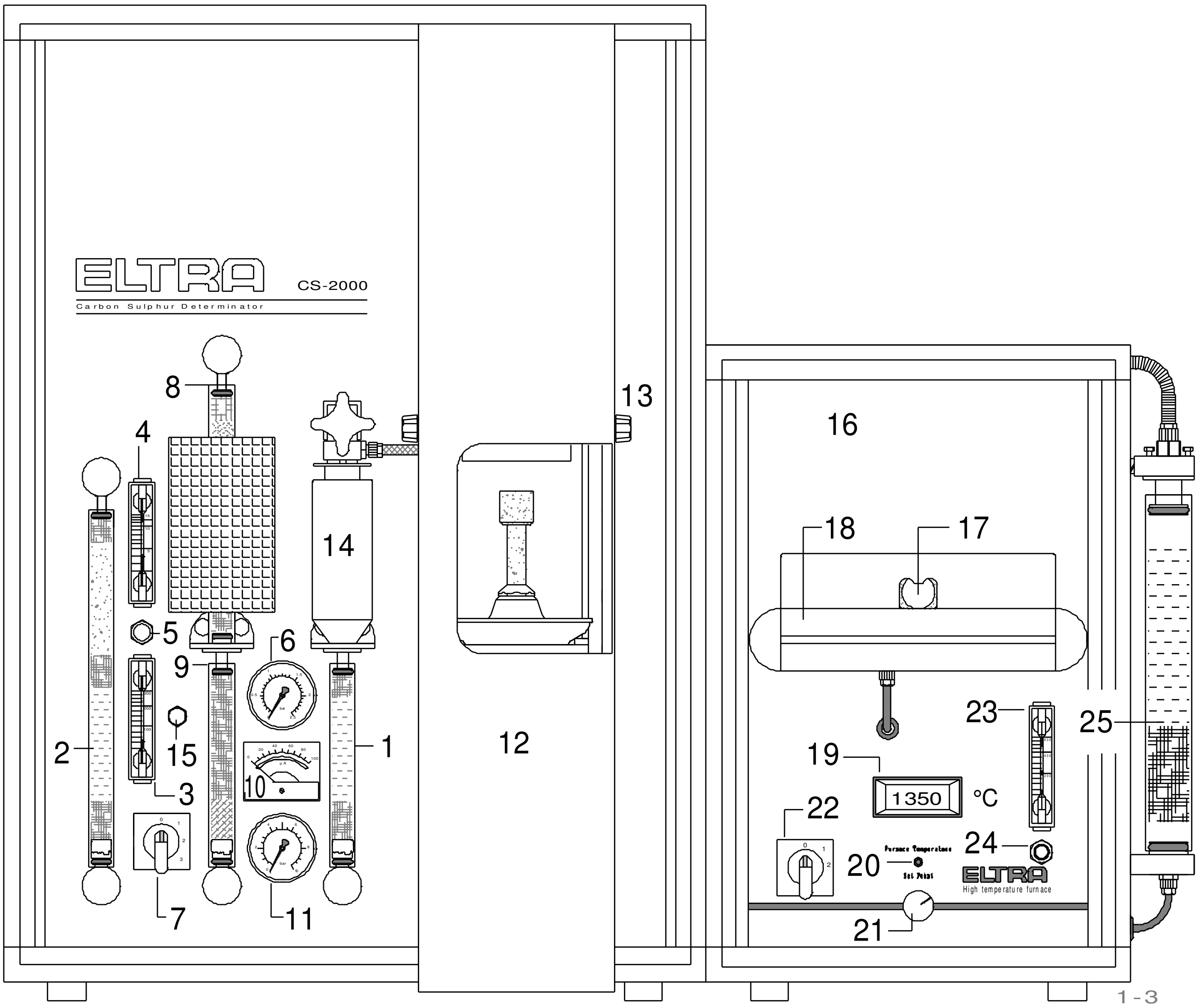
Although the analyser's operating environment does not necessarily need to be air conditioned, it is advisable to keep the room temperature between **18°C** and **30°C**.

Under no conditions should the device be placed in direct sunlight !
Avoid places exposed to the wind of air conditioners or to the wind blowing through open windows or doors.

1.2 Front panel illustration

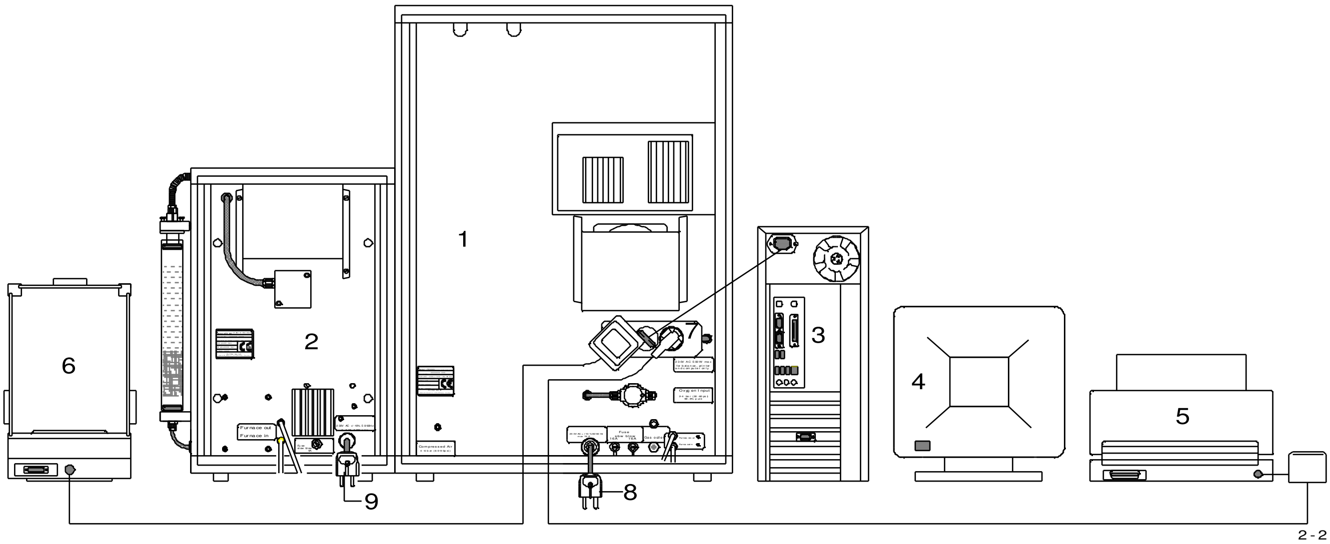


1	H_2O – trap	15	Push button for leakage test
2	CO_2 / H_2O – trap	16	Resistance furnace
3	Carrier gas flow	17	Furnace entrance
4	Infrared cell purge 10 l/h	18	Platform for combustion boats
5	Regulator for flow meter 4	19	Temperature display
6	Oxygen pressure 1,5 bar	20	Actual temperature/set point switch
7	Mains power switch	21	Set point adjustment
8	Catalysis furnace	22	Power switch
9	SO_3 – trap	23	Furnace input flow meter
10	Gas flow valve meter 30-70 µA	24	Adjustment for 23
11	Compressed air gauge 5 bar	25	Moisture trap
12	Furnace cover		
13	Cover attachment knobs		
14	Metal dust filter		

1.3 Mains power connections

Since the infrared cell requires about **1 hour** to reach a stable operating temperature, it is advisable to connect the analyser to the **mains power** first and then switch on before further installation work is carried out.

This waiting time is only necessary when **installing** the analyser. Since it is normally not switched off, and will always be in operating temperature.

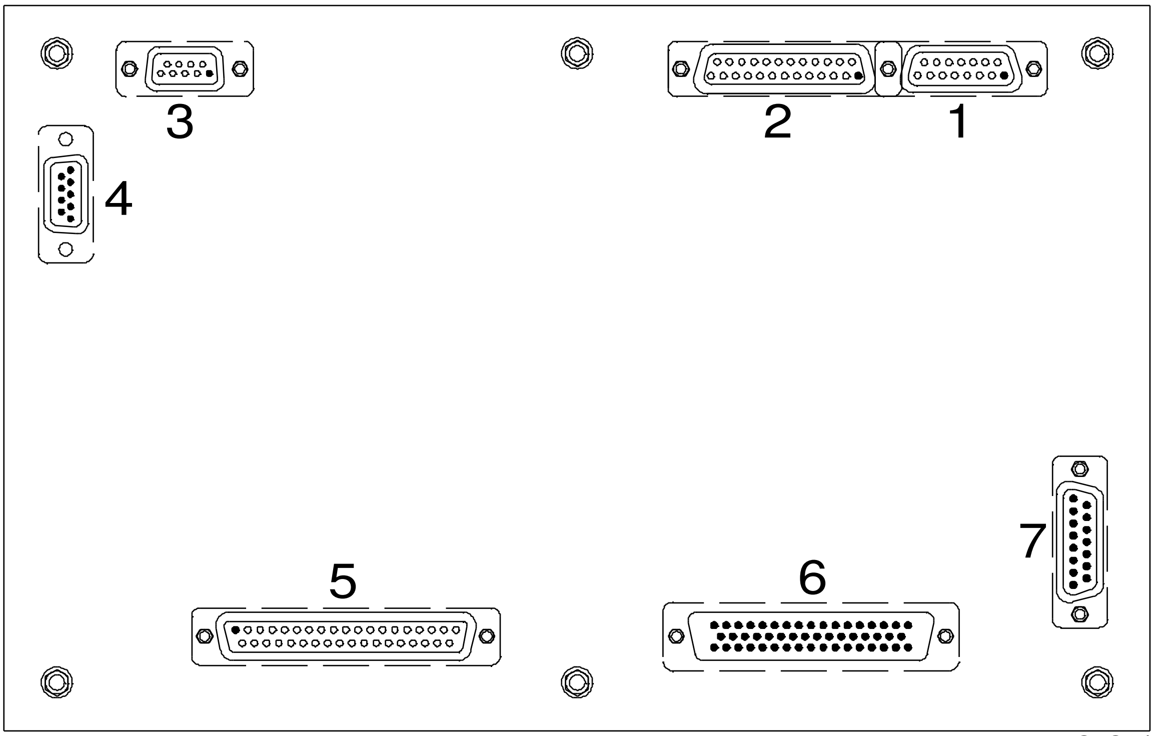


1 Analyser
2 Resistance furnace
3 Computer
4 Monitor
5 Printer
6 Balance
7 Triple socket
8 Analyser plug
9 Furnace plug

During the installation:
First connect the analyser to the mains power and switch it on. See 1.1. The switch, located on the fore side of the analyser, is to be set to **position 1**.

CAUTION:
Never plug the furnace plug **(9)** into the triple socket.

1.4 Data interface



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Rear side of UNI 1.3 board:

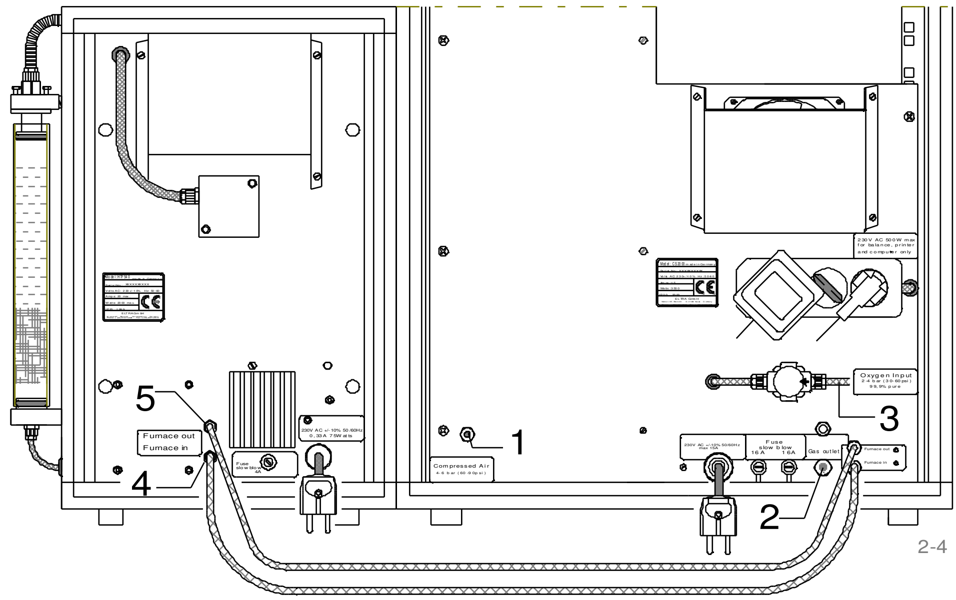
1 Micro-controller programming lock (remove for programming)
2 Micro-controller programming connection (LPT-interface)
3 Balance connection
4 PC connection
5 Analog input/output signals
6 Digital input/output signals
7 Autoloader connection

When all the units are connected to the mains power, then data connections can be made. The plugs are all different from each other, so that they cannot be interchanged. The required data cables are included if the additional units are supplied. These are adapted to the interfaces when the analysers are put into operation in our company.

As the **balance** transfers the weight to the analyser, its serial interface must be programmed.

The **computer** is already provided with an operating system and software for controlling the analyser.

1.5 Gas connections



1 Compressed air 4 to 6 bar (60 to 90 psi)
2 Oxygen outlet
3 Oxygen inlet 2 to 4 bar (30 to 60 psi)
4 Resistance furnace inlet
5 Resistance furnace outlet

Four tube connections are necessary for the operation of the analyser. The required tubes are included in delivery, **see diagram above**.

One tube for the Oxygen supply, it is soft and transparent with **5 meters length**.
One tube for the compressed air, it is harder and opaque with **5 meters length**.
One transparent tube of **0.8 meters** length for the resistance furnace inlet.
One white tube of **0.8 meters** length for the resistance furnace outlet.

These are delivered already provided with screw fittings for pressure regulators. An **R¼"** inner thread as well as the corresponding copper seals are also provided.

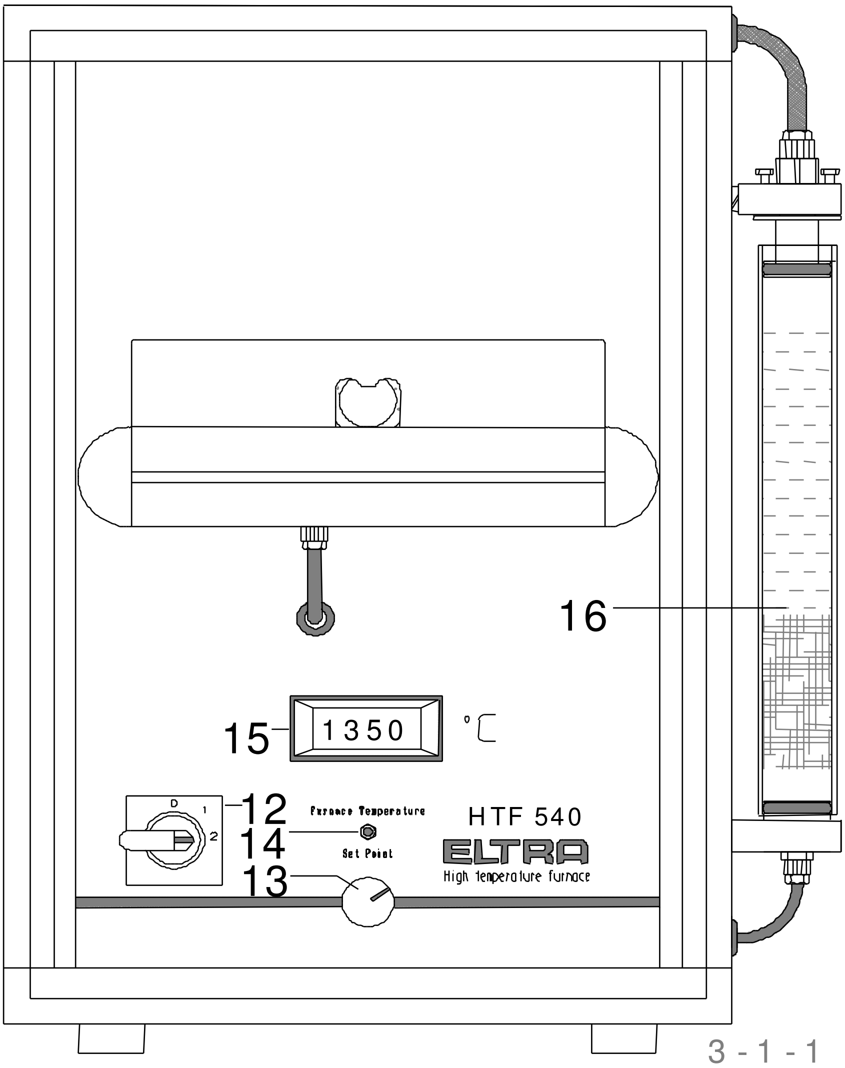
Tube fitting **(3)** connects the analyser with an oxygen bottle via a pressure regulator. This connection must be very secure, since the operating pressure in the tube is **1.5 bar**. Gas connection **(1)** is for the compressed air supply to the pneumatic furnace lock and the internal cooling for the induction coil. The pressure is even higher than that of the oxygen **(4 to 6 bar, 60 to 90 psi)**.

Gas connection **(2)** is for drawing off waste gas. It is generally not used, however, since only low quantities of **CO_2** and even lower quantities of **SO_2** result from the sample combustion.

When the analyser's mains switch is set to **position 2** a valve opens, and the oxygen can flow through the gas tubes. The flow rate is stabilised within a few seconds to **180 l/h** and can be read from the lower flow meter.

1.6 Adjusting the resistance furnace temperature

Depending on the material to be analysed, the necessary temperature of the resistance furnace may be different. Please, refer to **2.6** for applications. The procedure of adjusting the resistance furnace temperature is described below.



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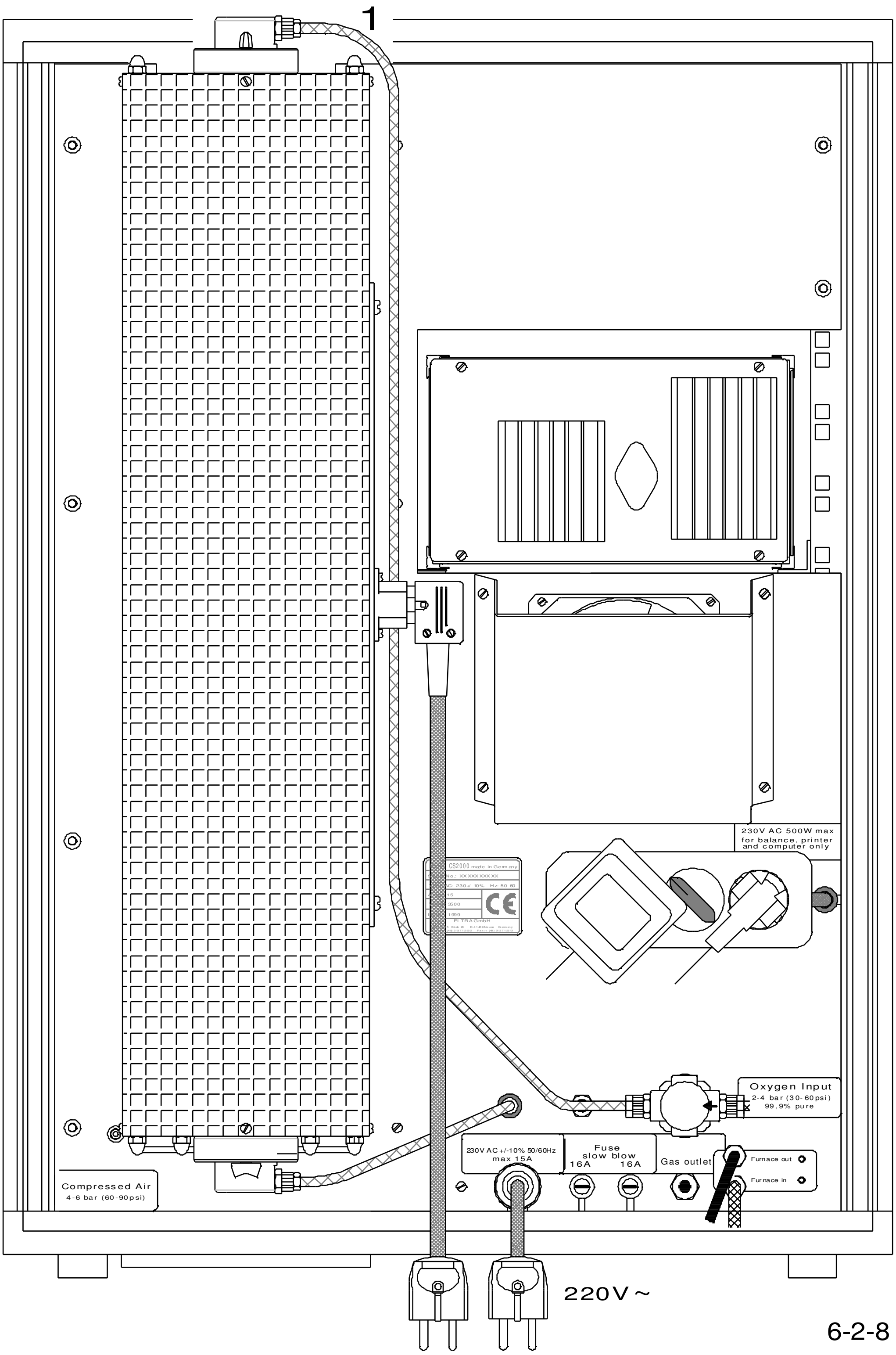
- Set the mains power switch to **position 2**.
- Set the switch **(14)** to **"Set Point"** position.
- Adjust **1350** on the display **(15)** by turning the potentiometer **(13)**.
- Set the switch **(14)** to **"Furnace temperature"** position.
- The display **(15)** shows now the actual furnace temperature.
- Normal operation temperature for the **CS-500** is **1350°C**.

1.7 Connecting the gas purification furnace

See **3.3 "Filling the reagent tubes"**.

(1) - tube for oxygen inlet.



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1.8 Auto loader

The **CS-2000** can be supplied with an automatic sample loading system. This loading system may also be retrofitted at a later date. Unlike many other auto loaders the **ELTRA** system can accommodate 130 samples giving hours of unattended operation. On request, the loader can be delivered for mor crucibles. The auto loader, which does not occupy any additional bench space, is mounted above the area where the balance, PC, monitor and consumables are normally situated. The crucibles positions in the loader are easily accessible to the operator even from siting position. The operation of the **CS-2000** with an auto loader, requires a PC for easy manipulation of sample weight storage and out of sequence samples. The PC software also includes all features of the software. For installing the auto loader, the resistance furnace should be positioned to the left of the analyser.

For instructions on installing and operating the auto loader refer to "**Loader installation, service and operation manual**".

2 ANALYSIS

2.1 Working procedure

With the **CS-2000** a wide variety of materials can be analysed. The analysis methods are therefore varied. As different materials burn differently, the chosen sample weight, the possible accelerators, the procedure for the insertion of the sample into the furnace and, finally, the sensitivity of the infrared cell will all be different. The user of the device can receive from us free advice regarding the different methods involved for different materials**.** The sensitivity of the device's infrared cell is optimised by us, free of charge, for each purpose.

Resistance furnace:
In the following, the procedures are described for the analysis of coal samples.

Before starting making analyses ensure the following:

- The temperature of the analyser is stable **(at least one to two hours on setting 1)**.
- The moisture trap **(16, 1.6)** is checked and, if necessary, the magnesium perchlorate is replaced. See 3.4.
- The incoming oxygen supply has a pressure of **2-4 bar** (30 to 60 psi).
- The mains switch is set to **setting 2** for at least **10 to 15 minutes**.
- The furnace has reached it's operating temperature. See 1.6.
- The software is started on the connected PC. **Please, refer to the "Help" function in the software for all instructions concerned the operation of the software.**

A **combustion boat** is then placed on the balance and, by pressing the **TARE** button, the weight of the combustion boat is tared. Around **300 mg** of coal sample are put into the combustion boat.
Pressing the **"F4-Balance"** button or simply **F4** on the keyboard of the PC, the weight is read from the balance and appears in the **"Weight-mg"** field above. The transfer function is performed regardless of how often the button is pressed. This enables a correction of any falsely entered weight.

- The weight which is shown on the screen when the **"F5-START"** button is pressed, is the weight which is used for calculation of the result for the running sample.
- While the analysis is running, the weight of the next sample can already be transferred to the PC. This way, work can be continued without wasting time.
- If necessary, after a weight transfer, an accelerator can be added. With coal samples, accelerators are normally not necessary. There are samples, however, that contain hard-to-burn components. In such cases, about 500 mg $FePO_4$ is recommended. With steel or casting samples, PbO_2 or Tin metal is recommended as accelerators; and V_2O_5 for cement samples.

CAUTION:
Only the sample weight must be read, under no circumstances the weight of the accelerator.

The combustion boat should be placed on the platform of the furnace. Then the **"F5-START"** button is pressed. The word "**ANALYSIS**" will appear on the screen in the status-window of the software and indicates the beginning of the analysis cycle. Immediately thereafter, the combustion boat is pushed into the hot area of the furnace. This is done with a **metal rod**. The rod is pushed into the furnace far enough so that the combustion boat reaches the boat stop. Afterwards, the rod is pulled out of the furnace.

The analysis then runs automatically, so that no more handling is necessary. The **infrared cell signals** can be observed and followed on the PC screen.

- In case of an overflow or when a new, untested sample is to be analysed, all ranges should be reactivated. Refer to the "Help" function of the software.

At the end of the analysis, the measurement results appear on the screen and the indication **"ANALYSIS"** disappears.

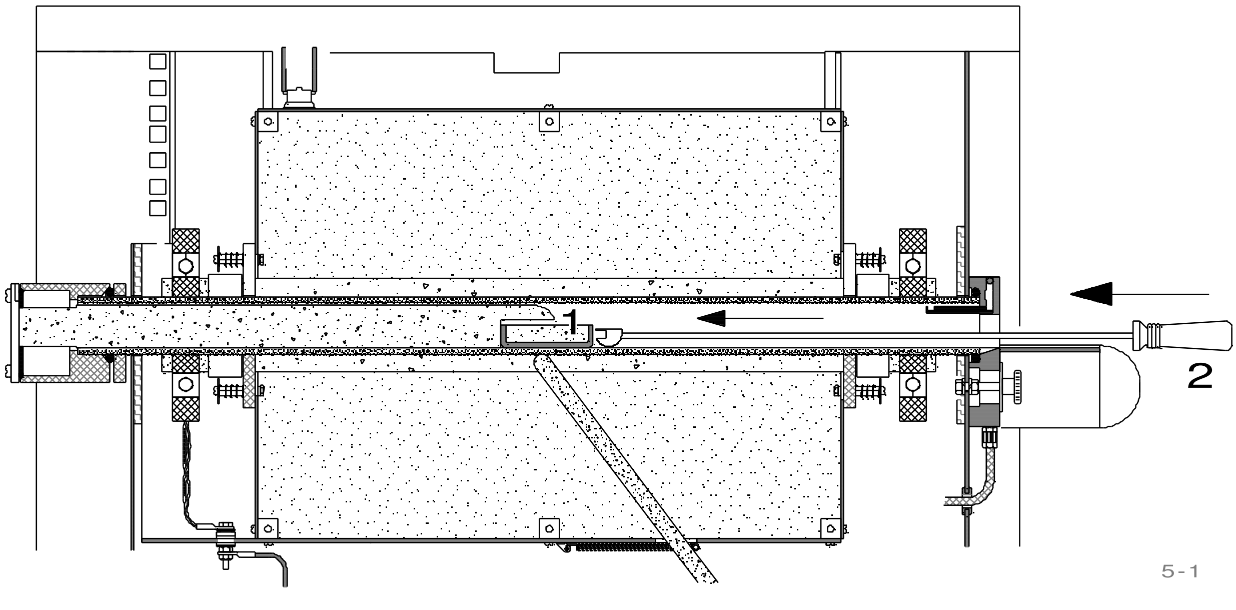
- Any overloaded range is automatically deactivated during an analysis.
- Any deactivated range is automatically reactivated after the end of the analysis.
- Only manually deactivated ranges remain inactive, until manually reactivated.

Remarks:

- The sulphur range should be deactivated when only carbon is required. This will avoid undue delay of the analysis caused by sulphur compounds which are difficult to burn, as it is in case of cement analysis. Accelerators are also not necessary.

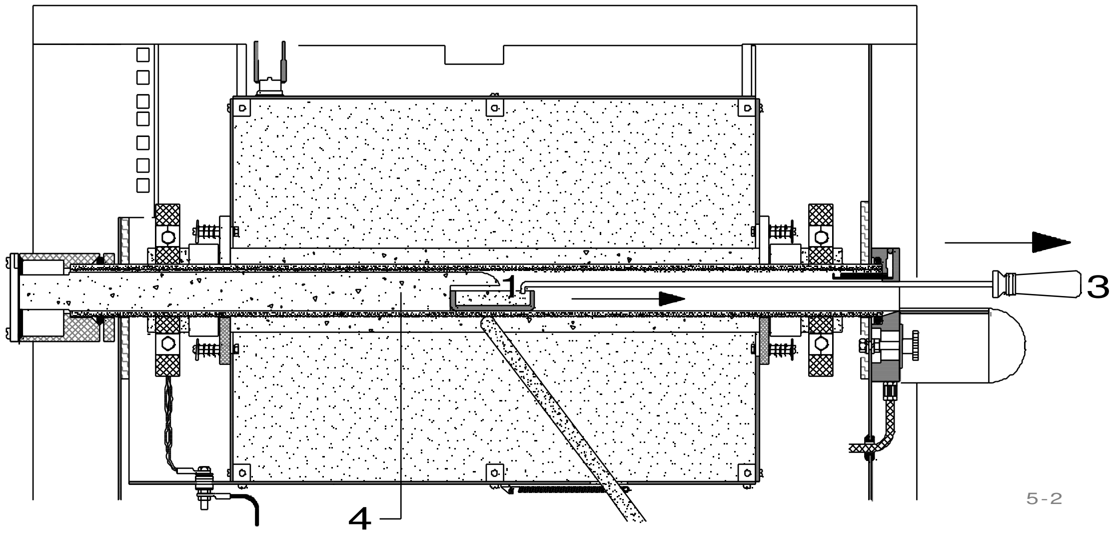
- In order to make the work easier, two different rods **(2/3)** are shipped. Make sure that the boat stop **(4)** is in the right position. See the picture below.

