

Operating Instructions
for the
HSE Isotonic Lever Transducer B40

Type 373

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The Isotonic Lever Transducer B40 Type 373 is manufactured by:

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Contents:	Page
1. General description, applications	2
1.1 Accessories, list of items	2
1.2 Unpacking, avoiding damage	2
1.3 Storage	2
1.4 Return shipment, packing	3
2. Operation of the B40	3
3. Notes on mounting in position	3
3.1 Thread clip, attachment	4
4. Overload and overload protection	5
5. Electrical connection	6
6. Calibration	6
7. Balancing the lever and adjusting the preload	7
8. Oscillation characteristic	11
9. Servicing and maintenance, notes on repair	11
10. CE Declaration of Conformity	13
11. Technical data	13
12. Literature references	13
13. Bridge amplifiers suitable for the B40	14

1. General description, applications

The HSE Lever Transducer B40 is a highly isotonic displacement transducer with a working range of 40 mm (± 20 mm at a distance of 100 mm from the axis of rotation). The lever is mounted on largely frictionless bearings and is made from a light material in order to ensure low inertia. The range can be varied to suit the experimental conditions, using a series of holes along the lever spaced 10 mm apart.

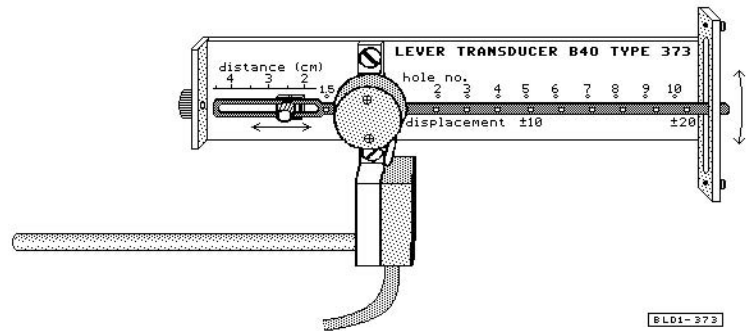


Fig. 1 : LEVER TRANSDUCER B40

A sliding counterweight permits balancing the lever or applying any preload required.

An integral calibration device permits simple calibration of the complete measuring system.

Applications: isotonic contraction measurement on isolated tissues.

1.1 Accessories, list of items

The B40 isotonic lever transducer is supplied in a plastic transport case. The standard accessories are normally attached to the transducer and consist of:

- mounting rod with male thread (8 mm dia., 155 mm long)
- movable weight (4 g)
- extra weight (3 g)
- calibration gauge for 0, 10 and 20 mm
- thread clip
- Operating Instructions for the B40
- calibration sheet

1.2 Unpacking, avoiding damage

Place the case in the correct position before opening it (narrow part of the case at the top!). The bearing (a sapphire pivot bearing) of the B40 is the most sensitive element. When you open the case, ensure that no uncontrolled forces can act on the lever and therefore on the pivot bearings. The B40 is effectively protected against overloads which might occur in normal use; but if the transducer is dropped, the measuring system may be damaged or even completely destroyed.

Check the contents of the case against the list above. If you cannot find one of the small weights immediately, look for it among the foam plastic inserts. These small parts may become loose and displaced during transport.

1.3 Storage

If the B40 is not in use it should be stored in its transport case for protection against damage. Never place it unprotected in a drawer together with other items; this is very likely to cause damage.

1.4 Return shipment, packing

If there is any need to return the B40 it is essential to use the transport case. Lock the lever by means of the calibration gauge into the centre position and ensure that it is otherwise free and cannot come into contact with other items during transport. The thread clip can be left attached to the lever.

2. Operation of the B40

The actual sensor of the B40 is based on the magneto-resistive principle; this is illustrated in Fig. 2. Two magnetically sensitive semiconductor resistors (field plates) R1 and R2 are mounted in the field of a permanent magnet. This magnet is linked mechanically to the lever. As the lever moves (movement S results in an angular displacement α), the magnetic induction at the field plates changes, resulting in corresponding resistance changes in the field plates.

