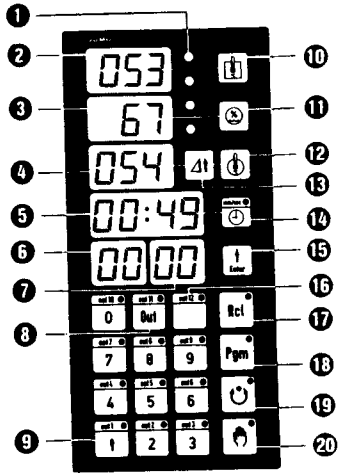
JUMO
MEASUREMENT AND CONTROL

Microprocessor Program Controller, KPF–92

for cooking, smoking and ripening installations



1. **Status** relay
2. **Actual** chamber temperature
3. **Actual** chamber humidity
4. **Actual** core temperature / Δ t
5. **Time**
6. **Program No.**
7. **Section No.**
8. **Function key** for outputs
9. **Number keys and operating outputs**
10. **Setpoint** chamber temperature
11. **Setpoint** chamber humidity
12. **Setpoint** core temperature
13. **Setpoint** Δ t
14. **Setpoint time,** h:min/min:sec
15. **Enter key**
16. **Insert / delete and humidity control**
17. **Setting "fixed program sections"/timing switches**
18. **Programming start/abort**
19. **Program on/off**
20. **Manual operation / stop**

B 75.0101.1

10.91/V 00089538

Brief Operating Instructions

M. K. JUCHHEIM GMBH & CO · 36035 Fulda · GERMANY

PROGRAM INPUT

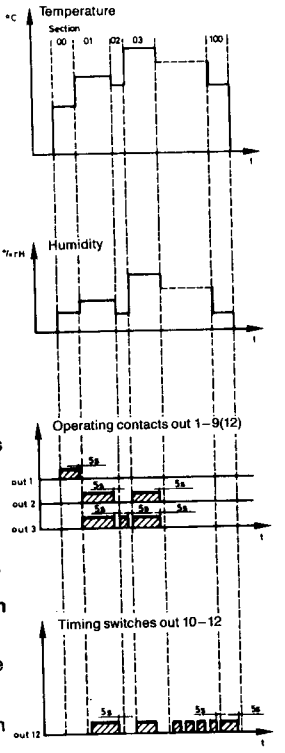
Setpoints and section times
Each section carries the setpoints for chamber temperature, relative humidity, core temperature and time. The sections are automatically numbered consecutively. The selected section time applies to all setpoints, operating contacts and timing switches.

Operating contacts
An operating contact (outputs "out 1" to "out 12") can only have a single switching status during a section. The operating contacts are switched off 5 sec before the end of a section.

Timing switches
During a section the outputs "out 10" to "out 12" can also be programmed as timing switches. It is possible to enter an on-time and an off-time; the relay then switches at these intervals throughout the section. The timing switches are switched off 5 sec before the end of a section.

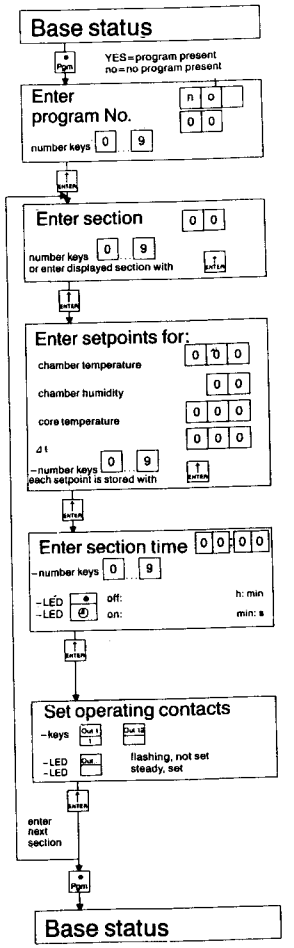
Stepping on to the next section
Stepping on to the next program section can be made to depend on various conditions by suitable programming:

- after the section time has elapsed: input desired section time; set core temperature = 0
- on reaching the core temperature:
  a) heating: setpoint of core temp. < chamber temp.
  b) cooling: setpoint of core temp. > chamber temp.
- after the section time has elapsed **or** after reaching the core temperature:
  input section time **and** core temp.; the condition which is reached first initiates the changeover to the next section.



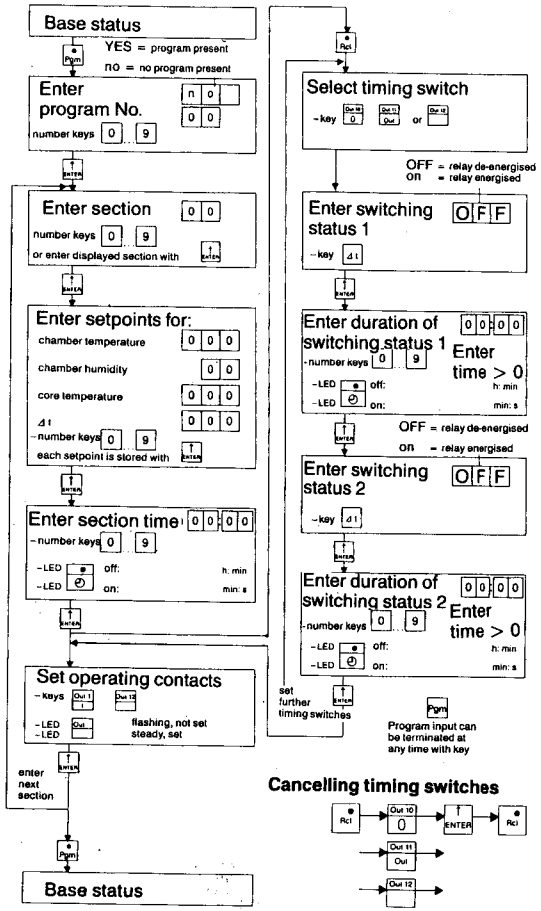
PROGRAM INPUT

Entering setpoints and operating contacts
The program input is always initiated and terminated with the "Pgm" key.
A flashing display requests input of a value or switching status. Each input is entered with the "ENTER" key.



PROGRAM INPUT

Entering/deleting timing switches



Cancelling timing switches

AUTOMATIC OPERATION

Starting and stopping the program

Before the program is started the program number has to be entered! The start section and the start delay can also be entered. No input is required if there is no start delay and the program starts with section zero. It is only necessary to acknowledge the displayed values with "ENTER".

The key has two functions:

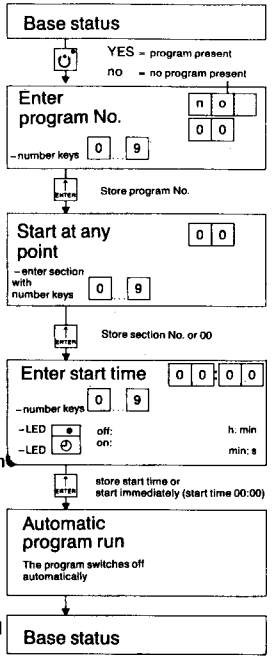
- selection of setpoint and
- changeover between h:min/min:sec; min:sec is selected when the LED in the key is alight.

The LED in the key indicates that a program is currently running

LEDs in the number keys indicate an active output.

The following values are displayed during the program run:
actual chamber temperature and humidity,
actual core temperature, residual section time, program number and the current section number.

The program run is stopped if the key is alight.



Displaying setpoints and programmed operation outputs

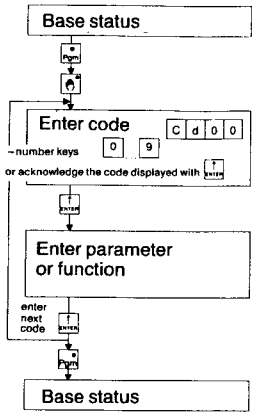
- Press key "Rc1" during automatic operation.

All setpoints and unprogrammed operating outputs of the current program section appear as a flashing display for about 10 sec. The programmed operating outputs are alight continuously. The outputs "out 10" to "out 12" flash more rapidly if they are programmed as timing switches.

SPECIAL FUNCTIONS

Entering codes

Special controller and program settings can be altered using a code (e.g. deleting programs, repeat of cyclic program runs, setting controller parameters). A number of codes are listed in the table below. Further codes are described in detail in the Operating Instructions D95.700. After the values have been input and entered, the instrument switches to the next Cd code. This does not apply to Codes 01, 02, 45, 46, 50, 51 and 52!



Code No.	Special functions	Display
Cd-01	Delete all programs	CLEAr
Cd-02	Delete one program	CPr-00
Cd-03	Display start of range	MB-Start
Cd-04	Display end of range	MB-End
Cd-05	Display type of probe	001=Pt 100
Cd-06	Display decimal point	0=no decimal point 1=one decimal place
Cd-44	Process correction to customer specification X0	000
Cd-45	Process correction to customer specification X1	000
Cd-46	Reset to factory setting	rEG-PAr
Cd-50	Enter fixed sections	F01–F12
Cd-51	Cyclic program runs	00
Cd-52	Pulse duration for humidity control	00:00

Deleting programs

Deleting all programs

- After selection of Code "Cd-01" the display shows "CLEAr".
- All programs are deleted by pressing the "ENTER" key.

Deleting one program

- After selection of Code "Cd-02" the display shows "CPr-00".
- The program to be deleted is selected with the number keys (shown as flashing display)
- Pressing the key "ENTER" deletes the program together with all switching contact states and timing switch programs stored under this number.

Note

Only programs are deleted, not the Cd functions!

Difference cooking process

The difference cooking process can be operated not only during heating but also during cooling ($\Delta t \neq 0$ adjustable between 0 and 99).

Heating

Here the chamber temperature setpoint is set by e.g. 20°C above the core temperature and increases parallel with it until the chamber temperature is reached. The core temperature then continues to rise until the core temperature setpoint is reached. The controller then switches to the next program section.

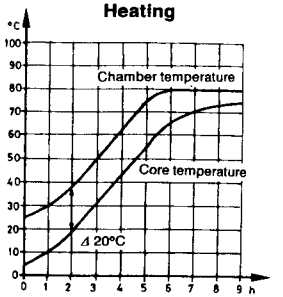
Cooling

If the chamber temperature setpoint is below the core temperature setpoint, cooling operates in the same way.

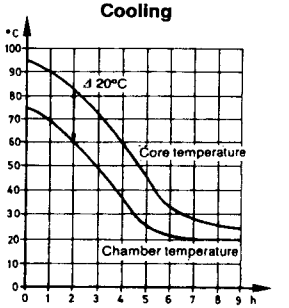
Example

Control of core temperature by the difference cooking process, 20°C below core temperature. The final core temperature has been programmed as 25°C setpoint. The final chamber temperature has been programmed as 20°C setpoint. As already mentioned, there are now 3 possibilities for stepping on to the next section (see end of page 2).

