Vacuum Pumps

Instrumentation

Fittings and Valves

LEYBOLD

LEYBOLD VACUUM

GA 09.014 / 2.02

VISCOVAC VM 212

(Licence: Research Facility GmbH, Jülich, F.R.G.)

Cat. No.
158 83

Operating Instructions

Leybold-Service

If an appliance is returned to LEYBOLD VACUUM GmbH, indicate whether the appliance is free of substances damaging to health or whether it is contaminated. If it is contaminated also indicate the nature of hazard. LEYBOLD must return any appliance without a declaration of contamination to the sender's address.

General Note

The right of alterations in the design and the technical data is reserved.
The illustrations are not binding.

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1 Description

1.1 General

These Operating instructions contain important information on the functions, installation, start-up, operation, troubleshooting and maintenance of the VISCOVAC VM 212.

Important remarks concerning operational safety and protection are emphazised as follows:

Caution Indicates procedures that must be strictly observed to prevent hazards to persons.

Important Indicates procedures that must strictly be observed to prevent damage to, or destruction of, the VISCOVAC VM 212.

Note
Indicates special technical requirements that the user must comply with.

The references to diagrams, e.g. (4/5), consist of the Fig. No. and the item No. in that order.

Numbers in square brackets [] refer to the references given in Appendix B.

Unpack the VISCOVAC VM 212 immediately after delivery, even if it is to be installed at a later date.

Examine the shipping container for any external damage.

Completely remove the packaging materials.

Note
Retain the packaging materials in the event of complaints about damage.

Check that the VISCOVAC VM 212 is complete (see Section 1.4).

Carefully examine the VISCOVAC VM 212 visually.

If any damage is discovered, report it immediately to the forwarding agent and insurer. If the damaged part has to be replaced, please get in touch with the orders department.

1.1.1 Purpose

The VISCOVAC VM 212 is intended for the measurement of vacuum pressures in the range between $1 \cdot 10^{-7}$ to 1 mbar in connection with the gauge head VK 201 and a gauge tube VR 200 (or VR 201 or VR 202) in accordance with the technical data given in Section 1.2.

1.2 Technical Data

Measurement range	$1 \cdot 10^{-7}$ bis 1 mbar
Measurement uncertainty in the range from	
$1 \cdot 10^{-7}$ to $1 \cdot 10^{-2}$ mbar	$1 \cdot 10^{-7}$ mbar + 4 % of the measured value
$1 \cdot 10^{-2}$ to 1 mbar	increasing to 10 % of the measured value

When a DKD calibrated ball is used the uncertainty is reduced by 1.5 % in all ranges.

Long term stability	better than 1 % over 1 year
measurem. period adjustable	betw. 0.5 and 30 s
Chart recorder output	0 to 10 V, $R_a \geq 10$ kΩ linear or logarithmic limits freely adjustable
2 switching contacts	250 V; 1 A; 100 VA for trigger or interval operation, limits freely adjustable
Mains connection	100 / 120 / 220 / 240 V 50 / 60 Hz
Operating temperature range	+ 10 bis + 40 °C
Cabinet	19“ housing, 3 height units
Dimensions (W x H x D)	483 x 132 x 310 mm
Weight	6.4 kg approx.

1.2.1 Technical Data of the VK 201 Gauge Head

Operating temperature range	+ 5 to + 60 °C not bakeable
Number of signal coils	4
Length of the fixed connection cable	3 m
Dimensions	see Fig. 5
Weight	0.4 kg

1.2.2 Technical Data of the Gauge Tubes

Bakeout temperature with gauge head removed:	
Gauge tube VR 200; DN 35 CF	400 °C
Gauge tube VR 201; DN 16 CF	400 °C
Gauge tube VR 202; DN 16 KF	below 200 °C
Dimensions	see Fig. 6
Weight	0.2 kg approx.

Material in contact with the medium	Stainless steel 1.4301 / 1.4541

1.2.3 Typical Data of the Balls Supplied by Leybold, Referred to 20 °C

Material of the ball	Stainless steel 1.3541
Diameter	4.500 mm
Mass density	$7{,}720 \cdot 10^3$ kg·m^{-3}
Expansion coefficient	$1 \cdot 10^{-5}$ m·K^{-1}

1.2.4 Technical Data of the VISCOVAC Printer

Type of printer	Metallized paper printer
Characters per line	20
Paper width	7 cm

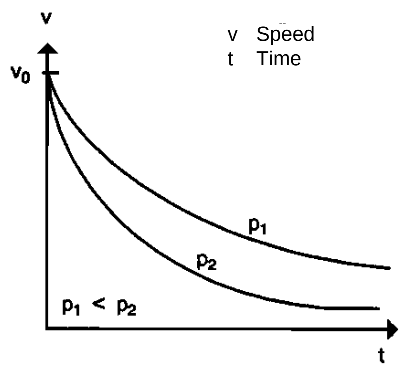


Fig. 1 Speed of the ball as a function of time for two different pressures with p_2 being greater than p_1

1.3 Technical Description

1.3.1 The Measurement Principle

The reduction in speed of a ball rotating freely in a viscous medium as a result of gas friction [2] is expressed as

$$\nu(t) = \nu_0 \cdot \exp\left(-\frac{10 \cdot \sigma \cdot p}{d_B \cdot \rho B} \sqrt{\frac{M}{2 \cdot \pi \cdot R \cdot T}} \cdot t\right) \qquad (1)$$

where

υ_o speed of the ball at time = 0
υ (t) speed of the ball at time t
d_B diameter of the ball
ρB mass density of the ball
M relative molecular mass
T absolute temperature of the gas and the ball
R general gas constant
p gas pressure
σ coefficient of friction

The expression is valid provided that the mean free path of the gas particles is large in comparison with the distance of the surface of the ball from the stationary wall of the apparatus or, in the case of the wall being far away, large compared to the ball diameter. In practice this means that the above-mentioned relationship is valid for gas pressures up to 10^{-2} mbar approx. Given in Fig. 1 is a schematic representation of this relationship for two different pressures.

According to [1] the gas pressure can be determined from the reduction in the speed of the ball over time:

$$p = \frac{d_B \cdot \rho B}{10 \cdot \sigma} \sqrt{\frac{2 \cdot \pi \cdot R \cdot T}{M}} \cdot \frac{1}{t} \cdot \ln\left(\frac{\nu_o}{\nu(t)}\right) \qquad (2)$$

The reduction in the speed of the ball with time is determined by the VISCOVAC VM 212 by measuring the times t_1 and t_2 of two successive ball rotations. With $t_M = t_1 + t_2$ the following applies in close approximation:

$$-\frac{1}{\nu} \cdot \frac{d\nu}{dt} = \frac{1}{t} \cdot \ln\left(\frac{\nu_o}{\nu(t)}\right) = \frac{t_2 - t_1}{(t_M / 2)^2} \qquad (3)$$

As the uncertainty of the measurement is very high when measuring the time required for a single rotation of the ball, the VISCOVAC VM 212 carries out approx. 200 to 12,000 of these measurements depending on the measurement time selected (see Section 2.5.1) and by suitable statistical processing of the obtained values the deceleration of the ball is determined with considerably less uncertainty.

1.3.2 Magnetic Suspension, Drive System and Signal Retrieval

The rotating ball, whose deceleration is used to determine the gas pressure, is magnetically suspended in order to avoid mechanical friction. This magnetic suspension is implemented by two permanent magnets and two stabilizing coils which are centred on the same axis as the permanent magnets. In addition the gauge head contains further coils for stabilization and signal sensing (pick-up coils).

Given in Fig. 2 are the important inner design features of the VK 201 gauge head. The position of the ball is stabilized by controlling the current in the stabilization coils. The control has been optimized with the aim of keeping the energy transfer to the suspended ball as small as possible.

The signal is picked up by four pick-up coils. The magnetic moment of the balls is never completely axially symmetrical to the rotational axis of the ball. Since the ball rotates, while the pick-up coils are stationary, the magnetic flux through the pick-up coils changes periodically as the ball rotates. The magnitude of the signal induced in the coils does not only depend on the above-mentioned axially asymmetrical components of the magnetic field but it is also proportional to the rotational frequency of the ball.

The range of rotational frequencies of the ball suitable for measurements is therefore restricted at lower frequencies. An upper limit of the suitable frequency range is set by the frequency dependence of the offset (see also Section 2.10).

The greater the measurement signal, the greater the amount of energy removed from the rotating ball, which in turn results in a deceleration which is independent of the gas pressure. Because of these conditions the operating range of the VISCOVAC VM 212 lies between 405 and 415 Hz, i.e. before a measurement is started the VISCOVAC VM 212 accelerates the ball to a rotational frequency of 415 Hz approx.

The actual measurement of the decelerating ball begins when it is no longer driven. When the rotational frequency has dropped to 405 Hz approx. the measurement is automatically interrupted and the ball is accelerated again. After reaching the upper 415 Hz limit the measurement is then automatically continued. The ball is driven by alternating magnetic fields which are produced by four drive coils.

1.3.3 Control, Monitoring and Operating Functions

The VISCOVAC VM 212 has a built-in microprocessor, the functions of which can be summarized in three categories.

- Control and monitoring of the ball suspension and the ball drive. The measurement and the drive is started automatically when the ball speed drops below a certain minimum. The latter is important when wanting to use the VISCOVAC VM 212 also at higher pressures as a process pressure measuring instrument.
- Control of the measurement sequence, internal processing of the primary measurement data and calculation of the output data. Thus marginal conditions of the mea-

Key to Fig. 2
1 Ball 4.5 mm dia. (type as used in ball bearings)
2 Vacuum tube, int. dia. 7.5 mm
3 Two permanent magnets, field at the point of the ball 0.05 Tesla
4 Two vertical stabilizing coils
5 Four drive coils, one is not shown for clarity
6 Water level
7 Connection flange

Not shown: 4 lateral stabilizing coils and 4 pick-up coils

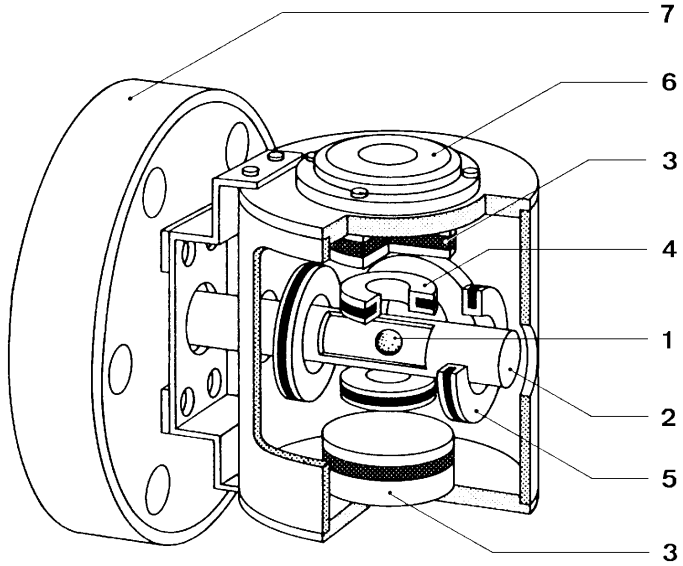


Fig. 2 Schematic sectional diagram of the VK 201 gauge head for the VISCOVAC VM 212 spinning rotor viscosity gauge.

surement (for example the measurement period) can be entered or different physical quantities may be output.
- Communication with the operator.

1.4 Equipment

1.4.1 Scope of Delivery

	Cat. No.
VISCOVAC VM 212 - Mains cable - Fuse 0.2 A and 0,4 A - 1 plug for the relay output - 1 plug for the analogue chart recorder output	158 83
Operating Instructions	GA 09.014
Operating Instructions for the interface	
RS 232 C / V.24	GA 518
IEC / IEEE interface	GA 517

1.4.2 Accessories

	Cat. No. / Ref. No.
Gauge head VK 201 with fixed 3 m long gauge head cable and a testing tube	**158 82**
Testing tube	**158 77**
Gauge tube VR 200 with DN 35 CF connection flange,1 set of balls	**158 71**
Gauge tube VR 201 with DN 16 CF connection flange, 1 set of balls	**158 75**
Gauge tube VR 202 with DN 16 CF connection flange, 1 set of balls	**158 76**
Printer module for the VM 212	**158 79**
DKD calibration, for the measurement range 10^{-5} to 10^{-2} mbar	**157 13**
90 ° elbow, DN 16 KF	**884 61**
90 ° elbow, DN 16 CF, with rotatable flange	**836 04**
90 ° elbow, DN 35 CF, with rotatable flange	**836 05**
1 set of balls (10 pcs.)	200 27 049
4 rolls of metallized printer paper for the VISCOVAC printer	701 50 013
Mounting bracket for installing in a 19“ cabinet (2 are required)	331 22 604

2 Operation

2.1 Installation

2.1.1 Placement of the Instrument

The VISCOVAC VM 212 will operate reliably under the normal industrial operating conditions. Refer to Section 1.2 „Technical data“.

The instrument is supplied built into a rugged table-top cabinet. The cabinet is made of metal and is fully enclosed. The VISCOVAC VM 212 contains as standard an external printer interface, a serial and a parallel interface and as an option a printer.

The feet which are screwed to the bottom panel permit several instruments to be securely placed on top of each other. The feet at the front may be folded out so that the facia is inclined for improved reading of the display.

Installation dimensions see Fig. 3

2.1.2 Installing the Printer

Switch off the VISCOVAC VM 212.

Disconnect the mains plug from the VM 212.

Remove the blank right hand front panel at the printer's place. To do this, loosen and remove the four screws at the edges of this blank panel.

Remove the upper instrument cover as follows:
- Loosen and remove the two crosshead screws on the cover panel.
- Carefully reach into the opening in the front panel and press the cover, which is now only secured by the two outer guide grooves, upwards.

Insert the printer into the opening in the front panel and screw the edges tight.

Connect the cables of the printer as follows:
- Insert the wide flat cable into the unused socket (20/1) of the control section (front and right).
- Insert the narrower flat cable into the unused socket on the pcb. standing upright behind the display.
- The cable shoe of the black ground conductor is inserted into the unused tab at the rear left hand side (when viewed from the front). The yellow / green ground conductor is already connected to the second tab.

Then insert the cover into the groove at one side, lift the middle section up a bit and let the cover engage into the other groove. Secure the cover with two crosshead screws.

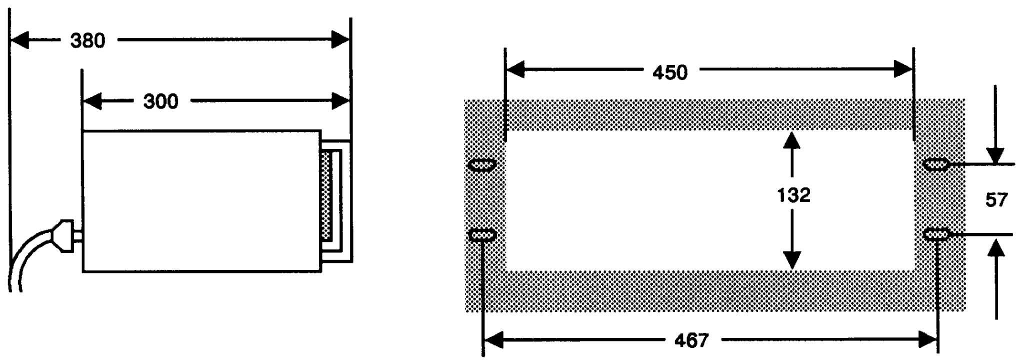
2.1.3 Installation Options

Rack mounting
By using the mounting brackets listed in Section 1.4.2 the table top unit can be easily installed in a 19“ rack; 3 height units are required.