Pushing the combustion boat in:



With the insertion rod **(2)** push the combustion boat into the furnace until the stop is felt.

Removing the combustion boat:



To remove the combustion boat **(1)** grab it with the hook **(3)** and pull it out.

Note:

The combustion boat **(1)** should be removed immediately at the end of the analysis. During the removal, the hot combustion boat **(1)** might possibly burn dust or sample remains in the combustion tube, thereby altering the base line of the infrared system. When this occurs after starting, the following message appears in the status window of the software:

“Waiting for stability”.

Only after this message disappears and the message “Analysis” appears on it’s place a combustion boat can be entered into the furnace.

- The sample weights are valid when the analysers have appropriate sensitivities and the right path lengths of the IR-cells. If not, the analysis condition can be improved by sample weight variation.
- Generally, the weight has an optimum size when the peaks on the **screen** reach the middle of the range, i.e. the **maximum peaks** go up to **4 to 6 volts**.
- The sample weight should be reduced when the **IR-cell** is saturated. However, when the weight is lower than **100 mg**, the accuracy will be reduced due to the samples being not homogeneous and due to lower weighing accuracy.
- When the samples evaporate during combustion, the sample should be **analysed** like oil.

Induction furnace:

The **analysis of steel** is described in the following section, as an example.

Ensure that the **compressed air** and **oxygen** supplies are turned on. They should normally not be turned off in any case. By turning the mains switch to **position 3** the heating for the generator tube and air cooling are switched on, as well as a valve which allows the **oxygen** to flow through the analyser. It is advisable to let the **oxygen** flow through the analyser for several minutes before beginning analysis, so that the temperature inside the analyser is stabilised. During brief work breaks, therefore, the **oxygen** is not turned off and the mains switch is left on **position 3**.
The proper chemicals should be used. See 3.3.
A crucible is placed on the balance and tared by pressing the **"TARE"** key.

CAUTION:
The crucible must only be picked up with clean crucible tongs and **never** be handled with **fingers!**

1.5 g of tungsten are then weighed out and the balance is newly tared. Next, the sample is weighed out. A weight of about **500 mg** steel or cast iron is usual. Then the weight is transferred to the PC and can be seen on the screen.

NOTE: For all instructions on operating the PC software refer to the Help-function of the software.

CAUTION:
Only the sample weight must be read, on no account the weight of the accelerator.

The crucible is placed on the pedestal and the analysis is started. The furnace will close. **"ANALYSIS"** appears in the "status" window of the software, indicating that the analysis cycle is running. The analysis now runs by itself, so that nothing more needs to be done manually. The signals from the **infrared cells** are monitored on the "graphics" window of the software. At the end of analysis the results are shown on the screen.

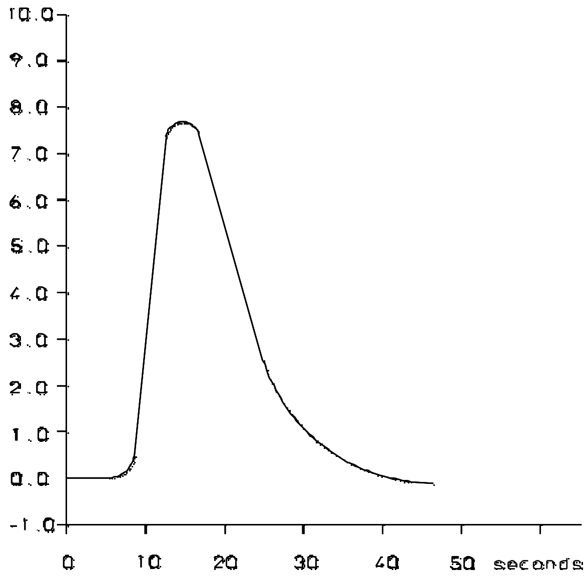
When the **range** is being **overloaded**, it is switched off. If a low range has been built in and it is overloaded, the analyser changes **automatically** over to the **high range**. If high ranges are overloaded, a row of asterisk will appear on the display. When the next analysis is started, the overloaded channel is reactivated automatically.

CAUTION:
The mains switch must not be changed from position **3** while "**ANALYSIS**" appears in the status window. If, however, the analysis is **mistakenly** started while the mains switch is in **position 1**, the analysis should be interrupted with the **"Abort"** button. The sample weight must be re-entered, then the analysis is restarted.

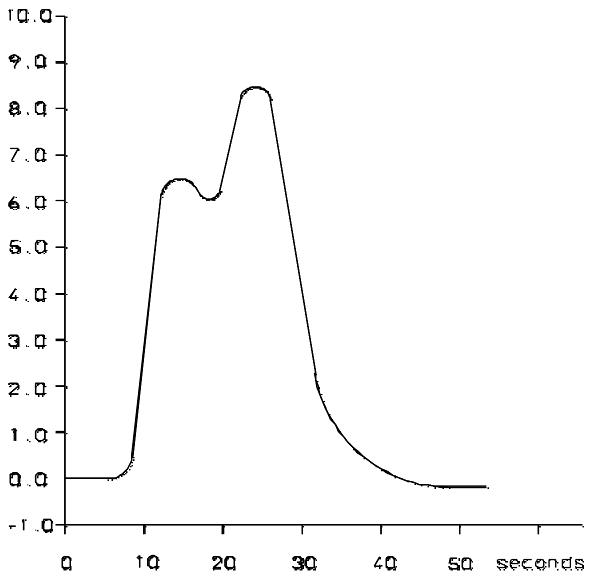
NOTE:
Before pressing **"Abort"**, a note should be made of the sample weight, because it must be re-entered manually before restarting. The first analysis after switching to **position 2** should be carried out after **10-15 minutes**, because the **oxygen** supply and the blower are thereby switched on, causing temperature drift of the **infrared cell**.

Analysis examples.
The analysis of **steel** and **cast iron** is generally carried out with approx. **500mg** of sample (normally grains or pieces) and **1,5g** of **tungsten** accelerator.

The combustion is quite rapid and the peaks on the PC screen look as follows:



Double peaks mean incomplete combustion.



The reason is, that either the sample doesn't contain enough **iron** or the sample is made up of **metal powders**.
In this case take **2 grams** of **tungsten** instead of **1.5 gram**. If the combustion still provides double peaks or there is yellow dust on the surface of the crucible after the analysis, take **1g** of tungsten, **500 mg** pure Iron and **500 mg** of sample.

In case of metal analysis the dust trap has to be cleaned and the moisture trap has to be replaced every **100 analyses** or at least **every two days**. See **3.1**.
The **combustion tube** doesn't need any **cleaning** by the operator, due to the **automatic** cleaning after each analysis.

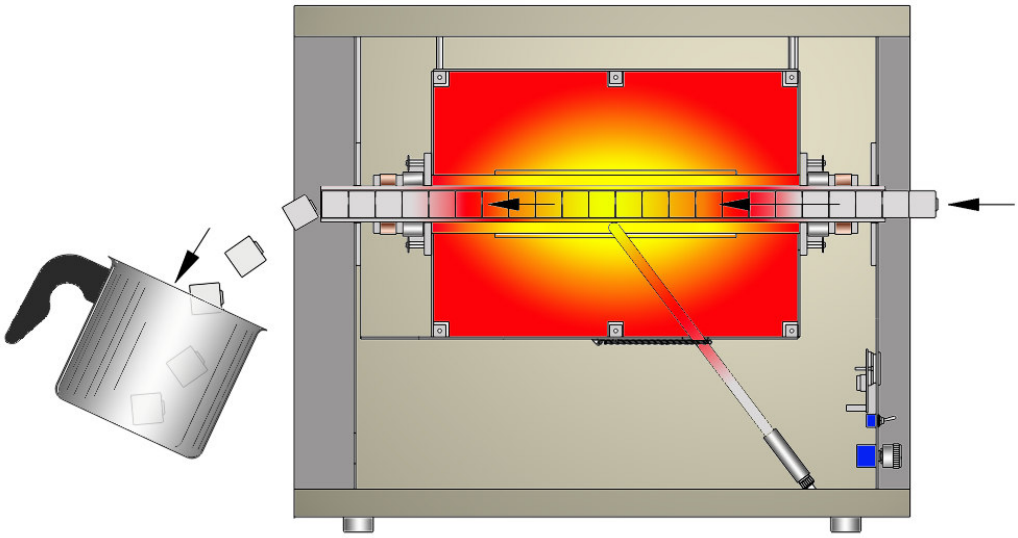
2.2 Work breaks

Work breaks, e.g. during **lunch breaks**, the mains switch remains on **position 2 or 3**. The resistance furnace schould remain switched on (**pos.2**) as well, if it was in operation. During **longer** interruptions, e.g. after finishing work for the day, the mains switch (analyser and furnace) is set to **position 1** (standby). The analyser's thermostatic control is then still working and no long warm-up time is needed, when re-starting the analyser. Energy consumption and wear are negligible on standby.

The mains switch is set to **pos.2** or **pos. 3** for about **10-15 minutes** before starting the first analysis. Air, and any moisture which has entered the analyser is expelled by the **oxygen flow**. The slight influence which the **oxygen flow** has on the temperature of the **infrared cell** is balanced out. The analyser may only be switched off **(pos. 0)** when it is not used for several days or weeks. The analyser is designed for long term use, so that no **damage** results.

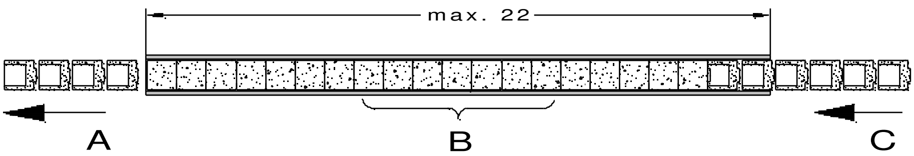
The induction furnace should always be kept closed during work breaks, so that no moisture can enter. The furnace only remains open when the analyser is completely switched off. The **mains switch is only set to zero for safety reasons**, the crucible lift is then at the bottom.

2.3 Pre-heating the crucibles



The above furnace is used for preheating the crucibles. It is an **ELTRA** accessory and can be purchased as such.
When analysing samples with a low concentration of **carbon** or **sulphur (<1000 ppm)**, the pre-heating of the crucibles is absolutely necessary. The crucibles themselves have their own concentration of carbon, which can vary from **20 to several hundred ppm**, depending on their quality. Additionally, the above blank value is not constant; it can vary from crucible to crucible. These problems, of course affect the accuracy of the analyses, therefore by pre-heating the crucibles, the carbon inside them will be largely eliminated. The remaining **blank value** therefore, will be very low and, what is very important, it will remain fairly identical for each crucible.
This residual value can easily be offset, by performing a blank value calibration.

Operating the pre-heating furnace:



B = hot zone inside furnace
WARNING!
do not move more then 4 crucibles at one time into the furnace, or else the combustion tube may break, due to temperature shock.

After **five minutes** feed-in the next **four** crucibles **(C)**.
Up to **22 crucibles** can fitted inside the furnace. **(B)** is the hot zone inside the furnace.
Eventually, the pre-heated items will drop from the furnace outlet **(A)**.

2.4 TIC–determination

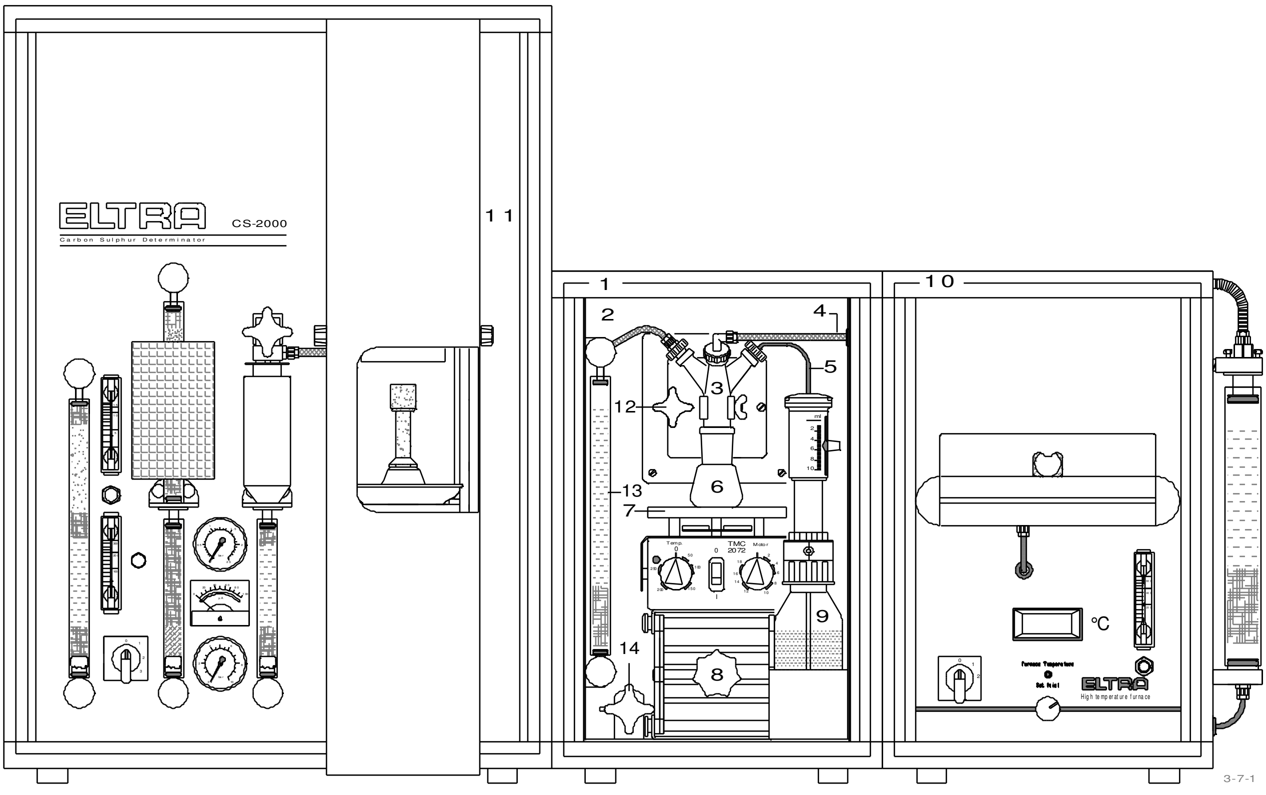
TIC-module
Due to the modular design of the **CS-2000**, a module for Total **Inorganic Carbon** (TIC) can be placed between the resistance furnace and the analyser. For the TIC determination, the sample is treated with **acid** in the TIC module.

TIC and total carbon (TC) can be alternatively analysed without modifications.

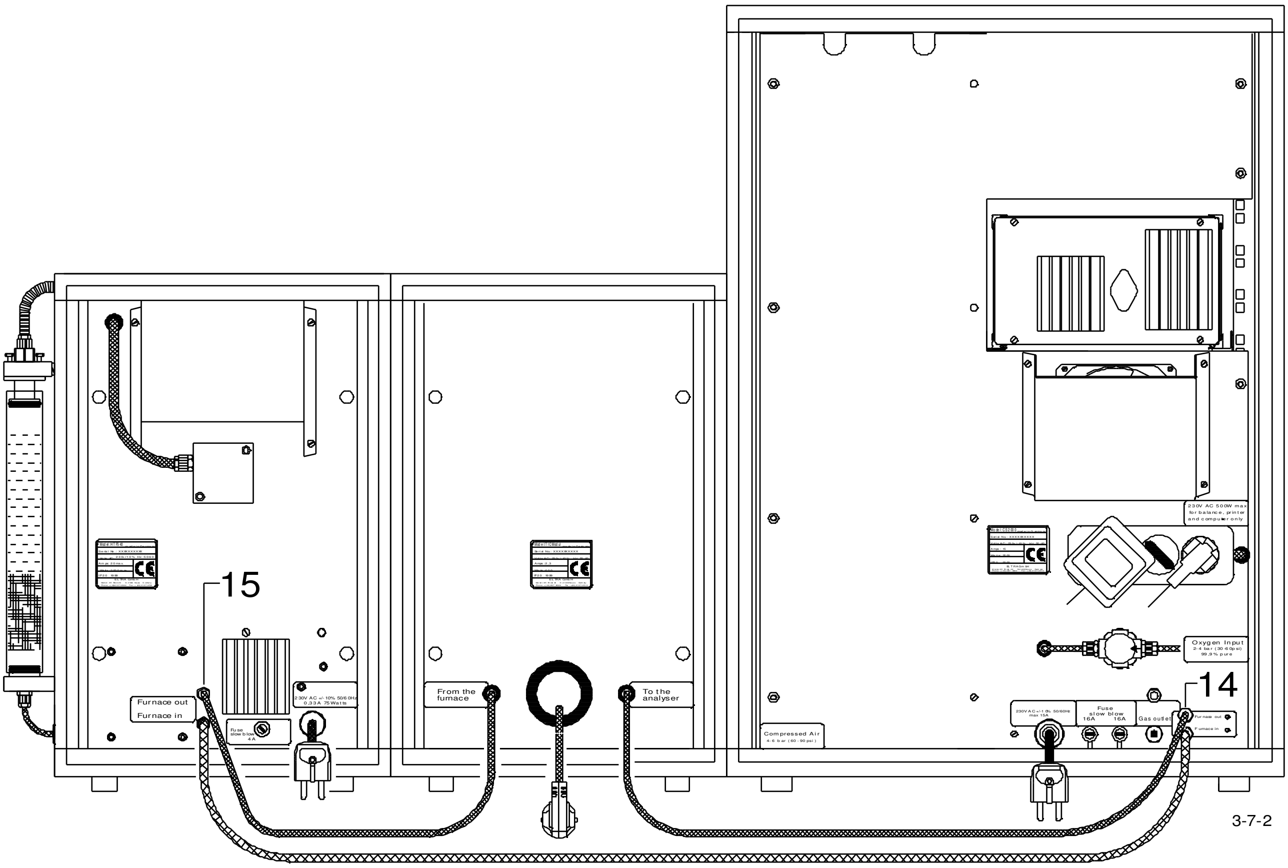
For TIC analysis:
The sample is treated with acid in an **Erlenmeyer** flask inside the TIC-module. The acid decomposes the carbonates in the sample, creating **CO_2**.

The oxygen flow purges the **CO_2** out of the flask, through to the infrared detector. TIC is determined when the sample is introduced into the furnace for combustion and IR-detection.

Installation:



1 TIC - module
2 Connection to the analyser
3 Glass distributor
4 Connection to the furnace
5 Acid supply
6 50 ml glass flask
7 Heater with magnetic stirrer
8 Support with variable height
9 Acid bottle with dispenser
10 Furnace
11 Analyser
12 Position adjustment
13 Moisture trap
14 Analyser inlet **see below**
15 Furnace outlet **see below**



The TIC module is placed between the furnace and the analyser:

- The outlet **(15)** of the furnace is connected to the connection **(4)** of the glass distributor **(3)**.
- The outlet **(2)** of the glass distributor **(3)** is connected to the upper fitting of the moisture trap **(13)**.
- The lower fitting of the moisture trap **(13)** is connected to the analyser inlet **(14)**.
- The bottle of acid with dispenser **(9)** is placed to the right of the platform **(8)** and is connected to the connection **(5)** of the glass distributor.
- The glass distributor **(3)** with the glass bottle **(6)** are adjusted so that the whole surface of the bottom of the glass bottle **(6)** touches the surface of the heater **(7)**.
- The heater **(7)** is switched on and the **temperature** is set between setting **3** and **4**.

Operating procedure. See next page.

Operating procedure

- Place the empty glass flask **(6)** on the balance.
- Press tare.
- Put the sample into the flask and enter the weight into the analyser.
- When powder sample is stuck in the flask neck, add **2 mls** of water.
- Place a magnetic stirrer into the flask and attach the flask to the distributor **(3)**.
- Raise the adjustable platform to touch the flask. Check, and if necessary, readjust the flask.
- **Start the analysis.**
- Inject the acid in two or three doses.
- The rotary speed of the stirrer should be kept low. The rotary speed and the acid dosing should be done in such a way as to avoid sample particles being pushed up and stick to the inner glass surface .
- The heater must be switched on. **Do not allow boiling and evaporation of the solution in the flask!**
- When all the $\mathbf{CO_2}$ has been released from the sample, the analyser's signal will return to the baseline level and the analysis will be terminated.

The table below shows approximate sample weight and acid volume depending on the expected TIC content in the sample.

TIC-content	Sample weight	Acid
>5 %	100-200 mg	2×2 ml
1-5 %	200-500 mg	3×2 ml
<1 %	1000 – 2000 mg	3×3 ml

Acid:
Acetic acid **25%** concentration or phosphoric acid **50%** concentration.

CAUTION:
Only the carbon of easily decomposable carbonates can be determined. Carbonates which are difficult to decompose cannot be measured. For example, **elementary carbon** (graphite, soot) and **cyanides** cannot be analysed.

2.5 Applications – Induction furnace

Material/ Analysis time (s)	Sample + Accelerators	Calibration		Typical results
Aluminium	1.5 g ± 0.2 g Tungsten	**LC**	0.1 % C Steel	60 ppm C
50 s.	700 mg ± 50 mg Sample	**HC**	2.0% C Steel	3 % C
	0.7 g ± 0.1 g Nickel	**LS**	0.1 % S Steel	0.2 % S
		HS		
Ash	1.6 g ± 0.2 g Tungsten	**LC**	0.1 % C Steel	
50 s.	120 mg ± 50 mg Sample	**HC**	2.5 % C Steel	3.5 % C
	0.5 g ± 0.1 g Iron	**LS**	0.1 % S Steel	
		HS		
$BaCO_3$	1.7 g ± 0.2 g Tungsten	**LC**		
50 s.	110 mg ± 30 mg Sample	**HC**	6.08 %C $BaCO_3$	6.08 % C
	0.8 g ± 0.2 g Iron	**LS**		
		HS		
$BaSO_4$	1.0 g ± 0.2 g Tungsten	**LC**		
50 s.	200 mg ± 100 mg Sample	**HC**		
	1.0 g ± 0.2 g Iron	**LS**		
		HS	13.7 %S $BaSO_4$	13.7 % S
Lead pieces	2.5 g ± 0.2 g Tungsten	**LC**	0.1 % Steel	60 ppm C
100 s.	2.0 g ± 0.1 g Sample	**HC**		
Comparator level =1		**LS**	0.1 % S Steel	100 ppm S
		HS		
Lead powder	2.5 g ± 0.2 g Tungsten	**LC**	0.1 % Steel	60 ppm C
100 s.	800 mg ± 100 g Sample	**HC**		
Comparator level =1		**LS**	0.1 % S Steel	100 ppm S
		HS		
Soil	1.8 g ± 0.2 g Tungsten	**LC**	0.048 % C Steel	0.03 % C
60 s.	250 mg ± 50 mg Sample	**HC**	1.03 % C Steel	3.0 % C
	0.7 g ± 0.1 g Iron	**LS**	0.13 % S Cast iron	1.0 % S
		HS	0.336% S Steel	2.0 % S
$CaCO_3$	1.7 g ± 0.2 g Tungsten	**LC**		
50 s.	110 mg ± 30 mg Sample	**HC**	12 % C $CaCO_3$	12 % C
	0.8 g ± 0.2 g Iron	**LS**		
		HS		
CaO	1.7 g ± 0.1 g Tungsten	**LC**	0.048 % C Steel	
60 s.	370 mg ± 20 mg Sample	**HC**	1.33 % C Steel	0.192 % C
	0.8 g ± 0.1 g Iron	**LS**	0.13 % S Cast iron	0.017 % S
		HS	0.336% S Steel	
Cast iron	1.2 g ± 0.2 g Tungsten	**LC**		
50 s.	400 mg ± 100 mg Sample	**HC**	1.33 % C Steel	0.192 % C
	0.3 g ± 0.1 g Iron	**LS**	3.0 % S Cast iron	0.017 % S
		HS	0.1% S Cast iron	
Ceramics	2.2 g ± 0.2 g Tungsten	**LC**		
60 s.	150 mg ± 50 mg Sample	**HC**	12 % C $CaCO_3$	5.98 % C
	0.7 g ± 0.1 g Iron	**LS**	0.103 % S	
		HS	0.336 % S Cast iron	2.57 % S
Cement	0.8 g ± 0.1 g Tungsten	**LC**		
60 s.	200 mg ± 50 mg Sample	**HC**	12 % C $CaCO_3$	
	0.8 g ± 0.1 g iron	**LS**		
		HS	13.7 % S $BaSO_4$	

Cement 60 s.	200 mg ± 50 mg Sample 1.1 g ± 0.1 g Iron	**LC**	1 % C Cement	
		HC	2% C Cement	
		LS	1% S Cement	
		HS		
Chrome 70 s.	1.5 g ± 0.2 g Tungsten 200 mg ± 50 mg Sample 0.8 g ± 0.1 g Iron	**LC**	0.048 % C Steel	0.003 % C
		HC	1.33 % C Cast iron	
		LS	0.13 % S Cast iron	0.001 % S
		HS		
Chrome oxide 50 s.	1.5 ± 0.2 g Tungsten 220 mg ± 50 mg Sample 0.6 g ± 0.1 g Iron	**LC**	0.1 % C Steel	0.02 % C
		HC		
		LS	0.1 % S	0.025 % S
		HS		
Limestone 60 s.	1.8 ± 0.1 g Tungsten 250 mg ± 50 mg Sample 0.8 g ± 0.1 g Iron	**LC**	0.048 % C Steel	
		HC	1.3 % C Steel	1.5 % C
		LS	0.13 % S	0.11 % S
		HS		
Cobalt 50 s.	1.8 ± 0.2 g Tungsten 350 mg ± 50 mg Sample 0.3 g ± 0.1 g Iron	**LC**	0.048 % C Steel	
		HC	1.3 % C Steel	1.5 % C
		LS	0.13 % S	0.11 % S
		HS		
Coal and coke 50 s.	1.5 ± 0.2 g Tungsten 50 mg ± 10 mg Sample 0.5 g ± 0.1 g Iron	**LC**		
		HC	3.0 % C Cast ironl	70 % C
		LS	0.1 % S Steel	5 % S
		HS		
Copper 50 s.	5 g Sample	**LC**		
		HC		
		LS	15 ppm S Copper	10 ppm S
		HS		
Copper pin 50 s.	2.0 g ± 0.2 g Tungsten 1.0 g ± 0.1 g Sample 0.1 g ± 0.01 g Iron	**LC**		
		HC		
		LS	0.1 % S Steel	10 ppm S
		HS		
Cu-Ni 50 s.	2.0 g ± 0.2 g Tungsten 0.7 g ± 0.1 g Sample	**LC**	0.048 % C Steel	0.036 % C
		HC	1.03 % C Steel	
		LS	0.1 % S Steel	40 ppm S
		HS		
Nickel 50 s.	2.0 g ± 0.2 g Tungsten 0.8 g ± 0.1 g Sample 0.8 g ± 0.1 g Iron	**LC**	0.048 % C Steel	
		HC	1.03 % C Steel	
		LS	0.1 % S Steel	17 ppm S
		HS		
Fe-Cr 50 s.	2.5 g ± 0.2 g Tungsten 450 mg ± 50 mg Sample 0.2 g ± 0.1 g Iron	**LC**	0.1 % C Steel	0.2 % C
		HC	1.03 % C Steel	6 % C
		LS	0.1 % S Steel	0.3 % S
		HS		
Fe-Mn Fe-Mo 50 s.	1.5 g ± 0.2 g Tungsten 250 mg ± 50 mg Sample 0.4 g ± 0.1 g Iron	**LC**	0.1 % C Steel	0.2 % C
		HC	3.0 % C Cast iron	6 % C
		LS	0.1 % S Steel	0.3 % S
		HS		
Fe-Ni 50 s.	1.7 g ± 0.2 g Tungsten 700 mg ± 100 mg Sample	**LC**	0.1 % C Steel	0.2 % C
		HC	3.0 % C Cast iron	6 % C
		LS	0.1 % S Steel	0.3 % S
		HS		

Fe-Si 50 s.	1.5 g ± 0.2 g Tungsten 250 mg ± 50 mg Sample 0.9 g ± 0.1 g Iron	**LC**	0.1 % C Steel	0.2 % C
		HC	3.0 % C Cast iron	6.0 % C
		LS	0.1 % S Steel	0.3 % S
		HS		
Fly ash 60 s.	2.2 g ± 0.1 g Tungsten 100 mg ± 20 mg Sample 0.3 g ± 0.05 g Iron	**LC**	0.048 % C Steel	
		HC	6.08 % C $BaCO_3$	10 % C
		LS	0.13 % S Cast iron	0.3 % S
		HS		
Gypsum 60 s.	0.8 g ± 0.1 g Tungsten 200 mg ± 50 mg Sample 0.8 g ± 0.1 g Iron	**LC**		
		HC	12 % C $CaCO_3$	
		LS		
		HS	13.7 % S $BaSO_4$	18 % S
Ores 60 s.	1.0 g ± 0.2 g Tungsten 130 mg ± 30 mg Sample 1.0 g ± 0.2 g Iron	**LC**		
		HC	12 % C $CaCO_3$	10 % C
		LS	0.1 % S Steel	≈3 % S
		HS	13.7 % S $BaSO_4$	30 % S
Ores 60 s.	1.0 g ± 0.2 g Tungsten 130 mg ± 30 mg Sample 1.0 g ± 0.2 g Iron	**LC**		
		HC	12 % C $CaCO_3$	10 % C
		LS	0.1 % S Steel	≈3 % S
		HS	13.7 % S $BaSO_4$	30 % S
Iron ores 60 s.	2.0 g ± 0.2 g Tungsten 250 mg ± 50 mg Sample 0.5 g ± 0.1 g Iron	**LC**		
		HC	12 % C $CaCO_3$	10 % C
		LS	0.1 % S Steel	≈3 % S
		HS	13.7 % S $BaSO_4$	30 % S
Rock sample 60 s.	2.2 g ± 0.2 g Tungsten 150 mg ± 50 mg Sample 0.7 g ± 0.1 g Iron	**LC**		
		HC	12 % C $CaCO_3$	5.98 % C
		LS	0.103 % S Steel	
		HS	0.336 % S Steel	2.57 % S
Rubber 60 s.	1.5 g ± 0.2 g Tungsten 40 mg ± 10 mg Sample 0.5 g ± 0.1 g Iron	**LC**		
		HC	3.0 % C Cast iron	60 % C
		LS	0.1 % S Steel	1.9 % S
		HS		
Silicon 60 s.	1.7 g ± 0.2 g Tungsten 80 mg ± 20 mg Sample 0.4 g ± 0.1 g Iron	**LC**		
		HC	12 % C $CaCO_3$	
		LS	0.1 % S Steel	0.02 % S
		HS		
Silicon Carbide 70 s.	2.0 g ± 0.2 g Tungsten 60 mg ± 10 mg Sample 0.7 g ± 0.1 g Iron	**LC**		
		HC	12 % C $CaCO_3$	30 % C
		LS	0.1 % S Steel	0.02 % S
		HS		
Slag 60 s.	1.0 g ± 0.2 g Tungsten 500 mg ± 100 mg Sample 1.0 g ± 0.2 g Iron	**LC**	0.1 % C Steel	
		HC	2.0 % C Cast iron	
		LS	0.1 % S Steel	0.8 % S
		HS		
Steel 50 s.	1.5 g ± 0.2 g Tungsten 500 mg ± 100 mg Sample	**LC**	0.1 % C Steel	0.1 % C
		HC	3.0 % C Cast iron	6 % C
		LS	0.1 % S Steel	0.3 % S
		HS		
Titanium 50 s.	1.4 g ± 0.2 g Tungsten 500 mg ± 100 mg Sample 0.6 g ± 0.1 g Iron	**LC**	0.1 %C Steel	0.016 % C
		HC		
		LS	0.1 % S Steel	10 ppm S
		HS		

Titanium oxide 60 s.	2.2 g ± 0.2 g Tungsten 300 mg ± 50 mg Sample 0.6 g ± 0.1 g Iron	**LC**	0.048 % C Steel	
		HC		
		LS	0.013 % S Cast iron	23 ppm S
		HS		
Titanium oxide 60 s.	2.0 g ± 0.2 g Tungsten 220 mg ± 20 mg Sample	**LC**	0.048 % C Steel	0.230 % C
		HC		
		LS		
		HS		
Tungsten carbide 70 s.	1.7 g ± 0.2 g Tungsten 200 mg ± 50 mg Sample 0.6 g ± 0.1 g Iron	**LC**		
		HC	6.14 % C WC	6.14 % C
		LS		
		HS		
Uranium 50 s.	1.0 g ± 0.1 g Tungsten 800 mg ± 100 mg Sample 0.5 g ± 0.1 g Iron	**LC**	0.1 % C Steel	0.50 % C
		HC		
		LS	0.1% S Steel	0.07 % S
		HS		

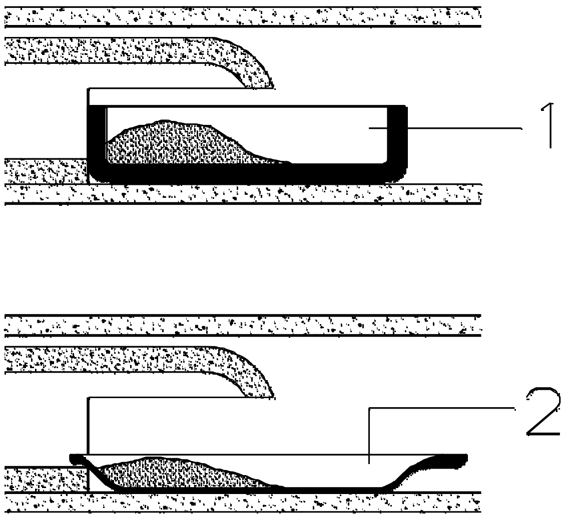
LC – low carbon measuring range
HC – high carbon measuring range
LS – low sulphur measuring range
HS – high sulphur measuring range

2.6 Applications - Resistance furnace

ANALYSIS of COAL.