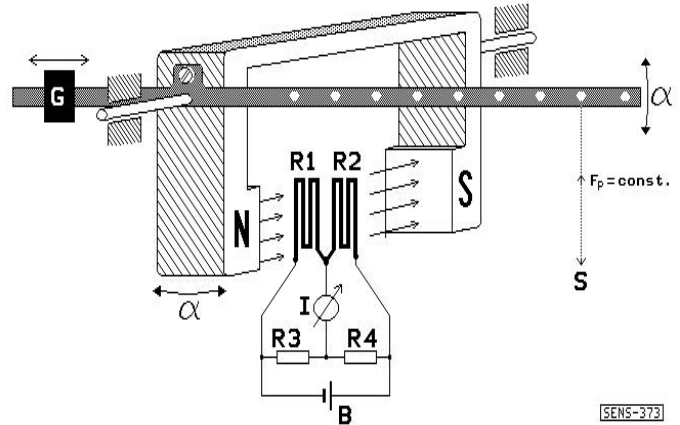


Fig. 2: Schematic diagram of the B40

The field plates R1 and R2 are connected electrically with two replacement resistors to form a Wheatstone bridge circuit. The measuring system is adjusted so that the bridge is zeroed in the centre position. When the lever and with it the magnet is displaced in the direction of the angle α , the bridge is unbalanced. This out-of-balance of the bridge can be measured with the meter (I). In the case of the B40 the meter (I) and the battery (B) are replaced by a bridge amplifier (see Fig. 6). The diagram in Fig. 3 shows a typical output signal and the error curve of a B40 isotonic lever transducer.

The counterweight (G) is adjusted so that the desired preload F_p (= upward tension) is obtained.

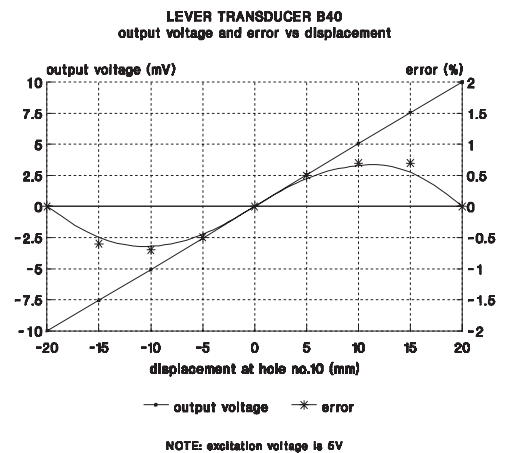


Fig. 3: Output curve and error signal

3. Notes on mounting in position

The B40 lever is secured on the apparatus by means of the mounting rod supplied (8 mm dia., 155 mm long, with M5 thread). The central plastic body (opaque white) carries a suitable female thread in three different positions to screw in the mounting rod. Select the optimum position for your set-up.

In order to permit simple and accurate adjustment of the mechanical zero on the B40 lever during the experiment it is convenient not to secure the lever directly on the apparatus. Instead it is preferable to use a so-called vernier control as an intermediate fitment. Suitable vernier controls are available from HSE.

Note the following points during positioning:

- place the B40 so that no liquid can pass into it, in particular no Tyrode solution or vapour.

- arrange the B40 so that the tension thread is at right angles to the lever (in the centre position).
- in order to minimise temperature drift, ensure that the B40 is not exposed directly to heat sources (lamps, heaters, direct sunlight etc.)
- do not overload the bearings of the B40 (max. 1N). In particular, ensure that the black lever does not come into contact with any object during handling.

3.1 Thread clip, attachment

The thread clip is used for attaching the tension thread to the lever arm. The clip itself is shown in Fig. 4A. It is made from stainless steel spring wire. Two separate clip sections are linked together by a loop. The upper clip section (a) is hooked directly on to the lever in the appropriate hole (2 to 10). The lower section is used for attaching the thread. Fig. 4B illustrates the method of introducing the thread through both eyes of the clip. "Open" the clip by pressing it at the two points marked with the arrows (P), using thumb and forefinger. Fig. 4C shows the clip with the thread attached.

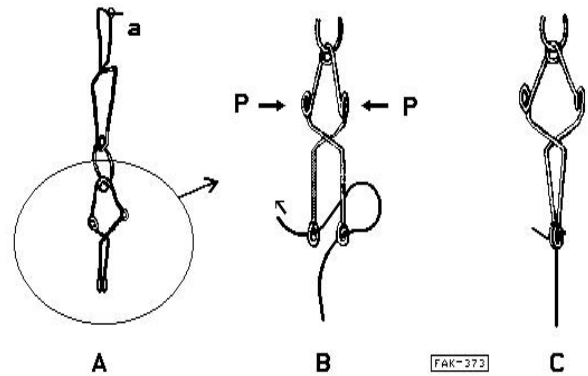


Fig. 4: Thread clip
For explanation see text

If the thread has been passed through the two eyes in the way described above, it is held firmly within the appropriate force range of a few cN and does not slip. If the thread length at the tissue has to be adjusted, this can be done very easily by pressing at (P) as shown in Fig. 4B and thereby open the eyes. After attaching the thread, do not cut it off too short so that it can still be extended if required.