Mount the mounting brackets as follows:
Two mounting brackets are required.

Important Always install the mounting brackets one after the other.

Conversion of the right hand side:
- Unscrew and remove two crosshead screws each above and below the coloured side strip.
- Use a small screwdriver to remove the side strips
- Loosen and remove the two slotted screws next to each other in the vicinity of the handle.
- Pull out the handle to the front.
- Unscrew the handle from the holding panel and screw it to the mounting bracket.
- Insert the mounting bracket with the handle attached on



All dimensions in mm

Fig. 3 Installation dimensions of the VM 212

the right hand side of the VM 212 and secure it by tightening the four screws and securing washers.
- Insert the side strip and screw it tight.

Conversion of the left hand side:
The left hand side is converted in the same way as the right hand side.

Unscrew the feet.

Insert the VM 212 into a 19“ rack and secure it using the mounting brackets.

Important The VM 212 must be supported within the 19“ cabinet as the front panel alone cannot carry the full load.

Panel mounting
The dimensions required for panel mounting are given in Fig. 3. For this type of installation the two mounting brackets have to be installed in the same way as for as for rack mounting.

2.1.4 Electrical Connection

Note
Generally the currently valid VDE 0100 regulations must be observed.

The electrical connection of the VISCOVAC VM 212 is located at the rear. Refer to Fig. 4.

Important Before connecting the instrument to the mains check the mains voltage setting of the instrument. This also includes checking, and if required, exchanging the mains fuse (4/3).

At any voltage setting the instrument may be run on 50 / 60 Hz mains.

The VISCOVAC VM 212 is factory set to 240 V and is equipped with the corresponding 0.2 A fuse.

If the instrument is to be converted for 100 or 120 V mains, fuse (4/3) has to be replaced by the 0.4 A fuse which is also supplied.

Switches (4/1) and (4/2) are used to set the mains voltage. Switch (4/1) selects the voltage range 100 / 120 or 220 / 240 V.

Switch (4/2) is used to select between the normal voltages of 100 V or 220 V and the overvoltages of 120 V or 240 V.

Example: 240 V mains voltage
- Insert 0.2 A mains fuse (4/3)
- Set switch (4/1) to the 0.2 A position (range (220 / 240 V)
- Set switch (4/2) to 240 V

Note
In special cases, such as for example 230 V always select the higher voltage setting (240 V).

The mains voltage is connected via the plugable mains cord, which is plugged into the mains socket (4/4) on the rear.

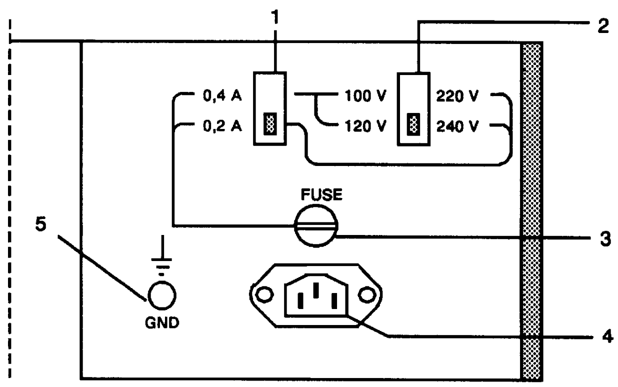
Important Only 3-core mains cables may be used. The instru. may not be operated without a connected ground conductor.

2.1.5 Installing the Measurement System

The relevant dimensions required for installing the gauge head and the various gauge tubes are given in Figs. 5 and 6.

Note
Before mounting the gauge tube to a vacuum chamber insert the ball into the gauge tube.

Inserting the ball:
To insert the ball remove retaining ring (7/4) within the connection flange (7/1) and remove the washer (7/5) behind it.



Key to Fig. 4
1 Mains voltage selector switch, coarse (S2)
2 Mains voltage selector switch, fine (S3)
3 Fuse holder
4 Mains voltage connection socket
5 Ground connection

Fig. 4 Mains voltage setting and connection of the VM 212

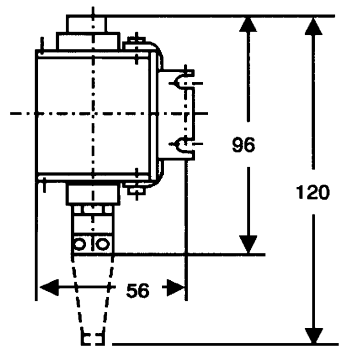


Fig. 5 Dimensions of the VK 201 gauge head

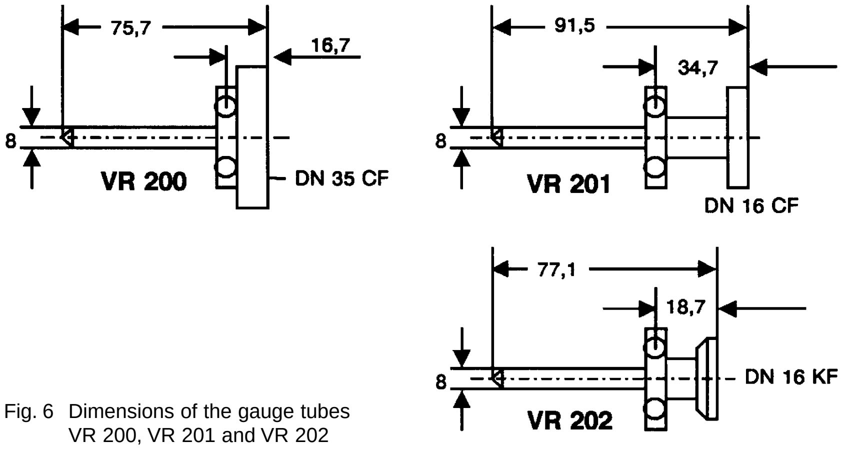


Fig. 6 Dimensions of the gauge tubes VR 200, VR 201 and VR 202

Take the wire grille (7/6) out of the flange.

Insert the ball (7/7) into the gauge tube.

Reassemble in the reverse order.

The operating principle requires an exactly level installation of the gauge tube; if required use the flange components given in Section 1.4.1. The flange must be orientated so that the gauge head mount (7/3) is orientated in a perpendicular position. Therefore in the case of gauge tubes with a CF flange it is recommended to make the opposing flange rotatable.

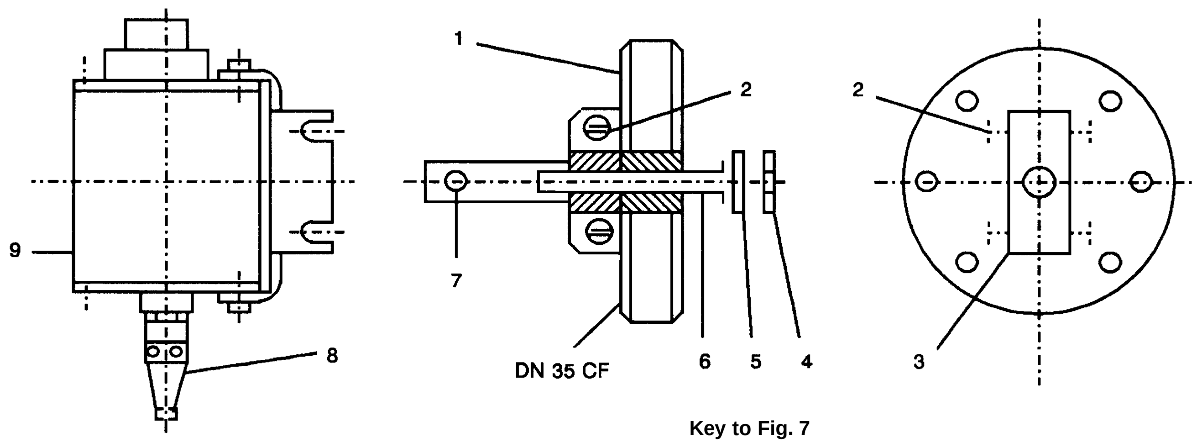
Push the gauge head over the gauge tube and screw it tight at the point of the gauge head mount (7/3). Especially note the vertical orientation of the gauge's axis. The water level on the gauge head can be used as an aid and for checking. The bubble must be located exactly in the middle of the black ring.

In order to prevent any disturbances as far as possible, vibrations should be kept away from the gauge. Should this not be possible then mechanically decouple gauge head and gauge tube.

Especially vibrations from running vacuum pumps can have a disturbing effect. Moreover, care should be taken to prevent strong external fields in the vicinity which might not only influence the measurement signal but also the suspension and the drive system of the ball.

2.1.6 Connection of the Gauge Head

Gauge head and operating unit are interconnected by a two-core signal cable and a multi-core cable for the signals which control the suspension and the ball drive.



Key to Fig. 7

1 Connection flange	6 Wire grille
2 Fixing screw	7 Ball
3 Gauge head mount	8 Cable connection
4 Retaining ring	9 Gauge head VK 201
5 Washer	

Fig. 7 Gauge head and gauge tube

2.2 Controls and their Functions

2.2.1 Controls on the Front Panel

An overview of the controls and displays on the front pannel is given in Fig. 8. These are explained or commented briefly in the following.

Charge monitoring LED „CHARGE“
The VISCOVAC VM 211 is equipped with an accumulator so that the suspension of the ball can be maintained for a maximum of one hour in the event of a mains failure. As a relatively high current is required for this, the charging status of the accumulator is indicated by the charge monitoring LED (8/1). During charging the red LED lights up; the LED goes out when the accumulator is sufficiently charged.

Display
The display (8/2) consists of 16 green alphanumerical display elements.

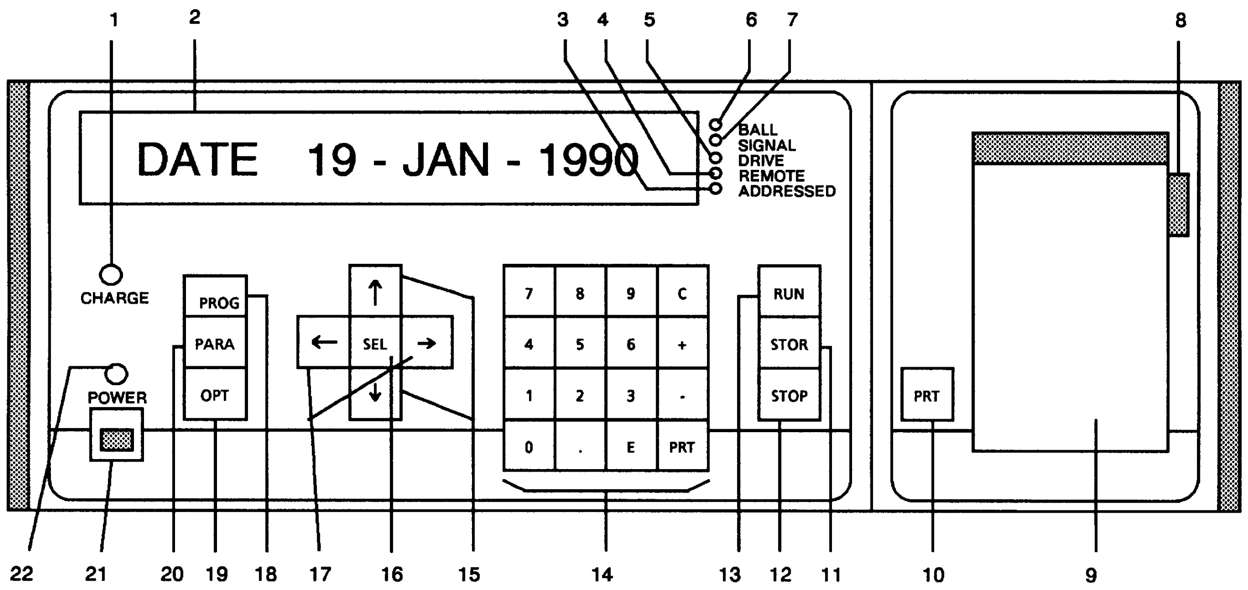
Suspension monitoring LED - „BALL“
LED (8/6) is out when the ball is correctly suspended. The LED comes on when there is a fault in the suspension system or when it is out of operation.

LED - „SIGNAL“
LED (8/7) comes on as long as the signal level at the signal input is insufficient.

Ball drive monitoring LED - „DRIVE“
LED (8/5) comes on when the ball is driven.

LED for interface operation - „REMOTE“
LED (8/4) comes on when the instrument is operated via the interface; it is out when operating the VISCOVAC VM 212 via its keyboard.

LED for GPIB addressing - „ADDRESSED“
LED (8/3) comes on when the instrument is addressed by the external GPIB controller.



Key to Fig. 8

1 Charge monitoring LED
2 Display
3 LED for GPIB addressing (green)
4 LED for interface operation (green)
5 LED for ball drive (green)
6 LED for ball suspension (red)
7 LED for measurement signal (red)
8 Paper advance
9 Internal printer
10 Printer pushbutton for internal printer
11 STOR pushbutton
12 STOP pushbutton
13 RUN pushbutton
14 Key pad
15 Cursor control pushbuttons
16 SEL pushbutton
17 Cursor control pushbuttons
18 PROG pushbutton
19 OPT pushbutton
20 PARA pushbutton
21 Mains switch (S1)
22 Mains monitoring LED (green)

Fig. 8 Front panel of the VISCOVAC VM 212

Paper advance
The metallized paper in the printer may be advanced manually by turning knob (8/8).

Metallized paper printer with 20 characters per line
Printer (8/9) can be used to print out measurement programs, options and measurement data as well as their statistical analysis.

„PRT“ pushbutton
The „PRT“ pushbutton (8/10) and the „PRT“ pushbutton located in the numeric key pad are used as the print command for the internal or external printer.

„STOR“ pushbutton
The „STOR“ pushbutton (8/11) is used for storing of previously entered equipment parameters. Details see Section 2.4.1

„STOP“ pushbutton
The „STOP“ pushbutton (8/12) is used to terminate activated equipment functions; also for termination of the measurement and braking of the ball. Details see Sections 2.4.3, 2.6 and 2.8.

„RUN“ pushbutton
The „RUN“ pushbutton (8/13) is used to start the measurement program or any previously selected equipment functions. Details see Sections 2.4.3 and 2.8

Key pad
The key pad (8/14) is used to enter numerical values. Additional pushbuttons are provided for entering „+“, „-“, the decimal point and „E“ for entry of exponents. The „C“ (Clear) pushbutton us used to clear any incorrect entries.

The „PRT“ pushbutton is used to activate any internal or externally connected printer. This pushbutton has the same function as the „PRT“ pushbutton (8/10) next to the built-in printer.

Cursor control pushbuttons
The cursor control pushbuttons (8/15) and (8/17) are used to move the cursor within a „Parameter page“. For details refer to Section 2.4.4. Further functions have been assigned to the cursor control pushbuttons when running software options (see also Section 2.8).

„SEL“ pushbutton
The „SEL“ pushbutton (8/16) is used to select from a range of preset values, if there are only a few to select from. These are especially non-numerical entries (see also Section 2.4.5). Further functions have been assigned to the SEL pushbutton when running software options (see also Section 2.8).

„PROG“ pushbutton
The „PROG“ pushbutton (8/18) is used to operate various equipment functions. For details see Section 2.4.

„OPT“ pushbutton
The „OPT“ pushbutton (8/19) is used to select the software options. For details see Section 2.8.

„PARA“ pushbutton
The „PARA“ pushbutton (8/20) is used to select the editing mode. For details refer to Section 2.4.