Furnace temperature 1350°C.
Sample weight around **300mg**, depending on the sensitivity of the analyser and on the **C** and **S** content of the sample. The sample weight should not be higher than **500mg**.
The sample should be put into the front part of the combustion boat. The combustion boat is pushed directly into the hot zone up to the boat stop after pressing **"START"**. Usually, no accelerators are needed. Only in exceptional cases, when the sample contains pyrites, the furnace temperature has to be set at **1500°C** or approx. **300mg** of **iron phosphate** have to be spread upon the sample.

There are two different types of combustion boats available:



Due to the front shape of the combustion boat **type 2,** it should be carefully pushed up to the boat stop, otherwise it may slide into the boat stop. Stop pushing as soon as the boat stop is reached.

- The combustion boat **(1)** is reusable (10, 20, 30 analyses or more).
- The combustion boat **(2)** can only be used once.

ANALYSIS of OIL, ASPHALT and RUBBER.

Using fuel oil and other thick oils, the sample weight is approx. **80mg**.
The sample weight should never exceed **100mg**.
Using thin oil analysis, the sample weight should not be higher than **50mg**.

- Adjust the furnace temperature to **1450 °C**.
- Weigh the sample of the above mentioned materials, **50** to **100mg**.
- Transfer the weight to PC.
- Start analysis.
- Insert the boat **very slowly** into the furnace.
- When you hear the noise of the ignition, **stop pushing** and put a marker on the insertion rod, at the beginning of the platform of the boats.

The marker can be a piece of tape wrapped around the rod. Check the right position of the marker by pushing another sample up to the level of the marker. The marker is at the correct position when the sample takes **3** to **5 seconds** to ignite after stop pushing. Otherwise repeat and check again.

Once the marker is at the correct position, all the samples of this kind of material are inserted in the furnace shown by the marker on the rod and **left there** for analysis. This position corresponds to an area inside the furnace, situated just before the hot zone. The sample then ignites in about **3** to **5 seconds**. The signals of the **IR-cell** go up. They can be observed on the computer screen.

When the signals are moving down and have reached about **25%** of their maximum peaks, push the combustion boat up to the boat stop to reach the middle of the hot zone, to completely burn any rest of the sample.

CAUTION:
It is extremely important to run the analysis this way!
Never push such kinds of samples immediately into the hot zone.
Some fumes may leave the hot zone without being completely burned. They may contaminate the gas flow system, including the infrared cell.

Some users push the sample “slowly” into the furnace up to the hot zone. This is wrong. The sample must **stay** at the ignition point and **after** the peak came down to a low level, **then** the boat should be pushed into the hot zone.

ASH ANALYSIS (C and S determination in ash).

- Adjust the furnace temperature to **1450 °C**.
- Take **200 mg** sample weight. The weight can also be much higher, depending on the **C** and **S** concentrations and on the sensitivity of the **IR-cells**.
- After starting the analysis, push the sample up to the middle of the hot zone, resp. up to the boat stop.

ASH CONTENTS DETERMINATION.

Close the adjustable flow restrictor (on the front panel, below the flow indicator). Turn it fully clockwise. Adjust the furnace between **790 °C** and **800 °C**. Take about **1g** of sample in a quartz boat. Insert the sample into the furnace, just at the beginning of the hot zone. Leave the sample for one minute. Push the sample into the hot zone and leave it there for **6-7 minutes**.

After combustion, remove the sample. After cooling down, weigh the sample again. This is the weight of the remaining ash.

The percentage of the ash contents is calculated as follows:

$$C[\%] = \frac{W_{after}}{W_{before}} \cdot 100$$

where: C – ash contents in the sample;
W_{after} – sample weight after combustion;
W_{before} – sample weight before combustion;

CAUTION:

For **sulphur** and **carbon** analysis, readjust flow restrictor until lower flow indicator shows **200 l/h**. Ensure that the moisture absorber is dry, replace if necessary, even if the signals from the infrared cells are ignored. The gases passing through the **IR-cells** have to be dry in any case.

GRAPHITE ANALYSIS.

- Analysers with a range of 100% C can be calibrated with graphite.
- Any furnace temperature over **1000 °C** is sufficient.
- Sample weight approx. **400 mg**.
- The boat is pushed directly up to the boat stop.

ANALYSIS of CALCIUM CARBONATE.

- This can be used for calibration in the range of 12% C.
- Depending on the sensitivity of the IR-cell, the weight can be between **100mg** and **500mg**.
- Any furnace temperature over **800 °C** is high enough.
- The sample is directly pushed up to the boat stop.

LIMESTONE ANALYSIS.

- The furnace temperature **1250 °C** or higher.
- Calibrate with calcium carbonate of 12% C.
- The usual weight is **500mg**.
- Push directly up to the boat stop.

CEMENT ANALYSIS.
If only the carbon value is required, deactivate the sulphur range.

- The sample weight is between **200mg** and **500mg**, depending on the C-concentration and on the sensitivity of the IR-cell.
- Adjust the furnace temperature to **1250 °C**.
- Enter the sample directly up to the boat stop.
- For sulphur analysis in cement we recommend an induction furnace analyser.

ANALYSIS of GYPSUM and desulphurisation products (of power plants). If only the carbon value is required, deactivate the sulphur range.

For carbon analysis:
- Adjust the furnace temperature to **1250 °C**.
- Take **300** to **1000mg** sample weight, depending on the C content and the sensitivity of the IR-cell. Enter the boat directly up to the boat stop.

For sulphur analysis:
- Take nitrogen as carrier gas (instead of oxygen).
- Adjust the furnace temperature to **1450 °C**.
- Take **30** to **50mg** sample weight. Add **500mg** iron phosphate.
- Enter the sample directly up to the boat stop. The calibration can be done with pure gypsum 18,6 % S.

ANALYSIS of PLASTICS.
- Adjust the furnace temperature to **1450 °C**.
- Weight the sample of the above mentioned materials, **50** to **100mg**.
- Enter the boat very slowly into the furnace.
- When you hear the noise of the ignition, stop pushing and put a marker on the insertion stick, at the beginning of the platform of the boats

The marker can be a piece of tape wrapped around the stick. Check the right position of the marker by pushing another sample up to the level of the marker. The marker is at the right position when the sample takes **3** to **5 seconds** to ignite. Otherwise correct and check again. After the marker is at the right position, all samples of this kind of material are inserted up to the beginning of the hot zone and left there for analysis.
They ignite after **3** to **5 seconds**. The signals of the **IR-cell** go up. They can be observed on the computer screen. When the signals are moving down and have reached about **25%** of their maximum peaks, push the combustion boat up to the boat stop to reach the middle of the hot zone, to completely burn any rest of the sample.

ANALYSIS OF WOOD.
- Use the big ceramic boats (58 x 22 x 14 mm).
- Adjust the furnace temperature to **1300 °C**.
- Take **350 mg** of sample.
- Set the minimum analysis time to **50 s**.
- Set the comparator level to **150**.

LOW CARBON ANALYSIS

The IR-path of the low carbon is usually 10mm only. The maximum possible length is 320mm. Even though with 10mm IR-path a sample of 50ppm can give reasonable results and good carbon peaks. This shows that the CS-500 is capable to analyse even much lower carbon values when the path length is 15 times longer! Please, note that it is not a problem to make the CS-500 very sensitive in carbon. The limits are set by the air entering the system and by the blanks of the boat. The good results can be obtained by using quartz boats. **NO CHANCE** to measure in this low range if you use ceramic boats. Their blanks and their deviations are huge compared to the sample's carbon.

Even without using any low carbon attachment for preventing the air from entering the furnace, it is possible to obtain acceptable results in the 50ppm range.

A PC should be connected so that the base line and the peaks of combustion can be seen. A first thing to do is to check the base line. The blank value should be set to zero and the analyser should be calibrated with a higher sample so that the calibration factor is at least in a correct range.

Enter manually a usual sample weight taken for low carbon analysis, i.e. about 1000mg. Start the analysis cycle without entering sample or boat into the furnace. Repeat this 3 to 5 times. This way you know what is the reading caused by the air entering the furnace as well as by the base line drift and noise. So, when you run analyses later on, any higher value comes from sample and boat.

Of course the boats themselves can also be tested without sample: Enter manually 1000mg, press START and enter empty boats. The difference of the results to those without boat give evidence about the blanks of the boats. These blanks and their deviations must be much lower than the expected sample results and much lower than the expected sample deviations, otherwise an analysis doesn't make any sense.

For even lower carbon samples, a furnace extension piece, supplied by ELTRA, needs to be attached to the furnace inlet.

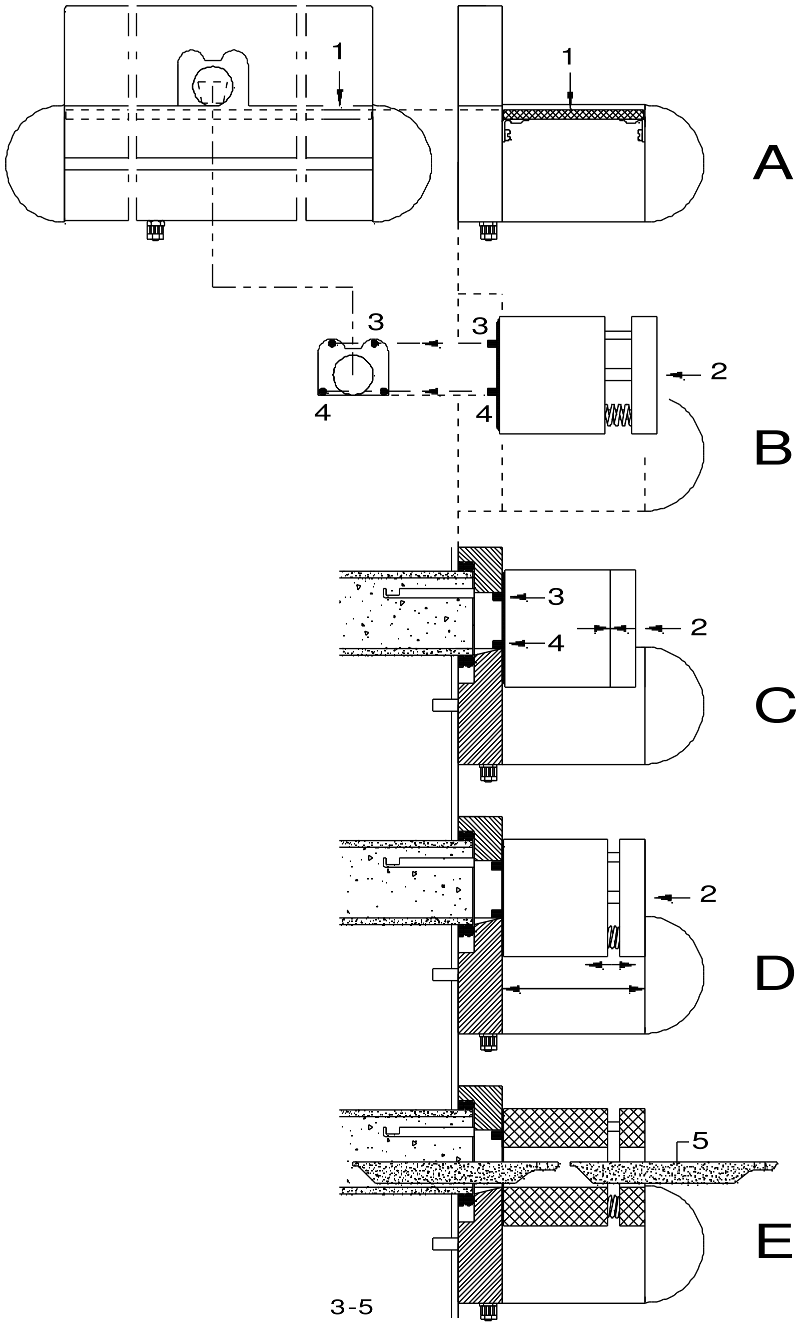
The reason is that the thick short combustion tube allows some air to enter the combustion area. The air contains some **CO_2** which is detected by the **carbon cell**. As the **CO_2** concentration resp. the air flow entering the furnace is not necessarily constant, the varying **CO_2** of the air will lead to a corresponding variations of the **base line**. Using **high carbon** analysis in **% range**, resp. for high carbon **IR-cells**, the **CO_2** of the entering air, practically doesn't have any influence on the results.For **low carbon** analysis, with sensitive **CO_2 cells**, the entrance of the resistance furnace has to be restricted.

The combustion boats that are used are the **slim quartz** boats. They have to be used, not only because the **bigger ceramic** boats can not pass through the restriction attachment, but also because the **quartz** boats have much **lower blanks** than the **ceramic** boats.

Even if the ceramic boats were able to pass through the attachment, they couldn't be used for **low carbon** analysis anyway, because of their high **carbon blanks**.

To Install the low carbon attachment: See drawing next page.

Installing the low carbon attachment.



- Lift and remove the glass platform **(1)** from the furnace inlet.
- Make sure that the two **hexagon** socket screws **(2)** are turned clockwise up to the end. Use **4mm** socket wrench.
- Attach the device to the **furnace inlet**, so that the pins **(3)** and **(4)** fit into the furnace inlet.
- Loosen the two screws **(2)** until the ring **(5)** holds the device firmly in place.
- The combustion boats **(6)** can now be moved in and out the furnace.

3 MAINTENANCE

3.1 General information

Resistance furnace operation:

Every 25 to 40 analyses:

- Replace the **magnesium perchlorate** of the moisture trap of the resistance furnace. To save material, replace first the **upper half**. The next time replace the whole of the **magnesium perchlorate**. It is not necessary to replace the **glass wool**, unless it is penetrated by dust and particles of the **magnesium perchlorate**.

Remark: The above is related to **coal** analyses.

Induction furnace operation:

Every 100 analyses or at least once a month:

- Replace the **magnesium perchlorate** after the metal filter. See 3.3. Brush the metal filter. See 3.7-3.

Every 500 analyses:

- Clean the metal filter in an ultrasonic cleaner. See 3.7-3.

Every 1000 analyses or if 1/3 of the material turned grey:

- Replace the paper filters. See 3.3-5. Replace the **magnesium perchlorate** of both glass tubes.
- Replace the sodium hydroxide. See 3.3.

Every 2000 analyses:

- Replace the **copper oxide** in the catalyst furnace. See 3.3.
- Replace the furnace cleaning brush. See 3.5.
- Replace the cotton wool. It should be replaced earlier when the upper half becomes dark. See 3.3.

Remark:
The above is related to steel analyses and oxygen 99.5% pure.

CAUTION!

There are specially developed chemical qualities and accelerators for analysis devices.

- **Anhydrone, ascarite, iron phosphate**, among others. Normal commercially available materials of this type either fall short or are entirely useless for this purpose.

- Normal **magnesium perchlorate**, for example, causes memory effects and therefore, is not repeatable. A further typical effect is that the analysis takes too long and often never comes to an end. This effect also occurs with **magnesium perchlorate** of suitable quality if it is saturated.

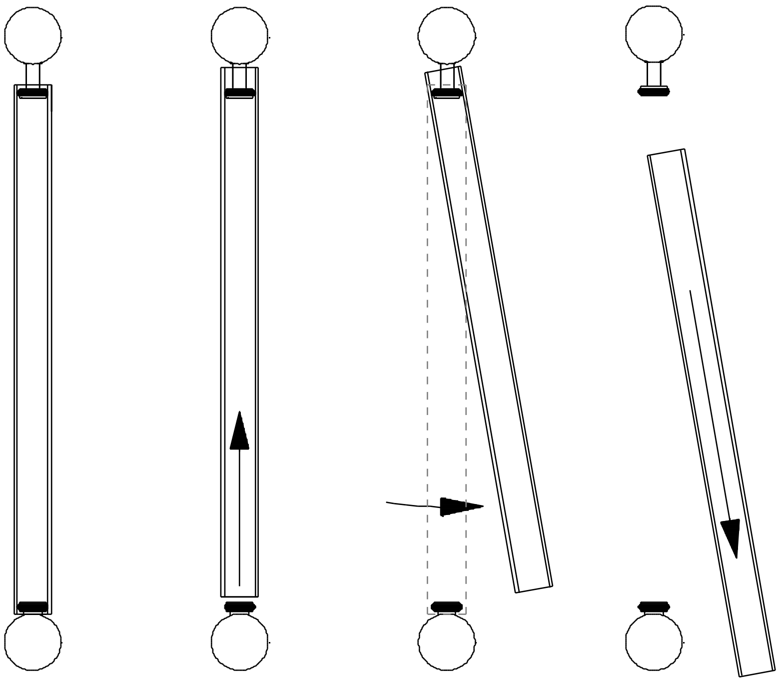
- Normal sodium hydroxide binds **CO_2** quite inadequately at room temperature. The special quality, on the other hand, reacts quite well at room temperature and has at the same time an indicator.

- The **glass tubes** and the **O-rings** should only be greased with **high vacuum grease**. Ordinary silicon grease is inadequate.

- It is left to the user to test normal materials. The device will **not** be damaged. When there are problems, the proper quality materials should be used, and these should be in absolutely unsaturated condition, **before** technical service is called.

- The chemical containers must be immediately and quite securely closed, so that they are not saturated with **CO_2** or **moisture**.

3.2 Installing and removing the reagent tubes



6-1-1

To replace the reagent tubes:
The reagent tubes are first lifted, then swung to one side, detached diagonally downwards and emptied.

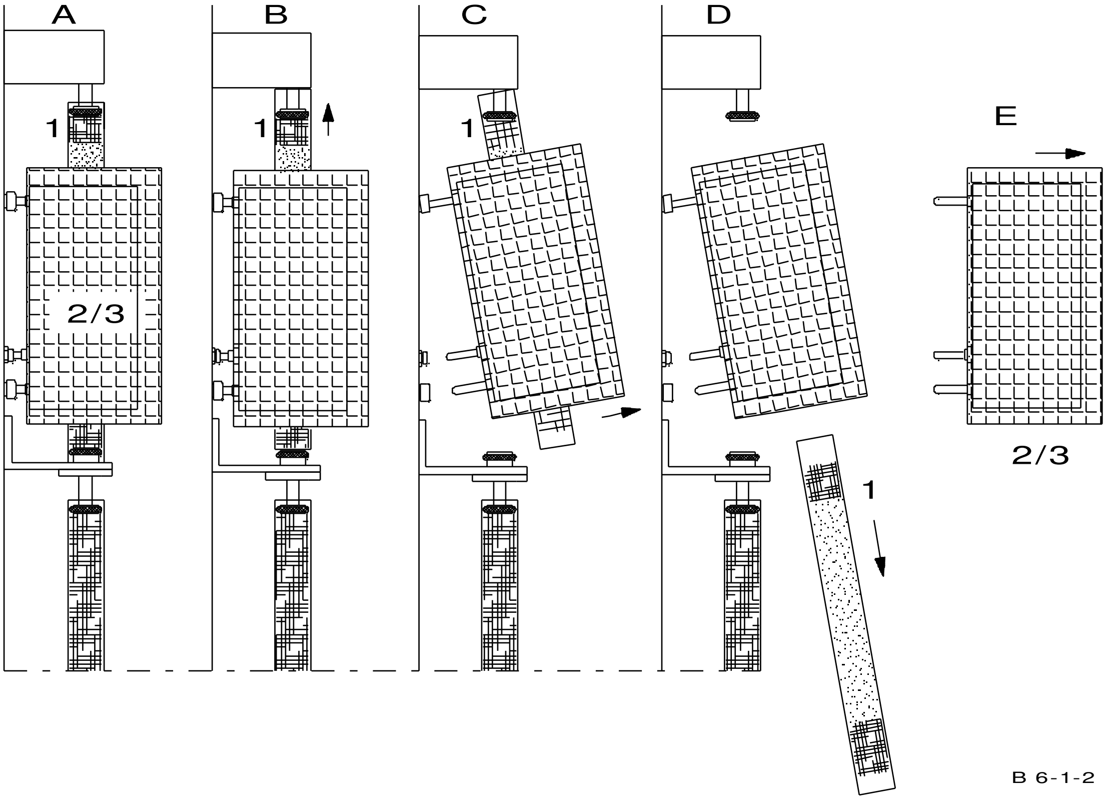
IMPORTANT:
The dimensions for filling the glass tubes given in the schematic of 3.3 should be respected in all cases.
When, for example, there is a rest of quartz wool in the bottom of the glass tube, it is possible that dust, forming **magnesium perchlorate** can fall through and block the fitting below or this can damage the analyser and the infrared cell.

NOTE:
Before the reagent tubes are fitted, both the O-rings and the inner ends of the tubes are lubricated with **high vacuum silicon grease**.

The components are refitted in reverse order.

CATALYST FURNACE:

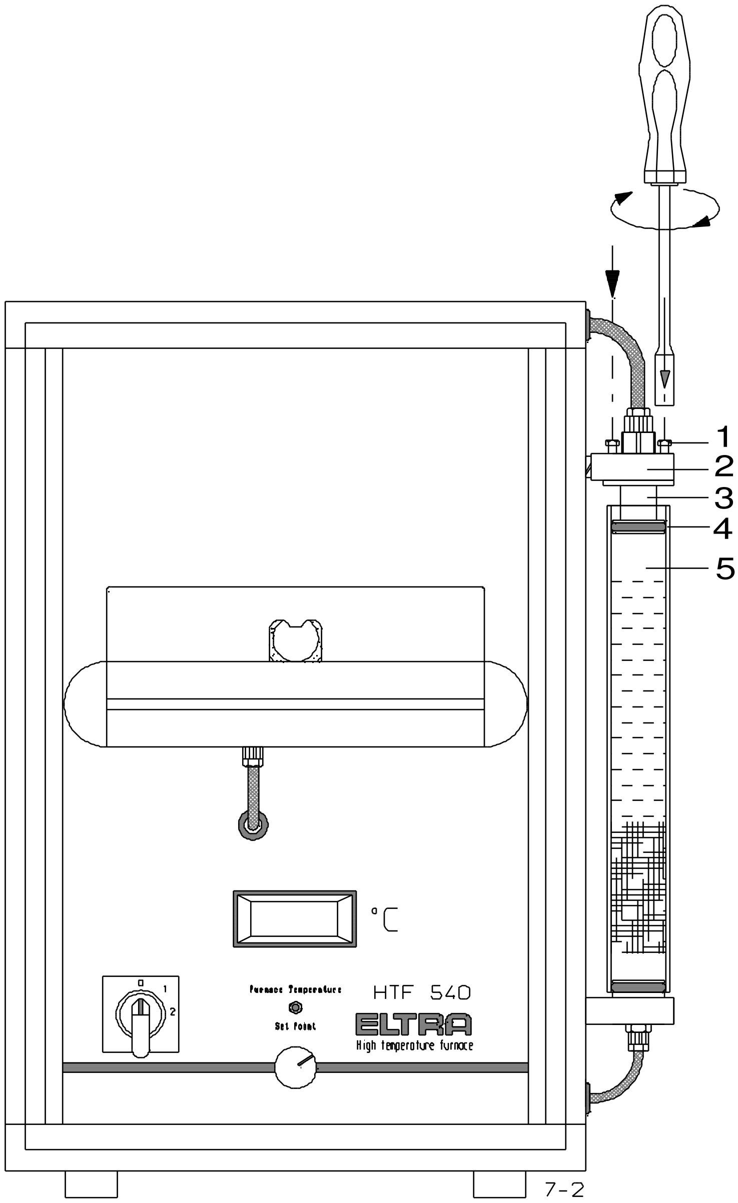
ATTENTION:
It should be remembered that the furnace temperature is about 450°, and protective gloves must be worn. It is safer, but not absolutely essential, to switch the analyser off.
Only the outside grid of the furnace is to be handled; the quartz reagent tube must only be held at the ends.



B: The quartz tube **(1)** of the furnace **(2 / 3)** is raised as far as it will go.
C: It is then swung out together with the furnace **(2 / 3).**
D: The quartz tube **(1)** is pulled put diagonally downwards
E: The furnace **(2)**, together with the grid **(3)** is removed.

The components are refitted in reverse order.

Replacing the moisture trap on the furnace



- Turn both screws **(1)** counter clockwise, until the ring **(3)** touches the part **(2)**.
- Lift the glass tube **(5)** upwards, tilt it to the side and pull downwards.
- Replace the magnesium perchlorate (anhydrone).
- Install the glass tube **(5)** in reverse order.
- Turn both screws **(1)** clockwise until the O-ring **(4)** is properly pressed on the inner surface of the glass tube **(5)**.

3.3 Filling the reagent tubes

The following chemicals are used:

Magnesium perchlorate (anhydrone)	as moisture absorber
Sodium hydroxide	as CO_2 absorber
Copper oxide	as oxidiser ($CO \rightarrow CO_2$)

The reagent tubes are replaced when they are saturated. See 3.1.
It is not possible to dry the **magnesium perchlorate** and use it again, as it is chemically changed after reacting with the moisture. The saturation of the sodium hydroxide changes it's color **(it turns to light grey).** If the absorber particles do not move (e.g. tapping on the glass), then this is a sign that the **magnesium perchlorate** is saturated. It is essential to change the absorber before it is completely solid. The moisture absorber should be checked after **100-200 induction analyses** and if necessary replaced **(glass tube underneath the metal filter).**

The reagents tubes are replaced when they are saturated with moisture. The moisture steams from the combustion and has two sources. One source is the water content of the sample. By drying the sample in a furnace at about **80°C**, the moisture content can be reduced. The drying process takes some **hours**. The sample is laid in a fairly flat bowl and should be spread as thin as possible. The second source is the sample's **hydrogen** content, which is found in the form of various **hydrogen** compounds.

Since different samples contain various amounts of **moisture**, it is hard to give a precise number of analyses that can be made before the reagent tubes should be replaced. In addition, the saturation level of the absorber are at highest at the gas entry point and fall off toward the exit. A clear sign of total saturation is when the absorber's particles do not move freely when the glass tube is tapped. Under any circumstances neglect the changing of the absorbers until it is completely hard. Normally, the moisture absorbers should be checked after **30 to 40 analyses.**

Please refer to the following schematics to identify the glass tubes on the analyser. In addition to the reagents in the glass tube, fill the bottom end of the tube with **annealed quartz/glass wool**. One should pay attention that the quartz/glass wool should be only as **thick** as necessary, otherwise the flow of gas can be **choked**. Under no conditions should the amount of quartz/glass wool be less than that given in the following schematics, since fine particles of **magnesium perchlorate** can pass through the wool and collect itself at the bottom of the tube, causing severe damage.

It should be pointed out that **magnesium perchlorate** is a very strong **oxidative material**. At both ends of the glass tube, you should leave sufficient space for the gas connections to be fitted. The free space at the tube ends serve as sealing space. They must be cleaned after filling. The **O-rings** must be cleaned. Both the **O-rings** as well as the **sealing** areas of the tube must be greased with **high vacuum silicon grease.** This eases the assembly as well as the disassembly and further improves the seal. Only the upper end of the **thick glass** tube and the corresponding O-ring should not be greased.
For instructions on removing and installing the glass tubes refer to 3.2.
Make sure that the O-rings are completely sealed around glass tubes.