Explanations to Fig. 5:

- (1) sensing element of the B40.
- (2) lever, $L = 112$ mm, attachment holes in the range 20 to 100 mm at 10 mm spacings.
- (3) attached tissue (diagrammatical).
- (4) clamping screw for sliding counterweight (4 g). The counterweight is used to balance the lever or to apply a preload acting on the attached tissue. The total weight can be increased by screwing on the extra weight screw (5) (from below).
- (5) extra weight screw (3 g) in its "parking" position, screwed to the plastic frame to prevent loss.
- (6) an optional additional weight (50 g max.) can be hooked on the lever in the hole close to the axis provided for this purpose (= low inertia!).

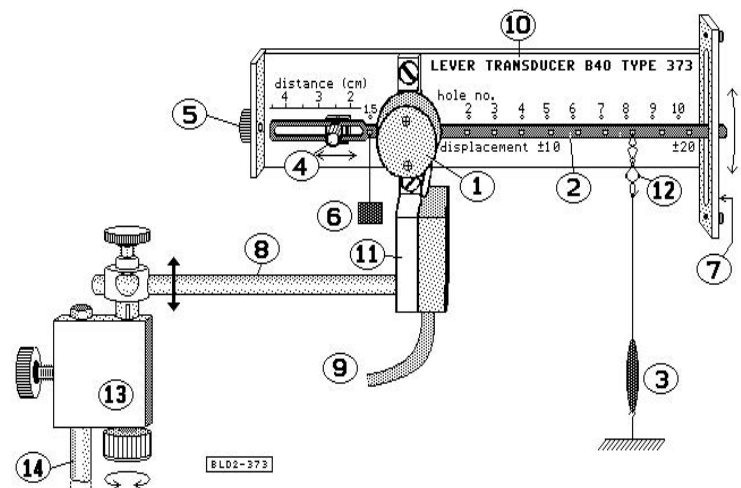


Fig. 5: Details of the B40

- (7) calibration gauge, movable, with five calibration settings: $x(-2)$, $x(-1)$, 0, $x1$, $x2$. The gauge is mounted on the side and cannot be seen in the illustration (see Fig. 7).
- (8) mounting rod for securing to laboratory stand (150 mm long, 8 mm dia.). In the position shown the rod is screwed into the side of the central carrier. It can also be inserted from the back into a thread (M5) provided for this purpose.
- (9) connecting cable to bridge amplifier.
- (10) plastic protection frame with printed help information and data of the B40. The serial number is engraved (top right).
- (11) centre plastic body (opaque white) as carrier. The adapter circuit is arranged underneath the plastic cover on the right side.
- (12) thread clip for attaching the tension thread and for simple adjustment of its length.
- (13) vernier height control (option). The vernier control permits accurate up and down adjustment of the lever transducer. It serves for accurate and simple adjustment of the zero.
- (14) mounting rod on the experimental apparatus. The vernier control (13) must be clamped by means of the knurled screw at the side.

4. Overload and overload protection

The component of the transducer which may be damaged by overloading is the rotary bearing which is located within the sensor unit. It is a so-called pivot bearing with jewels. These bearings produce minimum friction, but they are sensitive to overloads in a radial direction. In order to maintain the friction values specified in the technical data the B40 must be suitably protected.

In normal use there is very little danger of overloading the B40. It is effectively protected by the Plexiglass frame. Experience has shown that it is more likely to be damaged while it is being carried around without protection and while it is being fitted on the experimental apparatus. The B40 is particularly likely to be damaged permanently if it is dropped on the floor and hits it in the direction along the lever.

The bearing readily withstands radial forces up to 1 N (100 g). In the case of larger forces up to about 10 N (1 kg), permanent damage to the bearing must be expected (steel pivot deformed in the micro range or surface damage to the jewel bearing, also in the micro range). Any minor damage can be recognised through an increase in friction. Any friction can normally be rectified or at least reduced by re-adjusting the bearing. Do not attempt to do this yourself! Apart from technical know-how this work also requires considerable experience in order to avoid permanent damage when adjusting the bearing.

With even larger overloads, e.g. if the B40 drops to the floor, it is possible for metal parts in the sensor to become bent. This type of damage can be recognised through play in the bearing. In this case there is also an increase in the hysteresis error. Measurements can only be made to a limited extent and are subject to serious errors. The sensor has to be replaced by the manufacturer (price of sensor: approx. DM 500).

Avoiding overloads:

- When handling the B40 do not allow the lever rod to touch anything!
- Do not allow the B40 to drop to the floor!
- Take care when adjusting the preload. Special care is required when fitting and tightening the clamping screw of the sliding weight.

- Apply additional weights only up to 50 gram!
- Do not allow forces exceeding 1 N (100 g) to act on the lever!. There is particularly dangerous when the lever is against a stop or in one of the calibration slots. If e.g. you try now to adjust the mechanical zero with the vernier control it is very easy to generate large forces.