Mains switch - „POWER“
The mains switch - „POWER“ (8/21) is used to switch the VM 212 on and off. Note however, that the suspension is only backed up in the case of a mains failure with the mains switch on, and not when (inadvertently) switching off the instrument via the mains switch.

Mains monitoring LED
Mains LED (8/22) comes on when the mains switch (8/21) is switched on and the mains voltage is applied.

2.2.2 *Supply and other Connections on the Rear*

The arrangement of the supply connections and other sockets on the rear of the VISCOVAC VM 212 is shown in Fig. 9. These are explained or commented briefly in the following.

Signal input from the gauge head „PICKUP“
Socket (9/1) is used for connection of the signal cable from the gauge head.

Printer interface socket (CENTRONICS)
An external printer with Centronics interface may be connected to this socket (9/2). This output is equivalent to a printer output on a PC.

Serial interface V.24 / RS 232 C
This serial interface permits full operation of the instrument and access to all measurement data by an external computer which also has a serial interface. For details on how to operate this serial interface refer to Section 2.18 and Operating Instructions GA 518.

Parallel interface IEEE 488 or GPIB
This parallel interface permits full operation of the instrument and access to all measurement data by an external computer which also has a parallel interface of the same type. For details on how to operate this parallel interface refer to Section 2.18 and GA 517.

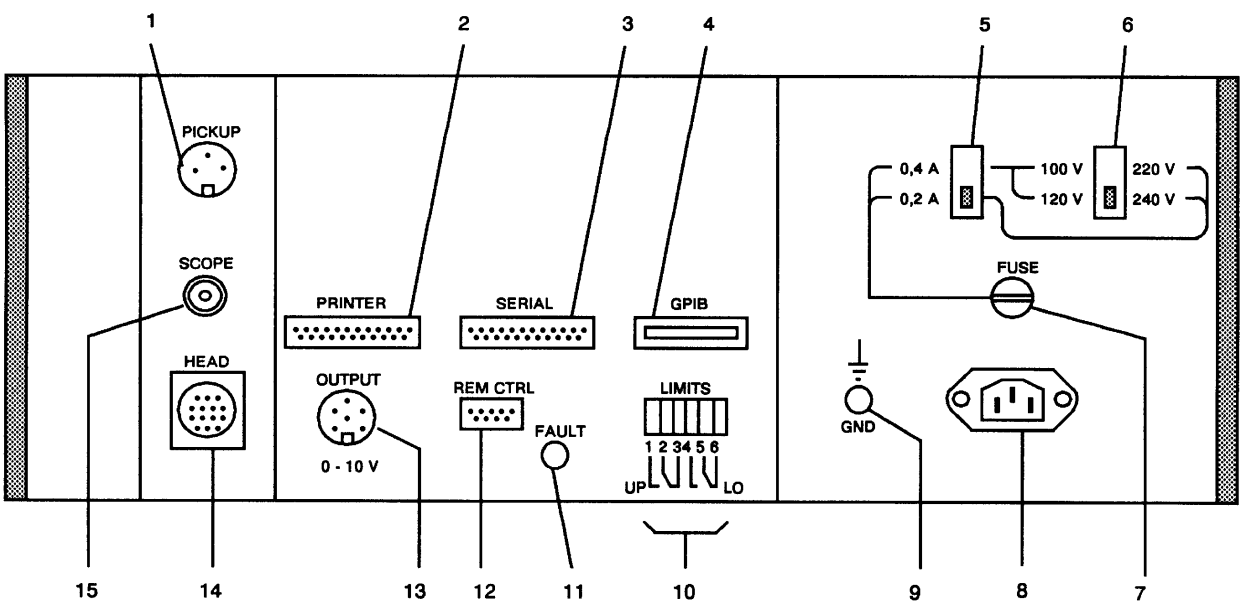
Mains selector switch, coarse
This mains selector switch (9/5) is used to adapt the VISCOVAC VM 212 to one of two mains voltage ranges.

Mains selector switch, fine
This mains selector switch (9/6) is used to accurately adapt the VM 212 within one to the two mains voltage ranges previously selected by switch (9/5).

Fuse holder
Holder (9/7) for the mains fuse (0.2 or 0.4 A, depending on the selected mains voltage range).

Mains socket
Mains socket (9/8) is used to connect the VM 212 to the mains.

Ground connection
The ground connection (9/9) is used for an external ground connection between the VM 212 and the measurement flange or other electrically conducting parts of the system.



Key to Fig. 9
1 Signal input from the gauge head
2 Printer interface socket (CENTRONICS)
3 Serial interface (RS 232 C)
4 Parallel interface (IEEE 488 or GPIB)
5 Mains selector switch, coarse (S2)
6 Mains selector switch, fine (S3)
7 Fuse holder
8 Mains socket
9 Ground connection
10 Switching outputs „LIMITS“
11 LED „FAULT“
12 Remote control socket with status signal outputs
13 Analogue output „OUTPUT“
14 Supply connections for the gauge head „HEAD“
15 Signal output „SCOPE“

Fig. 9 Rear of the VISCOVAC VM 212

Key to Fig. 10

Pin 1	RI FUNCT 1 (Anode across 3.3 kΩ)
Pin 2	RI FUNCT 2 (Anode across 3.3 kΩ)
Pin 3	RI OUTPT 1 (Collector)
Pin 4	RI OUTPT 2 (Collector)
Pin 5	Not connected
Pin 6	RI FUNCT 1 (Cathode)
Pin 7	RI FUNCT 1 (Cathode)
Pin 8	OUTPT 1 (Emitter)
Pin 9	OUTPT 2 (Emitter)

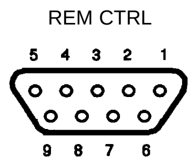


Fig. 10 Wiring of the REM CTRL socket

Switching outputs „LIMITS“
The relay outputs are accessible through socket (9/10), see also Sections 2.5.4 and 2.6.7. The mating plug is supplied with the instrument.

The switching output (9/10) comprises two changeover relays which are related to the switching levels UP and LO. In the rest position contacts 2-3 and 5-6 are closed. For further information on the switching outputs refer to Sections 2.5.4 or 2.6.6.

LED „FAULT“
This LED (9/11) comes on when switching on. After successful initialization of the microprocessor system it goes out. Should a fault occur in the microprocessor system during operation, the LED will indicate this.

Remote control socket with status signal outputs „REM CTRL“
Two configurable command inputs and two status signal outputs which may also be configured are available through this interface. For more information refer to Section 2.8.6 (Option 06).

The input signals are electrically isolated by opto-couplers from the circuitry of the instrument. Inputs and outputs are intended for 24 V operation (3.3 kΩ dropping resistor at the inputs). The outputs can deliver up to 20 mA.

The inputs are pulse inputs and must be driven with bounce-free pulses. Pulse duration 10 to 100 ms approx. Both inputs operate alternatingly and may therefore not be activated at the same time. The minimum time between two input pulses is 0.5 ms approx. The wiring of the 9-way REM CTRL socket is given in Fig. 10.

Analogue output „OUTPUT“
Socket (9/13) carries the analogue output signal (refer to Sections 2.5.5 and 2.6.5). The mating plug is supplied with the instrument. The wiring of this socket is given in Fig. 11. The pin numbers are given inside the supplied plug.

The analogue output (9/13) supplies a signal ranging from 0 to 10 V with reference to ground.

Supply connections for the gauge head „HEAD“
Socket (9/14) is used to connect the supply cable of the gauge head.

Signal output „SCOPE“
The signal output „SCOPE“ (9/15) carries the signal from the gauge head after preamplification and filtering.

Key to Fig. 11

Pin 1	Signal
Pin 2	Not connected
Pin 3	Not connected
Pin 4	Not connected
Pin 5	Not connected
Pin 6	Ground

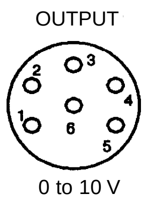


Fig. 11 Wiring of the analogue output

2.3 Start-up

- Install the VISCOVAC VM 212 according to Sec. 2.1.1.
- Install the printer according to Section 2.1.2.
- Set mains switch „POWER“ (8/21) to „OFF“.
- Check the electrical connection according to Sec. 2.1.4
- Connect the VM 212 to the mains using the supplied mains cable.
- Install the gauge head according to Section 2.1.5. Connect the corresponding signal cables to the VM 212 (see Section 2.1.6).
- Provide further connections on the rear according to Section 2.2.2.
- Set the mains switch „POWER“ (8/21) to the „ON“ position; mains monitoring LED (8/22) comes on.

A self test is run immediately after switching on. During this time the „FAULT“ LED (9/11) is on together with LEDs (8/3), (8/4), (8/5), (8/6) and (8/7). At the end of the self test LEDs (8/3), (8/4) and (8/5) go out. The LED for the ball suspension (8/6) and the measurement signal (8/7) remain red.

The display (5/2) indicates the name of the instrument and the number of the software release, for example:
VM 212 VERS. 3.3.

After completion of the self test the VISCOVAC VM 212 displays the date and the time which was entered before, followed by READY, or it immediately starts with a measurement, if the instrument was doing just this when it was switched off. In both cases the instrument is ready. LED (8/6) for the ball drive goes out and the red LED for the measurement signal (8/7) remains on.

Press the „PROG“ pushbutton (8/18) and „RUN“ (8/13); the measurement is started and the green „DRIVE“ LED comes on. After 1 minute approx. the red LED (8/7) goes out. After the ball has run-up (100 s approx.) the green „DRIVE“ LED (8/5) goes out.

Should the Lithium battery integrated into the RAM be exhausted, all operating parameters stored in it will be lost. When trying to start a measurement the VISCOVAC VM 212 will indicate this condition at the latest by displaying „PROG NOT DEFINED“. The program data will then have to be entered into the memory as described in Section 2.6.7.

2.3.1 Functional Test Using the Testing Tube

The testing tube Cat.No. 158 77 can be used to perform a functional test independently of a vacuum system.

To do this, install the gauge head in a suitable mount without the gauge tube, so that its axis is aligned vertically.

Now insert the testing tube into the opening for the measuring tube. Then operate the instrument as described above. The required commands for testing the entire arrangement are given in Section 2.6.

Note
The gas pressure within the testing tube is a variable quantity. The testing tube is therefore only suitable for a functional test, and it is in no way suitable for calibration purposes.

2.4 Operating Concept

2.4.1 The Default Principle

The VM 212 has been equipped with a program memory in which 18 parameter sets, which are also termed as „programs“ can be stored (see Section 2.5). Besides this there also is a main memory which contains the current parameter set of the measurement. This parameter set is also termed as the active parameter set. Moreover, there is an editing memory, in which parameter sets can be edited, i.e. displayed and modified.

Each entry position carries at all times a value, i.e. there are no empty places in the memory. This value is retained even when switching off the instrument. Should the memory back-up accumulator be discharged with the attendant loss of the stored information, the lost data may be reloaded into the memory.

The principle of the default values effects the following:
- in the editing mode all parameters have an assigned value,
- pressing the „PROG“ pushbutton causes - besides the echo „PROG“ - the number of the active program to be displayed,
- after selection for the first time pressing the „OPT“ pushbutton leads to the display of the number 01 besides the echo „OPT“. In all other cases the number of the activated option is displayed besides the „OPT“ echo,
- the VISCOVAC VM 212 automatically starts measuring, when it was switched off while a measurement was in progress.

The principle of the default values results in shorter commands when the default value coincides with the desired value. When starting a measurement it is then not required to reenter the program number. Thus the command is reduced to:

PROG-RUN
or simply
RUN

2.4.2 Cursor Control

The editing mode is entered by pressing the „PARA“ pushbutton. The display indicates the parameter 11 or the parameter used last. The other parameters are accessible by using the vertical cursor controls „↓“ and „↑“ (8/15).

The position of the horizontal cursors „→“ and „←“ (8/17) is indicated by flashing of the corresponding digit.

This is required for example when entering the date; see Section 2.5.

2.4.3 The Basic Commands and the Dialogue Principle

Each time a command is entered the VM 212 responds by either acknowledging that an entry has been received or by adding, if so required, a default value, or by indicating that the entered command is incomplete. The commands and the possible messages are listed in the following:
({nn} stands for the number of the parameter set)

PROG {nn} RUN
The parameter set {nn} is copied from the program memory into the main memory and a measurement is started using this parameter set. The VM 212 indicates:
„RUNNING PROG {nn}“
Program {nn} has been started but there are no measurement data.

„CHANGED PROG {nn}“
Note
This applies from software release 3.3 and later.

After changing it in the PARA mode the program {nn} is stored in the program memory and has been copied into the main memory. The message „CHANGED PROG {nn}“ appears only briefly, after which „RUNNING PROG {nn} is displayed.

„INVALID INPUT“ or „INVALID NUMBER“
A non-existing program number has been selected (see Section 2.17.1).

PROG {nn} STOR
The currently present parameter set in the editing memory is copied into the program memory {nn}

If this parameter set is to be directly used for further measurements, then directly enter PROG {nn} RUN (no longer required from software release 3.3 and later). The instrument indicates:
„STORED PROG {nn}“
The parameter set from the editing memory has been stored as program {nn}.

„CHANGED PROG {nn}“
After a change was made to the program of the same number in the editing memory the parameter set has been stored.

„INVALID INPUT“ or „INVALID NUMBER“
A non-existing program number has been selected (see Section 2.17.1).

PROG {nn} PRT
The parameter set {nn} is output to the printer selected in option 02.

PROG {nn} PARA
Parameter set {nn} is copied into the editing memory (independently of the parameter set currently in the main memory!)

OPT {nn} RUN
The software option {nn} is recalled and immediately displayed or the instrument displays:

„RUNNING OPT {nn}“
Software option {nn} has been recalled.

„NOT INSTALLED“
An option which is not yet available has been selected (see also Section 2.17.1).

„INVALID NUMBER“
It has been tried to select option 0 or an option number greater than 10, or 16 in the case of software release 3.3 or later.

OPT PRT
The configurable options are output to the printer.

PARA
The parameter set currently in the main memory is copied into the editing memory and the editing mode is recalled. The instrument indicates parameter 11 or the parameter used last.

„DISPLAY = aaaa“
If the PARA pushbutton is operated once more the program is newly loaded, any changes made, will be disregarded. Parameter 11 will appear.
IF RUN is pressed in the PARA mode, without having made a change to the entries, the PARA mode is terminated and the running program is started again. When pressing STOP the measurement mode is resumed with a possible loss of the changes made.

STOR
When in the editing mode, each change of a parameter has to be acknowledged by pressing the „STOR“ pushbutton in order to be transferred into the editing memory.

PRT
The „PRT“ command entered while in the measurement mode effects the output of the measured data to the printer. The data are output in the format defined by the printer parameters entered previously (see also Section 2.5.6).

STOP
The last command which was entered is cancelled. If a software option is just running it is stopped. Further information is given in Fig. 12.

2.4.4 *Types of Entry*

There are two groups of entry for the VISCOVAC VM 212. One group are the commands and the second group are the parameter entries. These in turn are subdivided into two further categories:

„Select“-entries
It is typical for a „Select“ parameter that it is possible to select only from a few possible entries. The entry values are marked by =, which flashes in case it has not been acknowledged. The „select“ parameter may be changed by operating the „SEL“ pushbutton (8/16) or by entry of a number between 0 and 9. The way in which these are related is described in Section 2.5.1.

Entry of numerical values
Most parameters are entered as a numerical value. A numerical key pad with sign and exponent is provided for this purpose. A numerical value may be entered as a whole or changed digit by digit aided by the horizontal cursor control.

Details on the process of changing parameters are given in Section 2.6.2.