Heating



Cooling



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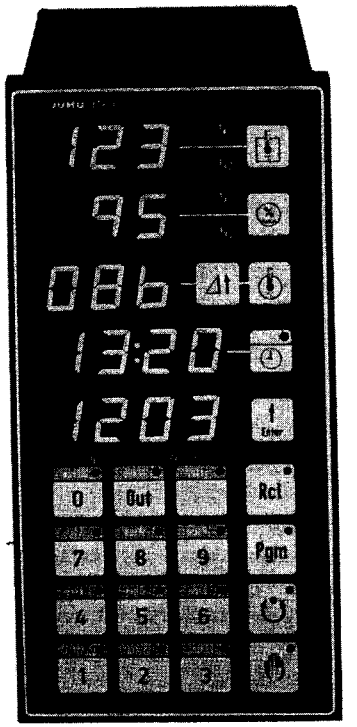
JUMO MEASUREMENT AND CONTROL

Microprocessor program controller for cooking, smoking and ripening installations

Housing to DIN 43 831 for flush panel mounting Bezel 96 x 192 mm



Type KPF-92

D 95.700

1.90/V

Operating Instructions

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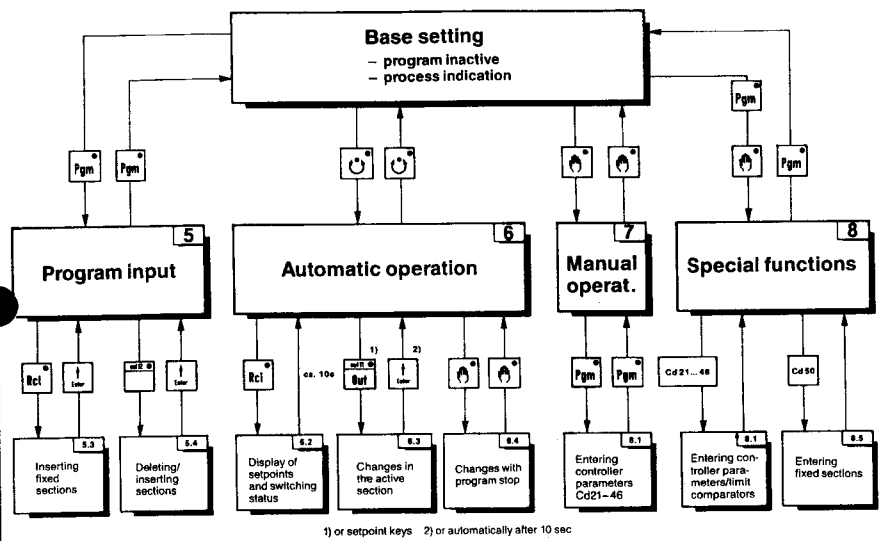
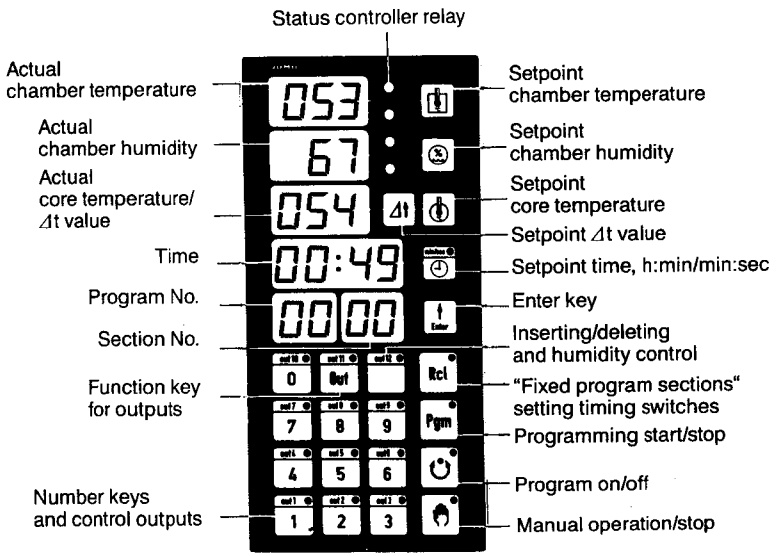
12 FOLD-OUT

12.1 Functional diagram of program controller KPF-92



12.2 Displays and controls



Important Note

All necessary settings and, where appropriate, alterations are described in these Operating Instructions. If, however, any difficulties should arise during start-up you must not carry out any manipulations on the instrument which are not permitted. – You could endanger your rights under the instrument warranty. Please contact the nearest office or the main factory.

Please fold out this page
for reference
when using the
Operating Instructions

CONTENTS

1 DESCRIPTION

This computer-controlled self-monitoring program controller has been developed to handle complicated operating and control processes in cooking and smoking chambers as well as in ripening installations. Up to 20 programs can be set up, stored, called up immediately, and modified as required.
Programs can have up to 100 program sections. The time for each section and the starting time can be programmed between 1 sec and 99 h:59 min.
Each program section carries the setpoints for chamber temperature, relative humidity, core temperature and time.
12 control contacts are available to operate functions such as exhaust, circulation, vents etc. The display indicates all actual values and setpoints, the residual program time, the selected program and the current program section.
All input keys are mounted on a clearly arranged membrane keyboard. The keyboard can be blocked through an external signal to prevent unintentional or unauthorised interference. The front panel is completely splashproof, scratch-resistant, unaffected by acids, and is easily cleaned.

Controller functions	Code
Single setpoint controller with maximum contact	1
Single setpoint controller with minimum contact	2
Double setpoint controller	3
Modulating controller	4

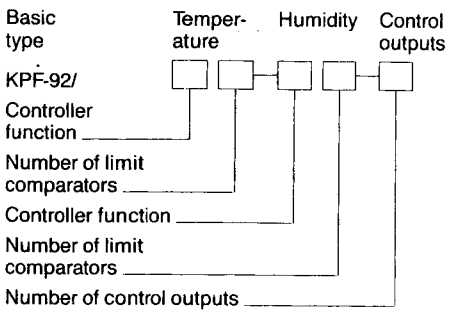
Limit comparators	Code
No limit comparators	0
1 limit comparator	1
2 limit comparators	2

Control outputs	Code
10 control outputs	10
11 control outputs	11
12 control outputs	12

1.1 Type designation

10 relays and 8 switched transistor outputs are available.

They are distributed over the two controllers, their limit comparators, and the control outputs.



Example

KPF-92/31-31-12

Microprocessor program controller
Bezel 96 x 192 mm
Chamber temperature: double setpoint controller
Chamber temperature: 1 limit comparator
Chamber humidity: double setpoint controller
Chamber humidity: 1 limit comparator
12 control outputs

Further details in plain language

■ Indication: °C

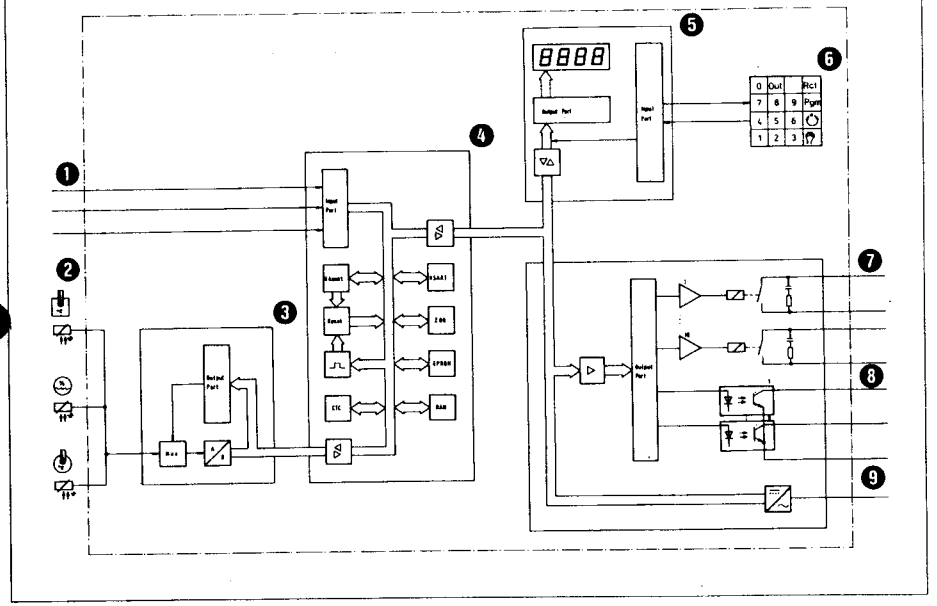
1.2 Standard accessories

2 Mounting brackets
1 Operating instructions

1.3 Accessory

Connector with 2.5 m cable LIY CY 10 x 0.14 mm², grey, for 9-pin subminiature D-socket, Ref. No. 64933

1.4 Block diagram



1.5 Operation

The program controller operates with a microprocessor ❹ which controls the program sequence and the DDC controller with its parameters.
The analogue signals chamber temperature, core temperature and relative humidity ❷ are converted to voltage signals in the input circuit ❸, passed through the analogue multiplexer to the analogue/digital converter and then digitised.
The control parameters and limit comparators can be programmed from the keyboard ❻. A total of 10 relay outputs ❼ with contact protection circuit and 8 transistor-switched outputs ❽ (open collector) are available for control, limit comparator and operating contacts. Control inputs ❶ are provided for keyboard lock, program lock and external stop. The 17-digit 7-segment display ❺ and the 21 LEDs are activated in multiplex.
The read/write memory (RAM) is backed up by a lithium battery in case of mains failure.
The voltage required to operate the unit is supplied from a switched-mode power supply ❾.

Timed programs
a total of 20 programs can be stored

Program running time
1 sec to 99 h:59 min per section

Program sections per program
up to 100 program sections
12 "fixed program sections" can be stored permanently.
A maximum of 3450 memory locations are available. A program section takes up approx. 14 locations.

Display
bright 7-segment LED displays, 13 mm high, red, for:

– chamber temperature in °C (°F)	3 digits
– relative humidity in % rH	2 digits
– core temperature and Δt in °C (°F)	3 digits
– program time in h:min or min:sec	4 digits
– number of selected program	2 digits
– program section	2 digits

Function keys
for
– manual operation
– automatic start/stop
– programming
– checking or calling up fixed program sections
– control contacts "Out"

Data keys
number keys 0 to 9

Selection of start time
through keyboard, 1 sec to 99 h:59 min

Temperature control

Range
–99+850 °C (–99+999 °F)

Input range
0+850 °C
0+999 °F

Transducer
resistance thermometer Pt 100 in 3-wire circuit

Line adjustment
not required

Humidity control

Range
0–99 % rH,
working range 0 to 100 °C

Transducer
The relative humidity is determined from the psychrometric difference between two Pt 100 resistance thermometers (wet and dry).
The dry probe is also used for temperature control.
The air velocity should be at least 2–5 m/sec.
The reference temperature for humidity control is compensated to the actual operating temperature.

Humidity control
through adjustable pulse/interval ratio

Control accuracy
temperature: 0.05 % max./0.01 % max. per 10 °C
humidity: ±1.5 %

Indication accuracy

temperature: ±0.3 %	±1 digit
humidity: ±1.5 %	
within 0–200 °C:	±1 °C ±1 digit

Timing accuracy
at least 0.05 %

Update rate
1/sec

Linearisation
fitted as standard

Single setpoint controller with max. or min. contact
Feedback: PD, PID, PD/PID
Proportional band, derivative time, reset time, switching differential, cycle time can be programmed.

Double setpoint controller
(for heating–cooling / humidifying–dehumidifying)
Feedback: PD, PID, PD/PID acting on both contacts.
Proportional band, contact spacing, derivative time, reset time, switching differential and cycle time can be programmed.

Modulating controller
(for operating motorised valves)
Feedback: PI, PID
Proportional band, contact spacing, derivative time, reset time, switching differential can be programmed.

Core temperature
resistance thermometer Pt 100,
range –99+850 °C
–99+999 °F

Contact rating controller/limit comparator/control outputs
660 W 3 A at 220 V 50 Hz
resistive load

Contact life
electrical contact life
approx. 10^6 operations at rated load

Supply
normally 93 – 264 V a.c., 40 – 60 Hz

Electrical connection
signal and control inputs and relay outputs through individual terminals, 2.5 mm² max., transistor-switched outputs (open collector) through 9-pin subminiature D-connector

Loading
17 VA approx.