The reagent tubes are filled as follows:

For the chemicals to be retained in the reagent tubes the lower end is filled with glass wool. Do not stuff the glass wool too tight, otherwise the gas flow is blocked. The rest of the tube is filled with the appropriate chemicals. The lower half of the reagent tube for the **oxygen** pre-cleaning tube is filled with anhydrite and the upper half with **sodium hydroxide.** The chemicals are separated by a quantity glass wool. The tube at the furnace outlet is filled with **2/3 anhydrone** and the remaining **1/3** with **glass wool**.

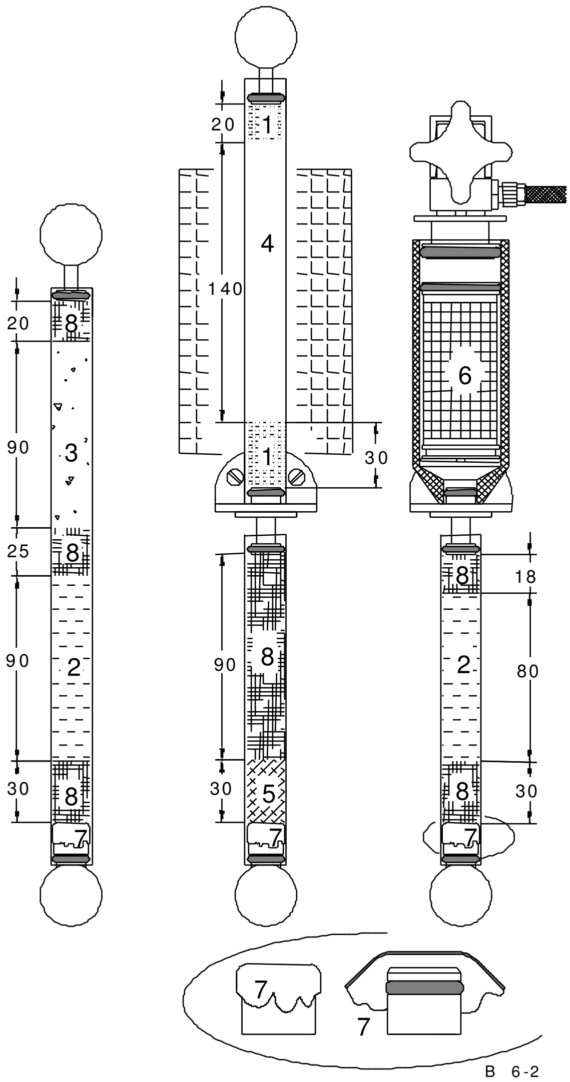
Sufficient **space** must be left at **both ends** of the tube so they can be attached to the glass fittings. The free inner surface at the ends of the tubes serve as sealing surfaces. And must be cleaned after filling.

The **O-rings** also have to be clean. Both the **O-rings** and the **sealing surfaces** on the tube should be greased with **silicon grease.** This simplifies the fitting and particularly the removal of the tube, and ensures proper **sealing**.

Make sure that the O-rings are completely sealed around the glass tubes.

Each filling quantity carries a tolerance of ± 20 %

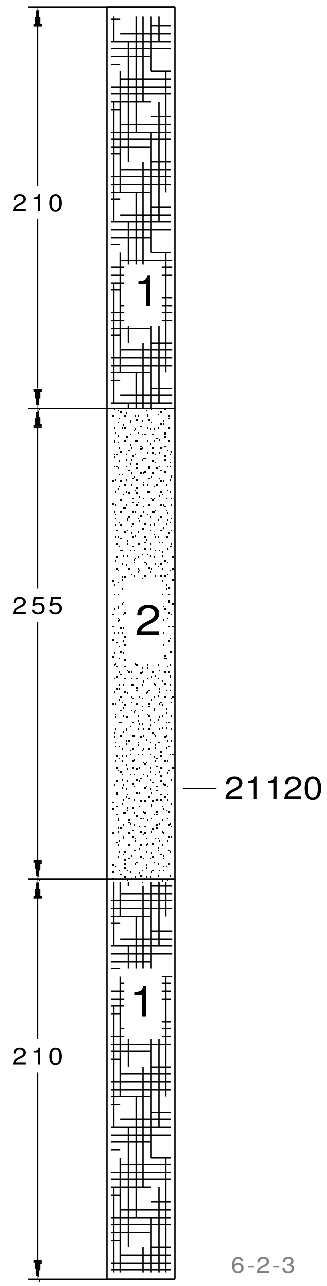
Material	Part No.
1. Quartz wool	90330
2. Anhydrone	90200
3. Sodium hydroxide	90210
4. Copper oxide	90290
5. Cotton wool	90340
6. Metal filter	11105
7. Paper filter	11185
8. Glass wool	90331



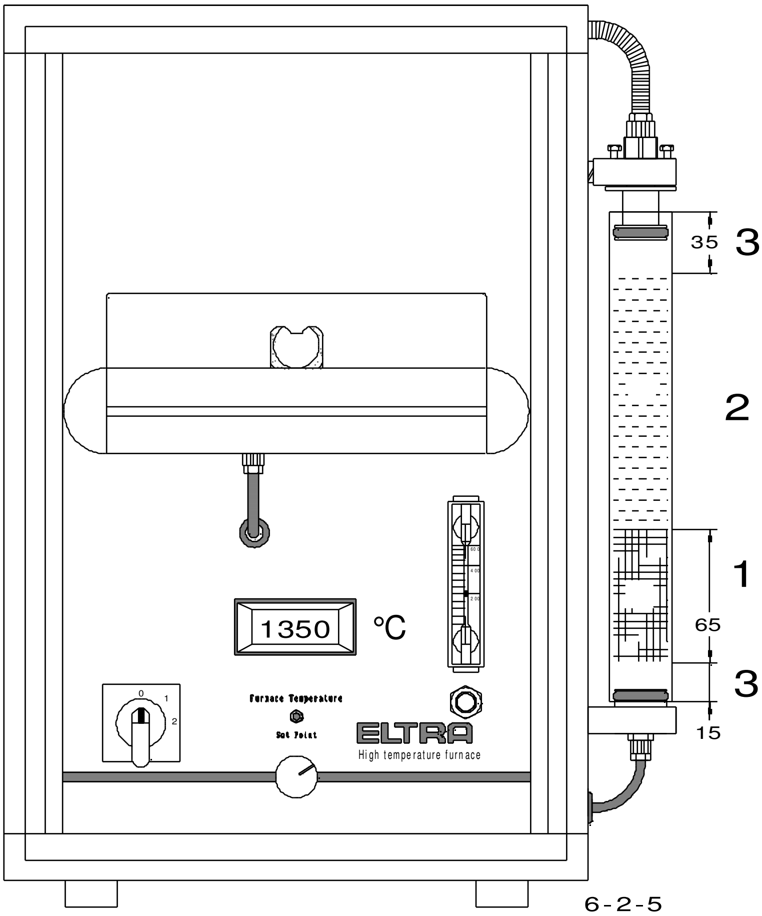
Filling the oxygen purifying furnace glass tube:

Each filling quantity carries a tolerance of ± 20 %

Material	Part No
1. Quartz wool	90330
2. Copper oxide	90290



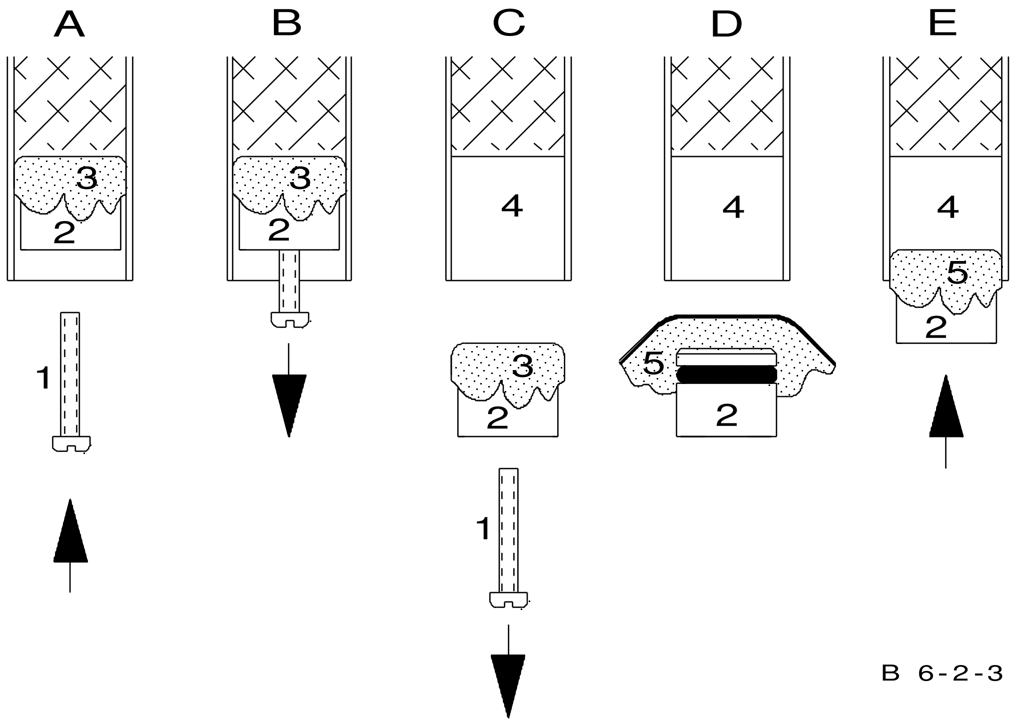
Filling the resistance furanace moisture trap:



Each filling quantity carries a tolerance of **± 20 %**

Material	Part. No
1. Glass wool	90331
2. Magnesium perchlorate (anhydrone)	90200
3. Free (empty)	

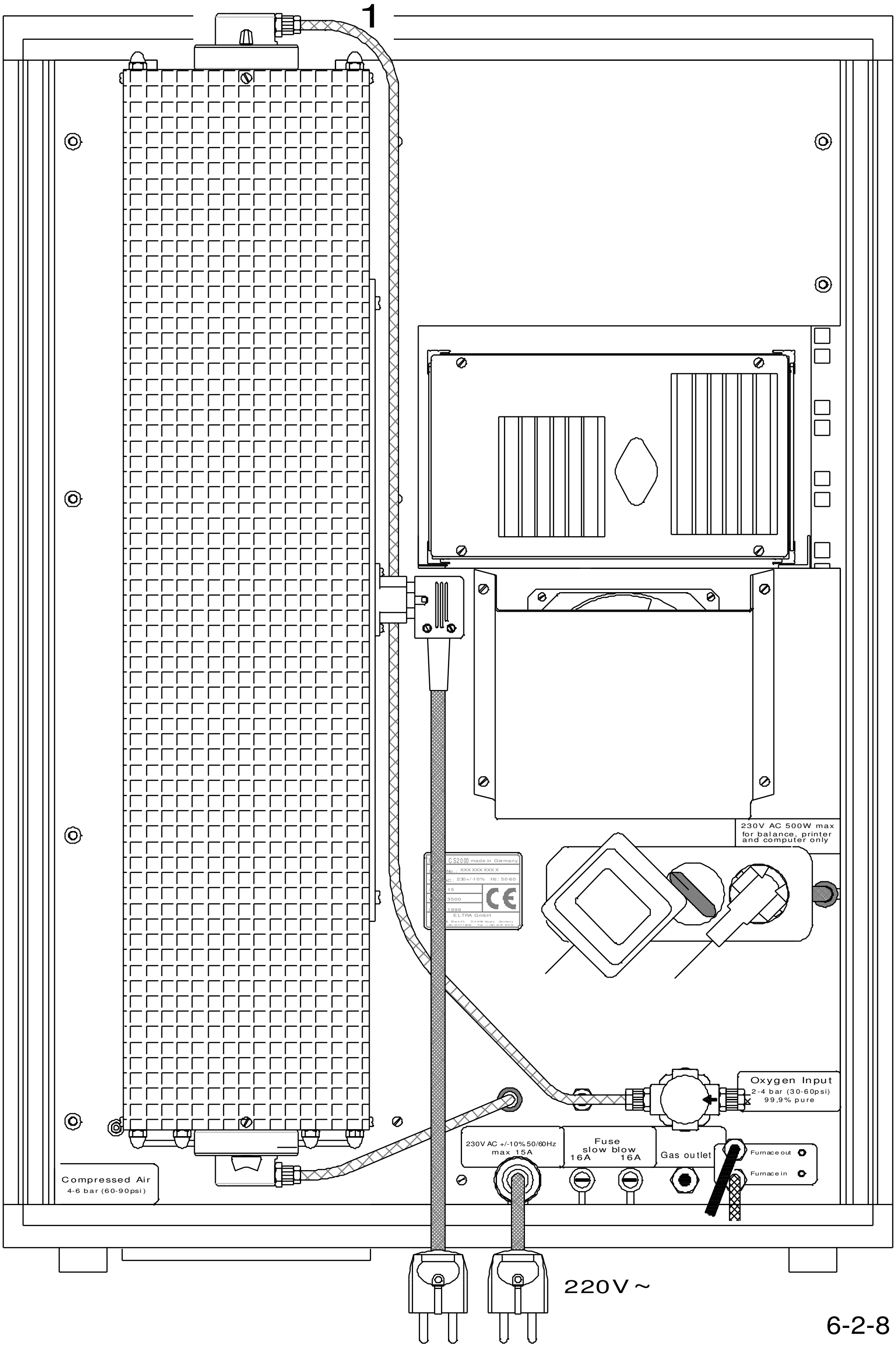
Changing the paper filter:



A Screw a M4 screw **(1)** into the paper filter holder **(2)**.
B With this screw, pull the filter holder **(2)** and the filter **(3)** out of the reagent tube **(4)**.
C Remove the screw **(1)** from the filter holder **(2).** Remove the old filter **(3)**.
D A new filter **(5)** is placed on the filter holder **(2)** and folded over.
E The filter holder **(2)**, with the new filter **(5)** is pushed carefully, back into the reagent tube **(4)**.

Connecting the furnace for gas pre-cleaning:

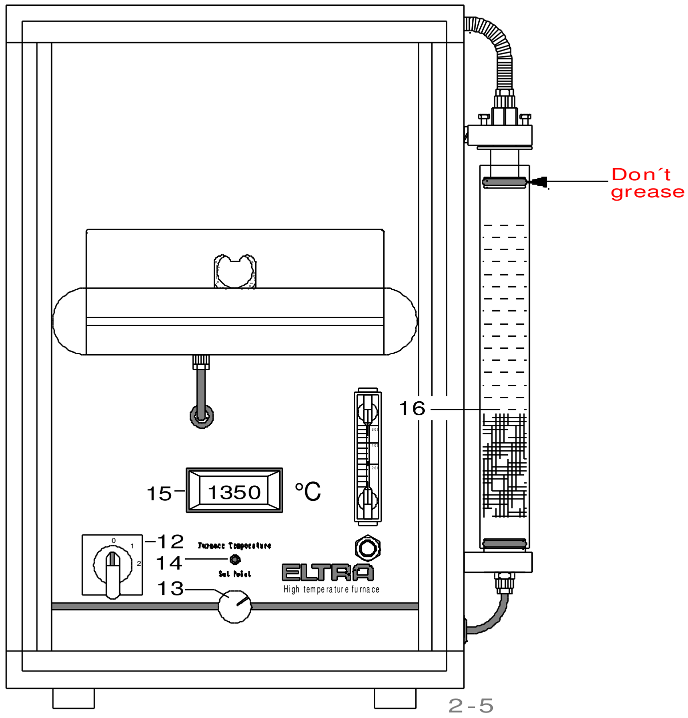
Tube for oxygen inlet **(1)**



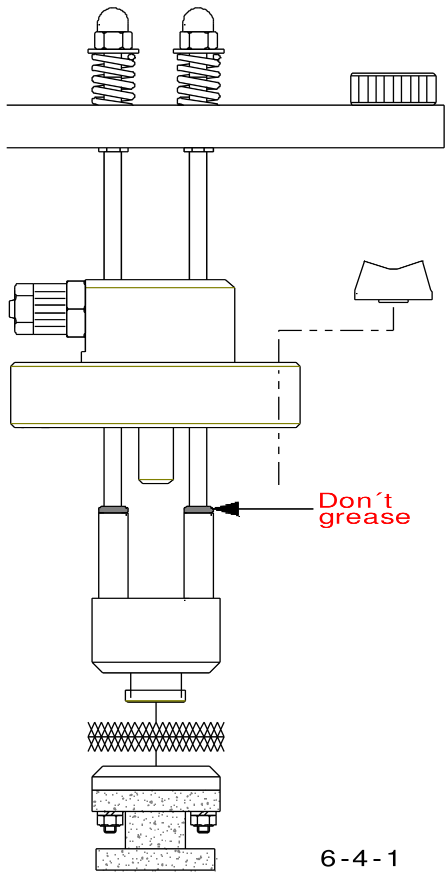
6-2-8

3.4 Replacing the O-rings

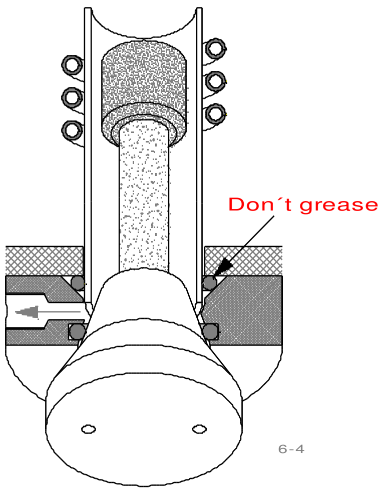
The **O-rings** are only replaced when they can no longer adequately seal, due to severe damage or age. When removing the **old** O-rings, be ensure that the sealing area of the fittings are not damaged. The groove in which the old O-ring sat must be cleaned, so that it is completely **free of grease.** The new O-ring should under **no-circumstances** be greased before installing, **only** after installation. Otherwise, **the O-ring will turn with the glass tube** when trying to remove it.



Neither the O-ring nor the upper end of the thick glass tube of the resistance furnace is to be greased.

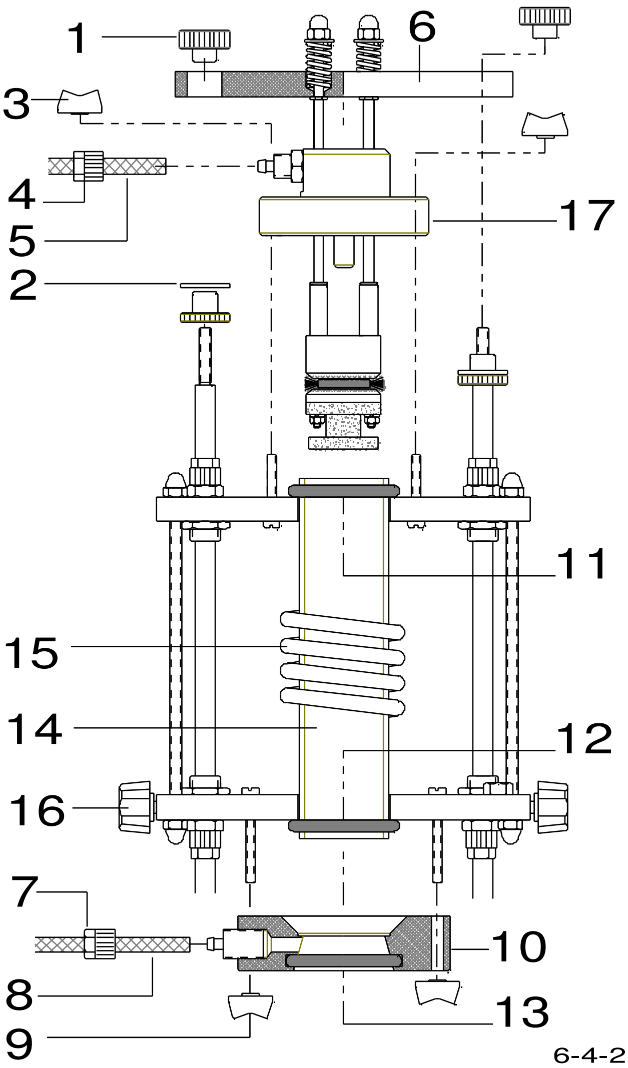


The small O-rings for sealing the top of the induction furnace should also not be greased.



The O-ring for sealing the cone should also not be greased.

O-rings for induction furnace:



1 Knurled nut
2 Washers
3 Wing nuts
4 Nut for gas inlet tube
5 Gas inlet tube
6 Mounting
7 Nut for gas outlet tube
8 Gas outlet tube
9 Wing nuts
10 Lower furnace lock
11 Upper O-ring for combustion tube
12 Lower O-ring for combustion tube
13 O-ring for lower furnace lock
14 Combustion tube
15 Induction coil
16 Nuts for furnace housing
17 Upper furnace lock

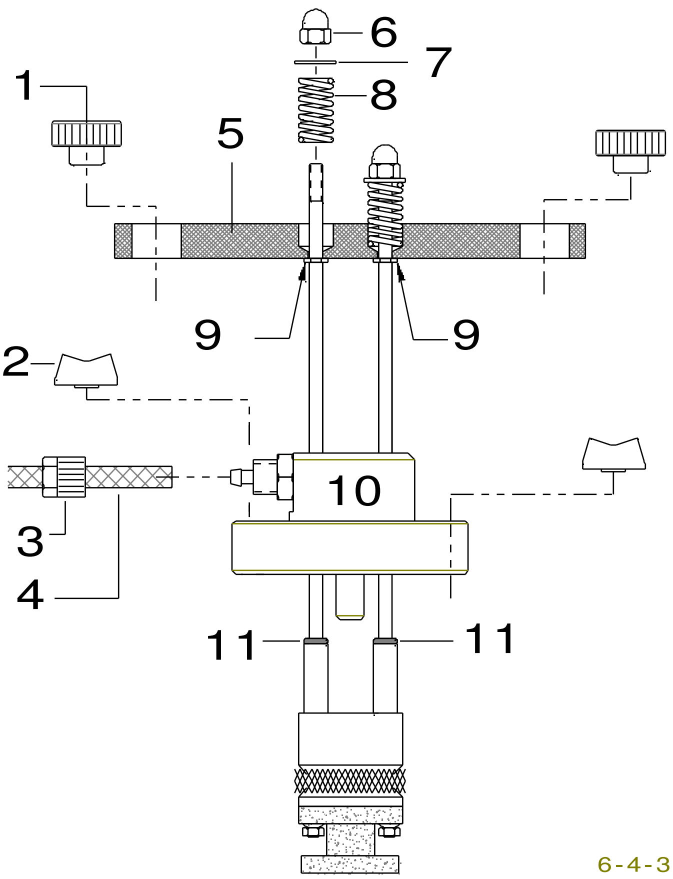
Replacing the O-rings (11 and 12) for combustion tube:

- Remove the furnace housing by just loosening the nuts **(16)**.
- Open the furnace.
- Unscrew the knurled nuts **(1)** and washers **(2)**.
- Unscrew the wing nuts **(3)**.
- Unscrew the nut **(4)** and detach tube **(5)**. If there are two tubes, remove them both.
- Remove the furnace cleaning system, by pulling up the mounting **(6)**.
- Unscrew the nut **(7)** and detach the tube **(8)**.
- Unscrew the wing nuts **(9)** and pull down lower furnace lock **(10)**.
- Now the O-rings **(11)** and / or **(12)** can be removed and replaced. Apply a **thin** layer of grease on the inner surface of the new O-rings, before mounting them. Apply a **thin** layer of grease on the outer surface of the combustion tube, where the new O-rings will be placed.
- Reinstall in reverse order.

Replacing the O-ring (13) for lower furnace lock:

- Remove the furnace housing by just loosening the nuts **(16)**.
- Unscrew the nut **(7)** and detach tube **(8)**.
- Unscrew the wing nuts **(9)** and pull down lower furnace lock **(10)**.
- Remove the O-ring **(13)** with a screwdriver; insert a new one **without greasing it**.
- Reinstall in reverse order.

Replacing the O-rings for induction furnace seal:



- Unscrew the knurled nuts **(1)**.
- Unscrew the wing nuts **(2)**.
- Unscrew the nut **(3)** and gas inlet tube **(4)** if there are two tubes, remove them both.
- Remove the furnace cleaning system, by pulling up the mounting **(5)**.
- Unscrew the nuts **(6)** and remove the washers **(7)** and springs **(8)**.
- Remove the mounting **(5)**.
- Remove the circlips **(9)**.
- Remove the upper furnace lock **(10)**.
- Remove and replace the O-rings **(11) do not grease these O-rings!**
- Reinstall in reverse order.

O-rings for reagent tubes:

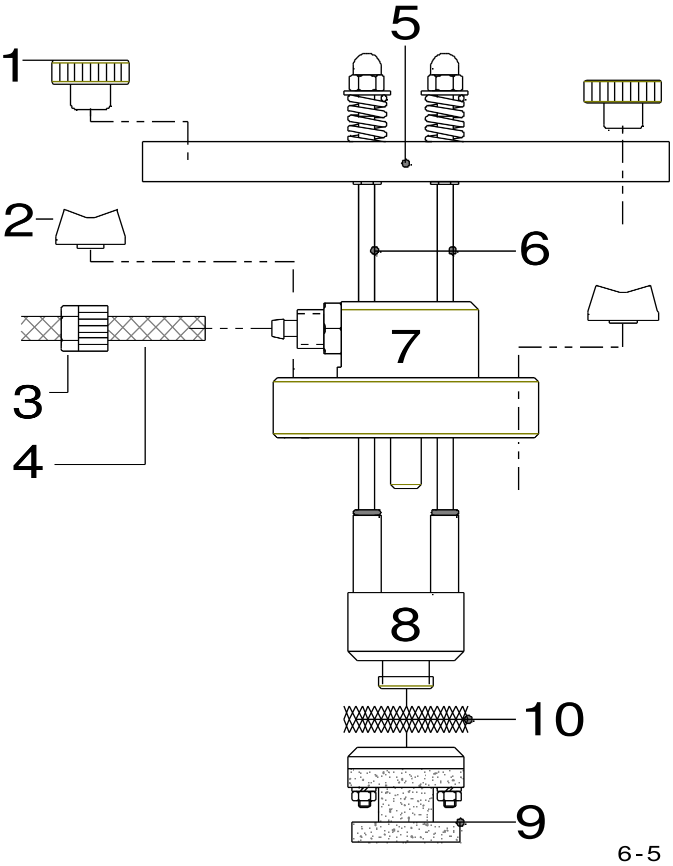
The O-rings should **only** be changed when they have **ceased** to seal properly, due to external **damage** or **ageing**. When removing the old O-rings, ensure that the sealing surface of the holder is not damaged. Once the new O-ring has been fitted, apply a very **thin** layer of grease on its outer surface. Clean and apply a very **thin** layer of grease, on the inner surface of the tube where the O-ring will rest, when mounting the tube.

3.5 Replacing the furnace cleaning brush

The furnace is equipped with a self-cleaning system. This mechanism contains a brush which cleans the **quartz tube** (combustion tube).

The position of the mains switch **(0, 1, 2 or 3)** is irrelevant.
If the brush is replaced during working time, then the mains switch of the analyser can be left in position **2,** and merely open the furnace.

1	knurled nut
2	wing nuts
3	nut for gas inlet tube
4	gas inlet tube
5	mounting
6	mounting rods
7	upper furnace lock
8	brush holder
9	heat shield
10	brush

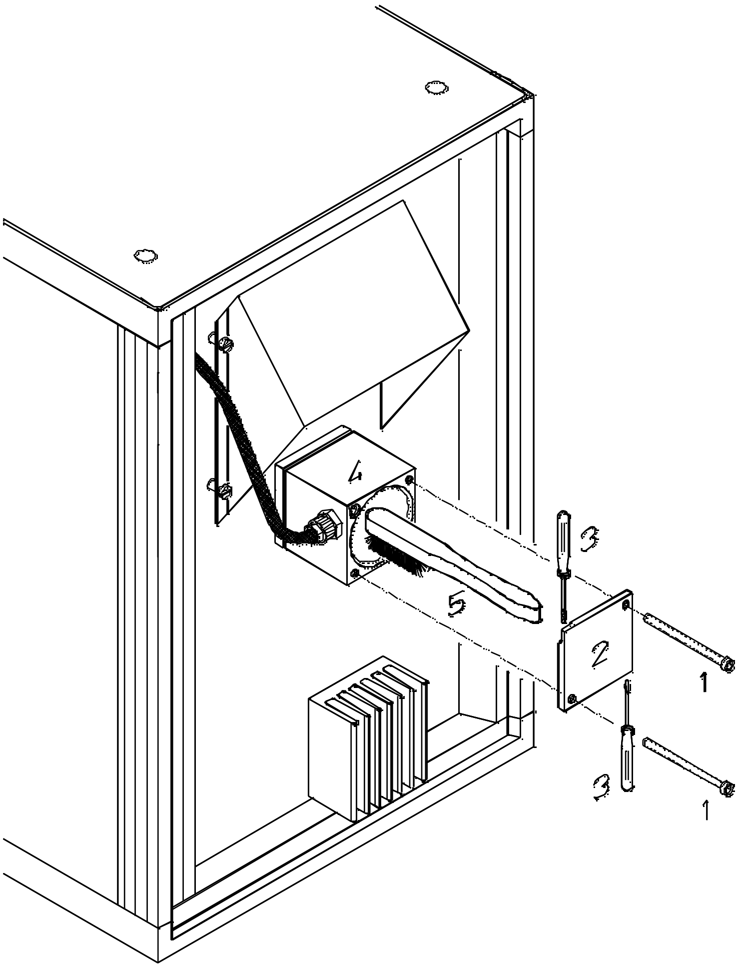


- Loosen the cover attachment knobs and remove the cover. See 1.2.
- Open the furnace.
- Remove the knurled nut **(1)**.
- Unscrew the wing nuts **(2)**.
- Loosen the nut **(3)** and detach the tube **(4)**.
- Remove the furnace cleaning system, by lifting up the mounting **(5)**.
- Hold the brush holder **(8)** tight and unscrew the heat protector **(9),** together with the brass ring.
- Remove and change the brush **(10)**.
- Reassemble in the reverse order.

IMPORTANT:

It is absolutely important to hold the brush holder **(8) and not** the mounting **(5),** when unscrewing the heat shield **(9),** or else the rods **(6)** will bend.