In case of new entries of parameters the value just entered can be cleared by pressing the „C“ pushbutton. The last valid value is then displayed again.

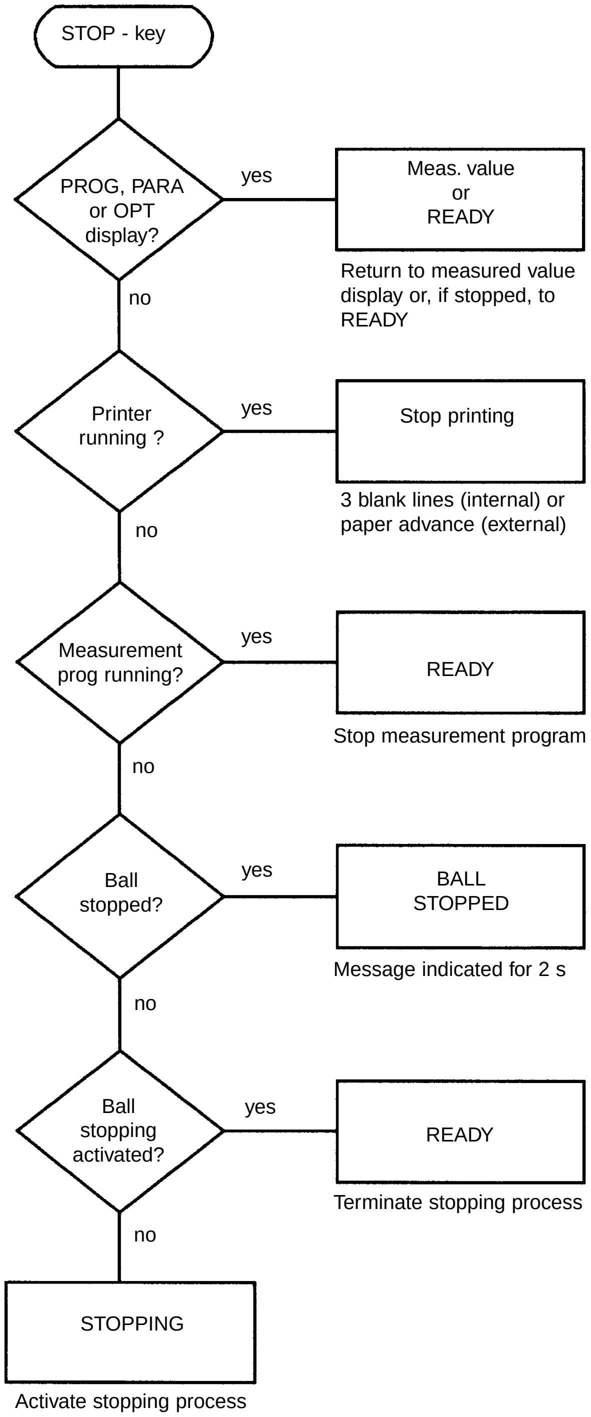


Fig. 12 Flow chart

2.5 Description of the Parameters

Each measurement is based on a number of parameters which

a) control the process until a display is obtained (process parameters 11 to 13),
b) describe the gas (gas parameters 21 to 23),
c) describe the ball (ball parameters 31 to 33),
d) determine the switching functions (switching parameters 41 to 43),
e) program the analogue output (output parameters 51 to 53),
f) determine the way in which the measurement data are output by the printer (printer parameters 61 to 63).

These parameters are the program parameters. A set of these parameters is called „The program“. Shown in Fig. 14 is an example of a print out of the fixed program described in Section 2.6.7. The parameters are explained in the following according to the groups mentioned above.

In the editing mode it is possible to display and modify three (four) further parameters besides the program parameters. These are termed „global parameters“:

IMAGE (if printer internal)
AUTOMATIC
DATE
TIME (from software release 3.3)

These parameters are independent of the program and apply generally. Their entry requires only a simple acknowledgement, i.e. they are active immediately without having to store the entire parameter set. When printing out the program though the optional printer or the external printer output only the program parameters are output, but not the global parameters. Individual description of the global parameters:

IMAGE
This parameter is displayed provided the internal printer has been activated. It determines whether the print out of the internal printer appears upright with the direction of feed or against the direction of feed. The entry is effected using the „SEL“ key or by entry of 0 or 1 via the numerical key pad. The following entries are possible:

Pushbutton 0 UP	The printed image appears upright (opposed to the direction of paper advance) When listing (PROG {nn} PRT or OPT PRT) the sequence of the characters is inverted so that the date will always appear at the top. When printing measurement data the sequence is **not** inverted. The line with the date is always printed first.
Pushbutton 1 DOWN	The printed image is inverted (in the direction of the paper advance). The line with the date is always printed first.

From software release 3.3 onwards this parameter is suppressed when option 02 is not set to internal printer.

```
MEAN VAL        = 5.4175  -04
MEAN STD        = 2.6184  -06
STD DEV         = 8.2801  -06
MAX DEV         = 1.7186  -05
          5.3684  -04   MBAR
          5.3711  -04   MBAR
          5.3706  -04   MBAR
          5.3670  -04   MBAR
          5.3714  -04   MBAR
          5.3679  -04   MBAR
          5.3683  -04   MBAR
          5.4690  -04   MBAR
          5.5323  -04   MBAR
          5.5894  -04   MBAR
NR  0001            PROG  04
DATE  14-AUG-90        14:13
```

Fig. 13 Typical print out of measurement data for software release 3.3 and later

```
DATE  14-AUG-90            14:07
PROG  01
FROM  14-AUG-90            12:58
11  DISPLAY              = MBAR
12  MTIME                   2.0
13  OFFST          0.0000 E +00
21  TEMP                  296.2
22  MOLWT               39.9500
23  VISC           2.2110 E -05
31  SIGMA                 1.000
32  BDENS            7.7260E+03
33  BDIAM                 4.500
41  LIMITS                = OFF
42  LOLIM          1.0000 E -07
43  UPLIM          1.0000 E +00
51  OUTPUT                = OFF
52  ZERO           1.0000 E -07
53  FSCAL          1.0000 E +00
61  PRINT                 =STAT
62  INTVL                     1
63  SAMPL                    10
```

Fig. 14 Print out of the fixed program as an example of a program parameter set

AUTOMATIC

The parameter AUTOMATIC permits the reacceleration process which automatically accelerates the ball when it has reached the lower permissible frequency limit, to be switched on or off. The entry is effected using the „SEL“ key or by entry of 0 or 1 via the numerical key pad. The following entries are possible:

Pushbutton 0	OFF	Automatic function off
Pushbutton 1	ON	Automatic function on

DATE

Except in the editing mode the parameter DATE is displayed also in the following cases:

- Software release number and DATE are displayed after switching on, for example: DATE 13-JUN-1990.
- When storing a program the currently valid date and time is stored under the corresponding program number together with the parameters. When printing out the program without the addition of a parameter number this date is output, indicating the creation date of the particular program, for example FROM 30-APR-1990.
- Also, each time the printer is activated the current date is output, for example DATE 22-MAY-1990 (see also Fig. 13 and Fig. 14).

In the case of instruments without a battery backed-up clock (software release 3.0) the date may have to be entered after switching on.

Entering a date

Each time the date is displayed it may be changed, i.e. not only when in the editing mode, but also after switching on the instrument. To change the date setting use the horizontal cursor pushbuttons to move the cursor to the position which is to be changed and then enter the desired date through the numeric key pad.

The setting of the month is effected through the „SEL“ pushbutton or through the key pad. The following entries are possible:

Pushbuttons 1 to 9	January to September
Pushbutton 0	October
Pushbutton .	November
Pushbutton +	December

The changed entries are terminated by pressing „STORE“. Dates from January 1, 1989 to December 31, 2088 can be entered.

TIME

The same applies for this parameter as described under the DATE heading. The clock is only available from software release 3.3 and later; it also updates the date. The time is entered using the cursor and the numeric key pad.

2.5.1 Process Parameters

11 Display

The parameter DISPLAY is used to select the dimension and unit of the displayed measured values. This is done either through the „SEL“ pushbutton or through pushbuttons 0 to 9. The following outputs are possible:

Pushbutton 0	JM	Mass flow density	($kg \cdot m^{-2} \cdot s^{-1}$)
Pushbutton 1	MBAR	Pressure	
Pushbutton 2	PA	Pressure	
Pushbutton 3	TORR	Pressure	
Pushbutton 4	JN	Particle current density	($m^{-2} \cdot s^{-1}$)
Pushbutton 5	RHOG	Gas density	($kg\ m^{-3}$)
Pushbutton 6	N	Particle density	(m^{-3})
Pushbutton 7	L	Free path	(m)
Pushbutton 8	TMON	Monolayer time	(s)
Pushbutton 9	DCR	Deceleration	(s^{-1})

Further explanations concerning the individual quantities are given in Section 2.11.

12 MTIME

The parameter MTIME is used to select the measurement time. This is the time in seconds which is required for obtaining an individual measured value. Time values between 0.5 and 30 seconds are possible. The relationship between measurement time and measurement accuracy is given in Section 2.16. From software release 3.3 onwards 0 can be entered to activate automatic selection of the measurement time. The instrument will then automatically determine the maximum possible measurement time, whereby 10 s cannot be exceeded.

13 OFFST

The parameter OFFST can be used to enter an offset (refer also to Section 2.10) which is subtracted from the measured values.

As the offset represents the gas-independent deceleration of the ball (see also Section 2.10) the only method which can be reliably used and which does not introduce any additional errors, is to determine the offset on the basis of the deceleration (DCR) and to enter it in the „unit“ DCR as the offset. In order to avoid unintentional errors the following method of entry is strongly recommended:

- **Set the parameter DISPLAY to DCR,**
- **Enter the offset in „UNITS“ of DCR,**
- **Reset the parameter „DISPLAY“ back to the desired output unit.**

The offset is always displayed in the dimension and unit which was determined when entering the parameter DISPLAY. Therefore, if for example, during the last stage of the entry process described above the DISPLAY parameter is set to MBAR, the pressure corresponding to the deceleration rate (DCR) which was entered earlier as the OFFSET parameter, will be displayed. The values of the other parameters just set are used for the conversion.

Positive and negative numbers within the range of

$1.0000 \cdot 10^{-30}$ and $1.0000 \cdot 10^{30}$ and 0 can be entered.

When trying to store OFFST in a different unit the message „IN DCR MODE ONLY“ will be displayed.

From software release 3.3 and later the SEL pushbutton may be used to fetch a statistical average, if available, or the current measurement value. It may be edited or used directly by pressing STOR. The cursor flashes on the first position of entry.

If the measurement is not made in the DCR mode the message IN DCR MODE ONLY will be displayed.

If a value for DCR is not (yet) available the message NO PRESENT VALUE will appear.

2.5.2 Gas Parameters

21 TEMP
The TEMP parameter is used to enter the temperature of the gas to be measured. The temperature is entered as a numerical value in units of Kelvin between 3.0 and 999.9 Kelvin.

22 MOLWT
The parameter MOLWT is used to enter the relative molecular weight of the gas to be measured. Calculation of the effective molecular mass of a gas mixture is described in Section 2.12.1. The molecular mass is entered a as numerical value in atomic mass units. Relative molecular masses between 1.0000 and 999.9999 atomic mass units can be entered.

23 VISC
The parameter VISC is used to enter the viscosity of the gas to be measured. The determination of the effective viscosity of a gas mixture is possible through Option 07 (software release 3.3 or later). The viscosity is entered as a numerical value in units of Pa·s. Viscosities between $1.0000 \cdot 10^{-30}$ and $1.0000 \cdot 10^{30}$ Pa·s and 0 can be entered. The entry of VISC = 0 switches linearization off!

When measuring at pressures below 10^{-2} mbar the viscosity does not significantly influence the measured values (see also Section 2.9). Thus the entry of the viscosity is not required for measurements within this pressure range.

2.5.3 Ball Parameters

31 SIGMA
The parameter SIGMA is used to describe the specific properties of the ball's surface concerning deceleration of the ball due to gas friction (see also Section 2.9). SIGMA is entered as a numerical value in the range between 0.001 and 1.273. For uncalibrated balls the standard value 1.000 can be entered.

32 BDENS
The parameter BDENS is used to enter the density of the ball material. It is entered as a numerical value in units of $kg \cdot m^{-3}$ in the range between $7.0000 \cdot 10^{3}$ and $9.0000 \cdot 10^{3}$ (see Annex A; Table of physical data).

33 BDIAM
The parameter BDIAM is used to enter the diameter of the ball used in the measurements. It is entered as a numerical value in units of mm in the range between 3.90 to 4.90 mm.

34 CDIAM
This parameter is factory-set to a DEFAULT VALUE. It is used to assign a value to a virtual measurement chamber-ball diameter. It is not required to change this default value when using gauges VR 200, VR 201 and VR 202.

For this reason the value is suppressed. When using other types of measurement chambers the parameter can be accessed through parameter 33 BDIAM and pressing of SEL.

Option 08 may be used to determine the effective ball chamber diameter (see also Section 2.8.8)

2.5.4 Switching Parameters

41 LIMITS
The parameter LIMITS is used to set up the operation of the built-in switching trigger relays. The relays are of the changeover type. The status of the relays as indicated on the rear (Fig. 9) is referred to as the rest position. The switching points are referred to as LO and UP according to the labelling on the rear. Entries are made through „SEL“ or through the entry of a number between 0 and 2. The following entries are possible:

Pushbutton 0 OFF	The switching points remain in their rest position independent of the setting for the parameters LOLIM and UPLIM and the current measured value. **Note** From release 3.3 onwards parameters LOLIM and UPLIM are suppressed.
Pushbutton 1 TRIG	The two switching points LO and UP are switched independently of each other, the LO switching point corresponds to the value of the parameter LOLIM, the switching point UP corresponds to the value of the parameter UPLIM. The switching function is shown in Fig. 15. Hysteresis is 3 % of the set limit value.
Pushbutton 2 INTV	The switching points UP and LO operate in parallel. Switching operation is shown in Fig. 15. Hysteresis is 3 % of the set limit. If the parameters UPLIM and LOLIM are entered in the INT-

VAL mode as UPLIM<LOLIM, the error message „PARAM SET ERROR“ will be displayed when trying to store this parameter set (see also Section 2.17.1).

Note
In the event of a mains failure, when switching off and when stopping of the measurement program or in case of a fault, both switching points always return automatically to their rest position!

42 LOLIM
With the parameter LOLIM a threshold value can be entered for the two built-in switching points. The interpretation of this entry is described above in Section 41 LIMITS. The entry is made by entering a number which is independent of the dimension and unit of the measured values as selected through the parameter DISPLAY. Entries from $1.0000 \cdot 10^{-30}$ to $1.0000 \cdot 10^{30}$ and 0 are possible. When changing a dimension or a unit the stored value is not recalculated.

43 UPLIM
With the parameter UPLIM a threshold value can be entered for the two built-in switching points. The interpretation of this entry is described above in Section 41 LIMITS. The entry is made by entering a number which is independent of the dimension and unit of the measured values as selected through the parameter DISPLAY. Entries from $1.0000 \cdot 10^{-30}$ to $1.0000 \cdot 10^{30}$ and 0 are possible. When changing a dimension or a unit the stored value is **not** recalculated.

Note (as of version 3.3)
- In the case of parameters UPLIM and LOLIM the SEL pushbutton may be used to fetch the current measurement value. It may be edited or used directly by pressing STOR. The cursor flashes on the first position of entry.
- If a measurement value is not (yet) available the message NO PRESENT VALUE will appear.