Data back-up
by lithium battery,
back-up time 3 – 5 years approx.
automatic low-battery indication

Action on supply failure
The program is interrupted. When the supply is restored the automatic program continues provided the difference between setpoint and actual chamber temperature is less than 10 %. If the difference exceeds 10 % the automatic program remains interrupted. Continuation or re-start is possible only after pressing the "ENTER" key.

External control inputs and outputs

Keyboard lock
all keys are blocked

Programming lock
the programming key is blocked.
The unit can be started or stopped.

External stop
through floating contact;
stop in automatic program

Control outputs
12 programmable control outputs.
Depending on the controller model and the number of limit comparators, the control outputs are provided as relays or switching transistors.
With certain controller/limit comparator combinations the number of control outputs may be reduced.

Transistor-switched control outputs
open collector, 500 mA max.;
U_{CE} = 50 V max.

Housing
aluminium die casting
bezel: 96 x 192 mm
depth: 181 mm

Permitted ambient temperature range
0 to 50 °C

Permitted storage temperature range
– 20 to + 70 °C

Climatic conditions
Class KWF to DIN 40 040
rel. humidity not exceeding 75 % annual mean, no condensation

Protection
to DIN 40 050
front IP 65 splashproof
(can be washed with water without pressure up to 70 °C);
rear IP 00

Operating position
vertical ⊥ NL 90 to DIN 16 257

Weight
approx. 2500 g

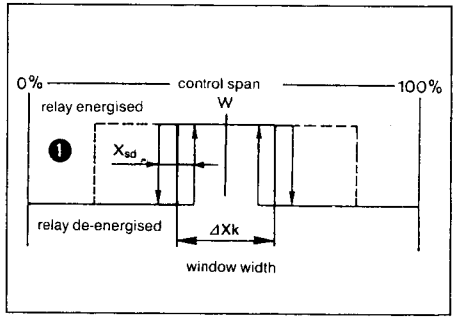
Limit comparator Ik1 to Ik8

Adjustment range: temperature 0 – 999 digit
humidity 0 – 99 digit
Switching differential X_{Sd} = 2 °C

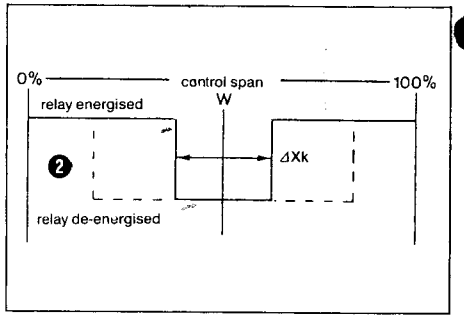
Operation

❶ Limit comparator Ik1

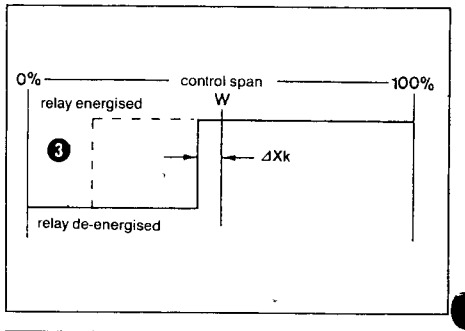
The relay is energised when the process is within the set window, and de-energised when the process is outside the window.
The setting is half the window width.



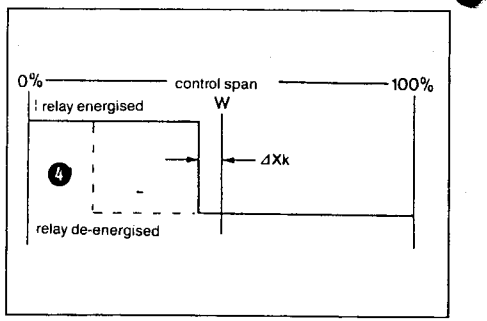
❷ Ik2 as ❶
but relay action reversed.
The setting is half the window width.



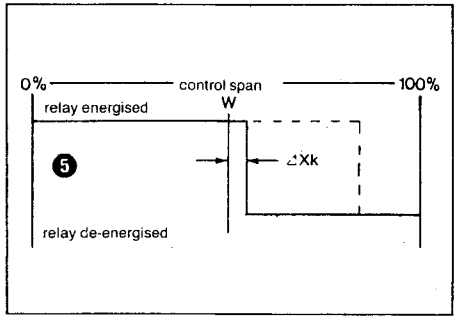
❸ Low alarm Ik3
(advance contact)
Action: relay is energised when process is above setpoint



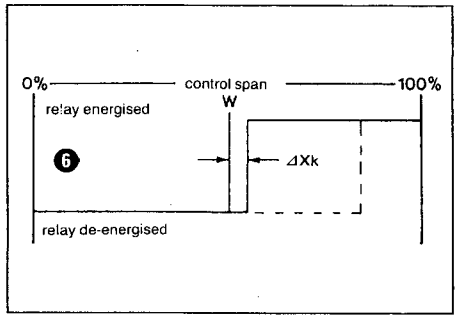
❹ Ik4 (advance contact) as ❸
but relay action reversed



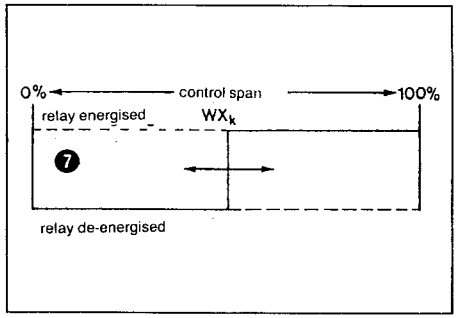
❺ High alarm Ik5
(follow-on contact)
Action: relay is de-energised when process is above setpoint



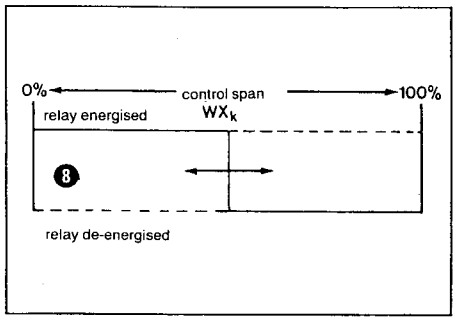
❻ Ik6 (follow-on contact) as ❺
but relay action reversed



❼ Ik7 adjustable over the entire control span
Action: relay is energised when process is above setpoint.



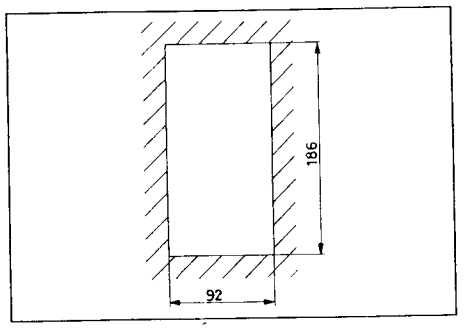
❽ Ik8 as ❼
but relay action reversed



3 INSTALLATION

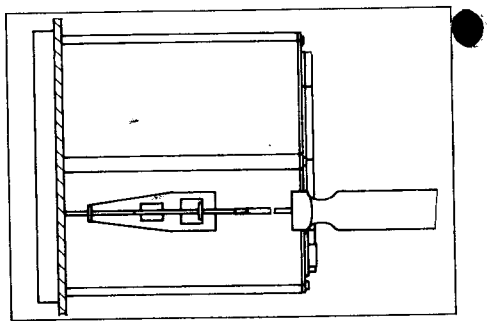
3.1 Location and climatic conditions

The location should as far as possible be free from vibration. Stray electromagnetic fields, e.g. from motors, transformers etc., should be avoided. The ambient temperature at the instrument location should be between 0 and 50 °C and the relative humidity not more than 75 %. Corrosive conditions or fumes reduce the life of the instrument.

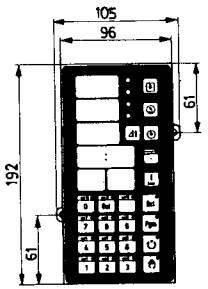


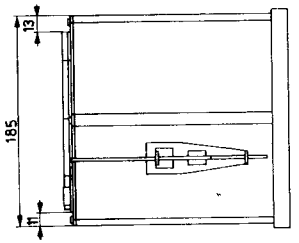
3.2 Fitting in position

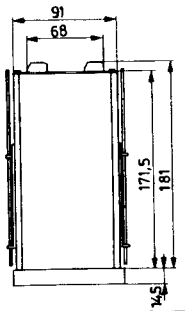
Insert the program controller from the front into the panel cut-out. The mounting brackets are then inserted from behind the panel into the cut-outs in the sides of the housing. The flat bracket faces must be against the housing. The brackets are then placed against the rear of the panel and tightened up evenly with a screwdriver.



3.3 Dimensions







4 ELECTRICAL CONNECTION

4.1 Important notes on installation

- All sensor and signal lines should where possible be run separately from the control and supply cables.
- Where several electronic units are installed it is preferable for each to have a separate supply cable including ground.
- Screened cables should be used and only be grounded at the program controller (PE).
- Where possible provide physical separation between electronic units and contactors.
- If there are inductive loads close to the unit, such as contactors, solenoid valves etc., it is advisable to reduce interference by fitting an RC module to the solenoid coil.
- No control circuit (relay, contactor) should be connected to the supply terminals of the instrument.
- Please observe the appropriate safety regulations for overtemperature limitation.

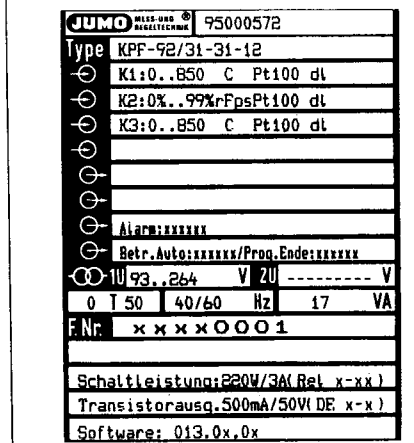
4.2 Identifying the model

- Ascertain the type of model from the instrument label and the type designation.
- Ascertain the relay designations from the connection diagram of the relay contacts (Chapter 4.3).
- Connect up according to the connection diagram (Chapter 4.4).