5. Electrical connection

Operation of the B40 requires a bridge amplifier with a stabilised bridge voltage in the range 0 - 10 Volt. The size of the bridge voltage determines the sensitivity of the transducer. It is recommended to set the supply **voltage to 5 Volt**. This value gives a low temperature drift combined with a sensitivity which is usually sufficient (see Technical Data).

The B40 transducer is normally fitted with a 6-pin Binder connector (male). To special order it can be fitted with other connectors. It is essential that the connections for bridge supply and signal output are made correctly. If the connections are interchanged the transducer will not operate properly; in particular an increase in the temperature drift has to be expected.

Connector: BINDER, 6-pin, male, Type 09-0321-00-06

The pin connections and the colour coding are shown in the test and calibration sheet supplied with each transducer.

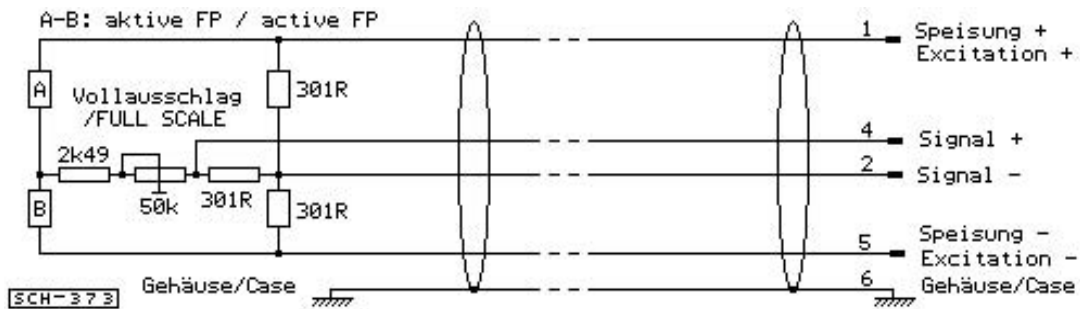


Fig. 6: Circuit of the B40 with standard plug connection

6. Calibration

The B40 transducer is fitted with a device to permit simple calibration. A sliding metal gauge with 5 calibration slots (-2, -1, 0, +1, +2) is arranged close to the end of the lever which protrudes on the right from the Plexiglass frame. **Fig. 7** shows this gauge in three different positions (when viewed from the right looking on the transducer). In Position (A) the gauge is moved to one side. This is the normal position for measurement; the lever (H) can move freely. In positions (B) and (C) the gauge has been moved forward to the calibration position. The lever is in one of the calibration slots (B=0, C=+1).

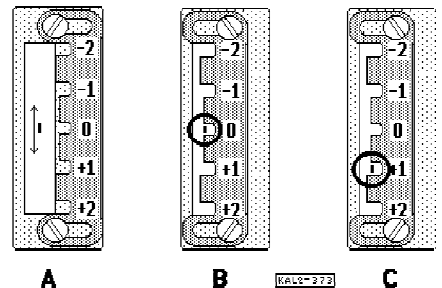


Fig. 7: Calibration gauge, B40 viewed from the right

Values of the calibration deflections

The calibration slots on the gauge are equally spaced and selected so that moving the lever from slot 0 to slot +1 corresponds exactly to the slot number in millimetre. For example, if you have attached the thread to hole No. 5, the thread would move by 5 mm during the procedure described above. If you have used hole No. 10, the displacement would be 10 mm. If you move the lever from slot 0 to slot 2, the corresponding calibrated displacement is twice as large.

Table 1 summarises the calibration displacements corresponding to the individual calibration slots for different positions of the attachment hole. The data are based on the centre position of the lever (0). It is preferable to start calibration from position 0; when changing the gain on the bridge amplifier or on the recorder you then obtain directly the correct amplitudes on the recorder.

If for any reason you do not use slot 0 as the starting point you have to add together the absolute values of the numbers shown in order to obtain the calibration step in mm for the appropriate attachment hole. The calibration value for the example marked in the Table (shown in bold) would then be 16 mm. The recorder deflection must in this case be adjusted iteratively with several repeats since changing the gain factor also displaces the zero position on the recorder. The reason is that on adjusting the zero position (lever in the starting slot) the signal voltage of the B40 is not 0 V but has a negative value (5 or 10 mV).

Table 1

Slot No.	Hole No.-> 2	3	4	5	6	7	8	9	10	Signal voltage $U_{\text{Sign.}}$ (mV)
-2	-4	-6	-8	-10	-12	-14	-16	-18	-20	-10
-1 (Value 1)	-2	-3	-4	-5	-6	-7	-8	-9	-10	-5
± 0	± 0	± 0	± 0	± 0	± 0	± 0	± 0	± 0	± 0	± 0
+1 (Value 2)	+2	+3	+4	+5	+6	+7	+8	+9	+10	+5
+2	+4	+6	+8	+10	+12	+14	+16	+18	+20	+10

7. Balancing the lever and adjusting the preload

For proper operation of the B40 transducer it is obviously necessary that the thread transmitting the movement is correctly tensioned.