2.5.5 Output Parameters

51 OUTPUT
The parameter OUTPUT is used to set up the mode of the built-in analogue output. Entries are made either through the „SEL“ pushbutton or through the entry of a number between 0 and 2. The following entries are possible:

Pushbutton 0	OFF	The analogue output is passive. The output voltage is Zero. **Note** From release 3.3 parameters ZERO and FSCAL are suppressed.
Pushbutton 1	LIN	The analogue output is active. The output voltage of 0 to 10 V is linearly related to the range of values limited by the parameters ZERO and FSCAL.
Pushbutton 2	LOG	The analogue output is active. The output voltage of 0 to 10 V is logarithmically related to the range of values limited by the parameters ZERO and FSCAL.

52 ZERO
The parameter ZERO is used to fix the lower limit of the permissible range of values to which the output voltage is related by the OUTPUT parameter.
The entry is made by entering a number which is independent of the dimension and unit of the measured values as selected through the parameter DISPLAY. Entries from $1.0000 \cdot 10^{-30}$ to $1.0000 \cdot 10^{30}$ and 0 are possible. When changing a dimension or a unit the stored value is **not** recalculated.

If a value greater or equal to the entered value of FSCAL is selected or in the case of the logarithmic output 0 is selected, the error message „PARAM SET ERROR“ will be displayed when trying to store this parameter set (see also Section 2.17.1).

53 FSCAL
The parameter FSCAL is used to fix the upper limit of the

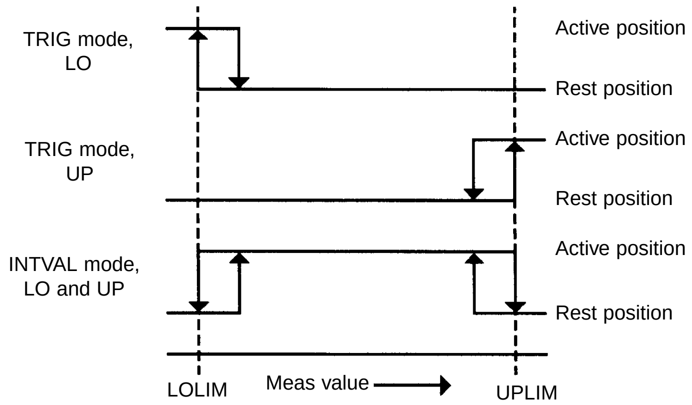


Fig. 15 Diagram giving the operation of the switching points

permissible range of values to which the output voltage is related by the OUTPUT parameter.

The entry is made by entering a number which is independent of the dimension and unit of the measured values as selected through the parameter DISPLAY. Entries from $1.0000 \cdot 10^{-30}$ to $1.0000 \cdot 10^{30}$ and 0 are possible. If a value lower or equal to the entered value of the parameter ZERO is selected, the error message „PARAM SET ERROR“ will be displayed when trying to store this parameter set (see also Section 2.17.1). When changing a dimension or a unit the stored value is **not** recalculated.

Note

- In the case of parameters ZERO and FSCAL the SEL pushbutton may be used to fetch the current measurement value. It may be edited or used directly by pressing STOR. The cursor flashes on the first position of entry.
- If a measurement value is not (yet) available the message NO PRESENT VALUE will appear.

2.5.6 Printer Parameters

61 PRINT

The parameter PRINT is used to determine the way in which the printer is to handle the output of measurement data. Entries are made either through the „SEL“ pushbutton or through the entry of a number between 0 and 4 on the numeric key pad. The following entries are possible:

Pushbutton 0	OFF	The printer is passive. Measurement data are not printed out.
Pushbutton 1	SING	The printer is active. If the „PRT“ pushbutton is pressed while a measurement is in progress the printer outputs date, program number, running number and a measurement value. From release 3.3 onwards the time is printed out in addition.
Pushbutton 2	CONT	The printer is active. If the „PRT“ pushbutton is pressed while a measurement is in progress the printer outputs date, program number, running number and then continuously measurement values, until the Stop pushbutton is operated.
Pushbutton 3	SAMP	The printer is active. If the „PRT“ pushbutton is pressed while a measurement is in progress the printer outputs date, program number, running number and a number of measurement values previously defined by the parameter SAMP. **Note** From release 3.3 onwards the entry of SAMP has been omitted.
Pushbutton 4	STAT	Same as SAMP, but in addition to the printed measurement values the mean value (MEAN VAL), the standard deviation (STD DEV) and the maximum difference of the values (MAX DIF) is also printed out. From software release 3.3 and later the value of the mean standard deviation (MEAN STD) is output instead of the mean deviation (MEAN DEV). The mean standard deviation is calculated from the standard deviation divided by the square root of n (n = number of measurements). **Note** From release 3.3 onwards the old SAMP function and STAT is invoked through pushbutton 3. Pushbutton 4 has no effect in this case.
Running number		The running number is used to identify the individual measurement data which are printed out. When switching on the instrument or when entering a new date the running number is reset to Zero; it is increased by one count each time a measured values is printed out and the running number precedes it; for example No. 1234. **Note** From release 3.3 onwards the running number is reset at 0 hours through the integrated clock. Moreover the time is also printed out when entering the print command.

62 INTVL

With this parameter it is possible to enter the print out interval period. Intervals ranging between 1 and 999 minutes (integers only) may be entered. The entry of 0 switches this mode off.

63 SAMP

The parameter SAMP is used to determine the number of measured values to be printed out within one cycle of the SAMP or STAT operating modes. Entries are made by entering an integer number between 3 and 999.

2.6 Brief Operating Instructions for the VISCOVAC VM 212

The following Sections provide information on the simpler type of commands for the VISCOVAC VM 212. With these commands it is possible to invoke the basic functions of the VISCOVAC VM 212.

In order to enable the VISCOVAC VM 212 to make any measurements it requires the entry of some parameters such as for example:
- the desired dimension and unit for the measured value (DISPLAY)
- the relative molecular mass of the measured gas (MOLWT) or
- the diameter of the ball used (BDIAM).

2.6.1 Start and End of a Measurement

When the instrument has been switched on a measurement can be started by entering:

PROG → n → n → RUN

where n stans for the digits of the program number.

The VISCOVAC VM 212 responds to this command by

„RUNNING PROG {nn}".

This display remains until the first measured value is displayed.

To terminate a measurement simply press „STOP".

The VISCOVAC VM 212 then terminates the measurement and responds by displaying

„READY".

2.6.2 Reading and Changing of Parameters

If parameters of the program just running are to be read or changed this can be done by operating the „PARA" pushbutton.

The VISCOVAC VM 212 responds to this command by displaying the parameter 11, for example

DISPLAY = MBAR

or from software release 3.3 and later the parameter which was called up last is displayed.

The other parameters can then be displayed by operating the cursor up or cursor down controls.

If the parameters of a program {nn} stored in the VISCOVAC VM 212 are to be read or changed enter the following before pressing „PARA":

PROG → n → n → RUN → STOP

The VISCOVAC VM 212 responds to this by displaying:

„RUNNING PROG {nn}",

but it terminates the measurement immediately and indicates

„READY".

Once a parameter has been displayed as described above, it may be changed. This can be done for the parameters DISPLAY (11), LIMITS (41), OUTPUT (51), PRINTER (61), IMAGE and AUTOMATIC either by operating the „SEL" pushbutton or by entering a number between 0 an 9 through the numeric key pad in order to select from what is offered. The VISCOVAC VM 212 responds to each changed parameter by flashing of the = symbol. The flashing stops as soon as the changed entry is acknowledged by pressing „STOR".

All other parameters (except DATE and TIME) can be changed by simply entering a new number. Here the changed entry is indicated by flashing of the digit which was entered last. When the changed entry is acknowledged by pressing „STOR" the parameter is converted to the corresponding display format and displayed without flashing. An incorrect entry is indicated by flashing of all entered digits. The entry may then be repeated.

If the date or the time is to be changed (parameters DATE or TIME) place the cursor at the desired point of entry by using the cursor-left and cursor-right controls. Enter the desired date through the entry of the digits, or in case of the month using „SEL" or through the pushbuttons of the numerical key pad (see Section 2.5.1). Here also acknowledge the entries by pressing the „STOR" pushbutton.

The changed date, time and the parameters IMAGE and AUTOMATIC are immediately effective when following the above.

In order to activate the other changed parameters for a measurement, the parameter set which was changed has to be stored by pressing

PROG → n → n → STOR

in the program memory under the selected number {nn}. If this is not done all changed entries will be lost.

With instruments running on software release 3.3 or later, any changes made to the program parameters will be transferred into the program memory and the main memory by pressing RUN, i.e. the parameter changes immediately take effect.

2.6.3 Printing out a Program

The command sequence „PROG → n → n → PRT" directly prints out the program. A running measurement is not interrupted by the printout. However the entry of a new command will terminate the printout process.

2.6.4 Printing out Measurement Data

The measurement data can be output through the printer by pressing „PRT“ while the measurement is in progress, provided the parameter 61 „PRINT“ of the program used has not been set to „OFF“ and provided the desired printer has been selected in Option 02 as internal or external. An example is given in Fig. 13.

2.6.5 Adjusting the Analogue Output

The analogue output is set up by entry of the output parameters 51 to 53. Refer to Section 2.5.5.

OUTPUT	Linear or logarithmic scaling
ZERO	Scale Zero (corresponds to 0 V).
FSCAL	Full scale (corresponds to 10 V).

2.6.6 Adjusting the Trigger Thresholds

The trigger thresholds are set up by entering the switching parameters 41 to 43. See Section 2.5.4

LIMITS: Trigger mode (TRIG) or interval mode (INTV).

Trigger-Modus
LOLIM: Threshold of trigger LO.
UPLIM: Threshold of trigger UP.

Intervall-Modus

UPLIM>LOLIM:	LOLIM and UPLIM limit the interval for the return hysteresis of the triggers UP and LO operating in parallel.
LOLIM>UPLIM:	Entry does not make sense in this case and is therefore not possible.

2.6.7 Fixed Program

The VISCOVAC VM 212 has been provided with a fixed program which is stored in its non-volatile memory (EPROM). It is the task of this fixed program to enable the entry of a useful set of data in the event of an occurring loss of data of the battery backed-up program memory, i.e to permit the entry of a set of data which the VISCOVAC VM 212 is able to interpret.

If, when trying to start a program the VISCOVAC VM 212 displays PROG NOT DEFINED (the back-up accumulator for the program memory has discharged itself during storage), the fixed program can be transferred into the main memory by entering: PROG → STOR.

It is possible to make measurements using the fixed program directly without having to reenter its individual parameters as these are already preset. The gas parameters of the fixed program are set for measurement with argon gas.

2.7 Switching off

Before switching off the VISCOVAC VM 212 the ball has to be stopped so that it released from the suspension while not rotating. Thus a high degree of reproducibility and a long life of the ball is ensured.

This is done by entering the STOP command, see Section 2.4.3. After the ball has been sufficiently decelerated the message „BALL STOPPED“ appears. The instrument may then be switched off.

Note
When switching off the instrument via the mains switch the ball suspension is also switched off. A previously determined offset value will then be lost.

2.8 Software Options

The software options belong to the standard equipment of any VISCOVAC VM 212. Currently there are 8 options.

The operating concept of the VISCOVAC VM 212 is so designed that future additions can be easily integrated as further options, without changing the basic operation of the instrument.

The software options are called up by the command OPT → {nn} → RUN, where {nn} stands for the option number. After the entry, the selected option number appears immediately on the display.The sotware option mode is terminated by pressing RUN or STOP.

It is possible to select between 8 options:

Option 01	Monitoring display
Option 02	Data output and remote control
Option 03	Configuring the IEEE 488 interface
Option 04	Configuring the RS 232 C interface
Option 05	Service option
Option 06	Configuring the remote control inputs and status signal outputs „REM CTRL“
Option 07	Determination of the effective viscosity
Option 08	Determination of the effective ball chamber diameter

If an option number greater than 08 is selected the VISCOVAC VM 212 responds by displaying „NOT INSTALLED“ or in the case of option numbers greater than 16 „INVALID INPUT“.

2.8.1 Option 01 - Monitoring Display

Option 01 is used to check the signal frequency (FRQ) and the signal scatter (SSC) especially while a measurement is in progress. From software release 3.3 and later the measurement time may also be displayed.

The signal frequency (FRQ) is displayed in Hz and the signal scatter (SSC) in USEC (= microseconds). Signal scatter represents the scattering of the primary time measurement and is thus a measure for the degree of interference in the measurement signal.

Very good values are below 1. If the measurement is disturbed for example by vibrations coming from the pump system the values may increase to 10 or more. However, it should be noted that there is not direct correlation between signal scatter and standard deviation in the actual measurement., i.e. a low degree of signal scatter is a necessary but insufficient condition for a low uncertainty of the measurement (see also Sections 2.13; 2.15 and 2.16).

In the case of the measurement time display (MTIME) either the fixed measurement time is displayed as entered or in the case of automatic measurement time selection the current measurement time is displayed.

Instructions for operation:
When starting option 01 by the command
OPT → 0 → 1 → RUN as described above, the signal frequency is displayed. The „Cursor up" and „Cursor down" controls or „SEL" can be used to switch between the two quantities FRQ and SSC.

If the option is selected while a measurement is in progress, the measurement is not interrupted, i.e. printer, analogue and switching outputs continue to function normally, only the display of the measured values is suppressed. After terminating option 01 by operating the STOP pushbutton the measurement is continued without interruption, whereby the measured values are indicated on the display again.

When selecting option 01 from the basic mode, i.e. when not measuring, only the frequency displayed is correct, whereas the value for the signal scatter is not valid in this case; any old value is displayed which is currently not applicable.

2.8.2 Option 02 - Data Output and Remote Control

After selecting option 02 the type of **data output** is displayed. This can be programmed via the „SEL" pushbutton or through pushbuttons 0 to 3 on the numerical key pad. The following is available:

Pushbutton 0 PRINTER = PARL
Data output via the Centronics printer interface (9/2).

Pushbutton 1 PRINTER = SERL
Data output via the serial RS 232 C interface (9/3).

Pushbutton 2 PRINTER = GPIB
Data output via the parallel IEEE 488 interface (9/4).

Pushbutton 3 PRINTER = INTL
Data output via the internal printer (option).

If it is tried to set up SERL or GPIB when this has already been done for REM CNTRL (or PRINTER) the message „USED FOR REM CTL" or „USED FOR PRINTER" will appear.

The vertical cursor is used to select the **remote control mode** via the interface. This can be programmed via the „SEL" pushbutton or through pushbuttons 0 to 2 on the numerical key pad. The following is available:

Pushbutton 0 REM CNTRL = OFF
Remote control switched off.

Pushbutton 1 REM CNTRL = SERL
Remote control via the RS 232 C interface (9/3).

Pushbutton 2 REM CNTRL = GPIB
Remote control via the IEEE 488 interface (9/4).

2.8.3 Option 03 - Configuring the IEEE 488 Interface

Option 03 permits the setting of the equipment address and the type of end sign output.

After selecting option 03 the equipment address is shown first in the display:

GPIB ADRS {nn} Values between 1 and 30 may be entered for {nn} via the key pad.

The vertical cursor is used to switch over to the type of end sign setting. This can be programmed via the „SEL" pushbutton or through pushbuttons 0 to 6 on the numerical key pad.

The following is available:

Pushbutton 0	NONE	(No end sign; only bus signal END)
Pushbutton 1	ETX	
Pushbutton 2	LF	
Pushbutton 3	CR	
Pushbutton 4	ETB	
Pushbutton 5	CRLF	
Pushbutton 6	LFCR	

Note
At all times all end signs (sequences) given in the list above are accepted. The setting refers only to the **output** in the **dialogue mode** (REM CNTRL = GPIB). In the printer mode (PRINTER = GPIB) CRLF is always output regardless of any settings.