3.6 Cleaning the resistance furnace

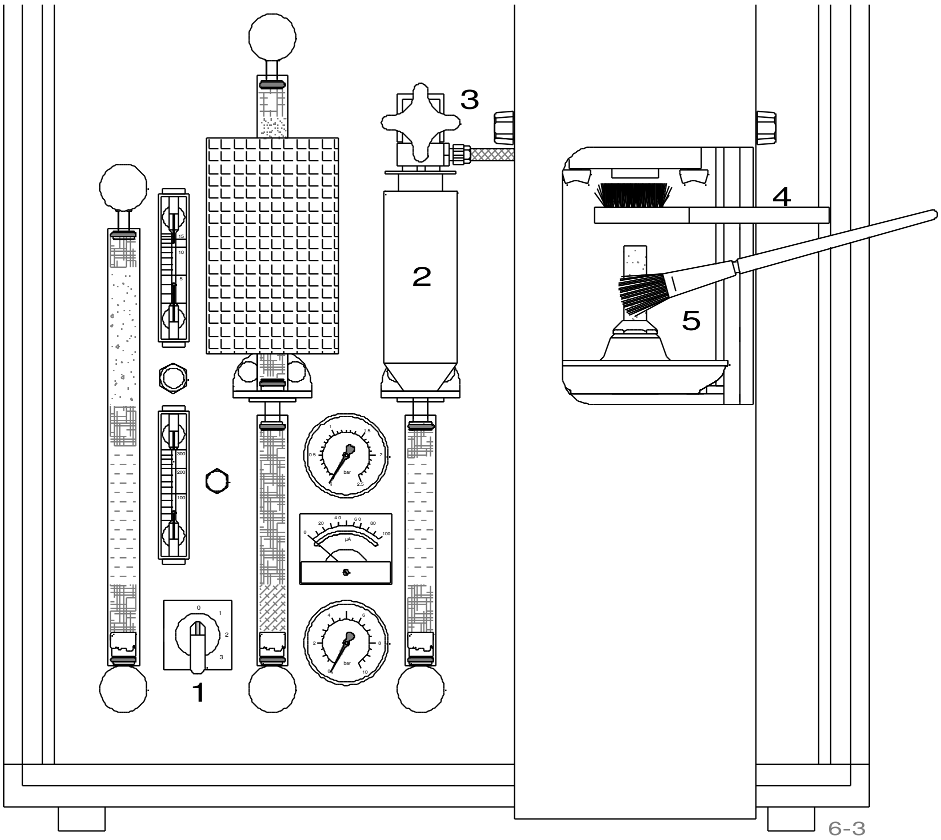


- Remove the two screws **(1)**.
- Remove the cover **(2)** using a screw driver if necessary.
- Remove the dust from the inside of the dust trap **(4)** using the brush **(5)**.
- Do the assembling in reverse order.

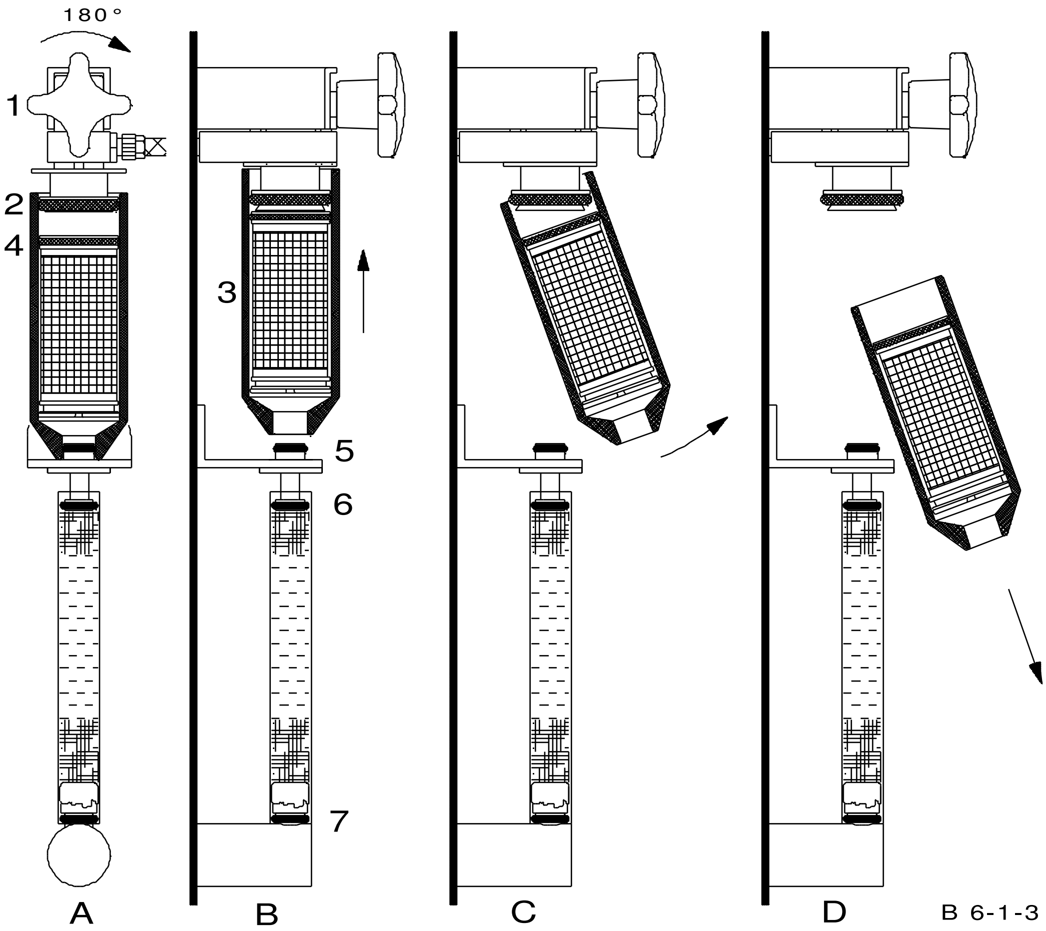
CAUTION:
The two screws **(1)** should be properly tighten to make sure that the system is sealed.

3.7 Cleaning the dust trap

Induction furnace:
The combustion chamber is automatically cleaned after each combustion; it is not necessary to clean the chamber manually.
The dust which exits in the furnace, together with the combustion gas, will be retained in the dust filter **(2)**. The dust filter only needs to be changed or cleaned after about **100** analyses. See 3.1.
Replacement of the dust filter takes only about 5 seconds.



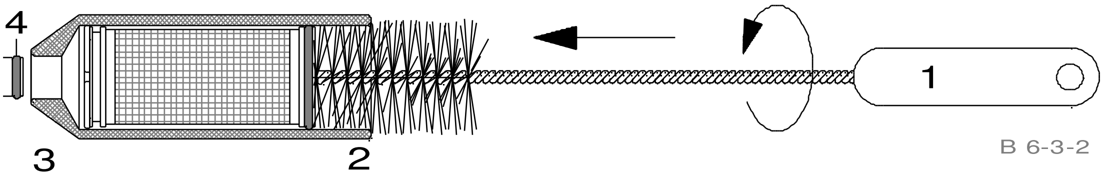
- The mains switch **(1)** stays at **position 2**.
- The oxygen is not turned off.
- Only the furnace is opened.
- The radiation shield **(4)** and the pedestal **(5)** can occasionally be cleaned.
- Remove the dust trap **(2),** see next page.



A The cock **(1)** is rotated by 180°, so that the O-ring **(2)** loosens.
B The dust trap **(3)** is raised as far as it will go.
C Swung to the side.
D Detached diagonally downwards.

A clean dust trap **(3)** is fitted in the reverse order. See **next page**.

Fast filter cleaning: **once every 200 analyses when using tungsten accelerator**
once every 100 analyses when using tungsten and Iron

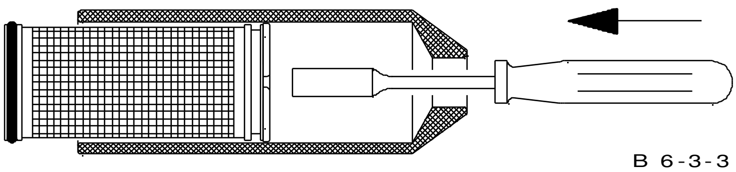


B 6-3-2

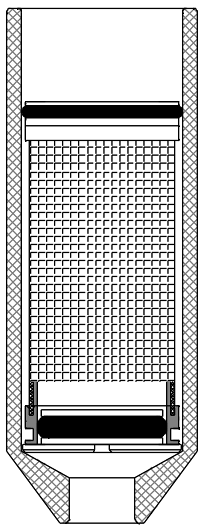
- Clean the dust using the brush **(1)** delivered with the analyser.
- Rotate in only one direction.
- Clean the upper end of the filter housing **(2)**.

CAUTION :
Lubricate only the lower end of the filter housing **(3)** and the lower O-ring **(4)**. The upper end of the filter housing **(2)** and the O-ring of the upper sealing mechanism should remain clean and absolutely **free of grease**.

For better cleaning: **once every 1000 analyses when using tungsten accelerator**
once every 500 analyses when using tungsten and Iron


B 6-3-3

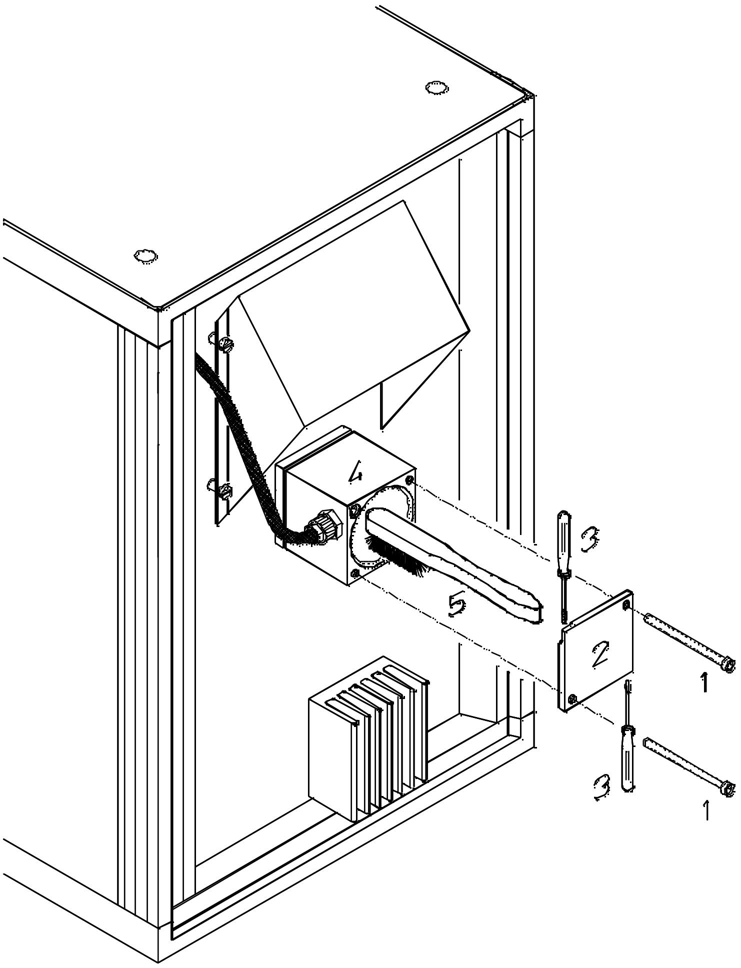
- Remove the metal filter out of the filter housing.
- Perform a preliminary cleaning, by using the brush.
- Clean the filter with an ultrasonic cleaner.
- Dry and, if necessary for assembling, lubricate the 0-ring.
- Clean the upper end of the filter housing **(2)** from any grease.


B 6-3-4

CAUTION:
Make sure that the filter is **absolutely dry (!!!)** after cleaning, since the inside of the filter is only **10 microns** net and it is impossible to see if the inside of the filter is dry. Therefore it is advisable to have a second filter, while drying the other one. The filter can be dried carefully, e.g. with hot air.

When reinstalling the filter in the filter housing, the O-rings must be correctly installed otherwise the gas flow will be completely blocked. Outer O-ring on top, inner O-ring to the bottom.

Resistance furnace:



- Remove the two screws **(1)**.
- Remove the cover **(2)** using a screw driver if necessary.
- Remove the dust from the inside of the dust trap **(4)** using the brush **(5)**.
- Do the assembling in reverse order.

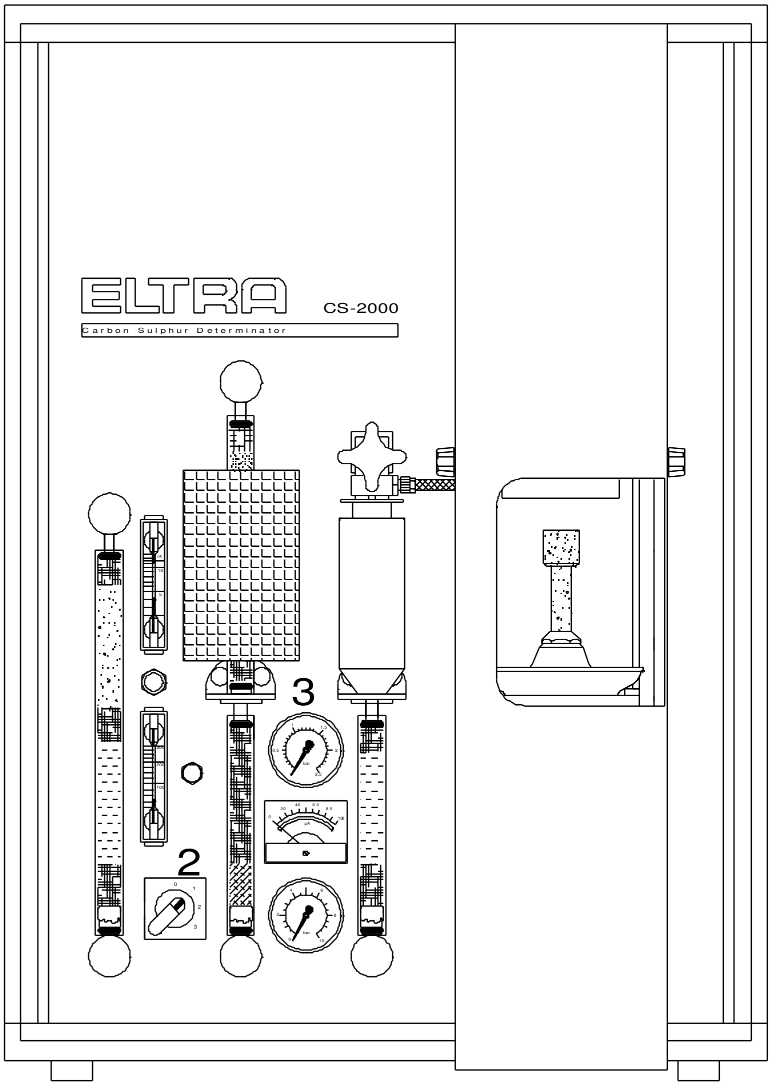
CAUTION:

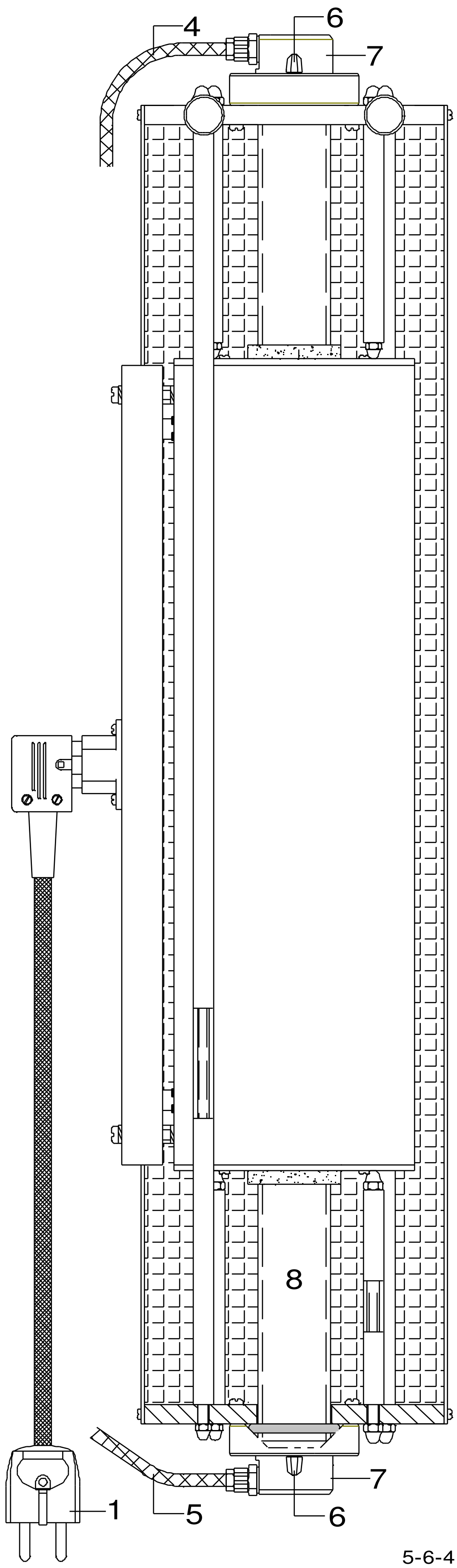
The two screws **(1)** should be properly tighten to make sure that the system is sealed.

3.8 Oxygen purifying furnace refilling

CAUTION: HIGH TEMPERATURE!

- Disconnect the power **(1)**.
- Close the oxygen supply (bottle).
- Keep the power switch **(2)** of the analyzer to position 1
- Wait until the pressure on the oxygen gauge **(3)** drops to zero.
- Disconnect the oxygen tubes **(4)** and **(5)** from the purification furnace.
- Lift the furnace and remove it from the analyser.
- Place the furnace in horizontal position.
- Unscrew all four nuts **(6)**.
- Remove the two parts **(7)**.
- Remove the glass tube **(8)** by pulling it horizontally.
- Empty and refill, see 3.3.



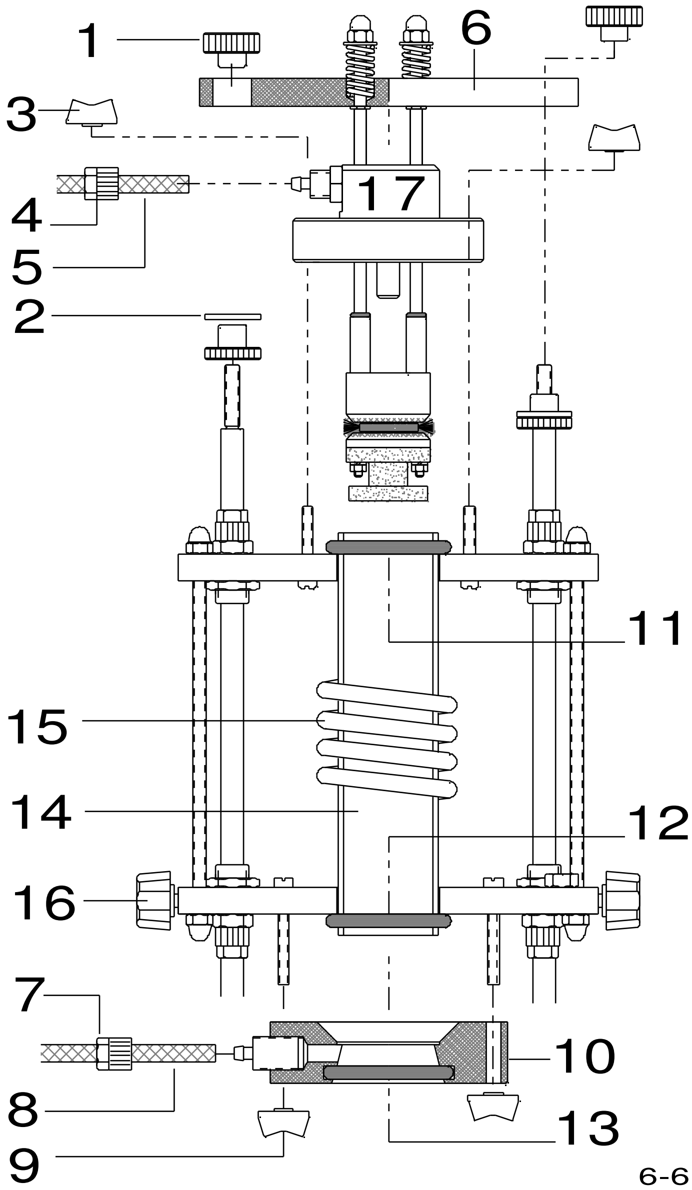


5-6-4

3.9 Replacing the combustion tube

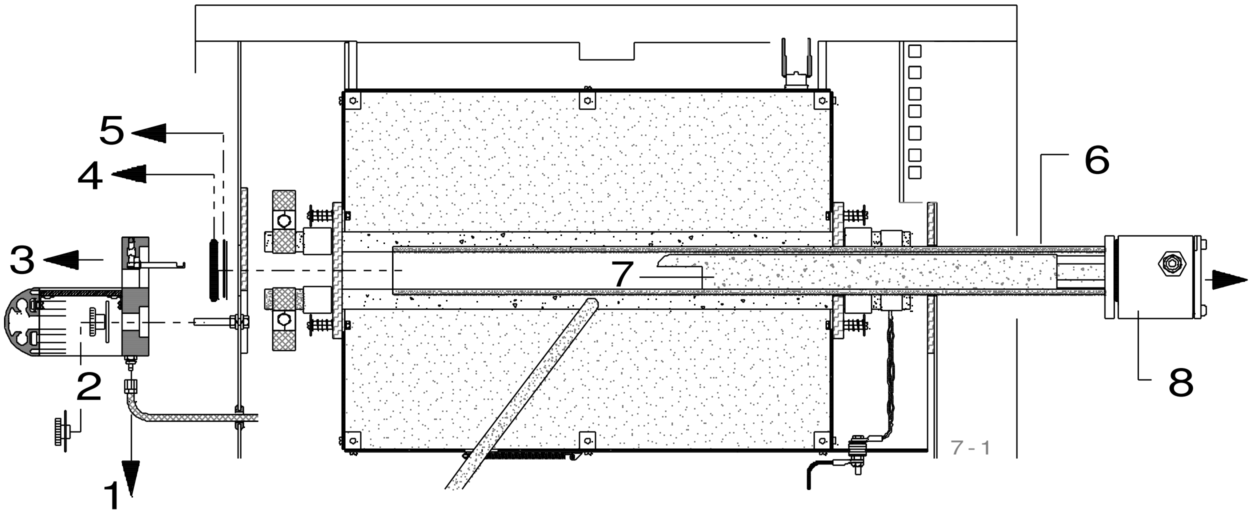
Induction furnace:

1	Knurled nut
2	Washers
3	Wing nuts
4	Nut for gas inlet tube
5	Gas inlet tube
6	Mounting
7	Nut for gas outlet tube
8	Gas outlet tube
9	Wing nuts
10	Lower furnace lock
11	Upper O-ring for combustion tube
12	Lower O-ring for combustion tube
13	ring for lower furnace lock
14	Combustion tube
15	Induction coil
16	Nuts for furnace housing
17	Upper furnace closing



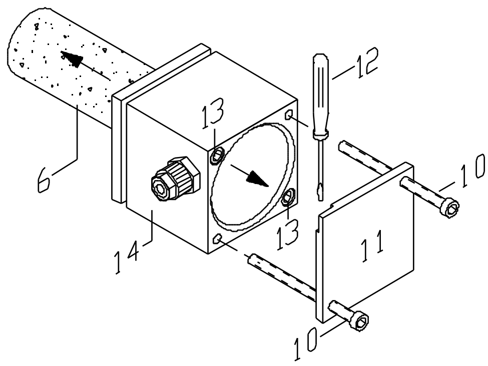
- Remove the furnace housing by just loosening the nuts **(16)**.
- Unscrew the knurled nuts **(1)** and washers **(2)**.
- Unscrew the wing nuts **(3)**.
- Unscrew the nut **(4)** and the detach tube **(5)**.
- Remove the furnace cleaning system, by pulling the mounting **(6)**.
- Unscrew the nut **(7)** and the detach tube **(8)**.
- Unscrew the wing nuts **(9)** and pull down lower furnace lock **(10)**.
- Pull-off the lower O-ring **(12)** from the combustion tube, remove the combustion tube **(14)** by pulling it up; remove the upper O-ring **(11)**.
- Apply a **thin** layer of grease on the inner surface of the new O-rings **(11)** and **(12),** before mounting them. Apply a **thin** layer of grease on the outer surface of the combustion tube, where the new O-rings will be placed.
- Reinstall in reverse order.

Resistance furnace:



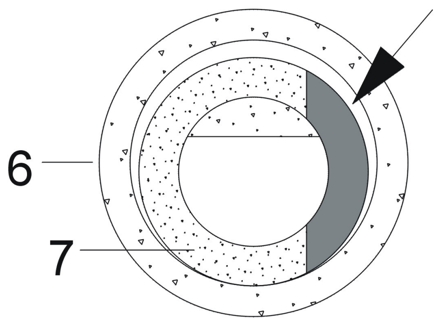
CAUTION: Unplug the main cable before opening this device!

- Switch off the furnace and disconnect the power plug.
- Remove the oxygen tube **(1)**.
- Unscrew the knurled nuts **(2)** and remove the platform assembly **(3)**.
- Remove the O-ring **(4)** and the safety spring **(5)**.
- Remove the plastic tube from the dust box **(8)** at the furnace outlet.
- Pull the dust box **(8)** out, together with the combustion tube **(6)** out of the rear of the furnace.
- Remove the boat stop **(7)** out of the combustion tube.
- Dismantle the dust box by removing the screws **(10)** and remove the cover **(11)** using a screw driver **(12)**, if necessary.
- Unscrew the screws **(13)** and remove the complete dust box assembly **(14)**.
- Remove the old combustion tube **(6),** install the new one.

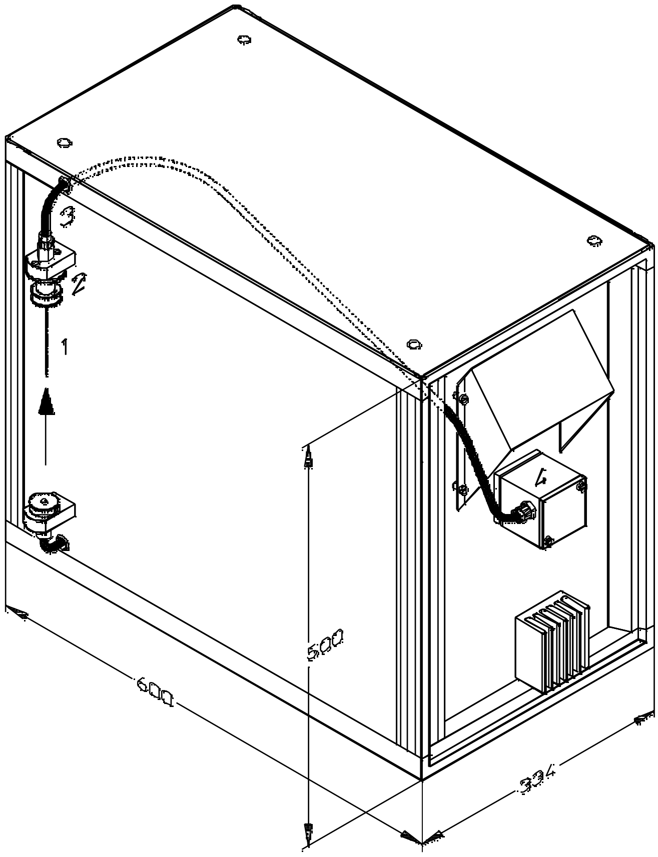


CAUTION:
Slide the new combustion tube **very slowly** and **perfectly horizontally** into the furnace or else the heater elements may get damaged.

- Slide the boat stop **(7)** into the combustion tube and ensure that it is positioned according to this drawing, (furnace rear-side).
- Reinstall furnace in reverse order.

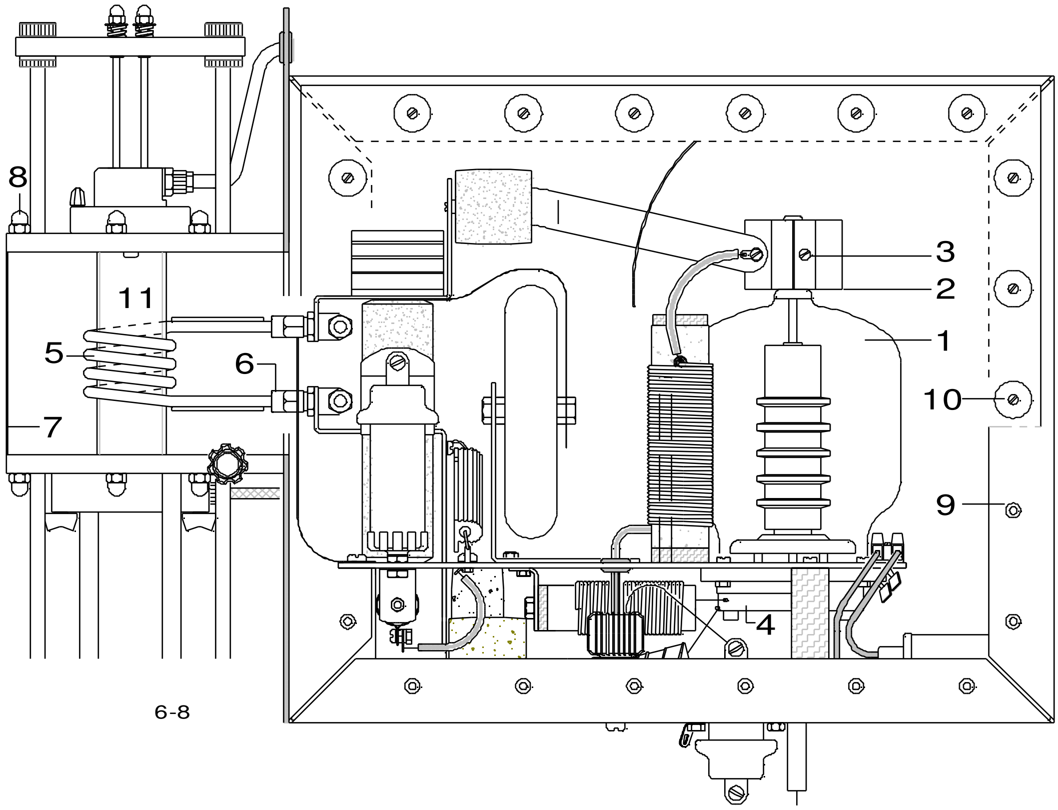


3.10 Cleaning the resistance furnace tube



Push the teflon (white tube) **(1)** through the upper glass tube assembly **(2),** pass it trough the tube **(3)** up to the inside of the dust trap box **(4).**
This can preferably be done when the glass tube has to be removed anyway, for replacing the **magnesium perchlorate (anhydrone**).