When the B40 is being used as intended - measurement of isotonic muscle contractions on isolated tissues - it is necessary for physiological reasons to have a certain preload which pre-tensions the tissue on test and which moves it into its optimum starting position. If this necessary preload is not known for a particular tissue it has to be determined by a series of measurements at the beginning of the experiment.

For further information on this subject refer to the appropriate literature, e.g. HSE Biomesstechnik I/83: "Muscle contractions - isotonic, auxotonic, isometric - electronic measurement and analogue evaluation".

In order to adjust the required preload the lever is provided with a sliding counterweight (4 g). Fig. 8 shows the weight and the various extensions. After releasing the clamping screw (knurled) the base weight can be moved along the slot in the lever.

If the 4 g basic weight should prove insufficient it is possible to screw the extra weight (3 g knurled weight at the side) from the bottom into the base weight, giving a total weight of 7 g.

If this weight is still not sufficient to obtain a particular preload, it is possible to apply an additional weight up to 50 g by means of a wire at the suspension hole provided, 1.5 cm from the axis of rotation. Please observe the specified weight limit in order to avoid damaging the pivot bearing.

How can an accurately defined pre-load be obtained?

Using the formula for mechanical levers it is possible to calculate a definite preload for each attachment hole. The procedure is not quite so simple in every-day use and the result is rather inaccurate because of the large variations in lever length. A method suitable for practical use is described below which is quick to perform and very simply produces accurately the required preload.

Adjusting the preload:

The procedure requires an attachment weight corresponding to the required preload, e.g. 1 g = 1 cN approx. = 10 mN.

- (1) Arrest the lever!
Arrest the lever in its centre position (move the calibration gauge forward).
- (2) Attach the tissue (at the top only)!
Make the connection to the tissue with the tension thread. Use the thread clip. Suspend the tissue in the perfusate but do not attach it at the bottom end. Select the thread length so that the tissue is immersed in the perfusate and floats in the liquid.
- (3) Attach the auxiliary weight!
Attach the weight corresponding to the required preload (1 g in this example) to the thread clip.
- (4) Balance the lever!
Release the lever by sliding the calibration gauge to the back and then balance the lever accurately (slide the counterweight to a suitable position!). Note that the tissue must remain immersed in the perfusate (buoyancy effect!) and that the thread does not become slack. This ensures that the weight of the tissue and of the thread is correctly allowed for during balancing.

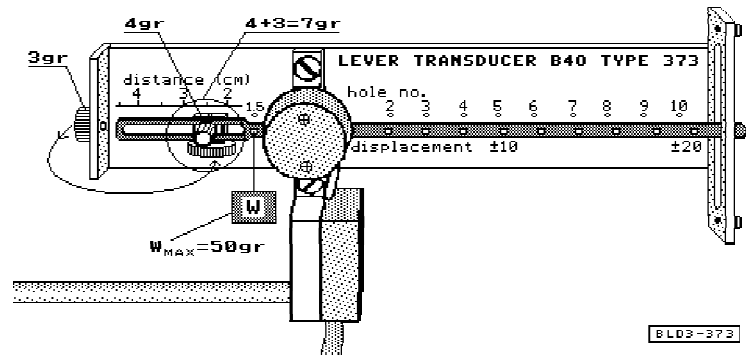


Fig. 8: Weights for balancing the B40 or applying a preload.

-
- (5) Remove the auxiliary weight, attach the tissue fully!
Remove the weight and attach the tissue at its lower end.
 - (6) Adjust the zero.
Finally adjust the required zero position of the lever by adjusting the threadlength or the vernier control (if fitted).

It is easy to see that after this procedure the tissue is subjected to a preload which corresponds accurately to the size of the auxiliary weight.

If you require a non-standard value as preload, there are two methods.

- (a) Obtain a suitable weight corresponding to the required preload, and proceed as described above, or
- (b) Use the lever formula and determine the appropriate attachment hole for an existing weight. Example: you want to set a preload of 0.5 cN at hole No. 8, but you only have a weight of 1 cN. According to the lever formula ($\text{load} \times \text{load arm} = \text{force} \times \text{force arm}$) it is a simple matter to determine that hole No. 4 is required. If you attach the 1 cN weight at hole No. 4 this corresponds to a weight of 0.5 cN at hole No. 8.

In order to save you making the calculation we have prepared Table 2. This summarises the corresponding values for appropriate preload forces at the various attachment holes.