2.8.4 Option 04 - Configuring the RS 232 C Interface

Option 04 permits the entry of the interface parameters baud rate, parity, XON / XOFF and the type of end sign for the serial interface.

The vertical cursor is used to switch over to the other interface parameters as given above. All the mentioned interface parameters can be entered via „SEL“ or by various pushbutton of the key pad.

Baudrate

Pushbutton 0 110
Pushbutton 1 300
Pushbutton 2 600
Pushbutton 3 1200
Pushbutton 4 2400
Pushbutton 5 4800
Pushbutton 6 9600
Pushbutton 7 19200

PARITY

Pushbutton 0 NONE
Pushbutton 1 EVEN
Pushbutton 2 ODD

XON / XOFF

Pushbutton 0 OFF
Pushbutton 1 ON

END SIGN

Pushbutton 0 ETX
Pushbutton 1 LF
Pushbutton 2 CR
Pushbutton 3 ETB
Pushbutton 4 CRLF
Pushbutton 5 LFCR

Note
The same applies to the end sign as stated in Section 2.8.3.

2.8.5 Option 05 - Service Option

Service option 05 should only be used in exceptional cases as it permits direct, so to speak manual access to the ball suspension and ball drive systems. As the thus entered commands are no longer checked by the internal logic of the instrument it is possible to endanger the ball by setting it down at high speeds. Therefore, special care must be taken, especially when using calibrated balls (the ball parameter Sigma may change slightly in case of such a crash).

As option 05 directly influences the motion of the ball, any measurements in progress are terminated when selecting option 05.

Instructions for operation:
When starting option 05 by the command
OPT → 0 → 5 → RUN the message „MANUAL BALL CTRL“ is displayed for approximately 2 seconds. The VISCOVAC VM 212 now awaits the entry of a command. The commands are entered via the four cursor controls and the SEL pushbutton. They effect the following:

Cursor up	Suspend the ball (response of the VISCOVAC VM 212: SUSP ON)
Cursor down	Release the ball (response of the VISCOVAC VM 212: SUSP OFF)
Cursor right	Drive the ball in the forwards direction (response of the VISCOVAC VM 212: DRIVING FWD)
Cursor left	Drive the ball in the reverse direction (response of the VISCOVAC VM 212: DRIVING REV)
SEL	Switch off the drive and display the Signalfrequency.

The frequency is also displayed approximately 2 seconds after the command entered by the cursor control pushbutton. This is especially useful when driving the ball, as it is then possible to follow the ball frequency during the driving process. This also enables the acceleration process to be terminated at the desired frequency by simply pressing the SEL pushbutton.

2.8.6 Option 06 - Configuring the Remote Control Inputs and the Status Signal Outputs „REM CTRL“

By selecting option 06 it is possible to program the two remote control inputs and the two status signal outputs which are accessible through the rear REM CTRL socket (9/12).

After selecting option 06 the display indicates:

RI FUNCT 1 = aaaaa

This message is related to **remote control input 1**. With the „SEL“ pushbutton or the pushbuttons 0 to 3 it is possible to select between the following remote control modes:

Pushbutton 0	OFF	The input is not active. If a signal is applied to the input the message RI FUNCT 1 OFF is displayed briefly. It is thereby possible to check the functioning of the connection without having to enter the measuring mode.
Pushbutton 1	RUN	The program which was entered last is started. Same function as the entry of PROG RUN.
Pushbutton 2	TRIG	Trigger pulse input for the output of the next measured value when the instrument is in the HOLD mode. Thus this makes only sense in connection with the function RI FUNCT 2 = HOLD.

Note
Operation is the same as for the interface commands SMH W1 (RS 232 C) or GET (IEC bus).

Pushbutton 3 PRINT Print command. Same function as the pushbutton PRT when in the measurement mode.

Access for setting of **remote control input 2** is gained by pressing the vertical cursor control pushbutton. The display indicates:

RI FUNCT 2 = aaaaa

Also in this case several remote control modes can be selected:

Pushbutton 0 OFF The input is not active. If a signal is applied to the input the message RI FUNCT 2 OFF is displayed briefly. It is thereby possible to check the functioning of the connection without having to enter the measuring mode.

Pushbutton 1 STOP Stopping of the measurement mode and deceleration of the ball down to standstill. Deviating from the function of the STOP pushbutton which is equivalent to an ESCAPE function this input acts directly as a stopping function for the gauge head. A second activation will not terminate the stopping process, as this would be the case for the „STOP" pushbutton.

Pushbutton 2 HOLD Switches the HOLD mode on and off. When switching on the HOLD mode, the currently displayed value and possibly that available at the analog output is frozen. When switching the HOLD function off, the measured values will then be updated again. TRIG and HOLD inputs are impulse inputs. Therefore continual activation will block the function.
Note
Has the same effect as the commands SMH W 0 or SMH W 2.

Pushbutton 3 ACCEL Post-acceleration or, if re-suring, running up of the ball and resuming the measurement. As opposed to RUN, the program is not activated. When the ball has to be run-up again, RUNNING PROG {nn} is displayed in the meantime. This may be used in the mode AUTOMATIC = OFF to accelerate the ball after the message SIGNAL LOW was displayed and after the status output SIGNAL was activated.

Pressing the vertical cursor control once more accesses **signal output 1**. The display indicates:

RI OUTPT 1 = aaaaa

Several selections are offered (see also Fig.16):

Pushbutton 0 PWRFL This output is set during the initialization phase when switching on and it remains set until a RUN function is carried out, i.e. RUN pushbutton, RUN input or the RUN command is entered via the interface. Automatic power up after a mains failure will not reset the PWRFL signal.

Pushbutton 1 ERROR This output is set during an error message such as SUSP FAILED, BALL SIGNAL etc. and is reset by the RUN function. After switching on ERROR is reset.

Pushbutton 2 SIGNL Combination of the message SIGNAL LOW (rotor speed has dropped below the required minimum) in the operating mode AUTOMATIC = OFF and the message SIGNAL displayed on the front panel (rotor speed cannot be determined). This is reset when the rotor speed has returned to its nominal range after acceleration.

Pushbutton 3 STOP This output is set when the ball has been stopped (STOP function). Corresponds to the display of BALL STOPPED.

When selecting **signal output 2** the display indicates:

RI OUTPT 2 = aaaaa

Several selections are offered (see also Fig. 16):

Pushbutton 0 BUSY This output is active as long as a measured value is in preparation, also when the ball is running up. This output is reset as soon as a measured value is ready, when the ball is being reaccelerated or when the next measurement run is started.

Pushbutton 1 MEAS This output is set as soon as there is a measurement value present and it is reset when the next measurement is started.
The duration is several 100 ms depending on the internal status and the speed of the rotor.

Pushbutton 2 READY This output is active as long as the VISCOVAC VM 212 is in the READY mode, for example after pressing „STOP" after an error has occurred or after switching

	on when the date is displayed. In this mode no measured value is in preparation.
Pushbutton 3 RUN	This output is active as long as the VISCOVAC VM 212 is in the RUN mode either through the RUN function (pushbutton, input or interface command) or in the event of automatic start-up. In this mode measured values are being expected.

2.8.7 *Option 07 - Determination of the Effective Viscosity (from rel.3.3)*

With the aid of this option it is possible to measure the viscosity with the VISCOVAC VM 212. For this it is required to enter

- as the output quantity, the relative speed reduction (parameter 11 DISPLAY = DCR)
- the temperature (parameter 21 TEMP) with the highest possible accuracy
- the approximate value of the saturation pressure.

If statistics have been printed out the average value of DCR is used in the calculation of VISC; otherwise the use the current DCR value. The calculated value of VISC will be displayed as „VISC+n.nnnnE-nn“ whereby the cursor flashes on the first position of entry. This value may now either be edited or used in the program directly by pressing STOR.

The viscosity is calculated using the following equation:

$$\mathrm{VISC} = \frac{((\mathrm{DCR} - \mathrm{OFFST}) \cdot \mathrm{BDIAM}^2 \cdot \mathrm{BDENS})}{\mathrm{cg} \cdot 6 \cdot 10^7} \quad \text{where}$$

$$\mathrm{cg} = \frac{1}{1 - \left(\frac{\mathrm{BDIAM}}{\mathrm{CDIAM}}\right)^3}$$

If the measurement is not run in the DCR mode the following message will be displayed:

IN DCR MODE ONLY

If a value for DCR is not (yet) available the following message appears:

NO PRESENT VALUE

2.8.8 *Option 08 - Determination of the Effective Ball Chamber Diameter (from rel. 3.3)*

With the help of this option it is possible to determine the effective ball chamber diameter CDIAM. For option 8 the same entries are required as for option 07 (refer to Section 2.8.7).

The value will appear as „CDIAM   n.nnnn“.

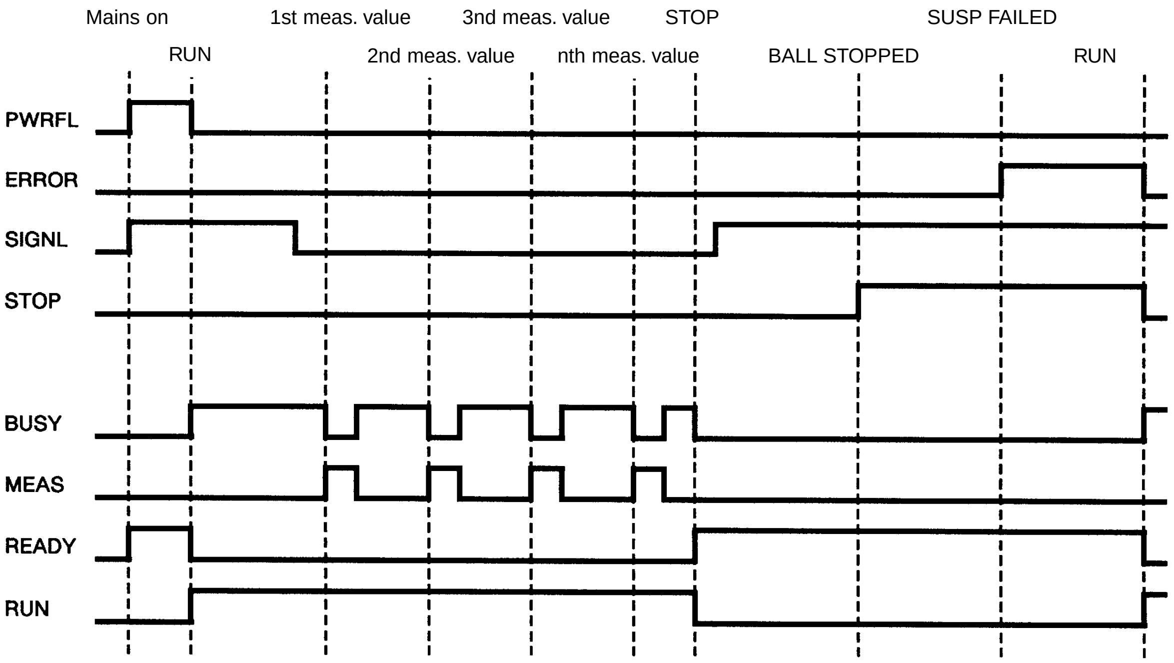


Fig. 16 Status outputs RI OUTP 1/2

CDIAM is calculated by the following equation:

$$\text{CDIAM} = \frac{\text{BDIAM}}{(1 - \frac{1}{x}) \cdot 0{,}3333333} \qquad \text{where}$$

$$x = \frac{((\text{DCR - OFFST}) \cdot \text{BDIAM}^2 \cdot \text{BDENS})}{\text{VISC} \cdot 6 \cdot 10^7}$$

2.9 Influence of the Ball Surface on the Gas Friction (Friction Coefficient)

The degree to which the rotating ball is slowed down by the gas atoms or molecules encountered depends, amongst other things, on the roughness of the ball surface. Ball roughness is described by the friction coefficient which is entered into the program as the parameter Sigma.

The friction coefficient may range between values of 0 and $4/\pi$ = 1.273, where 0 is equivalent to an ideally smooth surface and $4/\pi$ corresponds to maximum roughness. The balls supplied with the VK 201 gauge head or which are available as an accessory are smooth balls as used in ball bearings. For all types of gas their friction coefficient is 1.0 with an uncertainty of measurement of 3 % approx.

A DKD calibration (see Section 1.4.2) is able to reduce this to 1.5 % approx. The friction coefficient for roughened balls is greater than 1 and must in any event be determined by calibration.

2.10 Offset

As a result of the magnetic suspension, the ball is not subjected to any mechanical friction. Nevertheless, even at gas pressures below $1 \cdot 10^{-8}$ mbar a clear deceleration of the ball can be observed, which is equivalent to a gas pressure of 1 to $5 \cdot 10^{-6}$ mbar. This deceleration causes a residual value and is basically the result of two effects:

a) the asymmetry of the ball's relative magnetic moment relative to the magnetic field of the suspension and thus the rotational axis;
b) the energy lost due to tapping off the signal

The result of effect b) is, that balls which supply large signals (which can be measured at the „SCOPE“ output) generate a particularly high residual value.

The residual value is called offset. Once the offset of a ball has been determined at sufficiently low gas pressures (see above), it can be entered into the measurement program as parameter 13. It is then automatically subtracted from the measured pressures. The displayed value will then only represent the effect of gas friction.

From this it is clear that not the absolute value of the offset matters, but rather its stability and reproducibility determine the uncertainty of measurement and therefore the lower limit of the measurement range. Thus, for example, it is possible to obtain slightly varying offset values when repeatedly suspending the ball. Depending on the ball, uncertainties in the offset ranging below $1 \cdot 10^{-7}$ mbar are possible.

2.11 The Different Output Quantities

The relative deceleration $-\dot{\nu}/\nu$ described by equation 3 in Section 1.3.2 is termed DCR (deceleration rate) in connection with the VISCOVAC VM 212. It represents the actually measured quantity. All other quantities are derived by calculation form this by using general physical constants and material parameters of both gas and ball. These material parameters are an integral part of each measurement program (see also Section 2.5). Given in the following is the relationship between the primary quantity DCR and the other output quantities which can be selected using the VISCOVAC VM 212:

Particle current density:

$$\text{JN} = \frac{d_B \cdot \rho_B \cdot N_A}{10 \cdot \sigma \cdot M} \cdot \text{DCR}$$

Gas density:

$$\text{RHOG} = \frac{d_B \cdot \rho_B}{10 \cdot \sigma} \cdot \sqrt{\frac{2 \cdot \pi \cdot M}{R \cdot T}} \cdot \text{DCR}$$

Particle density:

$$N = \frac{N_A \cdot d_B \cdot \rho_B}{10 \cdot \sigma} \cdot \sqrt{\frac{2 \cdot \pi}{M \cdot R \cdot T}} \cdot \text{DCR}$$

Mean free path:

$$L = \frac{5 \cdot \sigma \cdot \eta}{d_B \cdot \rho_B} \cdot \text{DCR}^{-1}$$

Monolayer time:

$$TMON = \frac{40 \cdot \sigma \cdot \pi}{d_B \cdot \rho_B} \cdot \sqrt{\frac{\pi \cdot M}{R \cdot T}} \cdot DCR^{-1}$$

Mass flow density:

$$JM = \frac{d_B \cdot \rho_B}{10 \cdot \sigma} \cdot DCR$$

R = General gas constant (see also Annex A)
N_A = Avogadro's constant (see also Annex A)
d_B = Ball diameter
ρB = Density of the ball
σ = Friction coefficient
M = Relative molecular mass
T = Absolute temperature
η = Viscosity of the gas

2.12 Dealing with Gas Mixtures

Measurement of gas pressure and the other possible output quantities is also possible using gas mixtures if their average molecular mass and - for the higher pressure range - the corresponding viscosity is known. In the case of air these values can be taken from the table given in Appendix A.