Ordering example

KPF-92/31-31-12

Microprocessor program controller
Bezel 96 x 192 mm
Chamber temperature: double setpoint controller
Chamber temperature: 1 limit comparator
Chamber humidity: double setpoint controller
Chamber humidity: 1 limit comparator
12 control contacts



4.3 Connection diagram of relay contacts/switched transistor outputs

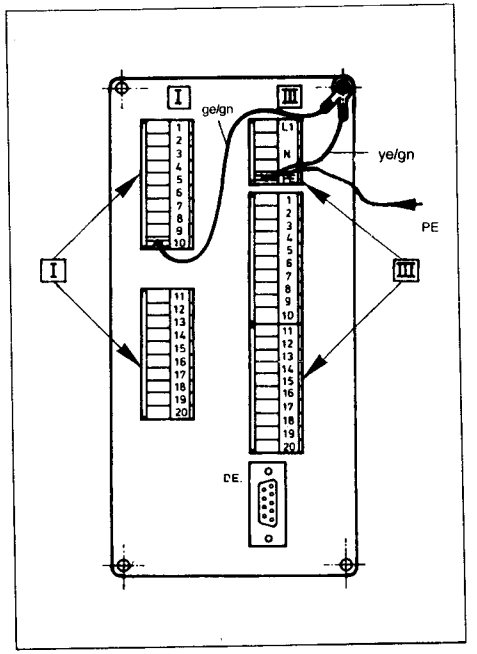
Channel 1			Channel 2			Control outputs
Controller		Ik 1 2	Controller		Ik 1 2	Relay contacts 1 2 3 4 5 6 7 8 / Switched transistor outputs 9 10 11 12
Relay	1		Relay	2		3 4 5 6 7 8 9 10 1 2 3 4
	1	3		2		4 5 6 7 8 9 10 1 2 3 4 5
	1			2	3	4 5 6 7 8 9 10 1 2 3 4 5
	1	3 4	Single-setpoint	2		5 6 7 8 9 10 1 2 3 4 5 6
	1		controller	2	3 4	5 6 7 8 9 10 1 2 3 4 5 6
	1	3		2	4	5 6 7 8 9 10 1 2 3 4 5 6
	1	3 4		2	5	6 7 8 9 10 1 2 3 4 5 6 7
	1	3		2	4 5	6 7 8 9 10 1 2 3 4 5 6 7
Single-setpoint	1	3 4		2	5 6	7 8 9 10 1 2 3 4 5 6 7 8
controller	1		Relay	2 3		4 5 6 7 8 9 10 1 2 3 4 5
	1	4		2 3		5 6 7 8 9 10 1 2 3 4 5 6
	1			2 3	4	5 6 7 8 9 10 1 2 3 4 5 6
	1	4 5	Double-setpoint	2 3		6 7 8 9 10 1 2 3 4 5 6 7
	1		controller	2 3	4 5	6 7 8 9 10 1 2 3 4 5 6 7
	1	4		2 3	5	6 7 8 9 10 1 2 3 4 5 6 7
	1	4 5		2 3	6	7 8 9 10 1 2 3 4 5 6 7 8
	1	4		2 3	5 6	7 8 9 10 1 2 3 4 5 6 7 8
	1	4 5		2 3	6 7	8 9 10 1 2 3 4 5 6 7 8
Relay	1 2		Relay	3		4 5 6 7 8 9 10 1 2 3 4 5
	1 2	4		3		5 6 7 8 9 10 1 2 3 4 5 6
	1 2			3	4	5 6 7 8 9 10 1 2 3 4 5 6
	1 2	4 5	Single-setpoint	3		6 7 8 9 10 1 2 3 4 5 6 7
	1 2		controller	3	4 5	6 7 8 9 10 1 2 3 4 5 6 7
	1 2	4		3	5	6 7 8 9 10 1 2 3 4 5 6 7
	1 2	4 5		3	6	7 8 9 10 1 2 3 4 5 6 7 8
	1 2	4		3	5 6	7 8 9 10 1 2 3 4 5 6 7 8
Double-setpoint	1 2	4 5		3	6 7	8 9 10 1 2 3 4 5 6 7 8
controller	1 2		Relay	3 4		5 6 7 8 9 10 1 2 3 4 5 6
	1 2	5		3 4		6 7 8 9 10 1 2 3 4 5 6 7
	1 2			3 4	5	6 7 8 9 10 1 2 3 4 5 6 7
	1 2	5 6	Double-setpoint	3 4		7 8 9 10 1 2 3 4 5 6 7 8
	1 2		controller	3 4	5 6	7 8 9 10 1 2 3 4 5 6 7 8
	* 1 2	5		3 4	6	7 8 9 10 1 2 3 4 5 6 7 8
	1 2	5 6		3 4	7	8 9 10 1 2 3 4 5 6 7 8
	1 2	5		3 4	6 7	8 9 10 1 2 3 4 5 6 7 8
	1 2	5 6		3 4	7 8	9 10 1 2 3 4 5 6 7 8

*** This arrangement of the relay contacts/ switched transistor outputs corresponds to the example and instrument label in Chapter 4.2 and to the stock version.**

For arrangement of relay contacts/switched transistor outputs for automatic operation, alarm, program stop etc. to customer specification see instrument label or the Output Data Table enclosed.

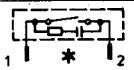
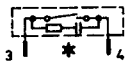
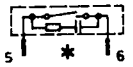
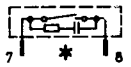
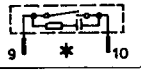
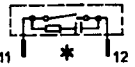
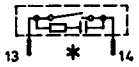
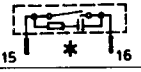
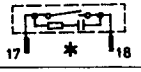
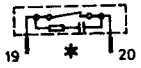
4.4 Connection diagram

The electrical connections are made according to the connection diagram below. The requirements of VDE 0100 "Regulations on the Installation of Power Circuits with nominal voltages below 1000 V" or the corresponding local regulations have to be observed when selecting the cable and connecting the instrument to the mains supply.

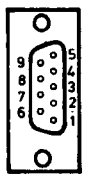


Connection for	Terminals	Terminal block I			
		Signal inputs			
		Chamber temperature	Rel. humidity	Core temperature	
		°C	%	°C	
Resistance thermometer in 3-wire circuit	w	1 2 3	4 5 6	7 8 9	1 2 3 4 5 6 7 8 9
Protective ground PE	10	⏚ Connection for screen			10 ⏚
Ext. input 1	18 17	floating contact GND	Keyboard lock		18 17 GND
Ext. input 2	19 17	floating contact GND	Programming lock		19 17 GND
Ext. input 3	20 17	floating contact GND	Program stop		20 17 GND
	12 11	used internally			

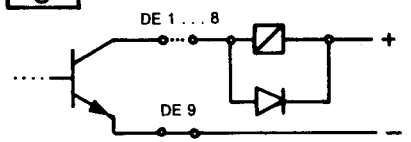
4 ELECTRICAL CONNECTION

Connection for		Terminals		Terminal block III
Supply		L1 N PE	Line Neutral Ground	
Relay outputs	1	1 2	(S) closing (P) common	
	2	3 4	(S) closing (P) common	
	3	5 6	(S) closing (P) common	
	4	7 8	(S) closing (P) common	
	5	9 10	(S) closing (P) common	
	6	11 12	(S) closing (P) common	
	7	13 14	(S) closing (P) common	
	8	15 16	(S) closing (P) common	
	9	17 18	(S) closing (P) common	
	10	19 20	(S) closing (P) common	
Switched transistor outputs	1	DE1 DE9	Subminiature socket DE, 9-pin	
	2	DE2 DE9		
	3	DE3 DE9		
	4	DE4 DE9		
	5	DE5 DE9		
	6	DE6 DE9		
	7	DE7 DE9		
	8	DE8 DE9		

DE.



U_{CE} max. = 50 V
I_{CE} max. 500 mA



* RC protective circuit 56Ω 0.5 W, 22 nF 1000 V

5 PROGRAM INPUT

Setpoints and section times

Up to 20 programs for temperature and humidity can be programmed. Programs can have up to 100 sections. Each section carries the setpoints for chamber temperature, relative humidity, core temperature and time.
The sections are automatically numbered consecutively. The selected section time applies to all setpoints, control contacts and timing switches.

Control contacts

There is also provision for activating control contacts within a section to operate fans, vents, valves etc.
A control contact can only have a single switching status during a section. The outputs "out1" to "out12" are available as control contacts. The control contacts are switched off 5 sec before the end of a section.

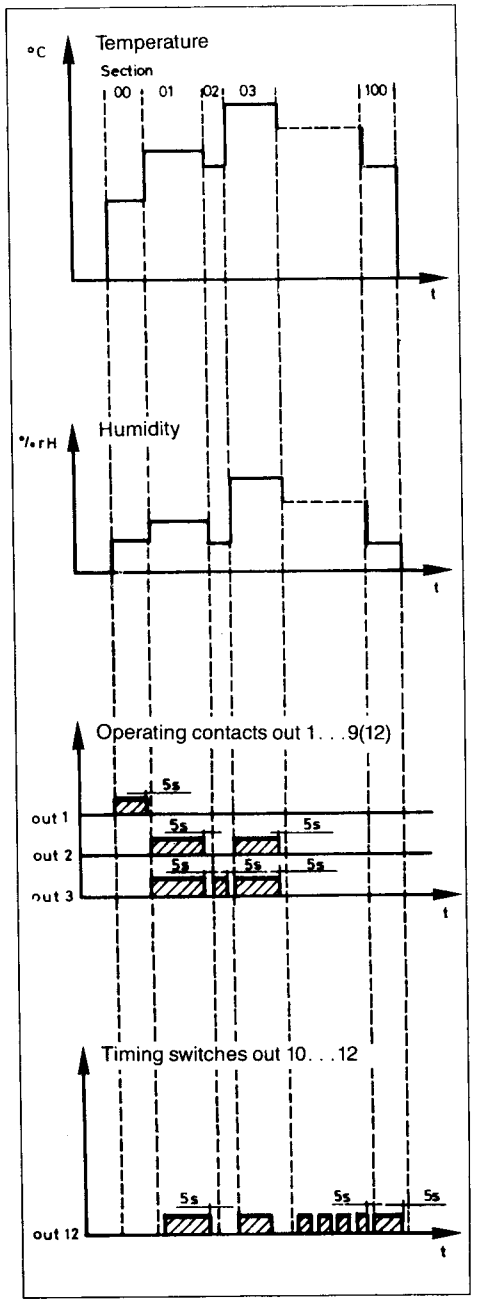
Timing switches

The outputs "out10" to "out12" can also be programmed as timing switches. They can be operated **during** a section. It is possible to enter an on-time and an off-time; the relay then switches at these intervals throughout the section. In this way it is possible, for example, to operate a fan for 30 seconds at 10-minute intervals during a one-hour warming-up phase. The timing switches are switched off 5 sec before the end of a section.

Stepping on to the next section

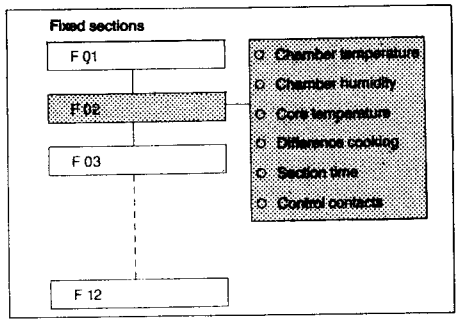
Stepping on to the next section during the program run can be made to depend on various conditions by suitable programming:

- after a time has elapsed:
  input of section time;
  input of core temperature = 0
- on reaching the core temperature:
  a) heating: core temp. < chamber temp.
  b) cooling: core temp. > chamber temp.
  input of core temperature;
  input of section time = 0
- after a time has elapsed or after reaching the core temperature:
  input of section time and core temperature.
  The condition which is reached first initiates the changeover to the next section.

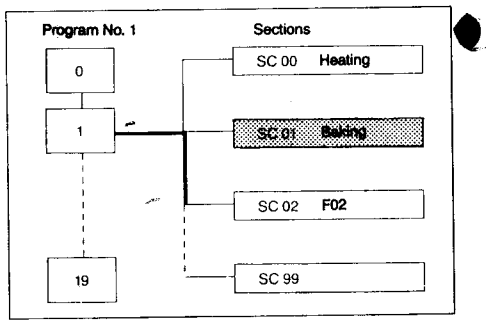


Fixed sections

During program input it is possible to insert so-called "fixed sections". These fixed sections are entered beforehand under Code 50 (see Chapter 8.5) and can then be assigned to any program. In this way sections which repeat regularly do not have to be entered again each time. Up to 12 "fixed sections" (F01 to F12) can be defined.