Table 2: Preload values corresponding to the individual attachment holes.

Reference load for hole No. 1 (not accessible on the lever)

Hole No. 2...10

(1)	2	3	4	5	6	7	8	9	10
1	0,50	0,33	0,25	0,20	0,17	0,14	0,13	0,11	0,10
2	1,00	0,67	0,50	0,40	0,33	0,29	0,25	0,22	0,20
3	1,50	1,00	0,75	0,60	0,50	0,43	0,38	0,33	0,30
4	2,00	1,33	1,00	0,80	0,67	0,57	0,50	0,44	0,40
5	2,50	1,67	1,25	1,00	0,83	0,71	0,63	0,56	0,50
6	3,00	2,00	1,50	1,20	1,00	0,86	0,75	0,67	0,60
7	3,50	2,33	1,75	1,40	1,17	1,00	0,88	0,78	0,70
8	4,00	2,67	2,00	1,60	1,33	1,14	1,00	0,89	0,80
9	4,50	3,00	2,25	1,80	1,50	1,29	1,13	1,00	0,90
10	5,00	3,33	2,50	2,00	1,67	1,43	1,25	1,11	1,00
11	5,50	3,67	2,75	2,20	1,83	1,57	1,38	1,22	1,10
12	6,00	4,00	3,00	2,40	2,00	1,71	1,50	1,33	1,20
13	6,50	4,33	3,25	2,60	2,17	1,86	1,63	1,44	1,30
14	7,00	4,67	3,50	2,80	2,33	2,00	1,75	1,56	1,40
15	7,50	5,00	3,75	3,00	2,50	2,14	1,88	1,67	1,50
16	8,00	5,33	4,00	3,20	2,67	2,29	2,00	1,78	1,60
17	8,50	5,67	4,25	3,40	2,83	2,43	2,13	1,89	1,70
18	9,00	6,00	4,50	3,60	3,00	2,57	2,25	2,00	1,80
19	9,50	6,33	4,75	3,80	3,17	2,71	2,38	2,11	1,90
20	10,00	6,67	5,00	4,00	3,33	2,86	2,50	2,22	2,00

Notes for using the Table: the top row lists the attachment holes on the lever and the first column a (theoretical) reference value for a preload for hole No. 1. The other values in the Table are calculated. Each horizontal row shows the preload corresponding to each attachment hole for a certain reference load.

Example: you are using hole No. 8 and want to set a preload of 0.75 cN. In this case look for the value 0.75 in the column for hole No. 8 (shown in bold!) and then look for an even value in the same row. You find 1.00 for hole No. 6, 2.00 for hole No. 3 and 3.00 for hole No. 2. This means that you can e.g. attach a calibration weight of 1 cN at hole No. 6 in order to set a preload of 0.75 cN, and then balance the lever as described above. Alternatively you can use hole No. 3 and attach a weight of 2 cN.

8. Oscillation characteristic

Preliminary note:

The lever transducer has no restraining spring and can therefore not oscillate by itself. A system capable of oscillating is only produced if an elastic tissue is attached through a thread and a preload is applied by means of a counterweight. The oscillation characteristic depends on many factors, including the size of the preload and the effective moment of inertia of the complete system.

Fig. 9 shows the typical oscillating characteristic under practical conditions. The frequency (Hz) is plotted along the X-axis and the displacement amplitude (mm) measured by the lever transducer along the Y-axis. The measurements were performed for the attachment holes 5 and 10.

During the test sinusoidal displacement signals of different frequencies were applied through a thread using a thread clip. A displacement of 5 mm (± 2.5 mm) was used at hole #5, and a displacement of 10 mm (± 5 mm) at hole #10. The preload was provided through suitable adjustment of the sliding counterweight. Care was taken to place the maximum possible weight as close to the axis of rotation as possible.

Unit of preload FP (P=preload): 1 cN = 10 mN = 0.01 N (approx. 1 g)