2.12.1 The Effective Relative Molecular Mass

If the relative molecular mass of the gas mixture is not known, the value can be calculated. The components of the mixture and the relative proportions of each constituent must be known. If a is the relative proportion of gas i having a relative molecular mass Mi, then,

$a_1 + a_2 + a_3 + ... = 1$

From equation (1) given in Section 1.3.2 it can be deduced that the exact mean must take the from of:

$\sigma \cdot \sqrt{M} = a_1 \cdot \sigma_1 \cdot \sqrt{M_1} + a_2 \cdot \sigma_2 \sqrt{M_2} + a_3 \cdot \sigma_3 \sqrt{M_3} + ...$

where σ_1 is the specific friction coefficient of the gas i. However, from Appendix A it can be seen that, in many cases, the various values of σ_1 for the various gasses differ only slightly from each other, so that generally the simplified equation

$\sqrt{M} = a_1 \cdot \sqrt{M_1} + a_2 \sqrt{M_2} + a_3 \sqrt{M_3} + ...$

can be applied.

2.12.2 The Effective Viscosity

It is not possible to determine the viscosity of a gas mixture by a simplified expression or formula, as is the case for the relative molecular weight (see Section 2.12.1).

But there are a variety of methods by which it is possible to obtain information on the effective viscosity of a gas mixture. For measurements at gas pressures below $1 \cdot 10^{-2}$ mbar the entry of the viscosity is not required at all (0.000 can be entered). The only exception to this is, if the output quantities free path or monolayer time are selected (see Section 2.11).

Initial information on the effective viscosity of the gas mixture can be obtained from the viscosities of the gas constituents. As can been seen from the table of physical data (Appendix A) the viscosities of the various gasses do not differ greatly. Therefore it will often suffice to conclude the effective viscosity of the mixture from the viscosities of the constituents. Given in the table is an example of the effective viscosity of air.

With the aid of option 07 it is possible to measure the effective viscosity with the VM 212 (see also Section 2.8.7).

2.13 Temperature Effects

Errors due to a constant temperature during the measurement deviating from the entered temperature are normally insignificant (details in [10]). But those errors produced by temperature fluctuations during a measurement should be noted. It is thus possible that, during the cooling of the ball, the pirouette effect (maintaining of the angular momentum) is greater than the gas friction, and that for this reason the rotational speed of the ball increases. This makes itself felt in that negative pressures are displayed. The deviation p_T of the displayed pressure as a result of temperature changes may be calculated by

$$p_T = \alpha \frac{d_B \cdot \rho_B}{5 \cdot \sigma} \cdot \sqrt{\frac{2 \cdot \pi \cdot RT}{M}} \cdot \frac{\Delta T}{\Delta t}$$

where
$\Delta T/\Delta t$ = is the change in temperature over time
α = linear expansion coefficient of the ball.

2.14 Linearization at High Gas Pressures

At high pressures gas friction is almost independent of the pressure. For pressures below approximately $1 \cdot 10^{-2}$ mbar gas friction increases proportionally to the pressure; at pressures greater than this gas friction reaches a limit value equivalent to a pressure between 0.1 and 1 mbar depending on the type of gas. In practice, however, the asymptotic behaviour of the function anticipated from theory has, for geometrical reasons only been found approximately. Fig. 17 shows this as an example for two gases. Here the curves are calculated based on the formula

$$p_i = p_{i,\,max} \cdot \left(1 - \exp. \frac{-p_r}{p_{i,\,max}}\right)$$

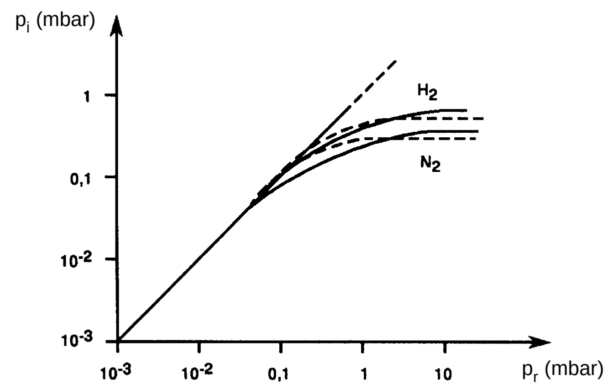
p_i displayed pressure

p_r true pressure

$p_{i,max}$ pressure equivalent of the maximum gas friction.

In order to expand the linear measurement range of the VISCOVAC VM 212 to the pressure range between 10^{-2} mbar to 1 mbar, the measured values are multiplied by a correction factor. This correction factor is determined from the measured deceleration DCR and the viscosity entered as parameter 05 and a table of values contained in the memory of the VISCOVAC VM 212, whereby this table is not derived from theory but from calibration measurements. The entry of VISC = 0 disables linearization.

However, there still remains some uncertainty in the correction factors as these depend on the individual ball and the composition of the gas, resulting in a low measurement uncertainty for the VISCOVAC VM 212 at high pressures.



———— = measured values
- - - - - - - - = values calculated according to Section 2.14

Fig. 17 Reading of the VISCOVAC VM 212 at high pressures; for H_2 ($p_{i,max.}$ = 0,333 mbar) and N_2 ($p_{i,max.}$ = 0,177 mbar)

2.15 Measurement Uncertainty

The total uncertainty of measurement E_{total} is composed of the uncertainties of measurement determined for each individual parameter of the measurement:

$$E_{total} = E_{Cal} + E_{LTS} + E_T + E_{OFF} + E_t \ (+E_{HP})$$

where,

E_{Cal} = Uncertainty of the friction coefficient (see also Section 2.9) (1.5 % for a calibrated ball)

E_{LTS} = Uncertainty of the long-term stability (1% for the recalibration period of one year; empirical value)

E_T = Uncertainty resulting from temperature fluctuations (see also Section 2.13) ($4 \cdot 10^{-8}$ mbar for temperature fluctuations of 0.3 $K \cdot h^{-1}$)

E_{OFF} = Uncertainty of the offset (see also Section 2.10) (about $5 \cdot 10^{-8}$ mbar for a good ball)

E_t = Uncertainty in the time measurement (about $7 \cdot 10^{-8}$ mbar for a measurement period of 15 s)

E_{HP} = Uncertainty in the linearization at high gas pressures (see also Section 2.14)

A more detailed discussion on the uncertainty of measurement can be found in [10].

2.16 Selection of the Measurement Period

As already discussed in Section 2.5.1, there is a relationship between the measuring time (MTIME parameter) and the accuracy of the measurement. For a constant pressure the deviation from the measured values decreases when the measurement period is increased. The standard deviation for at least three measured values is a measure for these deviations. It is in this way that the VISCOVAC VM 212 calculates the values as printed out in the statistics mode (PRINT:STAT).

When introducing the constant K, the following formula applies approximately between standard deviation STD DEV and the measurement period MTIME:

$$\text{STD DEV} = \frac{K}{\sqrt{M} \cdot \text{MTIME}^{2,5}}$$

(M = Relative molecular weight)

Although the value of K depends on the external conditions of measurement in each individual case, it is nonetheless possible to provide guide lines as to the length of the measurement period which will result in the desired measurement accuracy.

If s is the required standard deviation (measurement accuracy) in mbar or torr, the measurement period in seconds should be approximately selected as:

$$MTIME = \left(\frac{0{,}001}{\sqrt{M} \cdot s}\right) \cdot 0{,}4 \qquad [\, I \,]$$

No difference is made between mbar and torr as the corresponding difference in the recommended measurement period is only 10 % approx, and the recommended values do not come near this percentage.

If s is the required standard deviation (measurement accuracy) in Pa, the measurement period in seconds should be approximately selected as:

$$MTIME = \left(\frac{0{,}1}{\sqrt{M} \cdot s}\right) \cdot 0{,}4 \qquad [\, II \,]$$

Example
A standard deviation of $1 \cdot 10^{-6}$ mbar is required for Argon. As the standard deviation has been stated in mbar, equation (1) has to be used where
M = 40 and $s = 1 \cdot 10^{-6}$

$$MTIME = \left(\frac{0{,}001}{\sqrt{40} \cdot 1 \cdot 10^{-6}}\right)^{0{,}4} = 7{,}6$$

Entering 7.6 as parameter 02 (MTIME) should adequately meet the above requirements.

Instruments running on software release 3.3 or later the entry of 0 for the measurement time activates the automatic measurement time selection mode. The instrument will then automatically determine the maximum possible measurement time, but 10 s cannot be exceeded. The actual measurement time can be displayed through option 01.

2.17 Dealing with Errors and Faults

The error messages of the VISCOVAC VM 212 can be divided into three groups:
- Messages indication operating errors
- Messages indicating technical faults
- Messages indicating faults in the operating system.

The individual error messages are described in the following according to the groups above.

2.17.1 Operating Errors

As part of the dialogue principle the VISCOVAC VM 212 indicates operating errors so that they can be corrected. This type of error message is given in plain text without any form of numbering. The following list comments on the error messages and outlines ways of correction.

INVALID NUMBER or INVALID INPUT
- It has been tried to enter a program number outside the range 01 to 16. Enter a program number within this range.
- It has been tried to call up an option number outside the range 01 to 16. Enter an option number within this range.

INVALID COMMAND
One of the commands OPT → n → n → STORE has been entered.

NOT INSTALLED
It has been tried to call up an option number within the range between 09 and 16.

PROG NOT DEFINED
The message has only the from of an error message for an operating error, however, it indicates that the battery for buffering of the stored parameters is exhausted (replacement is required) or that the parameters have been lost because of a fault and the memory allocations do no longer contain valid data which might be interpreted by the VISCOVAC VM 212. Section 2.6.7 gives details on how the data can be copied into the memory; but the original parameters contained in the memory are lost in any case.

Flashing of a numerical input
It has been tried to enter a value which is not acceptable to this parameter. Enter a new value taking the limitations as described in Section 2.5 into account.

PARAM SET ERROR
It has been tried to store program parameters, which individually are valid, but in their combination do not make sense. This may occur when programming the switching outputs or the analogue output.

After the above error message which was displayed for approximately 2 seconds the VISCOVAC VM 212 automatically displays one of the parameters lines involved in the conflict.

OFF SCALE
This message is only partly a reaction to an operating error. It indicates that a measured value is out of the display range. The upper limit of the display range depends on the type of gas though the entered viscosity value. This may be due to the fact that the measured value is outside the measurement range of the VISCOVAC VM 212. It is also possible that the value which is to be measured is within the display range but the selected measurement period is so short that individual values are outside the range because of signal deviations. To prevent this, increase the measurement period. A further cause for measurement values which are seemingly to great may be the incorrect entry of parameters (particularly viscosity) thereby making the calculated values exceed the permissible range.

MTIME TOO LONG
As the measurement is only permitted within the frequency range of 405 to 415 Hz for the ball, measurements in the upper pressure range where deceleration of the ball is already very high can only be carried out with a short MTIME (the product of DCR and MTIME must be considerably lower than the frequency interval given above). Therefore, at the upper range limit the measurement period should be selected at around 1 second or use the automatic measurement time selection facility.

LOW SIGNAL
If AUTOMATIC OFF has been entered to switch off ball reacceleration, the message SIGNAL LOW will appear when the ball frequency has dropped below the lower limit required for correct measurements.

CHECK PRINTER
An internal printer has been entered in Option 02 without the printer installed.

NO PRINT MODE
It has been tried to activate the print command, inspite of parameter 61 set to OFF and no program activated (READY)

ONLY DCR MODE
It has been tried to enter the OFFSET in a unit other than DCR.

NO PRESENT VALUE
In case of parameters OFFST, LOLIM, UPLIM, ZERO or FSCAL it has been tried to display a current measurement value which is not (yet) available, by operating the SEL pushbutton.

KEYBOARD DISABLED
The instrument is in the REMOTE mode.

USED FOR PRINTER
USED FOR REM CTRL
This message is displayed when one tries to set up SERL or GBIP when this has already been done for REM CTRL (or PRINTER).

2.17.2 Technical Faults

There are five messages which indicate technical faults.

SYS FAULT
The VISCOVAC VM 212 has developed a considerable fault. Check the internal plug connections of the instrument. If this is not the cause of the fault get in touch with the LEYBOLD service.

SUSP FAILED
The ball cannot be suspended. Check the connections of the gauge head and, if necessary also its horizontal alignment.

MOTOR FAILED
The ball cannot be driven. Check the connections of the gauge head and, if necessary also its horizontal alignment.

MOTOR TIMOUT
The maximum time permitted for the ball to accelerate (90 s) has been exceeded (in Option 05)

BAD SIGNAL
The quality of the signal is insufficient; see Section 2.17.4 for possible measures.

The measures described above are to be taken as recommendations. Moreover, the list of possible causes listed is not complete. Nonetheless this list should help you to find and troubleshoot some of the faults rapidly and without much effort.

2.17.3 Faults in the Operating System

Faults of this last group are either to be located within the internal control program or there is a fault in the components involved in running the program. These faults cannot normally be cleared, but in most cases it will be possible to continue using the instrument.

ERROR nn @ xxxx
With this type of error message, the n refers to decimal numbers and the x to hex. numbers. This type of error message is caused by an unforeseen exceptional situation within the internal operating sequence. In all cases it will be possible to proceed by entering a new command. The VISCOVAC VM 212 will then immediately resume correct operation.

In the event of such an error we would be grateful if you could inform us about this giving the number which was displayed and the events before this error occurred. This information will enable us to correct the software accordingly.

nn @ nnnnn
If this type of error is displayed there is probably a serious fault within the VISCOVAC VM 212. One may try to restart the VM 212. If the error message is repeated contact the LH service. The n stands for decimal numbers.

2.17.4 Interferences Caused by High Levels of Signal Scattering

Fluctuations of measured values which occur during the measurements and which exceed the fluctuations which correspond to the selected measurement period can be traced to several causes.

- The measured quantity, for example the pressure within the vacuum system is not constant. As the VISCOVAC VM 212 has an exceptionally high resolution, even slight changes in the pressure of the gas will produce a value for the standard deviation, which will considerably exceed the value which corresponds to the selected measurement period (refer to Section 2.16 for the relationship between measurement period and standard deviation).

For investigation of the following it is important to connect an oscilloscope to the „SCOPE“ output, so that the signal produced by the gauge head is displayed.

Normally this signal will be an approximated sine wave having a frequency between 405 and 415 Hz, at an amplitude between 2 and 8 V_{rms}.

- The measurement system (gauge head and rotating ball in the gauge tube) is mechanically disturbed by oscillations or vibrations. One should try and avoid these by mounting the gauge tube on a different part of the vacuum system or by decoupling it from the oscillation by inserting a piece of corrugated tube and by mounting the gauge tube on a section which is free of vibrations. If the amplitude of the oscillations is sufficiently small it is also possible to mount the gauge head not to the flange of the gauge tube. In this case it will be required to ensure a good electrical contact between gauge head and frame ground.
- Electromagnetic interference from the system or coming from the vicinity of the gauge head are picked up by the signal cable. This makes itself felt as a strongly varying signal frequency or by frequencies well outside the nominal range of 405 to 415 Hz (see also Section 6.1). In any case care should be taken to provide a good electrical contact between gauge head and frame ground.
- The ball used is unable to produce a sufficient amplitude of 2 Vrms (see above). For this measurement an ordinary AC meter is sufficient without having to use an oscilloscope.