The upper diagram shows the parameters stored under the "fixed section" F02. In the lower diagram this function has been included in program 1 as section SC02 during input of the program.



Difference cooking process

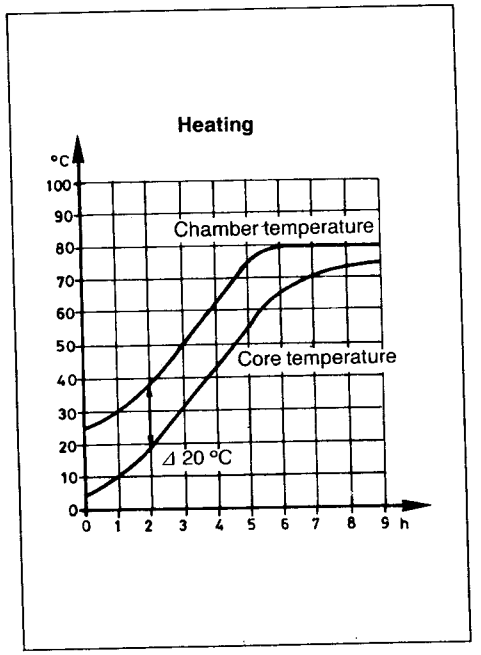
The difference cooking process ($\Delta t \neq 0$) is available not only during heating but also during cooling.

Heating

The chamber temperature setpoint is gradually increased so that it is always e.g. 20 °C above the actual core temperature until the selected chamber temperature is reached. The core temperature then continues to rise until the core temperature setpoint is reached; the controller then switches over to the next program section.

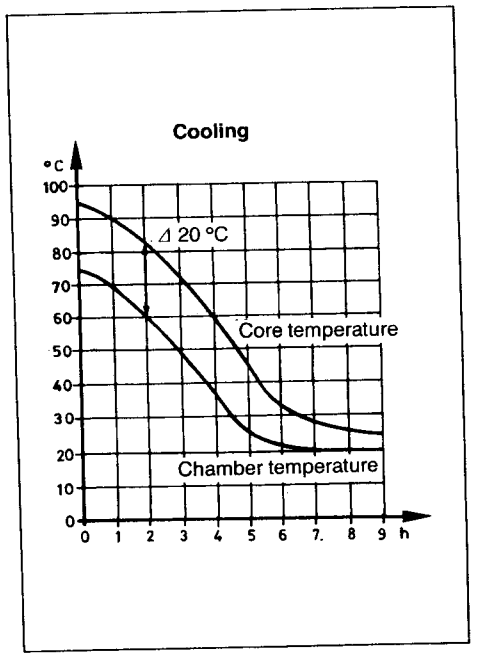
Example:

Control of core temperature by the difference cooking process, 20 °C above core temperature. The final core temperature has been programmed as 75 °C setpoint. The final chamber temperature has been programmed as 80 °C setpoint.



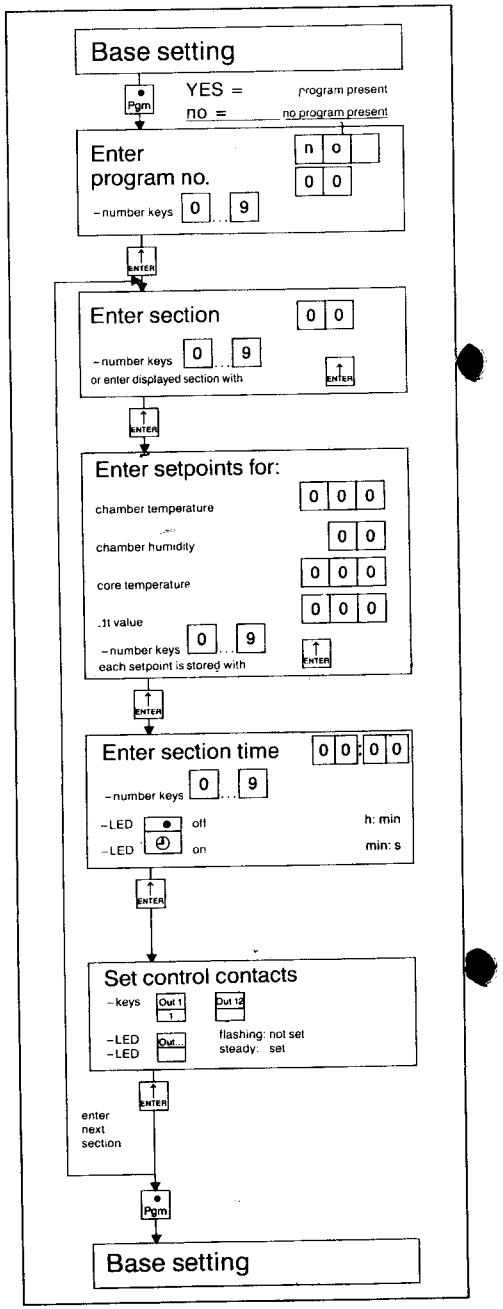
Cooling

If the chamber temperature setpoint is below the core temperature setpoint, a corresponding cooling process is operated.

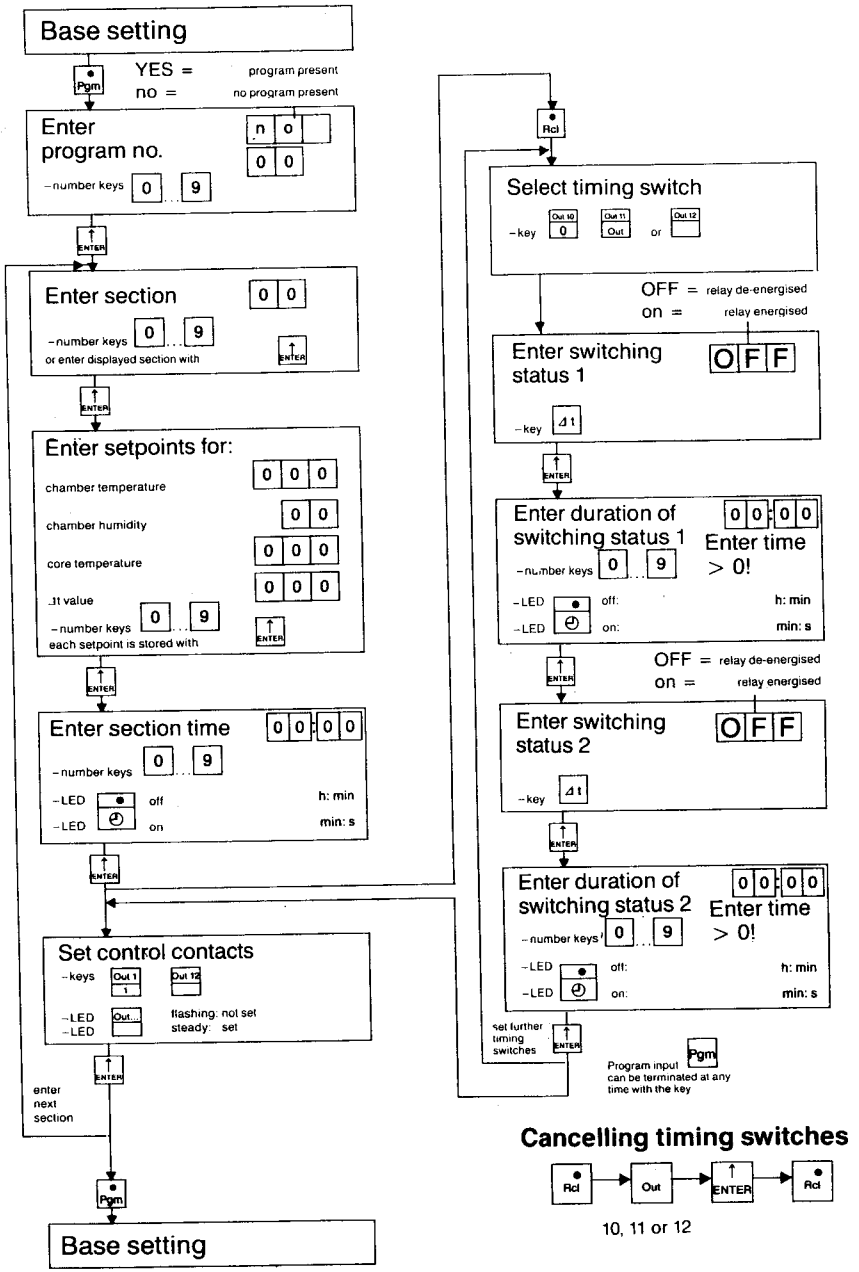


5.1 Entering setpoints and control contacts

The program input is always initiated and terminated with the "Pgm" key. A flashing display requests input of a value or switching status. Each input is entered with the "ENTER" key.



5.2 Entering/deleting timing switches

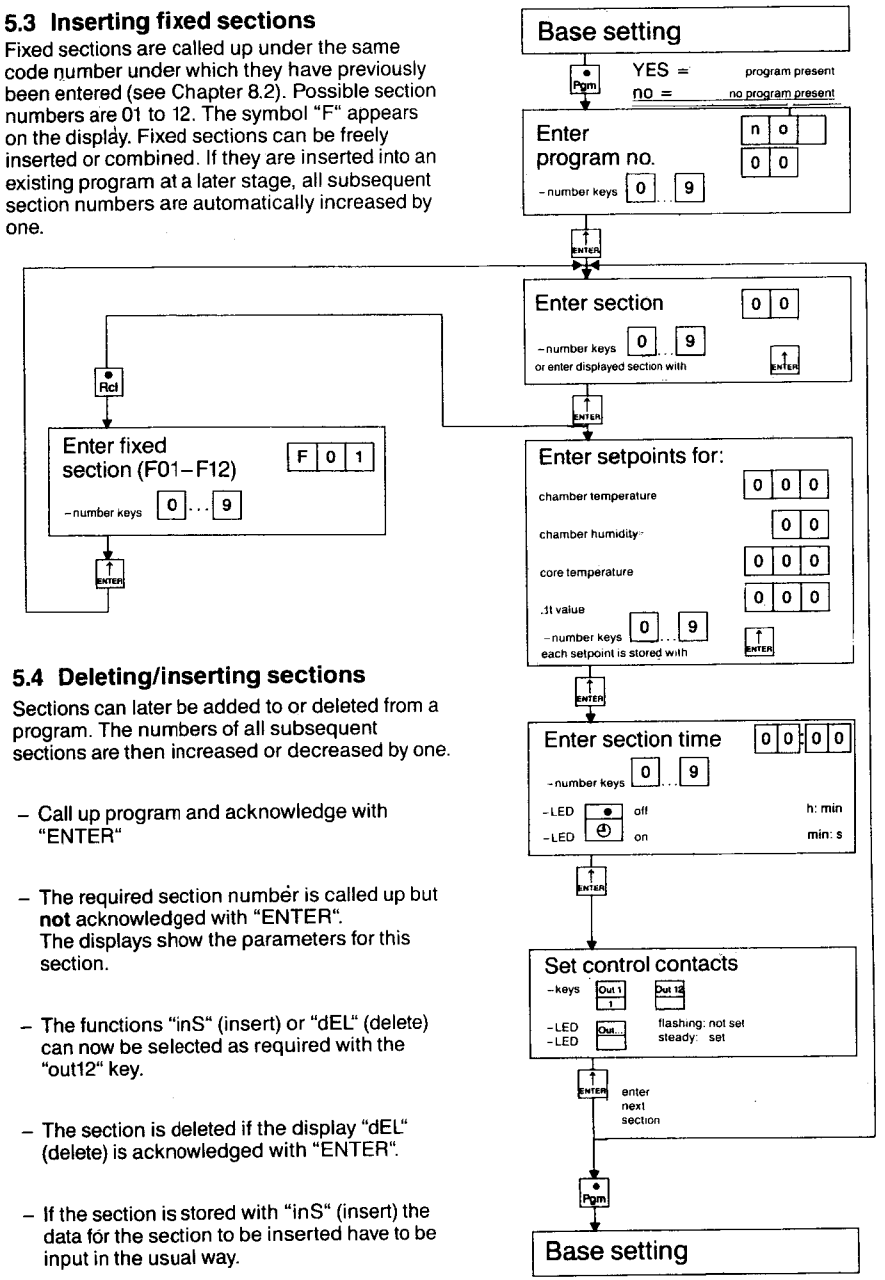


Cancelling timing switches

10, 11 or 12

5.3 Inserting fixed sections

Fixed sections are called up under the same code number under which they have previously been entered (see Chapter 8.2). Possible section numbers are 01 to 12. The symbol "F" appears on the display. Fixed sections can be freely inserted or combined. If they are inserted into an existing program at a later stage, all subsequent section numbers are automatically increased by one.