3.11 Replacing the generator tube



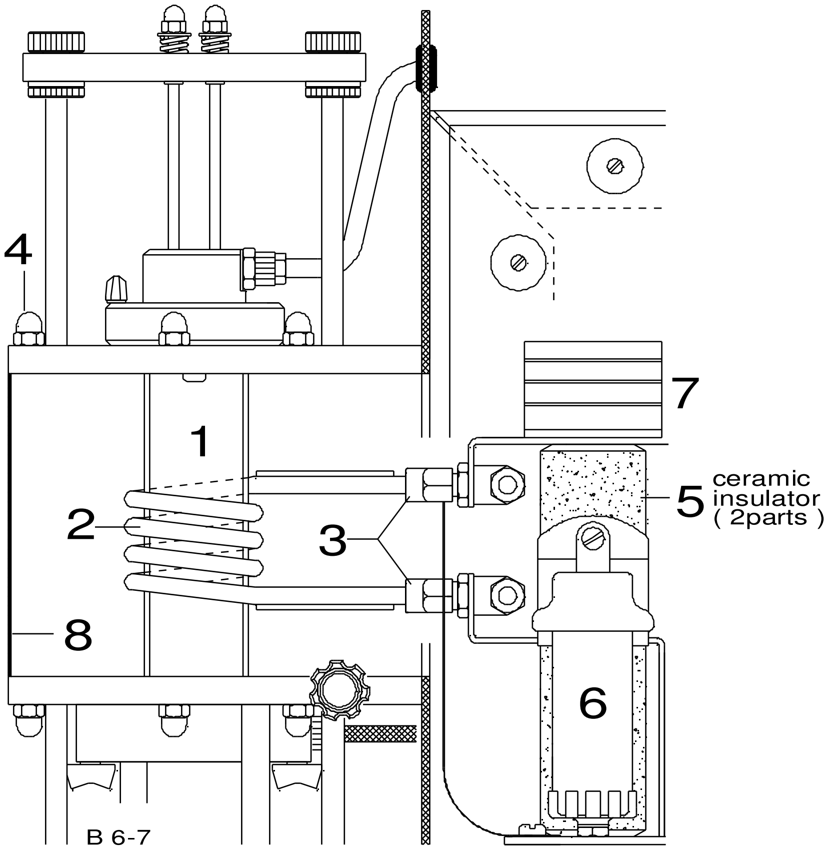
1	tube	7	furnace cover
2	anode connection	8	upper cap nut SW 8
3	screw	9	oscillator housing
4	socket	10	screw
5	coil	11	quartz tube
6	nut SW 12		

ATTENTION:

In order for the oscillator housing to be properly screened against radio frequencies, all screws **(10)** must be properly tightened ; otherwise there is a risk of radio frequency disturbance.

3.12 Changing the combustion coil

1 combustion tube
2 coil
3 nut SW12
4 cap nut SW8
5 ceramic insulator (2 parts)
6 500 pF capacitor
7 cooling system
8 furnace cover

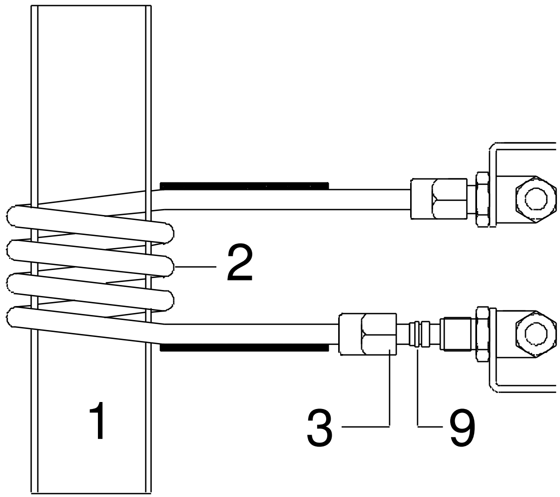


- set the mains switch to **position 1**
- loosen the upper cap nuts **(4)** (SW 8)
- detach the cover **(8)**
- remove the combustion tube **(1),** see 3.3.
- remove the nut **(3)**
- remove the coil **(2)**
- refit the coil **(2)** in the reverse order

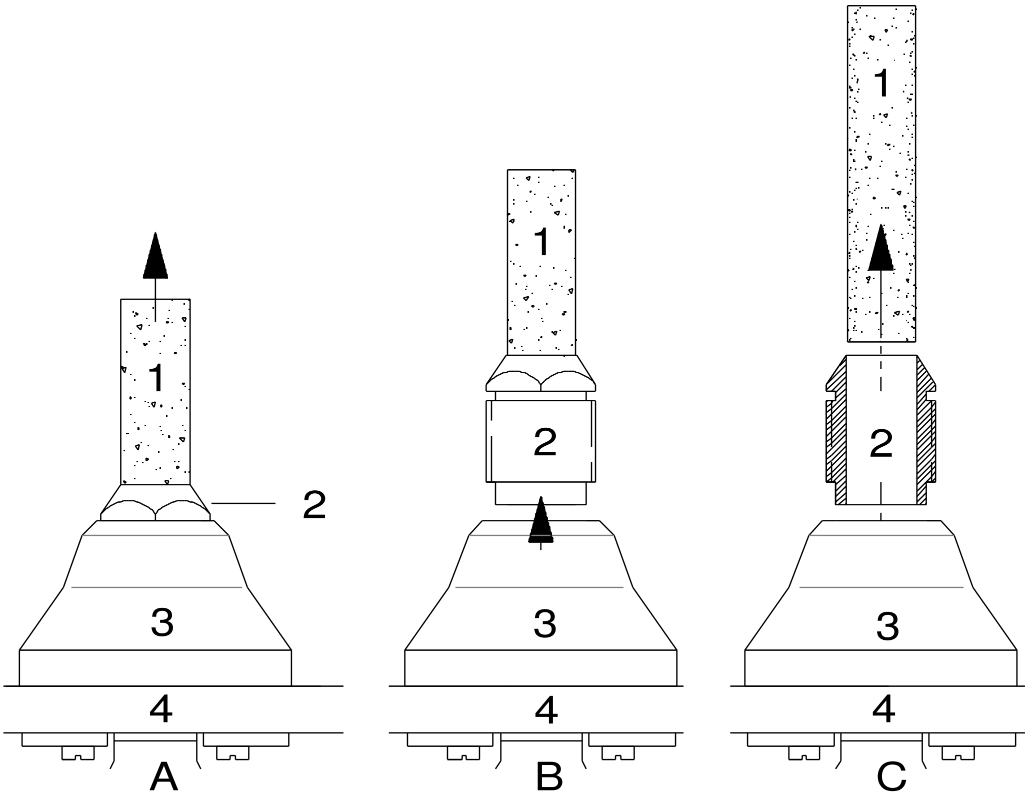
IMPORTANT:

The fastening for the coil arms **(4)** are adjusted to ceramic and metal material. Therefore it is necessary to use minimum force to change the coil **(2)**. While tightening or loosening the nuts **(3)** it is advisable to counterbalance the upper and the lower ceramic insulator **(5)** to avoid damage. **(they are sensitive and might crack or break)**. The contact of the coil arms is of great importance. A poor contact causes heating and oxidisation, so that the contact progressively deteriorates. It is advisable to clean the contact surface **(9)** and the screw fitting (threads) **(3)** with a thin wire brush to obtain the proper connection. See **drawing below**.
The coil **(2)** should be positioned so that it does **not touch** the combustion tube. For this reason, the nuts should not be pulled tight until the combustion tube **(1)** has been fitted. The nuts **(3)** should be tightened far enough, for the coil to be properly clamped at the ends.

1 combustion tube
2 coil
3 nut
9 contact surface



3.13 Removing the pedestal

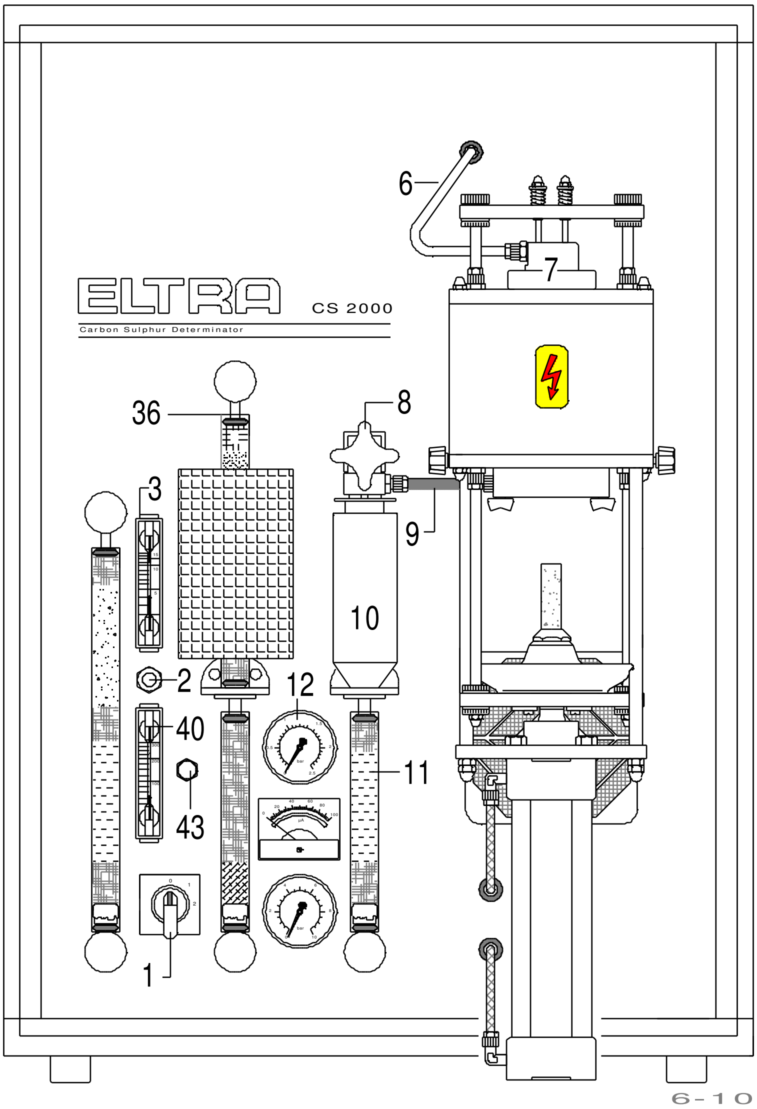


A: Remove the pedestal **(1)** from the furnace closing mechanism by lifting.

B: If the pedestal can not be easily extracted unscrew with a **24 mm** spanner the nut **(2)** from the cone **(3)**.

C: This will give access to the bottom of the pedestal allowing its extraction. When fitting nut **(2)** to cone **(3)** ensure there is no dust in the threads of the components. A vacuum cleaner can be used to clean the threads prior to assembly.

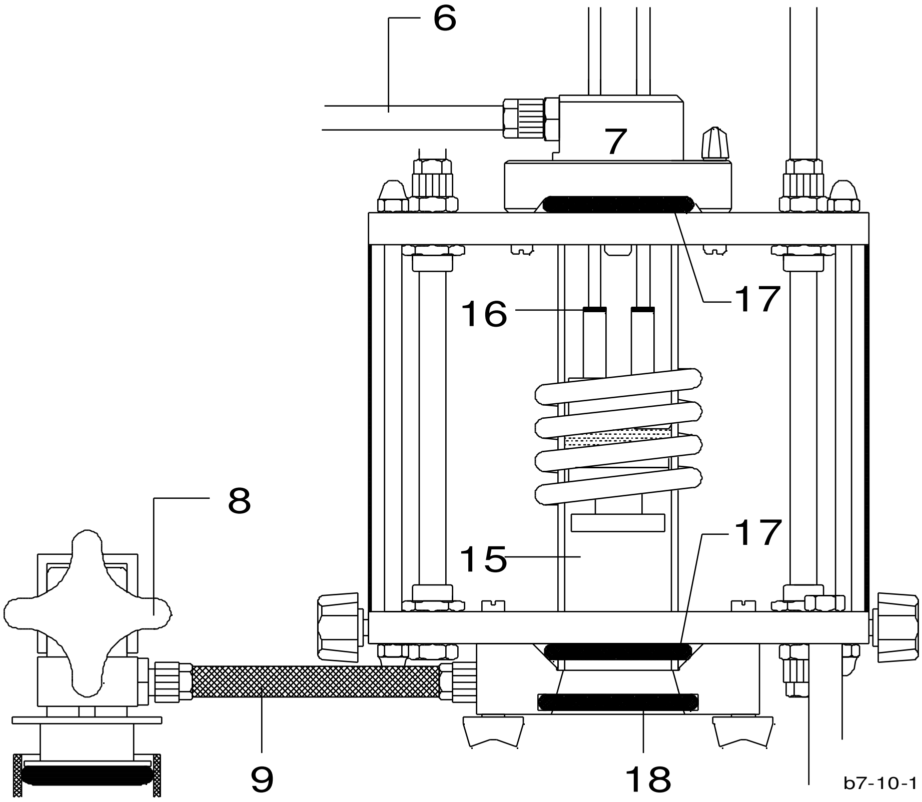
3.14 Checking for gas leaks



- Set the power switch **(1)** to pos. 2.
- Close the furnace
- Press and hold the push button **(43).** The entire system will be checked for leaks.

  After about 5 seconds of initial pressure drop, the pressure on gauge (12) remains constant, then the leakage test is completed. The gas system is ok.

- Should there be a continuous pressure drop, then release the push button **(43),** open the furnace, and press and hold the push button **(43)** again.
  If the pressure still decreases, then the leakage is situated inside the analyser. Contact a local **Eltra** agent or **Eltra GmbH** directly.
- If the pressure remains constant after an initial drop, then the fault can either be found inside the furnace or in its proximity.



- Release the button **(43),** close the furnace, squeeze the tube **(6) tightly** and press and hold the button **(43).**
- If the pressure on gauge **(12)** remains constant, then the furnace has to be checked for leaks.
- If the pressure shown on gauge **(12)** drops, then the leakage has to be found somewhere along the furnace inlet system.

Leaks in the furnace inlet system:

- After following the above instructions, check the inlet tubes **(6)** for leakage.

Leaks in the furnace:

- After following above instructions, close the furnace, squeeze tube **(9) tightly**, press and hold the button **(43),** observe the pressure gauge **(12).**
- If the pressure drops, then the furnace is leaking. Check whether the O-rings **(16), (17)** and **(18)** are dirty or defective. See **3.4**. Check whether the combustion tube **(15)** is broken or cracked.
- If the pressure remains constant, then the leakage has to be found in the furnace outlet system.

Leaks in the furnace outlet system:

After following the instructions in the section **„Leaks in the furnace“**, **check if the handle (8) is properly shut**, or else there will be a major gas leakage from the dust filter. Check the dust trap **(10)** and the glass tube **(11)** for leakage.

3.15 Gas pump repair and replacement

It is very unlikely for the pump to completely break down. The reason why the pump has to be repaired or even be replaced, is when the pump can not provide enough efficiency to keep the level of the required flow. **(fixed and electronically stabilised flow of about 160l/h)**.

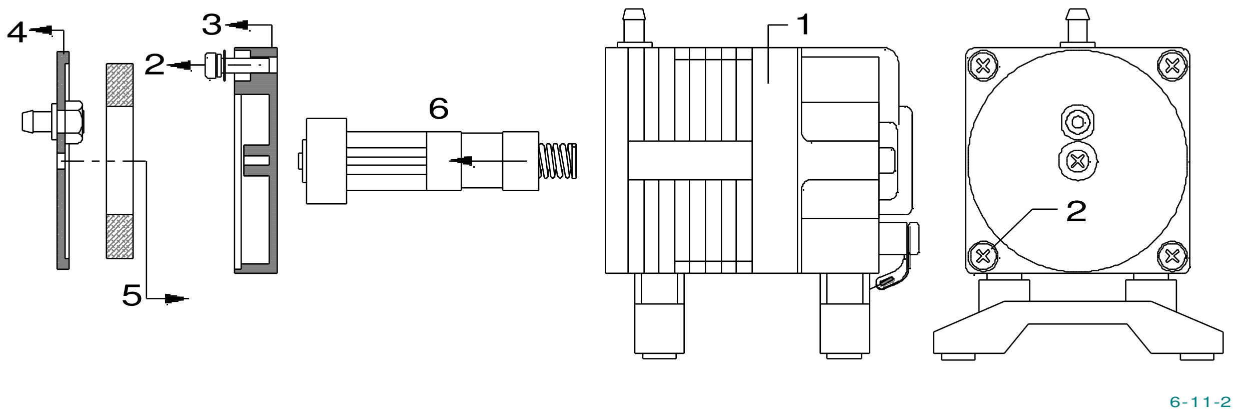
If the pump needs almost it's full power to keep the flow, the analyser and the connected PC will display the message:

"PUMP CAPACITY V.S. MAXIMUM"

In most cases there is a restriction of the flow due to depleted chemical or due to particles passing through the glass wool at the lower end of the glass tubes. This can happen when less glass wool is used than indicated in **3.3**.

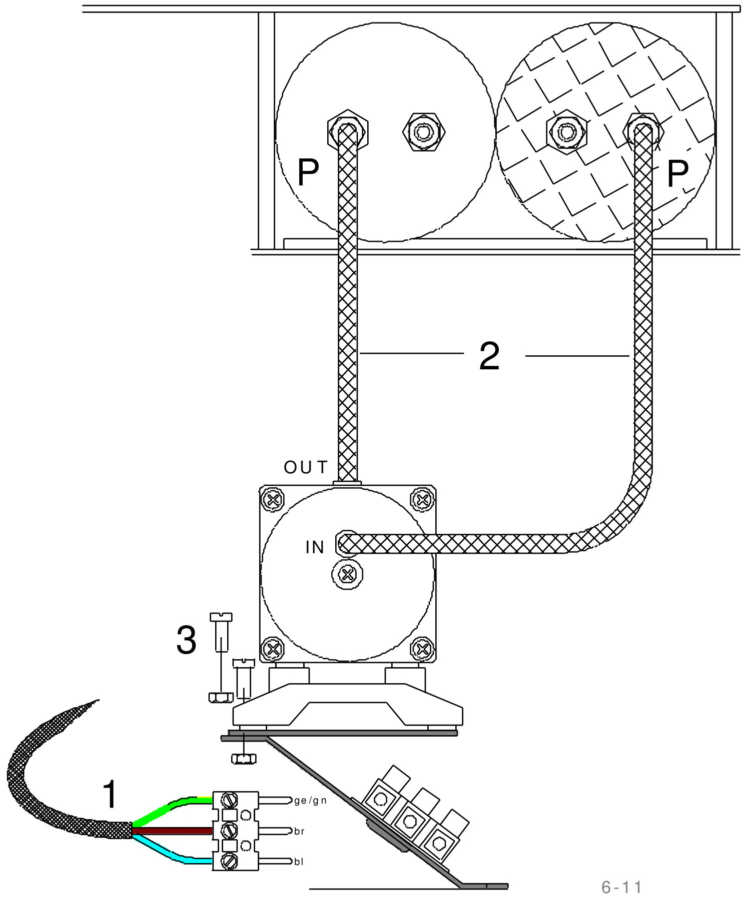
In case of no restriction, the reason for the pump message is the pump itself. The efficiency of the pump can be restored by replacing the plunger.

Replacing the plunger:



- Switch off the analyser.
- Remove the four screws **(2)**.
- Remove the lid **(1)**.
- Pull the plunger **(6)** out of the pump.
- Insert the new plunger and restore the original condition in reverse orders. After several times of replacing the plunger, the whole pump has to be replaced.

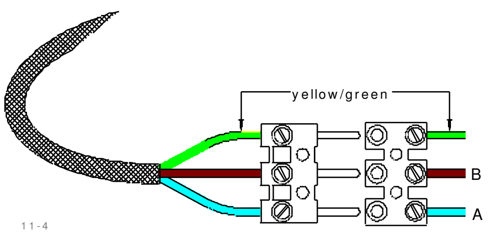
Replacing the pump:



- Switch off the analyser and disconnect the mains power plug of the analyser.
- Disconnect the plastic tubes **(2)**.
- Pull to the left and disconnect the plug **(1)**.
- Remove the two screws **(3)**.
- Install the new pump in reverse order.

CAUTION:

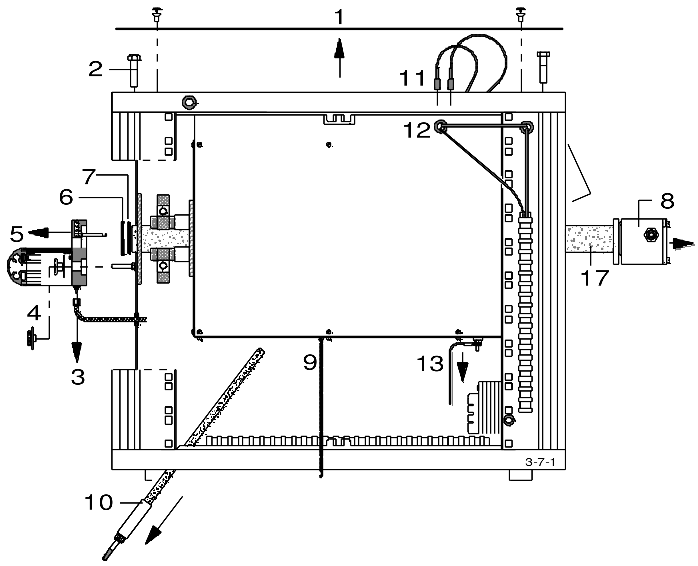
Before connecting the plug **(1)** make sure that on both parts of the connector, the ground connection (green/yellow cable) is on the upper pin.



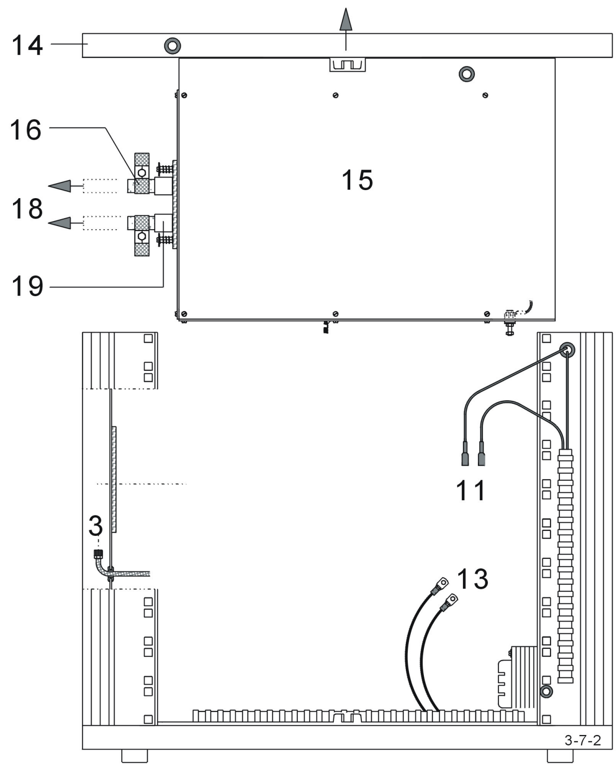
If the pump doesn't run at all (while the old one was running but with low efficiency) exchange the cables A and B.

Take care to connect the plastic tubes as shown in the drawing above. If they are connected the wrong way, the analyser will not work.

3.16 Replacing the heating elements



- Remove both sides panels of the furnace cabinet.
- Remove the cover plate **(1)** of the cabinet (4 screws on the top).
- Disconnect the oxygen tube **(3)**.
- Unscrew the two knurled nuts **(4)** and remove the front assembly **(5)**.
- Remove the O-ring **(6)** and the safety spring **(7)** from the front end of the ceramic tube.
- Pull the dust trap **(8)** with the ceramic tube **(17)** out of the furnace.
- Remove the spring **(9)** and pull the thermocouple **(10)** out of the furnace.
- Disconnect the connectors **(11)** of the temperature switch and pull the cables out of the hole **(12)**.
- Disconnect the cables **(13)**.
- Unscrew and remove the four screws **(2)**.



- Lift the top frame **(14)** together with the furnace block **(15)**.
- Remove the clamps **(16)** from the heating elements
- Install the new heating elements.
- Remove the ceramic spacers **(19)**.
- Re-assemble in reverse order.

CAUTION:

- Install the clamps **(16)** in a position which allows the heating elements to move at least **5 mm** in horizontal (axial) direction.
- Insert the thermocouple deep enough, to touch the combustion tube and fix it with the spring **(9)**.

4 DESCRIPTION OF FUNCTIONS

System overview:

The **CS-2000** automatic analyser incorporates the latest in combustion technology. It is designed for the rapid simultaneous determination of **carbon** and **sulphur in steel**, **cast iron**, **copper**, **alloys**, **ores**, **cement**, **ceramics**, **carbides**, **minerals**, **coal**, **coke**, **oil**, **ashes**, **catalysts**, **lime**, **gypsum**, **soils**, **rubber**, **leaves**, **soot**, **tobacco**, **waste**, **sand**, **glass** and other solid and fluid materials. The **CS-2000** can be supplied with up to three independent Infrared cells, giving the following options:
1.Two IR-cells for carbon and one for sulphur.
2.Two IR-cells for sulphur and one for carbon.
These configurations offer optimum precision for the analysis of high and low levels of the chosen element. The change over from the low to the high range is done automatically during the analysis and doesn't require any pre-setting by the operator.

4.1 Measuring principle

The measuring procedure is based on sample combustion and measurement of the combustion gases be means of infrared absorption.
A wide variety of sample materials in various forms is possible; powder, shavings, solid pieces and also some substances in liquid form. Typical materials are **coal, ashes, steel, cement, soil samples, rubber** etc.
During combustion, the sulphur and carbon components present in the sample are oxidised to form **SO_2** and **CO_2**, The usual combustion temperatures are **1250°C** and **1400°C** for cement samples.
Combustion is obtained by supplying **oxygen**, which at the same time acts as carrier gas. An electronic flow regulator keeps the flow quantity at a constant level of **180 l/h** (unless the analyser is a special model).
Dust traps and a moisture absorber ensure that a dry, dust free gas mixture is supplied to the infrared cells.
The signals emitted from the infrared cells are selective and correspond to the **SO_2** and **CO_2** concentrations in the gas mixture. They are electronically linearised and integrated, divided by the sample weight and digitally displayed as **%S and %C**
Since the sample weight is taken into account, the results are not dependent on the weight. For this purpose, the sample is weighed before being analysed and entered into the PC. If necessary, blank values can also be entered; the software takes them into account when determining the results.
The analyser is operating connected to PC, with the software **"UNI"** for controlling the analyser. **For the instructions on software, please, refer to the Help-function of the software.**
The graphical representation of the detectors' signals (peaks) is shown on the PC's screen during and after analyses. At the end of analysis the results are displayed as well. All analysis data for every finished analysis are saved in the PC and remain available for review, results recalculation, calibration, etc. and can be printed out on a printer or exported to other software, if necessary.

4.2 Gas flow system

- The **oxygen** supply is connected to the inlet of the **oxygen** system. Pure **oxygen** is available in steel bottles, with **99.5%** this is fully sufficient. Any CO_2 or H_2O which may be contained in the **oxygen** is retained in the H_2O trap. The upper half of the trap is filled with a CO_2 absorber and the lower half with a H_2O absorber.

- **Magnesium perchlorate** (anhydrone) acts as a H_2O absorber.

- **Sodium hydroxide** acts as a CO_2 absorber, preferably with an indicator, so that thedegree of saturation can be seen from the coloration.

- The **oxygen** inlet pressure should be **2 to 4 bar**, which is then regulated inside the analyser to **1.5 bar**, as shown on the pressure gauge. Any pressure fluctuation of the external **oxygen** supply has no influence on the accuracy of the measurements.

- The **oxygen** then enters the furnace through the **oxygen** valve. A pressure switch informs the **electronic module** as to whether there is sufficient pressure in the furnace to begin the analysis. And it can also detect whether the furnace is open or shut.

- The **combusted gases** from the furnace flow first through a dust trap and then through a H_2O absorber. Via the bypass valve, they reach the **electronic controlled** regulating valve, which is the adjusting element of the **electronic flow** regulation. Before reaching the **flow regulating** valve **V6**, the gas pressure is **0.35 bar**; therefore it is virtually an **atmospheric pressure** and flows constant, at a precisely controlled rate.