If one finds that the signal amplitude is too low the ball may either be magnetized, or especially if this is not successful use a new ball.

To magnetize the ball, the gauge head has to be detached. The ball may remain within the gauge tube so that it is not necessary to vent the vacuum system. Any ordinary permanent magnet can be used, for example those from magnetic clip boards.

After removing the gauge head pass the magnet along the gauge tube once from the inside to the outside. As the magnetization may not be too strong keep a distance of several mm between magnet and gauge tube when using stronger magnets.

After the gauge head has been reassembled, check the amplitude again. It should now lie between 2 and 8 V_{rms}. If the amplitude is still too low repeat the magnetization process. If the amplitude is too high baking out of the gauge tube may help as generally the first bake-out process will eliminate the additional magnetization by a degree which cannot be predetermined.

Please note that the increased magnetization and the subsequent increase in the signal amplitude produces also a greater offset. Normally this will not have a negative effect (see Section 2.10) as in most cases not the magnitude but the stability of the offset is of particular interest.

2.18 Operation of the V.24 or the IEEE Interface

For operation of either of the two interfaces select the required interface through option 02.

Further information on the operation of the interfaces is given in the corresponding Operating Instructions
GA 517 and GA 518, whereby the installation steps as described in Sections 3 and 4 may be omitted.

Given in the following is a list of the remote control commands currently accepted by the VM 212 running on software release 3.3.

Abbreviations used:

a{aaa}	1..4 characters, e.g. L or MBAR
n{n}	1 or 2 digits, e.g. 7 or 07
nn{nn}	2 or 4 digits, e.g. 90 or 1990
x	Real number, unformatted, e.g. 3.4E-5, 23.405, -0.5
I	alternatively

1. Individual parameters

DIS	Wn{n},a{aaa} I Rn{n}	11	DISPLAY
MTI	Wn{n},x I Rn{n}	12	MTIME
OFS	Wn{n},x I Rn{n}	13	OFFST
TEM	Wn{n},x I Rn{n}	21	TEMP
MOL	Wn{n},x I Rn{n}	22	MOLWT
VIS	Wn{n},x I Rn{n}	23	VISC
SIG	Wn{n},x I Rn{n}	31	SIGMA

BDE	Wn{n},x I Rn{n}	32	BDENS
BDI	Wn{n},x I Rn{n}	33	BDIAM
CDI	Wn{n},x I Rn{n}	34	CDIAM
LIM	Wn{n},a{aaa} I Rn{n}	41	LIMITS
LOL	Wn{n},x I Rn{n}	42	LOLIM
UPL	Wn{n},x I Rn{n}	43	UPLIM
ANO	Wn{n},a{aaa} I Rn{n}	51	OUTPUT
ZER	Wn{n},x I Rn{n}	52	ZERO
FSC	Wn{n},x I Rn{n}	53	FSCAL
PRI	Wn{n},a{aaa} I Rn{n}	61	PRINT
INT	Wn{n},x I Rn{n}	62	INTVL
SAM	Wn{n},x I Rn{n}	63	SAMPL

2. Parameter set

PAR Rn{n}	Display parameter set (clear text)
COD Wn{n},244(h) I Rn{n}	Parameter input / output (code)
INI Wn{n}	Initialize parameter set

3. Global parameters

IMA W,a{aaa} I R	IMAGE
AUT W,a{aaa} I R	AUTOMATIC
DAT Wn{n},aaa,nn{nn} I R	Date
TIM Wn{n},n{n},n{n} I R	Time

4. Measurement control

RUN Wn{n} I R	Start / hold measurement program
STP W I R	Decelerate rotor
SMH Wn{n} I R	Hold / trigger measurement data output

5. Measurement data / auxiliary quantities

VAL R	Measurement value (depends on DISPLAY)
FRQ R	Rotor frequency
SSC R	Signal scatter
AMT R	Current measurement time

6. Printer

PRS Wn{n}{,n{n}} I R	Printer command / printer status

7. System status

STS Wn{n} I R	Status byte
ERR R	Error number

8. Interface

ESQ W,a{aaa}	Set end sign
SRQ Wn{n} I R	SRQ operating mode
GTL W	Go-To-Local for serial interface
LLO W	Local-Lock-Out for serial interface

3 Maintenance

The VISCOVAC VM 212 does not require any maintenance.

3.1 Exchanging the EPROMS (D003)

Set the mains switch „POWER“ (8/21) to the „OFF“ position.

Disconnect the mains cable from the VM 212.

Remove the upper cover panel as follows:
- Loosen and remove the two crosshead screws on the top.
- Lift the cover panel which is now only retained by the two outer guides up in the middle and carefully remove it away to the top.

Remove EPROM (18/3) from its socket. To do this use a small screwdriver or forceps.

Insert the new EPROM into the socket. Note the orientation. The indentation of the EPROM must coincide with the indentation in the socket.

Viewed from the front the indentation points to the left. Take care that none of the IC pins are bent (visual check)!

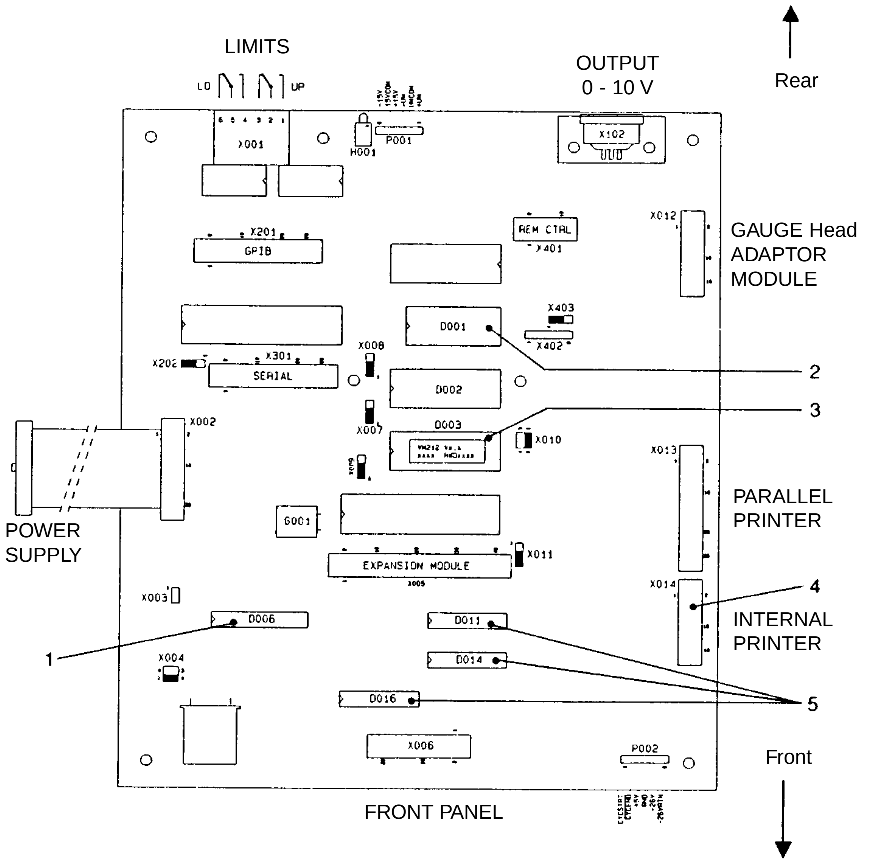
Insert the cover panel into the guide at one side, lift it up in the middle and let it engage into the other guide.

Secure the cover panel with the two crosshead screws.

3.2 Exchanging the RAM (D001)

The RAM is exchanged in a similar way as described for the EPROMs in Section 3.1.

Insert the new RAM (18/2) into the socket. Note the orientation. The black circular indentation on the RAM points to the left (when viewed from the front). Take care that none of the IC pins are bent (visual check)!



Key to Fig. 18
1 Location of PAL (D006)
2 Location of the RAM
3 Location of the EPROM
4 Connector for internal printer
5 Location of PALs
(D011; D014 and D016)

Fig. 18 Control unit

3.3 Exchanging the PALs (D006; D011, D014; D016)

The PALs are exchanged in the same way as described for the ERPOMS in Section 3.1.

3.4 LEYBOLD Service

If equipment is returned to LEYBOLD VACUUM GmbH, indicate whether the equipment free of substances damaging to health or whether it is contaminated. If it is contaminated also indicate the nature of the hazard. For this you must use a form which has been prepared by us which we will provide upon request.

A copy of this form is reproduced at the end of these Operating Instructions: „Declaration of Contamination of Vacuum Instruments and Components".

Please attach this form to the equipment or enclose it with the equipment.

This Declaration of Contamination is required to meet German Law and to protect our personnel.

LEYBOLD must return any equipment without a „Declaration of Contamination" to the sender's address.

Annex A

Table of physical data

Molecular weight and viscosity of some gases, referred to 20 °C [9].

Gas	Molecular weight $kg \cdot kmol^{-1}$	Viscosity 10^{-6} Pa·s
H_2	2.016	8.8
He	4.003	19.6
CH_4	16.043	10.8
NH_3	17.031	9.8
H_20[1)]	18.015	ca. 9
CO	28.011	17.6
N_2	28.013	17.5
Luft[2)]	28.96	18.2
O_2	31.999	20.2
HCI	36.461	14.2
Ar	39.948	22.1
CO_2	44.010	14.6
CI_2	70.906	13.2
CCI_2F_2	120.914	13.2

Further data can be found for example in the „Handbook of Chemistry and Physics", CCR PRESS, Inc.

To deal with gas mixtures refer also to Section 2.12.

Constants used for calculation of the output quantities:

$R = 8.314 \cdot 103\ J \cdot kmol^{-1} \cdot K^{-1}$,

$NA = 6.022 \cdot 1026\ kmol^{-1}$.

1) Water vapour

2) $0.78\ N_2 + 0.21\ O_2 + 0.01$ Ar

Annex B

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10) Dr. G. Reich, Gasreibungs-Vakuummeter VISCOVAC VM 211, UV 2112.03.84 GK 3.D LEYBOLD AG, Köln (1984)

Annex C

PRINTER	
1 STROBE	14 --
2 D1	15 --
3 D2	16 --
4 D3	17 --
5 D4	18 GND
6 D5	19 GND
7 D6	20 GND
8 D7	21 GND
9 D8	22 GND
10 ACKN	23 GND
11 BUSY	24 GND
12 --	25 GND
13 --	

SERIAL	
1 --	14 --
2 TXD	15 --
3 RXD	16 --
4 --	17 --
5 CTS	18 --
6 DSR	19 --
7 GND	20 DTR
8 DCD	21 --
9 --	22 --
10 --	23 --
11 --	24 --
12 --	25 --
13 --	

GPIB	
1 DI01	13 DI05
2 DI02	14 DI06
3 DI03	15 DI07
4 DI04	16 DI08
5 EOI	17 REN
6 DAV	18 GND
7 NRFD	19 GND
8 NDAC	20 GND
9 IFC	21 GND
10 SRQ	22 GND
11 ATN	23 GND
12 GND	24 GND

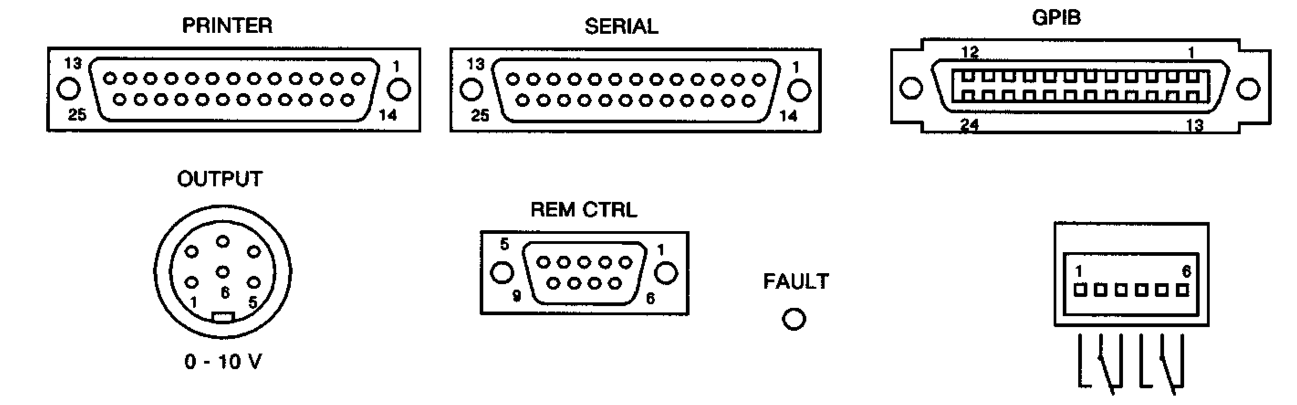

Fig. 19 Output sockets on the rear

OUTPUT
1 OUT
2 --
3 --
4 --
5 --

REM CTRL	
11 RIFCT1+	6 RIFCT1 -
2 RIFCT2+	7 RIFCT2 -
3 RIOUT1+	8 RIOUT1 -
4 RIOUT2+	9 RIOUT2 -
5 --	

Declaration of Contamination of Vacuum Equipment and Components (LEYBOLD / VDMA)

Declaration of Contamination of Vacuum Equipment and Components

The repair and/or service of vacuum equipment and components will only be carried out if a correctly completed declaration has been submitted. Non-completion will result in delay. The manufacturer could refuse to accept any equipment without a declaration.

This declaration can only be completed and signed by authorized and qualified staff.

1. Description of Vacuum Equipment and Components

- Equipment type/model: ______________________
- Code No.: ______________________
- Serial No.: ______________________
- Invoice No.: ______________________
- Delivery date: ______________________

2. Reason for Return

____
____
____
____
____
____

3. Condition of the Vacuum Equipment and Components

- Has the equipment been used?
  yes ❒ no ❒
- What type of pump oil/liquid was used? __________
- Is the equipment free from potentially harmful substances?
  yes ❒ (go to Section 5)
  no ❒ (go to Section 4)

4. Process related Contamination of Vacuum Equipment and Components:

- toxic yes ❒ no ❒
- corrosive yes ❒ no ❒
- explosive*) yes ❒ no ❒
- biological hazard*) yes ❒ no ❒
- radioactive*) yes ❒ no ❒
- other harmful substances yes ❒ no ❒

*) Vacuum equipment and components which have been contaminated by biological explosive or radioactive substances, will not accepted without written evidence of decontamination!

Please list all substances, gases and by-products which may have come into contact with the equipment:

Trade name Product name Manufacturer	Chemical name (or Symbol)	Dangerous material class	Measures if spillage	First aid in case of human contact
1.				
2.				
3.				
4.				
5.				

5. Legally Binding Declaration

I hereby declare that the information supplied on this form is complete and accurate. The despatch of the contaminated vacuum equipment and components will be in accordance with the appropriate regulations covering Packaging, Transportation and Labelling of Dangerous Substances.

Name of organisation or company: ______________________

Address: ______________________ Post code: ______________________

Tel.: ______________________

Fax: ______________________ Telex: ______________________

Name: ______________________

Job title: ______________________

Date: ______________________ Company stamp:

Legally binding signature: ______________________

 Order No.: 2121

Copies: Page 1 (white) to manufacturer or representative - Page 2 (yellow) attach to consignment packaging securety - Page 3 (blue) copy for file of sender

This page has been left blank for your comments.

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