5.4 Deleting/inserting sections

Sections can later be added to or deleted from a program. The numbers of all subsequent sections are then increased or decreased by one.

- Call up program and acknowledge with "ENTER"
- The required section number is called up but **not** acknowledged with "ENTER". The displays show the parameters for this section.
- The functions "inS" (insert) or "dEL" (delete) can now be selected as required with the "out12" key.
- The section is deleted if the display "dEL" (delete) is acknowledged with "ENTER".
- If the section is stored with "inS" (insert) the data for the section to be inserted have to be input in the usual way.

6.1 Starting and stopping the program

Before the program is started the program number has to be entered. Inputs are also possible to select the start section and the start delay. No input is required if there is no start delay and the program starts with section zero. It is only necessary to acknowledge the displayed values with "ENTER".

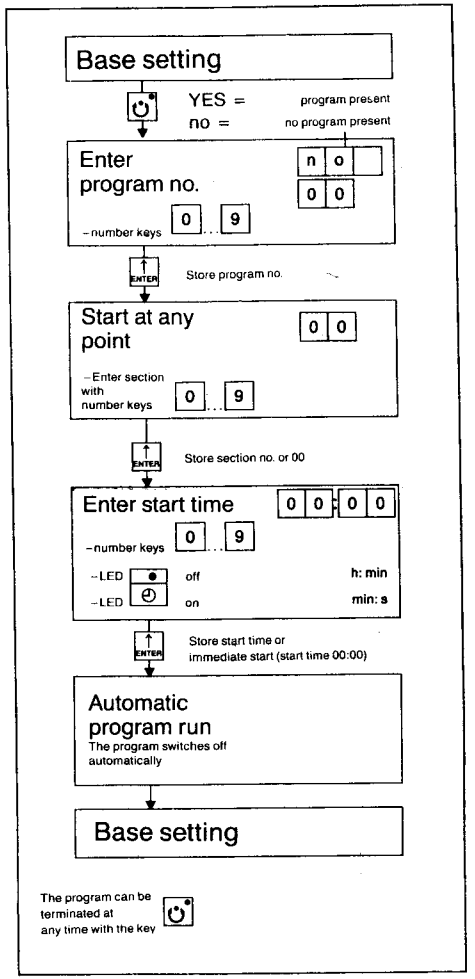
The key ⏲ has two functions:

- selection of setpoint and
- changeover between h:min/min:sec; min:sec is selected when the LED in the key is alight.

The LED in the key ⏲ indicates that a program is currently being run. LEDs in the number keys indicate that an output is activated.

The following values are displayed during the program run:
actual chamber temperature and humidity, actual core temperature, residual section time, program number and the current section number.

The timed program run is stopped if the key ✋ is also alight, see Chapter 6.4 and 7.



6.2 Displaying setpoints and programmed control outputs

- Press key "Rcl" during the automatic program run.

Alle setpoints and unprogrammed control outputs of the current program section appear as a flashing display for about 10 sec. The programmed control outputs are alight continuously. The outputs "out10" to "out12" flash more rapidly if they are programmed as timing switches.

6.3 Changes in the active section

Setpoints

- Press the setpoint key to the right of the corresponding display.
- Alter the flashing setpoint with the number keys.
- Store with the "ENTER" key.

Control outputs

- Press key "Out".
  The status of all relays entered in the current section are displayed.
- Enter the desired relay status with the keys "out1" to "out12" to correspond with the outputs 1–12.

  If the relay has been input as timing switch the amended switching status is maintained for the **total** section time.
- Enter with the "ENTER" key.

The alteration applies only to the current program run, i.e. the program entered under this number is not altered.
The time continues to run during the alteration.

6.4 Changes with program stop

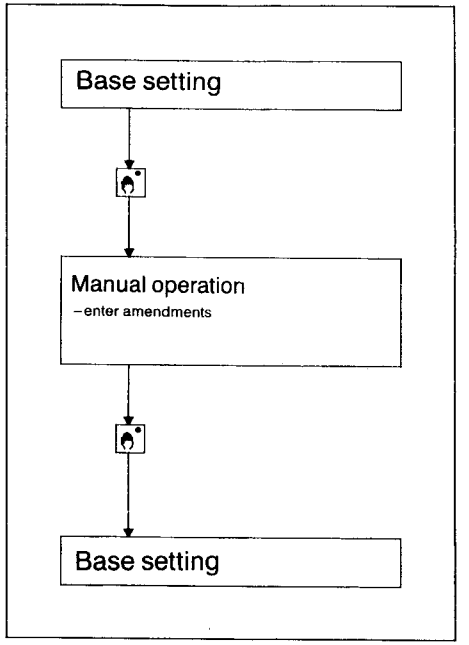
- Press "Hand" key.
  The time base of the program run is stopped.
- Changes can be made to the setpoints for chamber temperature, relative humidity and control outputs.

  The displays and alterations are the same as described under 6.3.
- After pressing the key "HAND" again the program continues from the point where it was interrupted. The unit continues to operate with the previous setpoints.

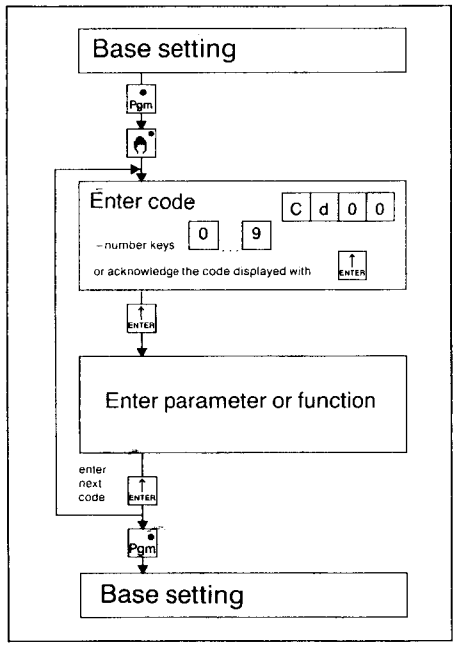
The program run is extended by the period of manual operation. Alterations are not transferred to the memory.

7.1 Control of fixed values

During manual operation it is possible to enter setpoints for chamber temperature, humidity and control outputs from the base setting without a program being active. The procedure is as described in Chapter 6.3.
After pressing the "Hand" key the program controller accepts the actual values as setpoints.



Special controller and program data such as "fixed program sections", deleting programs, controller parameters, defined cyclic program runs etc. can be input using a code. The codes are listed in the individual chapters.
After the values have been input and entered the instrument switches to the next Cd code. This does not apply to Codes 01, 02, 45, 46, 50, 51 and 52.



8.1 Entering controller parameters/ limit comparators

The program controller is preset at the factory in accordance with the order details.
Subsequent changes may be required, for example during optimisation of the control action.
After entering the code the upper display shows the parameters of the temperature controller, the lower display those of the humidity controller. The parameters of the various program controller types for temperature and humidity and the adjustment ranges and factory settings are listed in the Table alongside.
In case of incorrect input the corresponding display shows the minimum or maximum value permitted.
The instrument label shows the controller type and the number of limit comparators (up to 2 per controller) assigned to the temperature and humidity controller.

Change of channel during input of controller parameters:
With the Cd functions Cd21 to Cd45 it is possible to switch to parameter input "temperature" by pressing the setpoint key ⇧ or to parameter input "rel. humidity" by pressing the setpoint key ⇩.
All input values must be confirmed with "ENTER".

Single-setpoint controller max. contact/min. contact

Code No.	equals	Parameter	Feedback action none	PD	PID	PD/PID	Adjustment range	Factory setting
Cd21	Xp	Proportional band	0 digit	●	●	●	0 – 999 digit	4 digit
Cd24	Tv	Derivative time	–	●	0 sec*	●	0 sec, 8 – 999 sec	80 sec
Cd25	Tn	Reset time	–	0 sec	●	●	0 sec, 32 – 999 sec	350 sec
Cd26	Xd	Differential	●	–	–	–	0 – 999 digit	10 digit x 0.1
Cd27	CY	Cycle time	–	●	●	●	1 – 99 sec	20 sec
Cd30	Y1	Max. + ve stroke	–	●	●	●	0 – 100 %	100 %
Cd32	Y	Valve stroke %					—	—

Double setpoint controller

Code No.	equals	Parameter	Feedback action none	PD	PID	PD/PID	Adjustment range	Factory setting
Cd21	Xp1	Proportional band (heating contact)	0 digit	●	●	●	0 – 999 digit	4 digit
Cd22	Xp2	Proportional band (cooling contact)	0 digit	●	●	●	0 – 999 digit	0 digit
Cd23	XSh	Contact spacing (symmetrical)	●	●	●	●	0 – 999 digit	10 digit x 0.1
Cd24	Tv	Derivative time	–	●	0 sec*	●	0 sec, 8 – 999 sec	80 sec
Cd25	Tn	Reset time	–	0 sec	●	●	0 sec, 32 – 999 sec	350 sec
Cd26	Xd1	Differential (heating contact)	●	–	–	–	0 – 999 digit	10 digit x 0.1
Cd27	CY1	Cycle time	–	●	●	●	1 – 99 sec	20 sec
Cd28	Xd2	Differential (cooling contact)	●	–	–	–	0 – 999 digit	10 digit x 0.1
Cd29	CY2	Cycle time	–	●	●	●	1 – 99 sec	20 sec
Cd30	Y1	Max. + ve stroke	–	●	●	●	0 – 100 %	100 %
Cd31	Y2	Max. – ve stroke	–	●	●	●	0 to – 99 %	– 99 %
Cd32	Y	Valve stroke %					—	—

Modulating controller

Code No.	equals	Parameter	Feedback action none	Pt	PD	Adjustment range	Factory setting
Cd21	Xp	Proportional band	0 digit	●	●	0 – 999 digit	4 digit
Cd23	XSh	Contact spacing	●	●	●	0 – 999 digit	10 digit x 0.1
Cd24	Tv	Derivative time	–	●	0 sec	0 sec, 8 – 999 sec	80 sec
Cd25	Tn	Reset time Stroke time 60 sec	–	●	●	0 sec, 32 – 999 sec	350 sec
Cd26	Xd	Differential	●	–	–	0 – 999 digit	10 digit x 0.1
Cd32	Y	Valve stroke %				—	

Limit comparators

Code No.	equals	Parameter	Adjustment range	Factory setting
Cd34	1 – 8	Function of limit comparator 1 (lk.)	0 – 8[1)]	0
Cd35	setpoint	Setpoint of limit comparator 1	0 – 999 digit	000 digit
Cd36	1 – 8	Function of limit comparator 2 (lk.)	0 – 8[1)]	0
Cd37	setpoint	Setpoint of limit comparator 2	0 – 999 digit	000 digit

● = adjustable – = not adjustable ▒ = standard setting [1)]0 = no function (factory setting)
*Tv = Tn/4.5

Additional Cd Codes

Code No.	Special function	Display	Description see
Cd-01	Delete all programs	CLEAr	Chapter 8.2
Cd-02	Delete one program	CPr-00	Chapter 8.2
Cd-03	Display start of range	Start	—
Cd-04	Display end of range	End	—
Cd-44	Process correction to customer specification X0	000	Chapter 8.3
Cd-45	Process correction to customer specification X1	000	Chapter 8.3
Cd-46	Reset to factory setting	rEG-PAr	Chapter 8.4
Cd-50	Entering fixed sections	F01 to F12	Chapter 8.5
Cd-51	Cyclic program runs	00	Chapter 8.6
Cd-52	Pulse duration for humidity control	00:00	Chapter 8.7

8.2 Deleting programs

Deleting all programs:

- After selection of Code "Cd-01" the display shows "CLEAr".
- All programs are deleted by pressing the "ENTER" key.