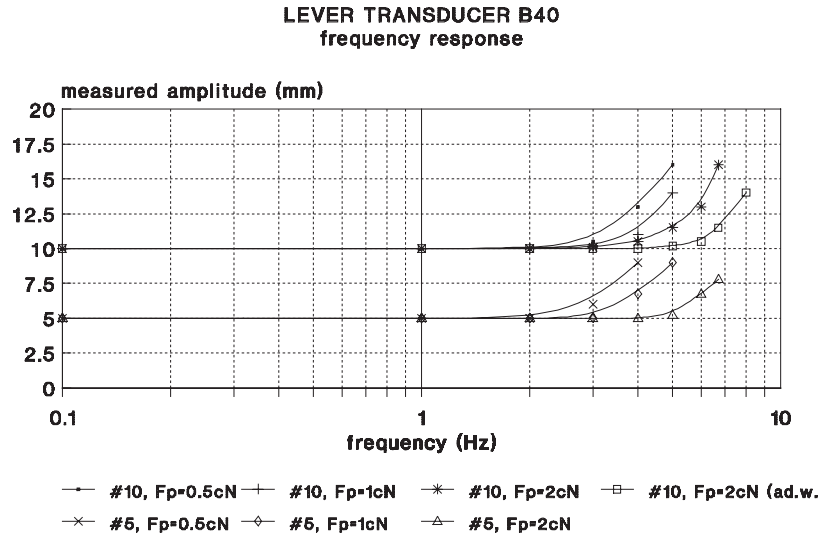
Discussion of results:

The curves (**Fig. 9**) show that there are practically no amplitude errors in measurements up to a frequency of 1 Hz. Above 1 Hz an overshoot appears sooner or later, depending on the prevailing conditions, which takes the form of an amplitude increase on the recorded curve. The frequency characteristic is slightly improved when working without the sliding weight and applying instead a suitable extra weight at the attachment hole provided (1.5 cm). The curve marked with the small squares is obtained under these conditions (extra weight: 20 g).

9. Servicing and maintenance, notes on repair

The B40 transducer requires no special maintenance.

Any dirt on the Plexiglass parts are best cleaned off with a moist cloth. With more severe contamination use a normal laboratory cleaning agent which does not attack Plexiglass (e.g. RBS 50 or MUCASOL). The cloth should not be too wet. It is essential to avoid moisture reaching the inside of the sensor element (round metal cover) or the electrical network (square plastic cover).



NOTE: #5 or #10 means hole no.5 respectively hole no.10. The applied displacement was 5mm resp. 10mm.

Fig. 9: Oscillation characteristic of the B40 depending on the preload, for attachment holes No. 5 and No. 10

Take care during cleaning that the lever bearings are not overloaded in order to avoid damaging the transducer.

WARNING: The transducer must never be immersed in a liquid, e.g. for cleaning!

Note on repair:

If the transducer exhibits increased friction, the reason is usually that it has been overloaded and therefore damaged. The friction can normally be rectified or at least reduced by re-adjusting the bearing. Do not do this yourself! It is better to leave this work to an expert. Apart from technical know-how the work also requires considerable experience in order to avoid permanent damage when adjusting the bearing. Return the transducer to the manufacturer for repair.

If the results are inaccurate and unstable or if there is any play in the lever bearing, the reason is usually that the bearing has been severely overloaded. The lever transducer has been dropped or the lever rod has received a hard knock during handling. In this case the fault can only be rectified by replacing the sensor element. Return the transducer to the manufacturer for repair (cost of sensor approx. EURO 250).

Address of manufacturer:

HUGO SACHS ELEKTRONIK-
HARVARD APPARATUS GmbH,
Gruenstrasse 1,
D-79232 March-Hugstetten, Germany.

Phone: 07665-9200-0,
Fax: 07665-9200-90,
e-mail: sales@hugo-sachs.de

10. CE Declaration of Conformity



This product and accessories conform to the requirements of the Low-voltage Directive 73/23 EEC as well as the EMC Directive 89/336 EEC and are accordingly marked with the CE mark. For conformity to the standards during operation it is essential that the details in the instructions provided are observed.

11. Technical data

Measuring range:	± 20 mm (0 - 40 mm)
Linearity:	better than $\pm 2\%$ of range
Zero drift:	less than $0.03\%/^{\circ}\text{C}$ (for full scale deflection) between 20 and 40°C
Friction movement of lever:	0.01 cN.cm nominal
Frequency range:	0 - 1 Hz (0 - 6 Hz with optimised preload)
Resolution (noise):	0.001% of full scale deflection
Input impedance:	550 Ω nominal
Output impedance	290 Ω nominal
Bridge supply voltage (input):	recommended: 5 V d.c. or a.c., maximum: 8 V
Output voltage (signal):	10 mV (with 5 V supply and full-scale lever deflection). The output signal can be adjusted internally up to about 40 mV.
Loading of bearing:	100 cN (100 g) max.
Connecting cable and plug:	1.5 m long with 6-pin Binder plug Type 09-0321-00-06. Other connectors to special order (see calibration sheet!)
Weight:	0.2 kg
Dimensions:	lever: 180 mm x 85 mm x 40 mm; mounting rod (can be fitted in 3 positions): 155 mm long, 8 mm dia.

12. Literature references

- I "Muscle contractions - isotonic, auxotonic, isometric - electronic measurement and evaluation". HSE Biomesstechnik I/83, obtainable from Hugo Sachs Elektronik.
- II "Experiments on smooth muscle". HSE Biomesstechnik III/78, obtainable from Hugo Sachs Elektronik.