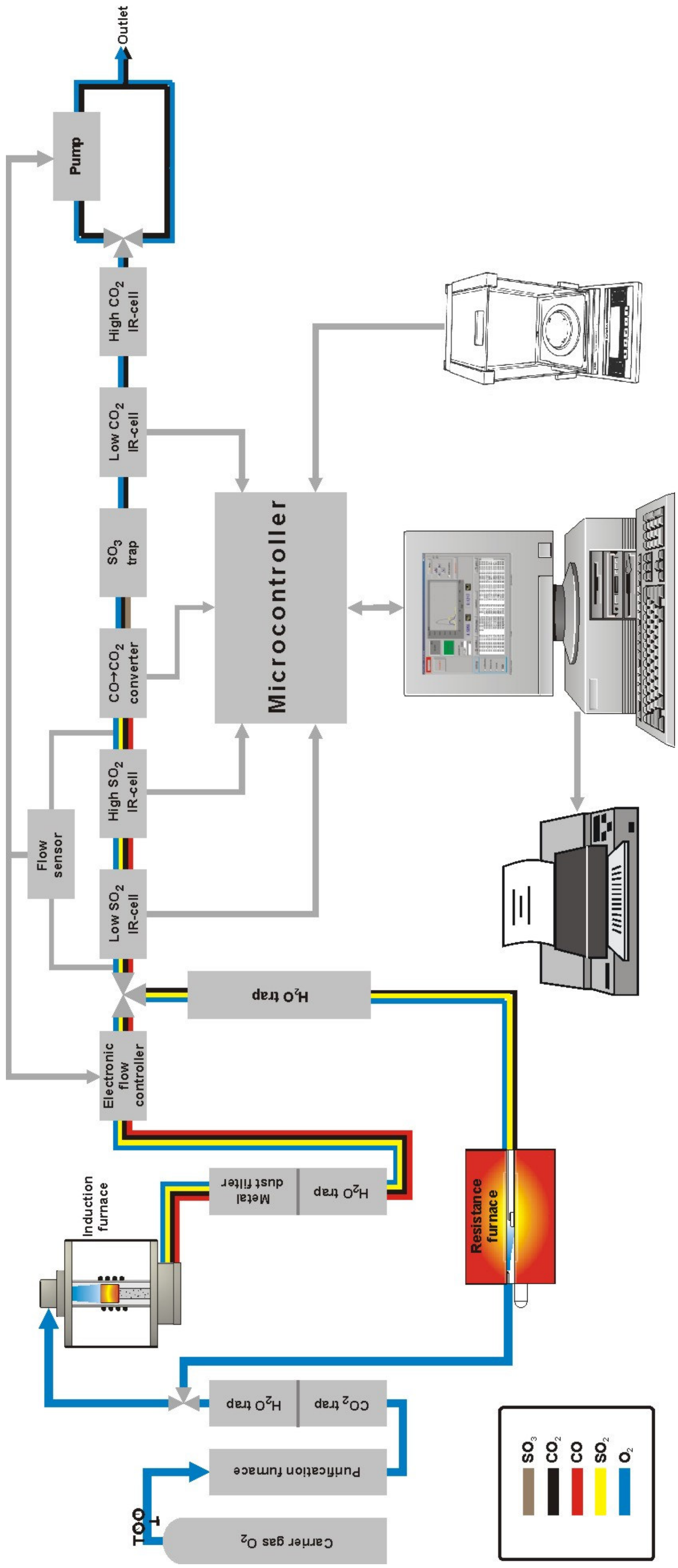
- Then, the gas flows through the **SO_2-selective channel** of the **infrared analyser**. Any **CO**-**copper oxide**, that may be present, is **oxidised** to CO_2. Unwanted SO_3, which results thereby from SO_2, is retained in the cotton wool-filled SO_3 trap.

- The analyser's CO_2 channel registers the CO_2 concentration. A flow indicator allows the gas flow to be **visually** monitored. The flow rate is set internally to **180 l/h**. The exact level of the flow is not important, since the calibration of the analyser takes this into account.

- It is extremely important that the flow rate is constant. The **electronic unit** ensures this. A slight **deviation** from the standard value or a **conflict**, as with mechanical regulators, cannot arise. The regulation either functions **precisely**, in which case the flow rate is correct or, in the event of a **defect**, the flow rate is completely **blocked** or extremely **high**.

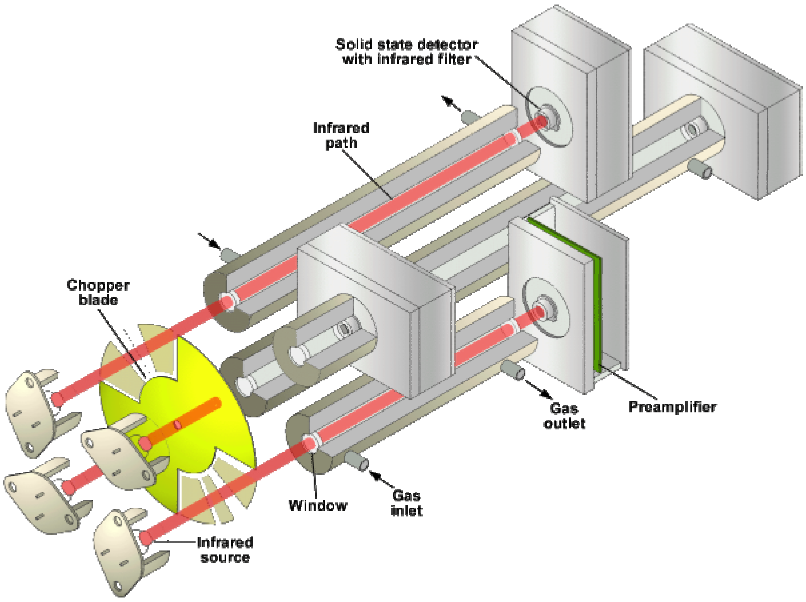
See **next page**.

Gas flow diagram:



4.3 Infrared cells

The measuring principle is based on the infrared radiation absorbing property of many gases. Each of these gases absorbs specific characteristic spectral wavelengths of infrared radiation. The absorption spectrum is determined by the number, configuration and type of the atoms in the gas molecules.



An infrared source is electrically heated and radiates broad-band infrared radiation.The light is interrupted by a rotating chopper blade, resulting in an alternating light. The chopper is crystal controlled, so that the chopper frequency is highly stable. The infrared radiation then passes through the measuring IR-paths, through wich a mixture of combustion gases and carrier gas flows. Depending on the composition of the gas mixture, certain frequencies of the infrared spectrum are absorbed. The rate of absorbtion depends on the concentration of the gases.

As the infrared beam leaves the IR-path, it passes through an infrared filter, wich only allows a narrow band of infrared radiation to pass. This narrow band must correspond to the IR wavelenght for wich the sample gas shows ist maximum absorbtion capacity. The intensity of the radiation after the filter thus corresponds to the concentration of a specific gas in the path. The beam finally strikes a solid state infrared detector, wich emits an electrical signal, in proportion to the intensity of the beam. Since the beam is interrupted by the rotating chopper, as mentioned above, the detector receives an alternating signal. Temperature and aging influences of the detector, as well as noise, are thereby suppressed.

The signal thus obtained is amplified and rectifed, so that it leaves the infrared cell as a d.c. value.

The infrared cells of the CS-2000 do not require any manual zero adjustments. The zero and sensivity adjustments of the infrared cells are permanently and automatically controlled by the electronics. The detectors utilize solid state sensors combined with infrared filters. The sensors are not gas filled, thus eliminating long term problems due to gas leakage. The CS-2000 can be equipped with up to four independent Infrared cells.

The lengths of all four cells can be individually optimized to obtain maximum precision for the target analyte levels of each customer. Each of the cells can be installed with infrared absorbtion lengths ranging between 1 mm and 320 mm.

The infrared cell rack is temperature-controlled, so that the sample gas which flows through it, is kept at a constant temperature.

4.4 The furnaces

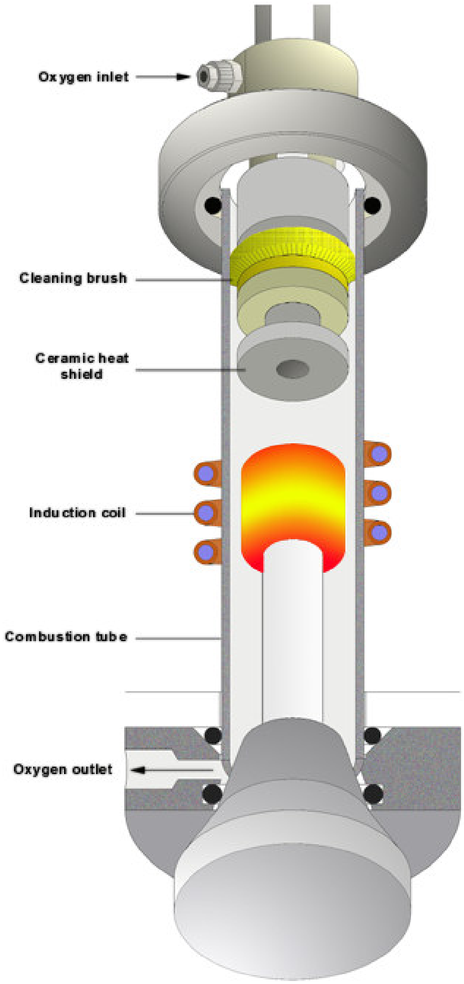
Induction furnace:

The combustion is carried out in a **high frequency induction furnace**. The sample is inserted into the induction coil of the oscillating circuit of the pedestal, then heated by high frequency induction and combusted by supplying **oxygen**.
By starting the analysis, the **HF generator's** high voltage supply is switched on. Inside the coil, a quartz tube is fitted to an **upper** and a **lower** holder. The gas flows **downwards**. The furnace inlet leads through a lance, which blows the **oxygen** for combustion **directly** into the crucible and onto the burning sample. When the sample is inserted into the furnace by the pedestal, the lower opening of the quartz tube is closed with the sealing cone.

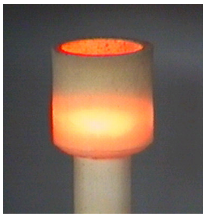
Automatic induction furnace cleaning.
The users of **carbon** and **sulphur** analysers with the induction furnaces knows that dust accumulates during the combustion (mainly of **iron** and **tungsten oxides)** in the combustion chamber.
The **CS-2000** induction furnace is cleaned **automatically** after each analysis, thus ensuring repeatable and accurate results. The **standard** cleaning apparatus is mechanically attached to the furnace **open**/**close system**, to ensure that the cleaning brush will not collide wit the hot crucible.

The cleaning brush will never burn !
The **efficient** design of the cleaning mechanism rules out any possibility of the cleaning brush to catch fire.
To confirm this fact, **ELTRA** offers **free** replacement of each burned cleaning brush, during the entire working life of the analyser.

Automatic furnace cleaning



- After each **analysis start**, a **thyristor** switches the high voltage transformer **"smoothly"** on, to prevent any current surge in the main power supply and therefore eliminating the risk of blowing any **fuses**.
- The **induction coil** is cooled internally with **compressed air**. The **outside** is cooled by the blower, which also ventilates the generator.
- The induction furnace uses standard ceramic crucibles, which are **1“** or **25 mm** in diameter.

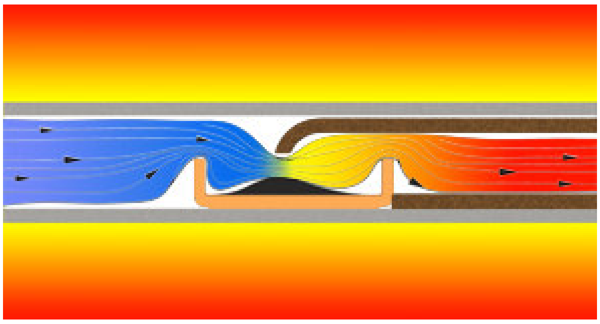


Resistance Furnace:

Description:
The temperature of this furnace is adjustable up to 1550°C. The combustion tube has an inner diameter of 27 mm and a hot zone of about 200 mm. The temperature, which is digitally displayed, can be adjusted with an accuracy right down to 1° C. The platform on the front-side of the furnace serves to carry samples for the analyses, as well as their hot remainders, once extracted from the furnace. Inside the furnace inlet there is gas supply jet, to ensure correct dosage of the combustion gas. On request, the HTF-540 can be supplied with a flow meter and adjustable restrictor for the adjustment of the inlet gas flow. At the furnace outlet there is dust trap, together with tube connection. A micro filter, made up of fine precious stone fibre, is also available. A glass tube is connected at the furnace outlet, which can be filled with e.g. moisture absorber or any other absorber. The furnace's robust housing, contains a built-in fan; thus ensuring low surface temperature, in order to prevent contact injuries.

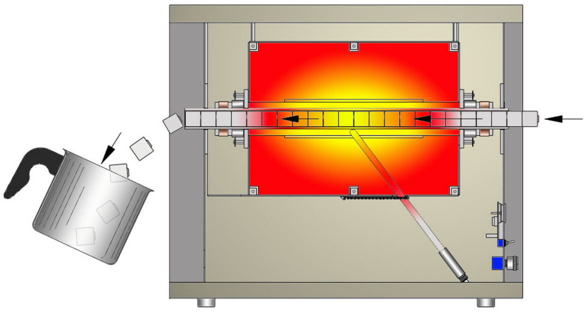
Temperature adjustment:
The HTF-540 employs silicon carbide heating elements. Full electronic control includes current limitation during cold-start conditions to promote long element life. A separate sensor is used to monitor ambient temperature and provide data for automatic reference point compensation ensuring that furnace temperature is not affected by fluctuations of ambient temperature. The furnace requires approximately 10 to 15 minutes to reach operating temperature.

Combustion efficiency
The design of the furnace boat stop ensures oxygen carrier gas penetrates into the crucible, ensuring efficient combustion. This design eliminates the need for fragile lances and honeycomb boat stops which tend to block easily with ash. Additionally the boat stop protects the combustion tube from the aggressive combustion products, thus extending the life of the tube.

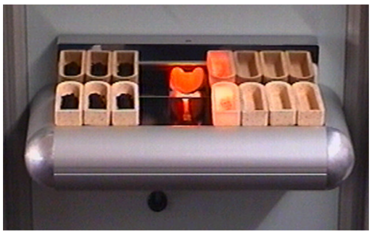


The combustion tube is a simple straight ceramic tube that is robust and inexpensive to replace. The life expectancy of the tube is measured in thousands of analyses and not hundreds as is the case with other analysers. (protected by German utility model).

Preheating crucibles:
The HTF-540 can be used for preheating of ceramic crucibles for induction furnaces. The crucibles have the standard size of 25mm (1") diameter and are used for combustion analysis of carbon and sulphur in solid materials. The preheating reduces the blank value of the crucibles.



This is important for analysis in the very low ppm range. The crucibles are inserted into the furnace tube and they remain preheated in the tube until needed. Each time a crucible is needed, a new one is inserted into the tube, and a preheated crucible falls out the other end of the furnace tube. The recommended pre-heating temperature is between 1250°C and 1350°C. For preheating crucibles the boat stop is removed.



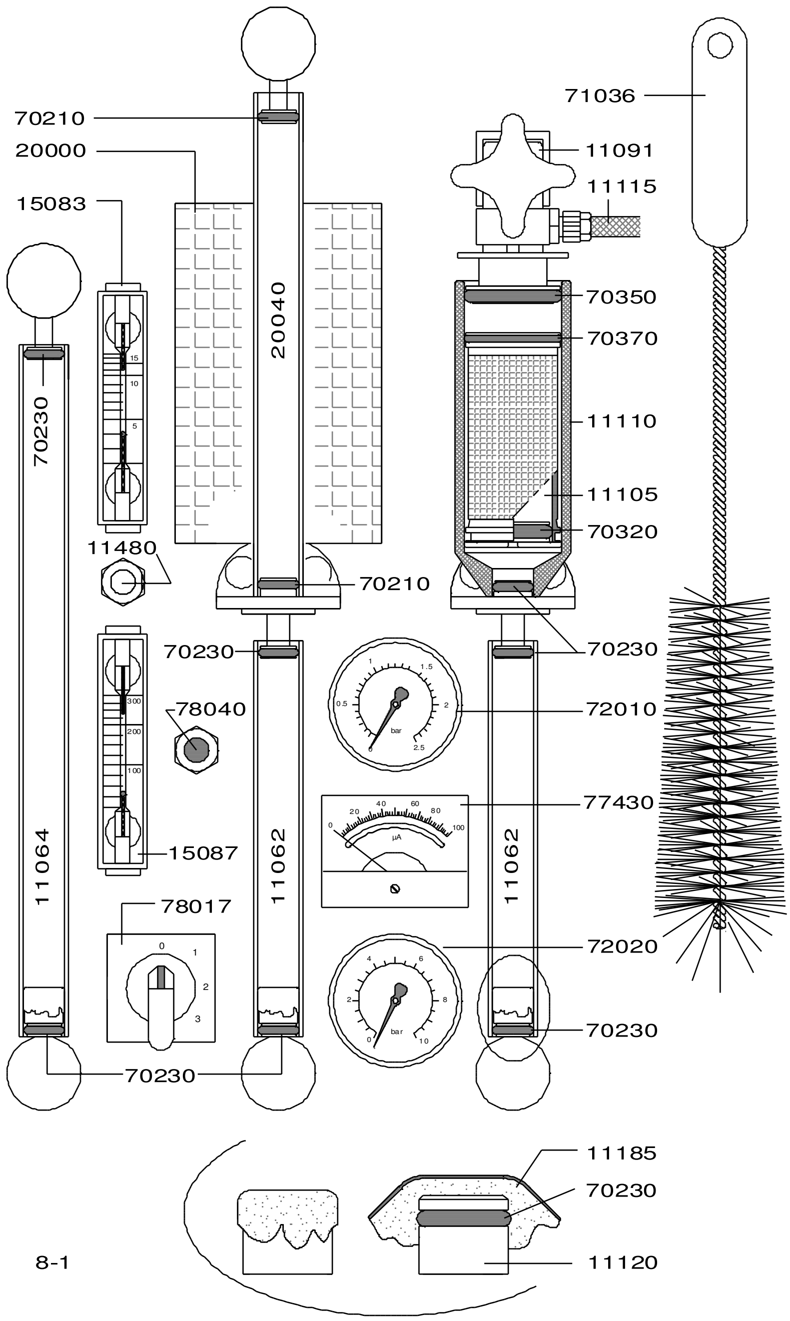
A variety of combustion boats can be used in the HTF-540 including the reusable ceramic boats (L=57mm, W=22mm, H=13mm). Porcelain or quartz boats are also an option.

5 MISCELLANEOUS

5.1 Ordering numbers

Front side:

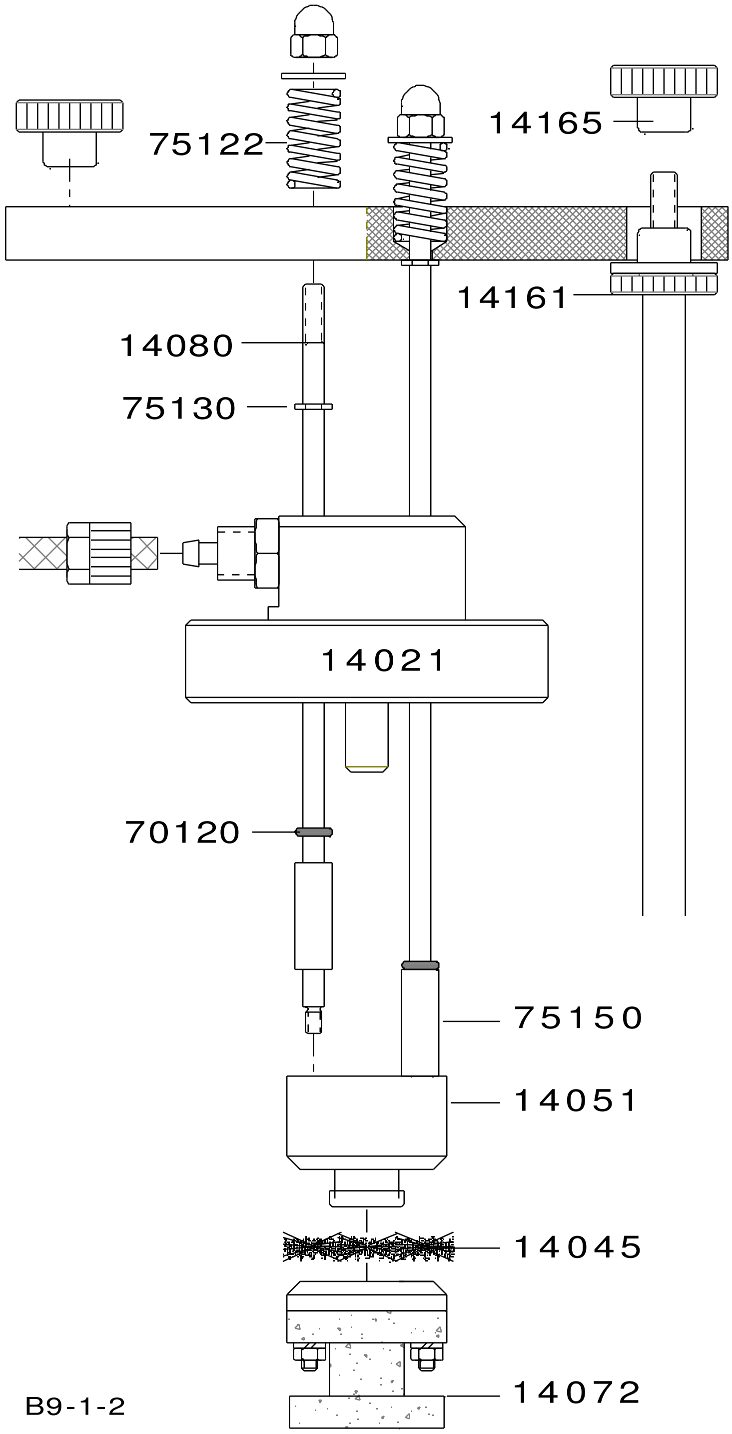
11062	Reagent tube
11064	Reagent tube
11091	Dust trap mechanism
11105	Metal dust filter
11110	Filter housing
11115	Furnace outlet tube
11120	Paper filter holder
11185	Paper filters
11480	Adjustable restrictor
15083	Gas flow indicator 15 l/h
15087	Gas flow indicator 300 l/h
20000	Catalyst furnace
20040	Catalyst tube
70210	O-ring
70230	O-ring
70320	O-ring
70370	O-ring
71036	Cleaning brush for filter
72010	Pressure gauge
72020	Pressure gauge
77430	Panel meter 100 µA
78010	Mains power switch
78040	Button for leakage test



Induction furnace cleaning assembly:

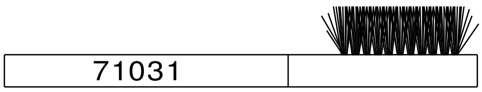
14014 **Complete furnace cleaning assembly unit:**

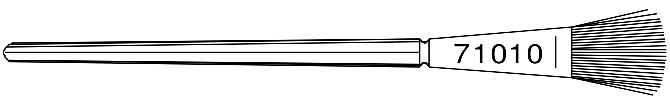
14021	Upper furnace lock
14045	Cleaning brush for combustion tube
14051	Brush holder
14072	Ceramic heat shield for brush
14080	Cleaning mechanism rod
14161	Lower knurled nut
14165	Upper knurled nut
70120	O-ring
75122	Spring
75130	Safety spring
75150	Metal tube

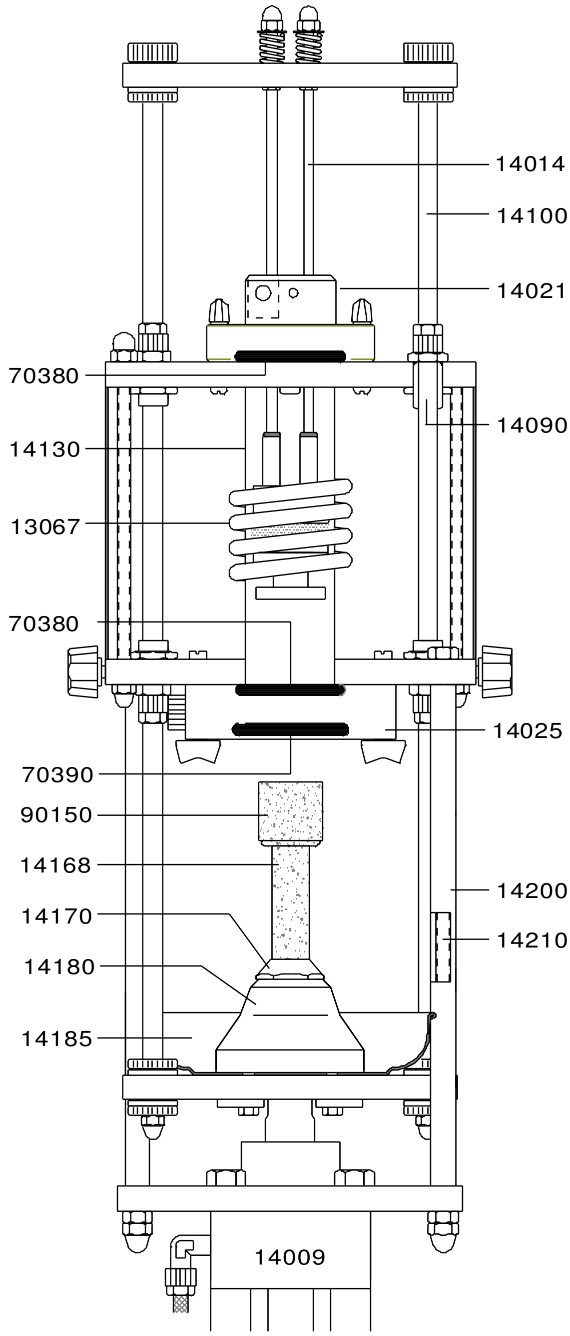


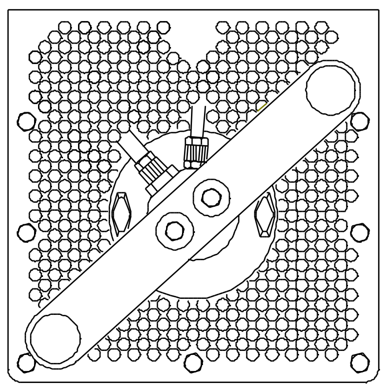
Induction furnace:

13067	Combustion coil
14009	Pneumatic cylinder for furnace lift
14014	Complete furnace cleaning assembly unit
14021	Upper furnace lock
14025	Lower furnace lock
14090	Bearing
14100	Mounting rod
14130	Combustion tube
14168	Pedestal
14170	Pedestal mount
14180	Furnace closure
14185	Tray
14200	Metal tube
14210	Threaded rod
70380	O-ring
70390	O-ring
71010	Cleaning brush for pedestal
71031	Cleaning brush for radiation shield
90150	Crucibles



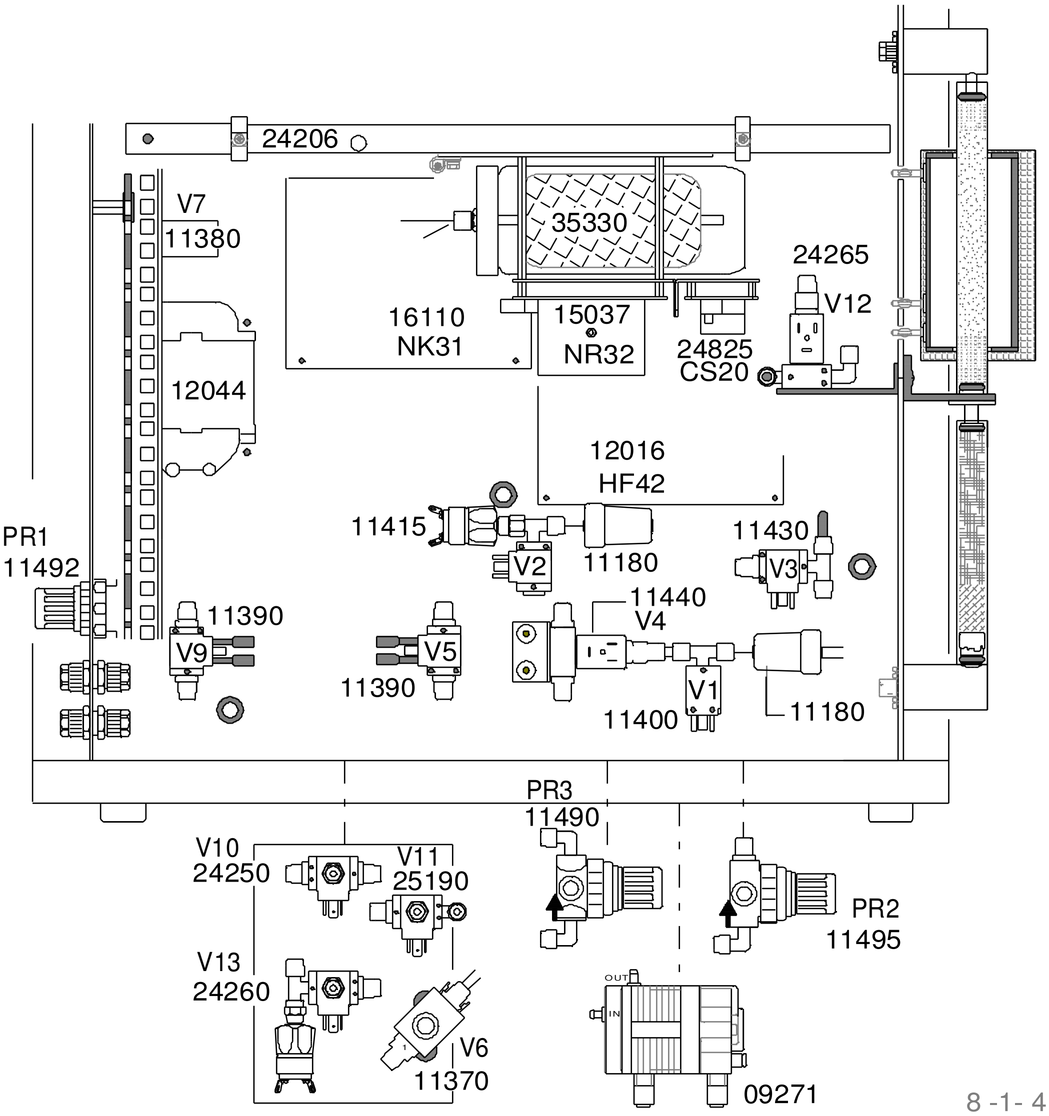






8-1-3

Left side:

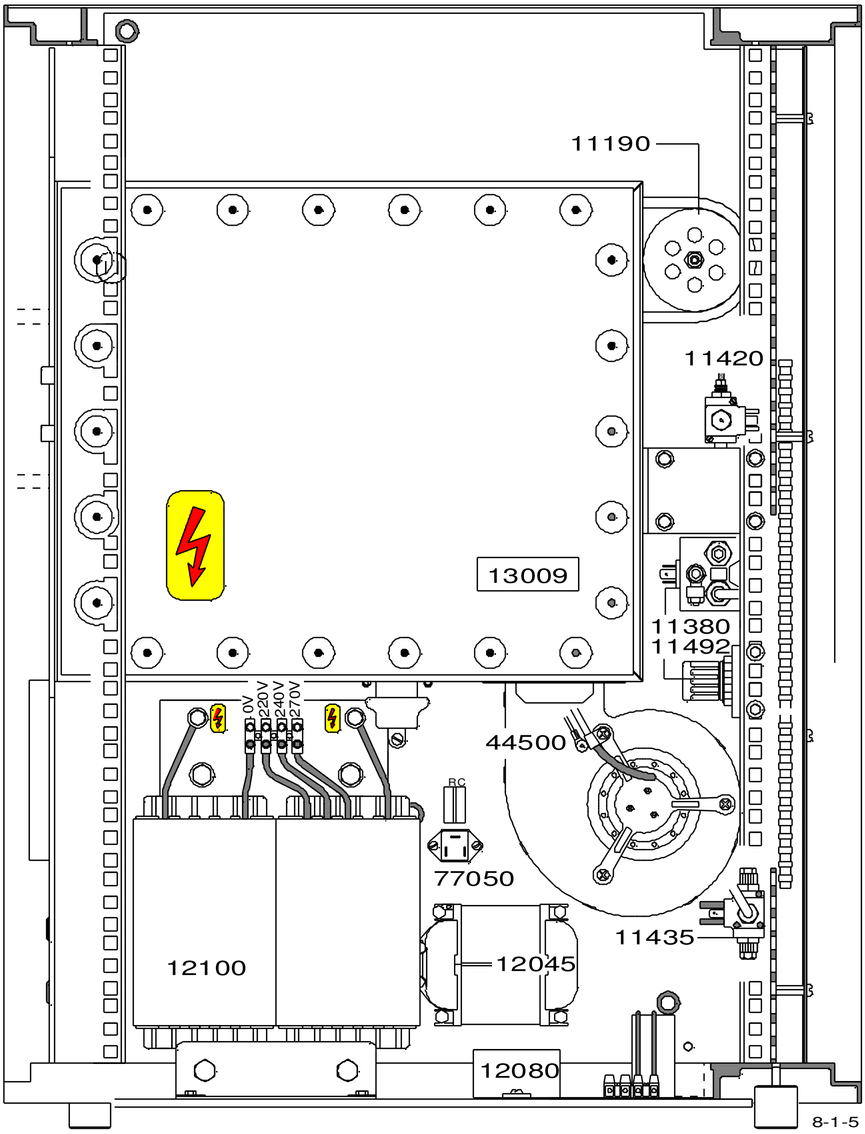


8 -1- 4

09271		Gas pump
11180		Dust filter cartrige
11370	V6	Gas flow regulating valve
11390	V5+V9	Oxygen solenoid valve
11400	V1	Outflow valve
11415	V2	Oxygen lance valve
11430	V3	Combustion chamber valve
11440	V4	Bypass solenoid valve
11490	PR3	Pressure regulator
11492	PR1	Inlet pressure regulator
11495	PR2	Purge pressure regulator
12044		Transformer
24250	V10	
25190	V11	Energised for resistance furnace operation
24260	V13	
24265	V12	
35330		Attenuator

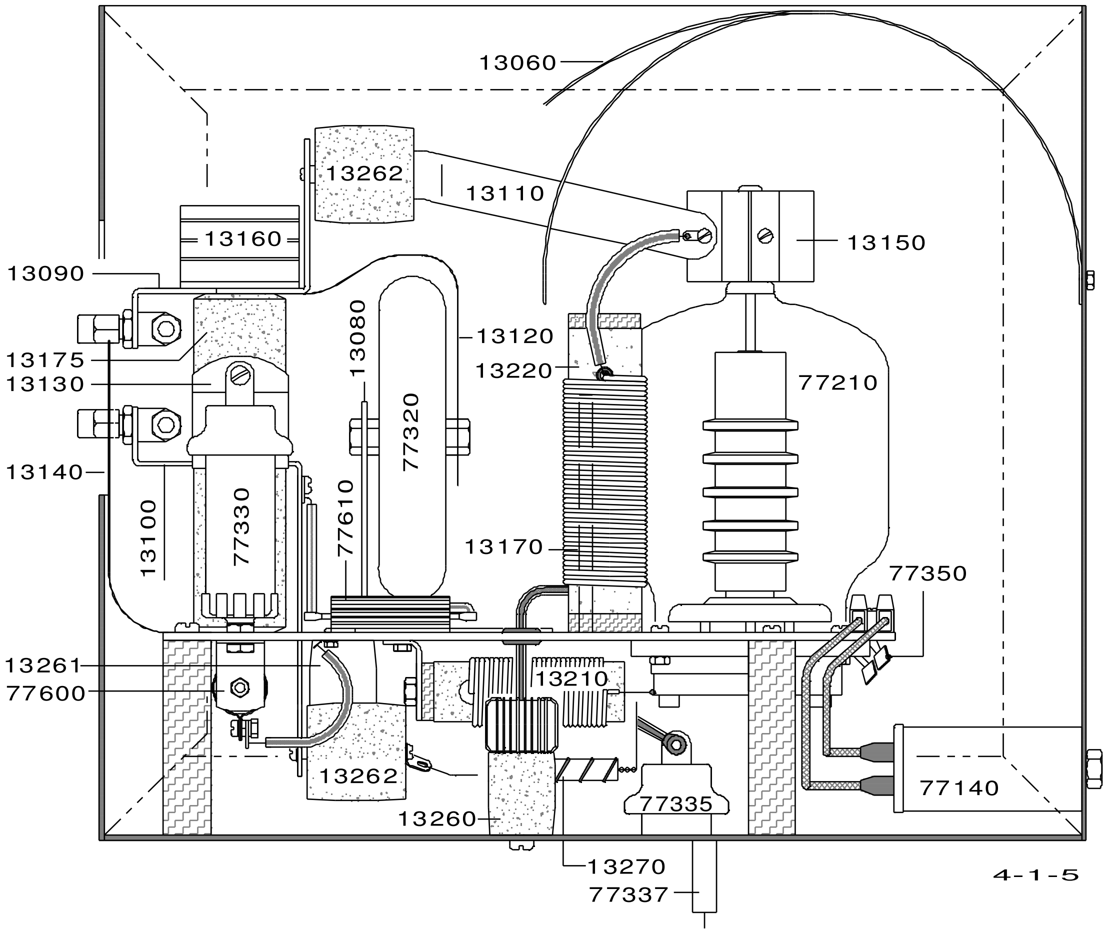
Right side:

ventilation



11190	Exhaust muffler
11380	Pneumatic valve
11420	Coil cooling solenoid valve
11440	Pressure switch-over solenoid valve
11492	Pressure regulator
12045	Transformer
12080	Rectifier
12100	Transformer
44500	Centrifugal blower
77050	TRIAC
77135	Capacitor

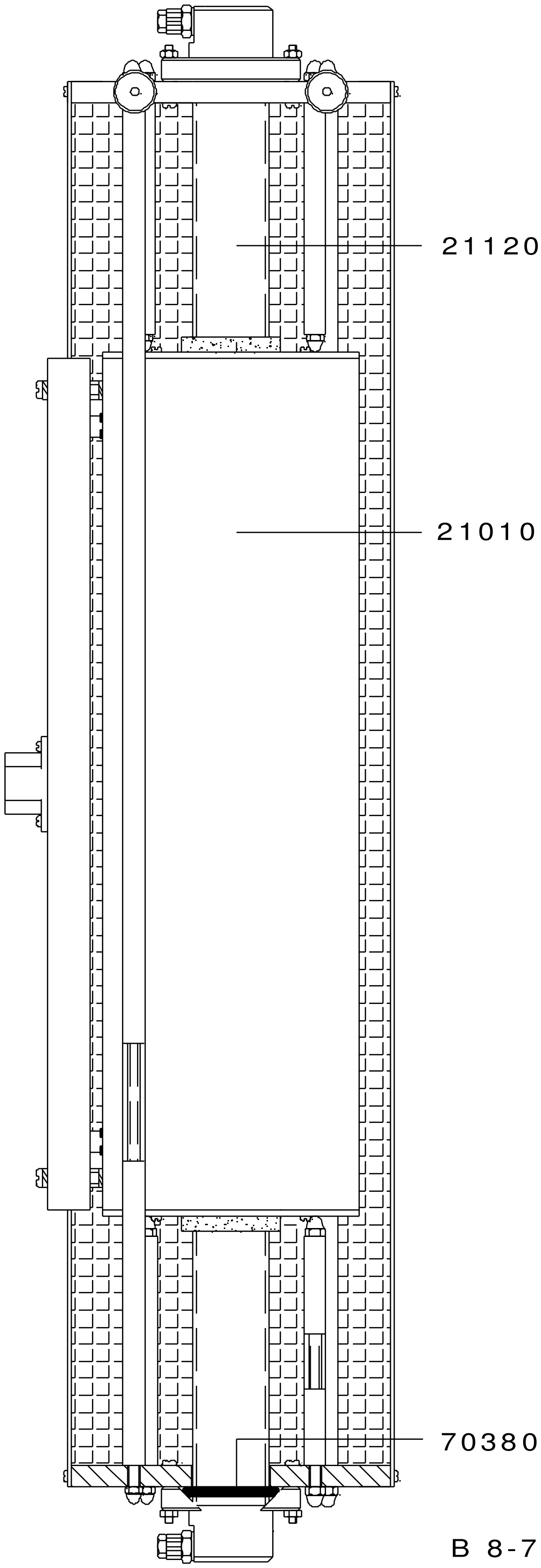
Oscillating circuit:



13080	Capacitor support	77140	HF - filter 250V
13090	Upper coil connector	77210	Oscillator tube
13100 q	Lower coil connector	77320	Capacitor
13110	Anode connector	77330	Capacitor
13120	Capacitor connector	77335	Capacitor
13130	Capacitor connector	77350	Capacitor
13140	Ground connector	77600	Resistor
13150	Anode heat sink	77610	Resistor
13160	Coil heat sink		
13170	Radiation shield		
13175	Insulator		
13210	Grid choke		
13220	Anode choke		
13250	Chassis support		
13260	High voltage filter		
13261	Capacitor		
13262	Capacitor		
13270	Resistor		

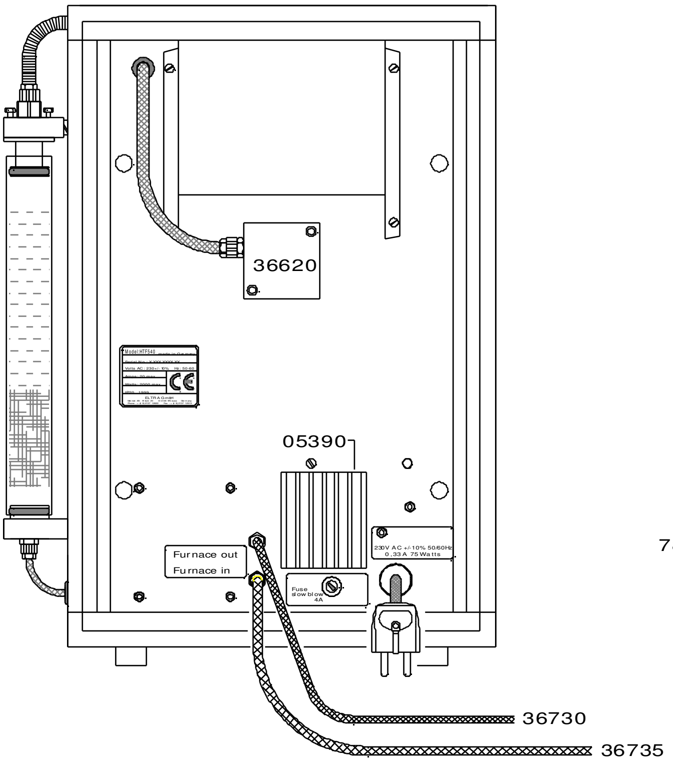
Oxygen purification furnace:

21010 Heather section
21120 Quartz tube
70380 O - Ring

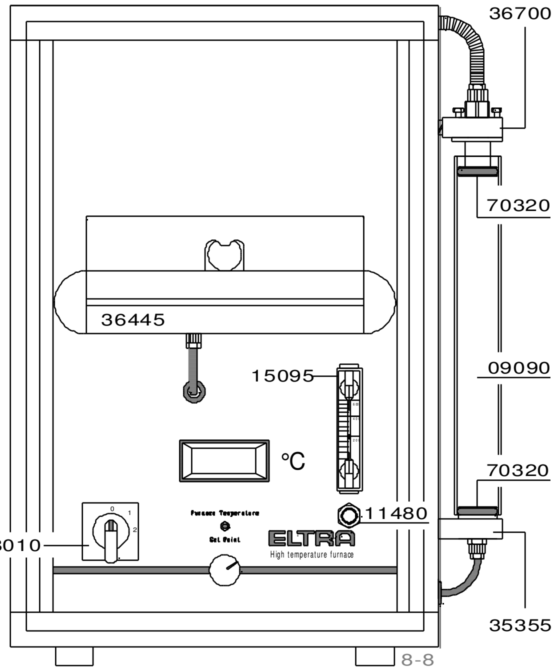


Resistance furnace:

Rear side:

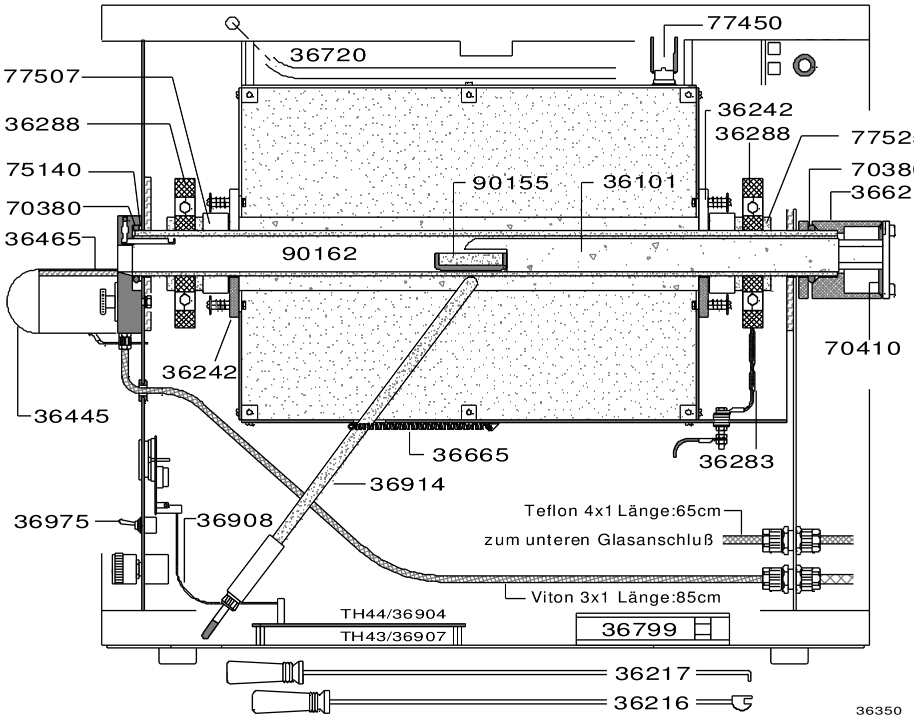


Front side:



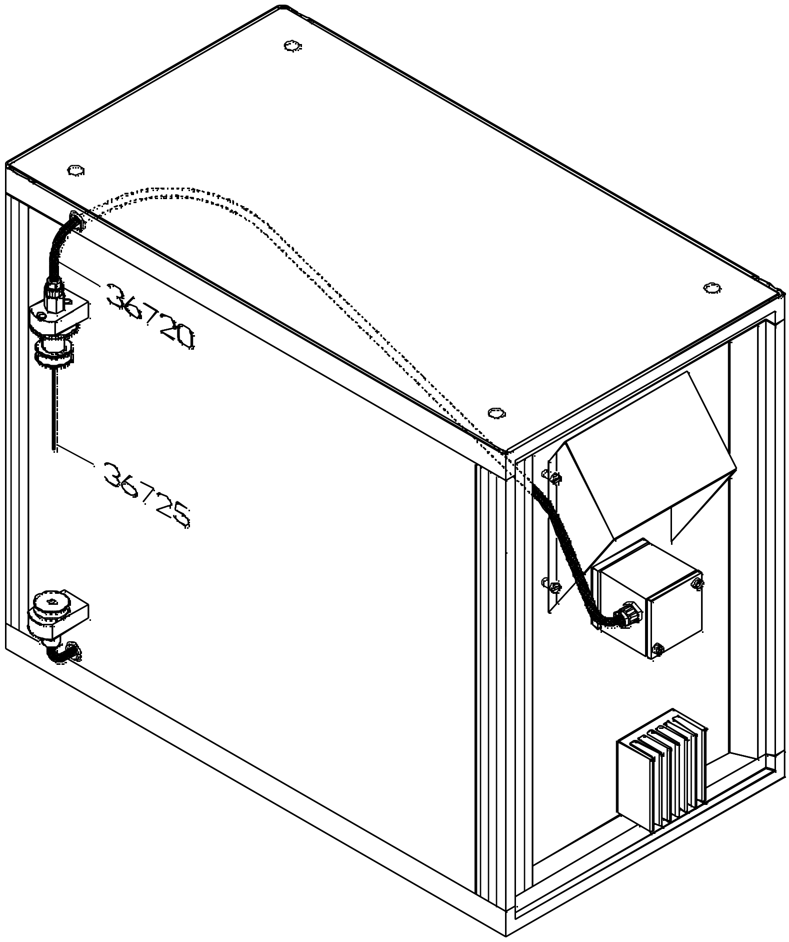
09090	Reagent tube
11480	Adjustable restrictor
15095	Flow display 600l/h
35355	Lower reagent tube connector
36445	Platform
36700	Upper reagent tube connector
36730	Teflon tube
36735	PVC tube
70320	O-ring
78010	Mains power switch

Resistance furnace:



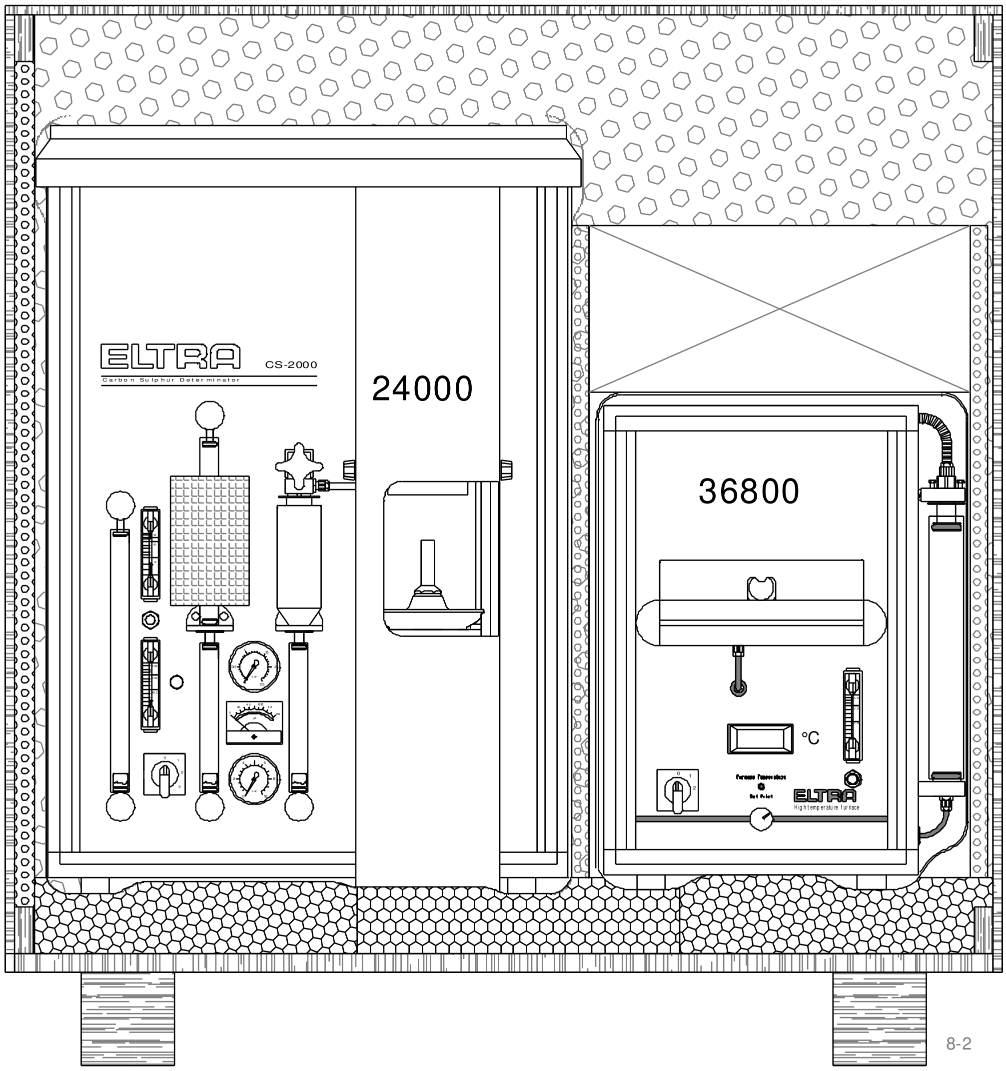
36101	Boat stop
36216	Combustion boat insertion stick
36217	Combustion boat removing stick
36242	Ceramic plate
36283	Heating element connector
36288	Heating element connector
36445	Front panel for the combustion boat
36465	Ceran plate
36620	Dust trap
36665	Spring
36799	Cooling fan
* 36907	Temperature control board TH 43 / TH 44
36908	Cable for TH 43 / TH 44
36914	Thermocouple
36975	LCD – display DVM 2
70380	O-ring
70410	O-ring
75140	Coil spring washer
77450	Temperature switch
77507	Ceramic tube
77525	Heating elements, 4 pcs
90155	Combustion boats
90162	Combustion tube

*** Note:**
36907 Temperature control board TH 43 is an older version.
36904 Temperature control board TH 44 is a newer version and fully compatible.



36720	Tube black
36725	Teflon tube for 36720

5.2 Packing

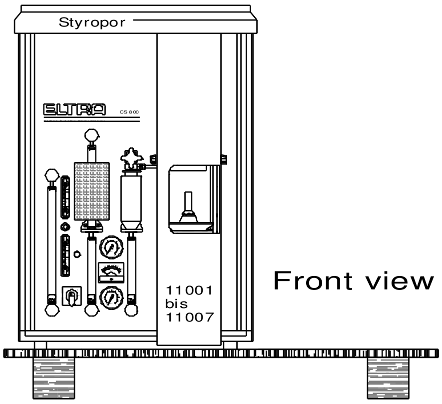


Before packing, the analyser and furnace must be wrapped in plastic foil, to protect it from moisture and dust, and then to be placed in a wooden case. The wrapped analyser, should be surrounded by a layer of **foam (chips**)of at least **10cm**, in order to avoid any **damage** due through transportation.

Especially the foam where the analyser is placed on, is very important. It should neither be too hard nor too soft. When the foam is too soft, the analyser will practically touch the wood. Fix the foam on the bottom of the wooden case by gluing.

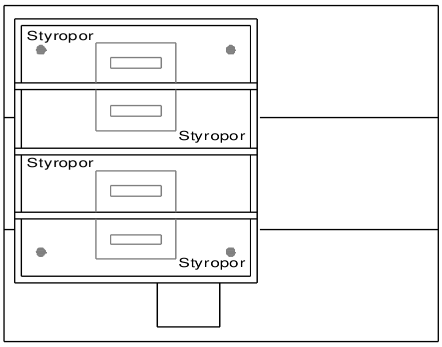
The analyser and the furnace should be wrapped in plastic foil, especially when you use chips or any other kind of material in small pieces. **The glass tubes must be empty.**
In case of transportation by vessel, use a seaworthy crate.

Packing is done as follows:



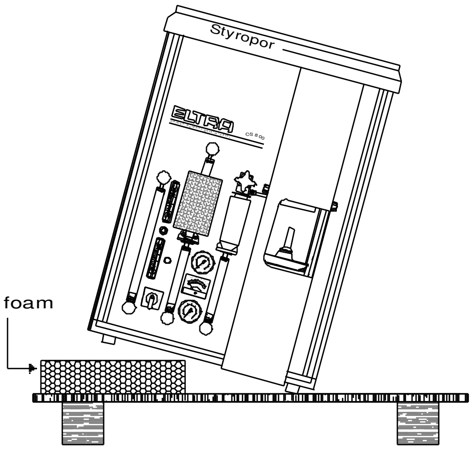
Front view:

a. Place the analyser directly on the pallet with the right side towards the middle of the pallet, because the furnace and the transformer are the heaviest parts of the analyser.



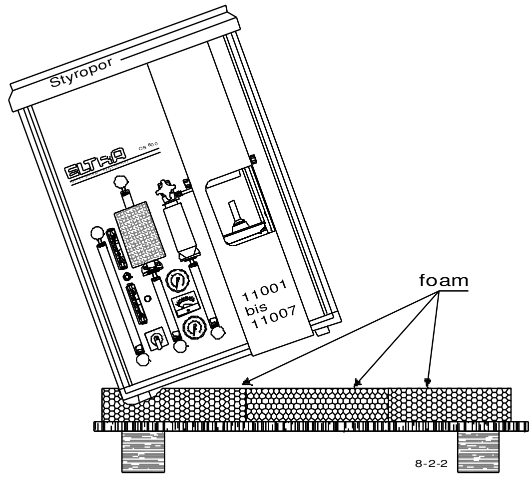
Top view:

b. Shift the analyser to the exactly required position.



Foam:

c. Tilt the analyser to the furnace side and place a piece of foam at the right position.



Foam:

d. Tilt the analyser to the other side and place the second piece of foam at the right place. If necessary, a third piece of foam can be placed on to the pallet.

5.3 CS-2000 Pre-installation guide

Following requirements apply, when installing the Analyser Eltra CS-2000:

Carrier gas	Oxygen 99.99% pure; 2 - 4 bar (30 - 60 psi)
Compressed air	4 – 6 bar (60-90 psi)
Mains power supply	230 VAC ±10%, 50/60 Hz; 16 A fuse
Analyser dimension	55 x 80 x 60 cm
Furnace dimension	33 x 52 x 60 cm
Analyser weight	ca. 150 kg.It is important to install the instrument on a stable place.

The balance should rest on a vibration free support.

Connections for Oxygen and compressed air; outer diameter = R¼".
(The tubes supplied together with the analyser, carry a connector with G¼" inner diameter).

ELTRA

CONFORMITY CERTIFICATE

We, **ELTRA GmbH**
Mainstr. 85, Block 20
D - 41469 Neuss
Germany
☎ : +49 02137 - 12822
Fax: +49 02137 - 12513

herewith declare, that the instrument CS-2000 produced and sold by us,
has been manufactured in accordance to the following CE standards:

	73/23/EEC	(Low voltage standard)
amendet to:	93/68/EEC	
	89/336/EEC	(Electromagnetic compatibility)

The instruments have been tasted in accordance to the following norms:
EN 61010 part 1 (VDE 0411 part 1)
EN 61010-2-010 (VDE 0411 part 2-010)
EN 55011 Group 2. Class A: 1991+A1: 1997+A2:1966
EN 50082-2: 1995 Parts: EN 61000-4-2, EN 61000-4-3, ENV 50204, EN 61000-4-4, EN 61000-4-6

The Eltra products can only be used in an industrial environment.

This declaration is based on:
Test report(s) of the independent and accredited EMC-Test-Laboratory

ELEKLUFT GmbH
Justus-v.Liebig-Straße 18
D - 53121 Bonn
Germany
☎ : +49 0288 - 6681 - 558
Fax: +49 0288 - 6681 - 792

Any alteration on the instruments without prior authorisation from Eltra GmbH, will cause this declaration to become null and void.

Signed in Neuss on this day of February 18, 1998

Managing Director
(J.Polemitis)

ELTRA
TÜV CERT
DIN EN ISO 9001
Zertifikat: 01 100 0020005

Inspection and Quality Certificate

We herewith confirm that the Eltra products manufactured according to the quality and quantity you require.

Thanks to a thorough inspection before shipment, the instrument, together with its accessories, the consumption materials and spare parts, are free of manufacturing defects and will provide excellent performance.
When treated in a proper way for the required application, according to the specifications from our offer, our order acknowledgement and in accordance with our catalogue specifications, the above products will show good results, and therefore will be used to your entire satisfaction.

Y. Polemitis	2005-02-11	
Name	Date	Signature

Approved Methodologies to Which ELTRA Instruments Conform

ASTM (ANALYTICAL SOCIETY FOR TESTING MATERIALS)

Metals

Instruments	Method	Elements	Materials
CS-2000 CS-800	ISO-9556	C	Steel & Iron
CS-2000 CS-800	ISO-4935	S	Steel & Iron
CS-2000 CS-800 ON-900 ONH-2000	ASTM E-1019	C, S, N, O	Steel, Iron, Nickel/Cobalt Alloys
CS-2000 CS-800 ON-900 ONH-2000	E-1587	C, S, N, O	Refined Nickel
ON-900 ONH-2000	E-1409	O	Titanium and Titanium Alloys
ON-900 ONH-2000	E-1569	O	Titanium
ON-900 ONH-2000	E-1937	N	Titanium and Titanium Alloys
OH-900 ONH-2000	E-1447	H	Titanium and Titanium Alloys
CS-2000 CS-800 CS-500	E1915-97	C, S	Metal Bearing Ores and Related Materials (f.e. tailings, waste rock)
CS-800 CS-2000	UOP-703-98	C,S	Catalysts

Organics

Instruments	Method	Elements	Materials
CS-2000 CS-500	ASTM D-1552	S	Oils & Petroleum Products
CS-2000 CS-500	D-4239	S	Coal & Coke
	D-5016	S	Coal & Coke Ash
CS-2000 CS-500	D-1619	S	Carbon Black
CS-2000 CS-500	PN-93 G-04514/17	S	Coal & Coke
CS-2000 CS-500	DIN EN 13137	TOC	Waste
CS-2000 CS-800 CS-500	ISO-10694	TC/TOC	Soil samples

CERTIFICATE

The TÜV CERT Certification Body of TÜV Anlagentechnik GmbH
Unternehmensgruppe TÜV Rheinland Berlin Brandenburg

certifies in accordance with
TÜV CERT procedures that

ELTRA

Entwicklungs- und Vertriebsgesellschaft von elektronischen und physikalischen Geräten mbH
Mainstraße 85
D – 41469 Neuss

has established and applies a quality management system for

Development, Production and Distribution of Analytical Instruments.

An audit was performed, Report No. **002005**.
Proof has been furnished that the requirements according to

DIN EN ISO 9001:2000

are fulfilled.
The certificate is valid until **2006-05-31**.
Certificate Registration No. **01 100 002005**

Deutscher Akkreditierungs Rat
DAR
TGA-ZM-28-96-00

Düsseldorf, 2003-06-03

TÜV

TÜV Rheinland
Berlin Brandenburg

TÜV CERT Certification Body of
TÜV Anlagentechnik GmbH

First certification 2000

10/093 BB 03.02_TGA 00