Deleting one program

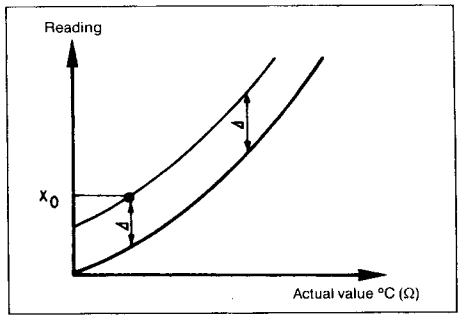
- After selection of Code "Cd-02" the display shows "CPr-00".
- The program to be deleted is selected with the number keys (shown as flashing display).
- Pressing the "ENTER" key deletes the program together with all switching contact states and timing switch programs stored under this number.

Note:
Only programs can be deleted, not the Cd functions!

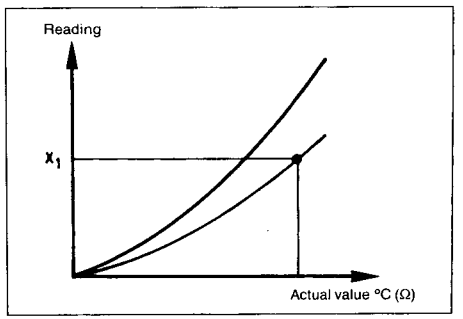
8.3 Actual value adjustment to user specification

An actual value indication which differs from the desired or true value can be adjusted with the keys. This may useful, for example, to obtain the same reading on several instruments or to compensate for the resistance of the sensor cable.
Two values have to be input, intermediate values are interpolated or extrapolated by the controller. When changing X0 and X1 the corresponding value must be applied at the signal input.

Cd 44: Start of range X0
Incorrect reading of the actual value at the start of range.
The reading is close to the ambient temperature.
Correction (see illustration alongside):
The desired process value corresponding to the actual value is entered in the memory location X0. The controller corrects its measurement by a constant value X so that this desired value is indicated instead of the measured value.



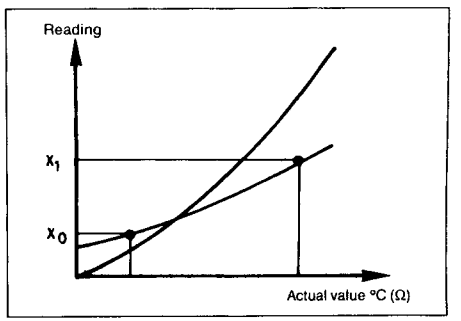
Cd 45: End of range X1
Correction of process indication at end of range.
The reading is close to the end of range.
Correction (see illustration alongside):
The desired process value corresponding to the actual value is entered in the memory location X1. The controller corrects its measurement by interpolation so that it indicates the corrected values at the points X0 and X1.
If X0 has not been programmed it is assumed that X0 = 0. These corrections can be repeated as often as required.



Correction of start and end of range
Example (see illustration alongside):
Measurement 1: 0 °C
Desired reading: 5 °C
Measurement 2: 350 °C
Desired reading: 340 °C

Correction:
Input during measurement 1: X0 = 5 °C
and during measurement 2: X1 = 340 °C
All intermediate values are corrected.

—— display without process value correction
—— display with process value correction



The correction is cancelled by entering 0 for X0 or X1. An input of X0 = X1 or X1 = X0 results in the error message Err 32 and the correction is cancelled. The error message can be acknowledged with the "ENTER" key.

8.4 Resetting to factory setting

With this function all parameters can be reset to the factory setting.
Code Cd 46; display rEG-PAr:
enter with the "ENTER" key.

Process corrections to user specification are also cancelled with this function.

8.5 Entering fixed sections

- Fixed sections are entered with Code "Cd-50".
- After entering Code 50 section F01 to 12 is selected. Then chamber temperature, chamber humidity, time etc. are entered in the usual way.

The number of fixed sections is limited to 12 (F01–F12)

8.6 Cyclic program runs

With Code Cd-51 it is possible to set the number of repeats of a program which has already been entered. 0 to 99 cycles or continuous repeat are possible.

- An unlimited number of repeats is programmed with the input "100"; display "CC".
- After Code 51 has been selected the number of the program to be repeated is entered; display in the field "core temperature".
  If there is no program under the number which has been entered, "no" appears in the time field, otherwise "YES" is displayed.
- The program number is entered with the "ENTER" key.
- The number of repeats is input with the number keys; display in the field "chamber temperature".
- After entering the input with the "ENTER" key the instrument returns to the base setting.

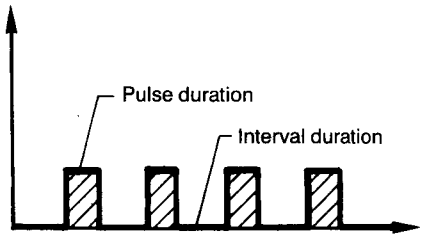
8.7 Humidifying by pulse/interval control

The relative humidity in the chamber can either be **controlled automatically** by the humidity controller or **controlled through** an adjustable pulse/interval ratio.

Pulse duration

The pulse duration is set with Code Cd-52.

- After selection of Code "Cd-52" the display shows "00:00".
- Set the pulse duration (adjustment range 1 sec – 5 min)
- Enter with the "ENTER" key.

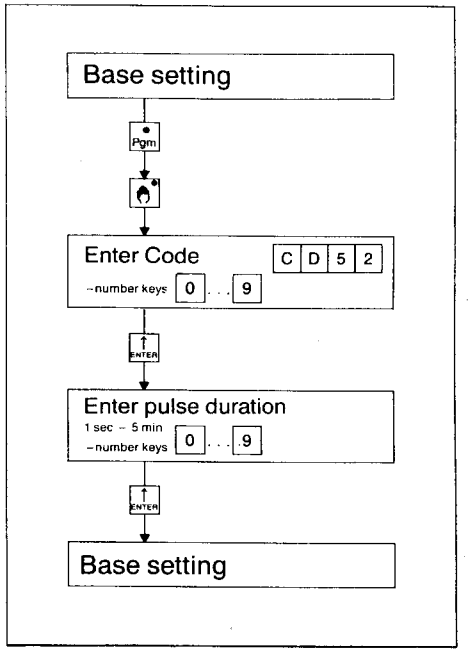


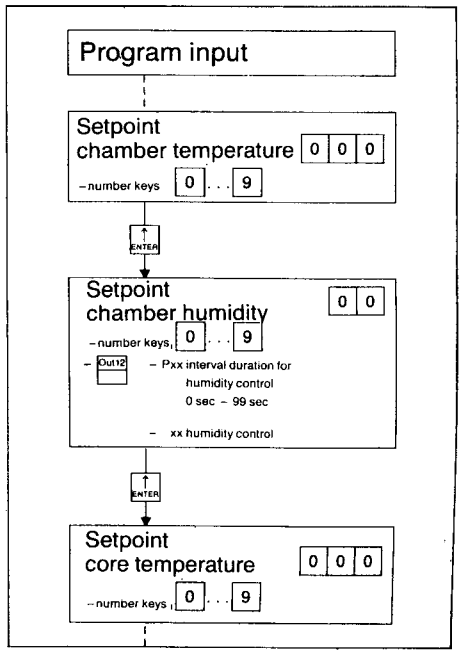
Interval duration

The changeover from "automatic control" to "pulse control" is made during the program input (see Chapter 5.1):

- Enter setpoint for chamber humidity
- Press key "Out12", the display shows "Pxx" before the setpoint (symbol for pulse/interval control).
- Set the interval duration (adjustment range 0–99 sec)
- Enter with the "ENTER" key.

Programming then continues with the core temperature setpoint.





9 EXTERNAL INPUTS

3 external inputs are available which are activated by a floating contact.

9.1 External stop

The effect of the external stop is the same as the "Hand" function during automatic operation. The time base is stopped, the LED in the "Hand" key flashes. The instantaneous values are retained. After cancellation of the external stop the remaining program continues.

9.2 External keyboard/programming lock

Protection against unauthorised operation.
Keyboard lock:
alle keys are blocked.

Programming lock:
only the "Pgm" key is blocked.

10 ACTION IN CASE OF FAULTS

10.1 Error messages

Faults which occur during operation are recognised by the controller and indicated with a message "Err-.". The display remains until the fault has been rectified and acknowledged by pressing the "ENTER" key.

Error message	Possible error	Remedy
-Err-10	Internal battery voltage too low, but the programmer continues the automatic run. After Reset or mains "On" the battery voltage is checked once.	Battery change through service organisation. Note! If the battery is faulty, programs may be lost completely or partly. New programming may be necessary. The error message is acknowledged with the "ENTER" key.
-Err-11	Hardware watchdog faulty.	Through service organisation or factory repair. This error message cannot be acknowledged.
-Err-20	Fault in analogue program (e.g. RAM faulty or data lost through external fault)	Delete program with special functions Cd-01, Cd-02 and enter again. If this does not rectify the fault, contact the service organisation.
-Err-21 -Err-23	No restart after mains failure. Internal restart data in RAM are lost.	Alarm relay active; error message can be acknowledged with "ENTER" key, the display returns to the base setting. Try to start program again.
-Err-24	Factory-set controller calibration data faulty.	Error message can be acknowledged with "ENTER" key. Controller continues to operate with a standard value. Full accuracy is no longer ensured.
-Err-31	Program does not fit into memory.	Acknowledge with the "ENTER" key; shorten program.
-Err-32	Incorrect setpoint adjustment to user specification.	Acknowledge with "ENTER" key; see Chapter 8.3.
r.	Serious hardware faults, e.g. RAM fault	Through service organisation or factory repair.

10.2 Action on supply failure

The program is interrupted. When the supply is restored the automatic program continues provided the difference between setpoint and actual chamber temperature is less than 10 %. If the difference exceeds 10 % the automatic program remains interrupted, the LED in the "Automatic" key flashes. Continuation or re-start is possible only after pressing the "ENTER" key.