13. Bridge amplifiers suitable for the B40 (see Fig. 10)

The following plug-in modules are available:

- TAM-A, transducer amplifier module Type 705/1 for PLUGSYS system
- TAM-D, transducer amplifier module Type 705/2 for PLUGSYS system
- Bridge coupler Type 570 as coupler for Mark VII recorder
- DBA, DC-bridge amplifier module Type 660 for PLUGSYS system
- CFBA, carrier frequency bridge amplifier Type 677 for PLUGSYS system
- BPA, bio-potential amplifier Type 675 for PLUGSYS system

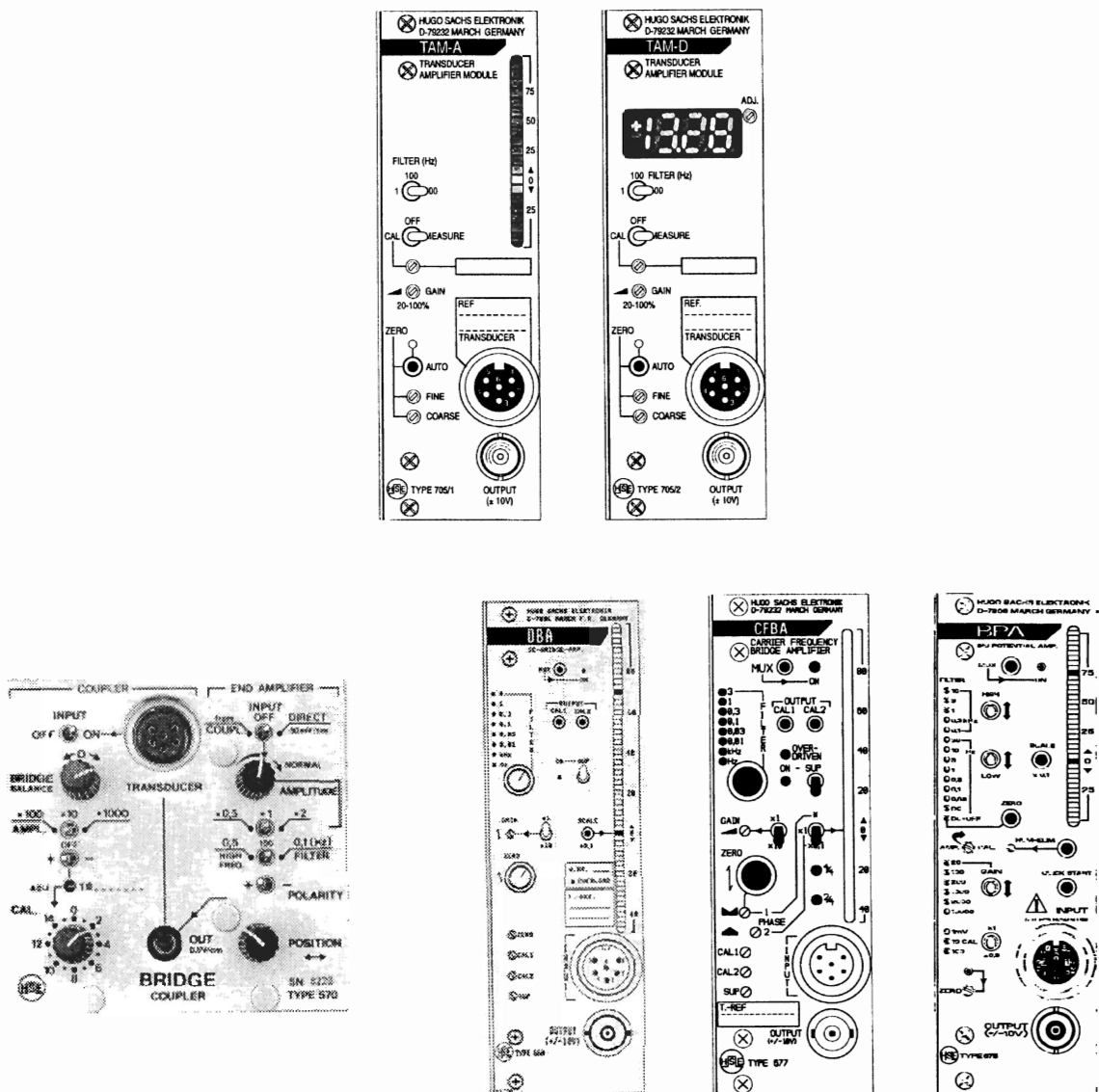


Fig. 10: The various bridge amplifiers of the HSE programm to which the B40 lever transducer can be connected