10.3 Action on probe break or short-circuit

A probe failure or short-circuit is signalled by the flashing display 999 or –99. The controller outputs become inactive. The limit comparator relays drop out. In case of core temperature probe failure 0 is entered for the setpoint and the program is continued on the time setting. In case of humidity probe failure 0 is entered for the setpoint.

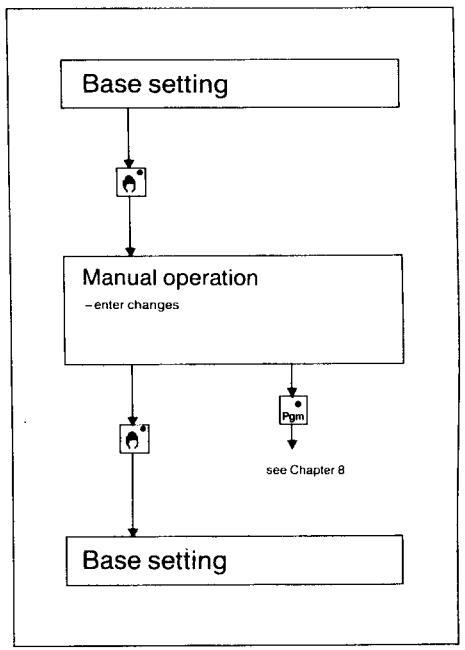
Alarm relay activated:*	
on chamber temperature probe failure	always
on core temperature probe failure	when setpoint is programmed
on humidity probe failure	

* output to customer specification

…racteristics are
…parameters for a defined
…can be determined precisely by
…mathematical procedure.
In practice, however, precise characteristics are rarely available, and practical adjustment criteria have therefore been developed which have proved themselves.
Even here the assumed conditions (e.g. sudden changes of the disturbance or setpoint at the loop input) are in most cases only approximately correct so that the results obtained can only be considered as a rough indication.
In practice it is useful to record a curve of the process variable under operating conditions in order to ascertain the optimum setting by stepwise changes of one parameter at a time.
A basic setting for controllers with PID action, based on the measured parameter values, can be obtained by the procedure described below.

11.1 Changing controller parameters

During manual operation there are facilities for changing controller parameters at a later stage for optimising the control action. The parameters are called up with a code and changed within their adjustment range. The procedure is described in Chapter 8.
The parameters of codes Cd-21 to Cd-46 (see page 22) can be adjusted during manual operation.



Oscillation method according to "ZIEGLER" and "NICHOLS"

This method applies to processes which may be rendered unstable for brief periods (Tg/Tu greater than 3). The controller is operated initially with the following settings: on switching controllers PD action with minimum Tv and on proportional controllers P action; Xp1 or Xp1 and Xp2 on maximum. The proportional band Xp is then reduced slowly (i.e. increasing the controller gain) to determine the stability limit at which the process performs undamped oscillations of constant amplitude. This test gives

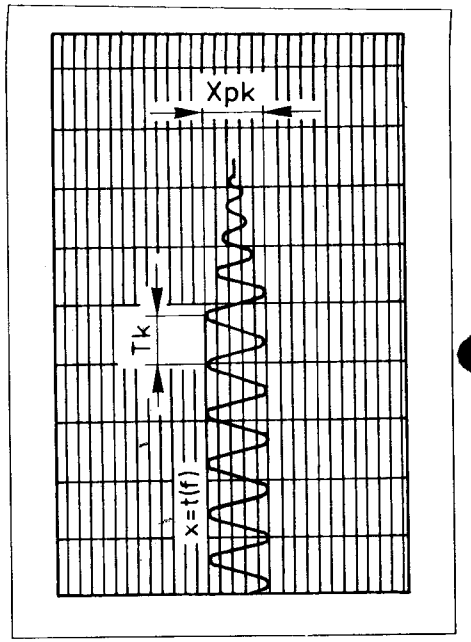
a) the critical oscillation amplitude X_{pk}

b) the critical oscillation period T_k

The optimum settings are then:

$X_p = 1.7\ X_{pk}$ $\quad T_n = 0.5\ T_k$

$T_v = \frac{T_n}{4.5}$



Adjustment according to the process characteristics

Not all control loops can be rendered unstable for brief periods. This method is therefore based on the process loop data. The transfer function (response to a sudden disturbance) is used to evaluate the following characteristic values:

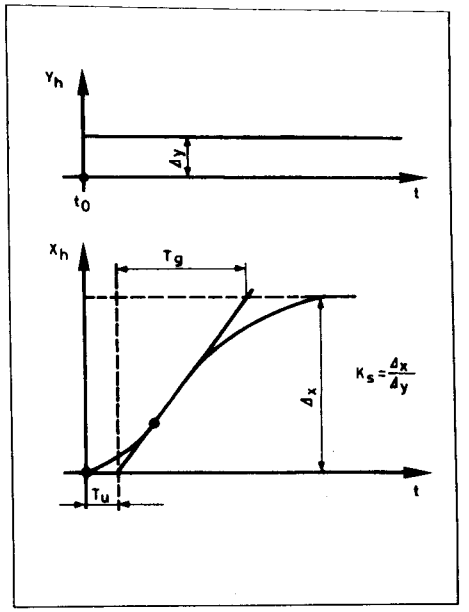
Ks = process transfer coefficient

$Ks = \frac{\Delta x}{\Delta y} = \frac{\text{output change}}{\text{input change}}$

T_u = delay time and
T_g = response time

The controllability of the process loop can be estimated from the ratio T_u/T_g.
For T_u/T_g less than 0.1 satisfactory control
0.1–0.3 just controllable
more than 0.3 difficult to control

The transfer function should be recorded near the operating point (setpoint). At time t_0 the input to the process is changed suddenly by an amount of Δy within the total adjustment range Yhs (for example 10 % of Yhs).
The result is a transfer function with the values for Δx, T_u and T_g.



Empirical rules for parameter setting

Control action	Setting
P	$X_p = Vmax \cdot T_u(°C)$
PI	$X_p = 1.2 \cdot Vmax \cdot T_u(°C)$
PD	$X_p = 0.83 \cdot Vmax \cdot T_u(°C)$ $T_v = 0.25 \cdot T_u(min)$
PID	$X_p = 0.83 \cdot Vmax \cdot T_u(°C)$ $T_n = 2\ T_u(min)$ $T_v = T_n/4.5(min)$
PD/PID	$X_p = 0.4 \cdot Vmax \cdot T_u(°C)$ $T_n = 2 \cdot T_u(min)$ $T_v = 0.4 \cdot T_u(min)$

If the power supplied cannot be changed in steps the transfer function is recorded with a 100 % change in power. As the process does not always permit this due to technical reasons there is another possibility for determining the control parameters. Here the maximum rate of rise of the transfer function is evaluated.

$Vmax = \frac{\Delta x}{\Delta t}$

$X_p = 0.83\ Vmax \cdot T_u$

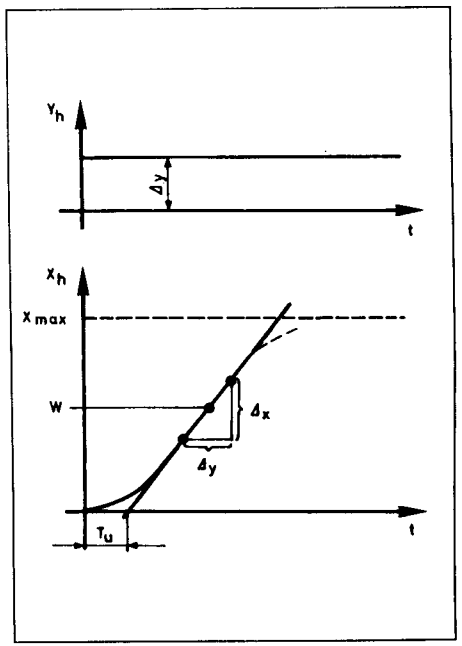
This gives the following values for PID controllers based on the example above:

$\Delta t = 3$ min

$\Delta x = 90$ °C $\quad Vmax = \frac{\Delta x}{\Delta t} = \frac{90\ °C}{3\ min} = 30 \frac{°C}{min}$

$X_p = 0.83 \cdot 30 \frac{°C}{min} \cdot 2\ min \qquad X_p = 49.8\ °C$

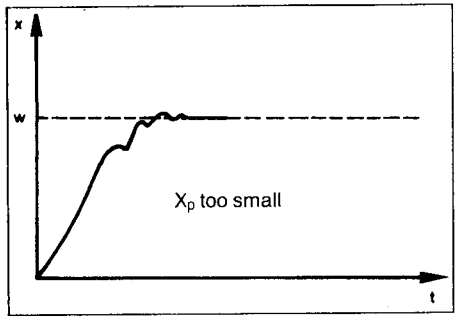
$T_n = 2\ T_u = 2$ min $\qquad T_v = \frac{T_n}{4.5} = 27$ sec

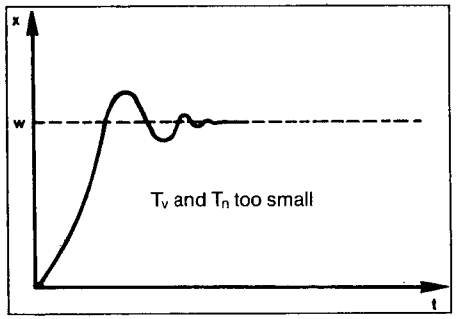


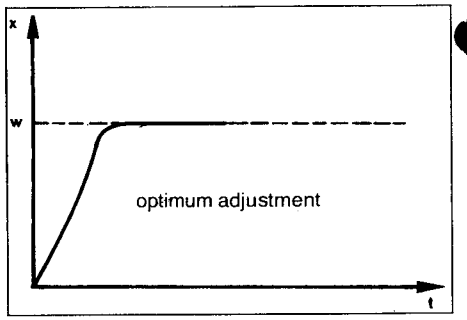
Checking the optimisation

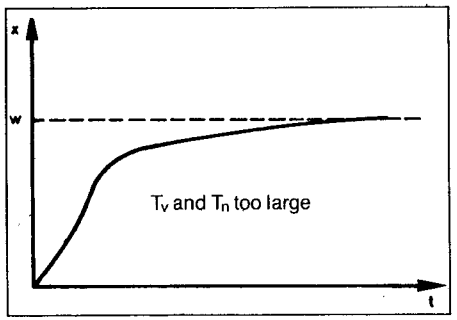
The optimum adjustment of the controller to the process can be checked by recording a start-up action with closed process loop.

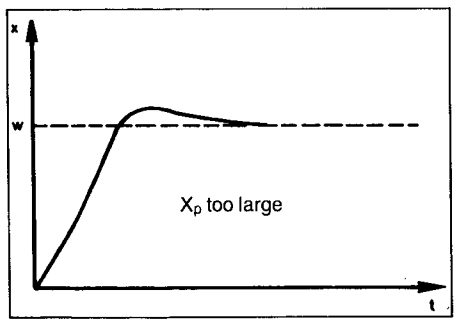
The diagrams below indicate possible incorrect adjustments and the correction required.
This shows that increased X_p and increased T_n both result in a more stable and more sluggish control action.
Smaller X_p or T_n produces a less damped control action.











mm	inch
11	0.43
13	0.51
14.5	0:57
61	2.40
68	2.68
91	3.58
92	3.62
96	3.78
105	4.13
171.5	6.75
181	7.13
185	7.28
186	7.32
192	7.56

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