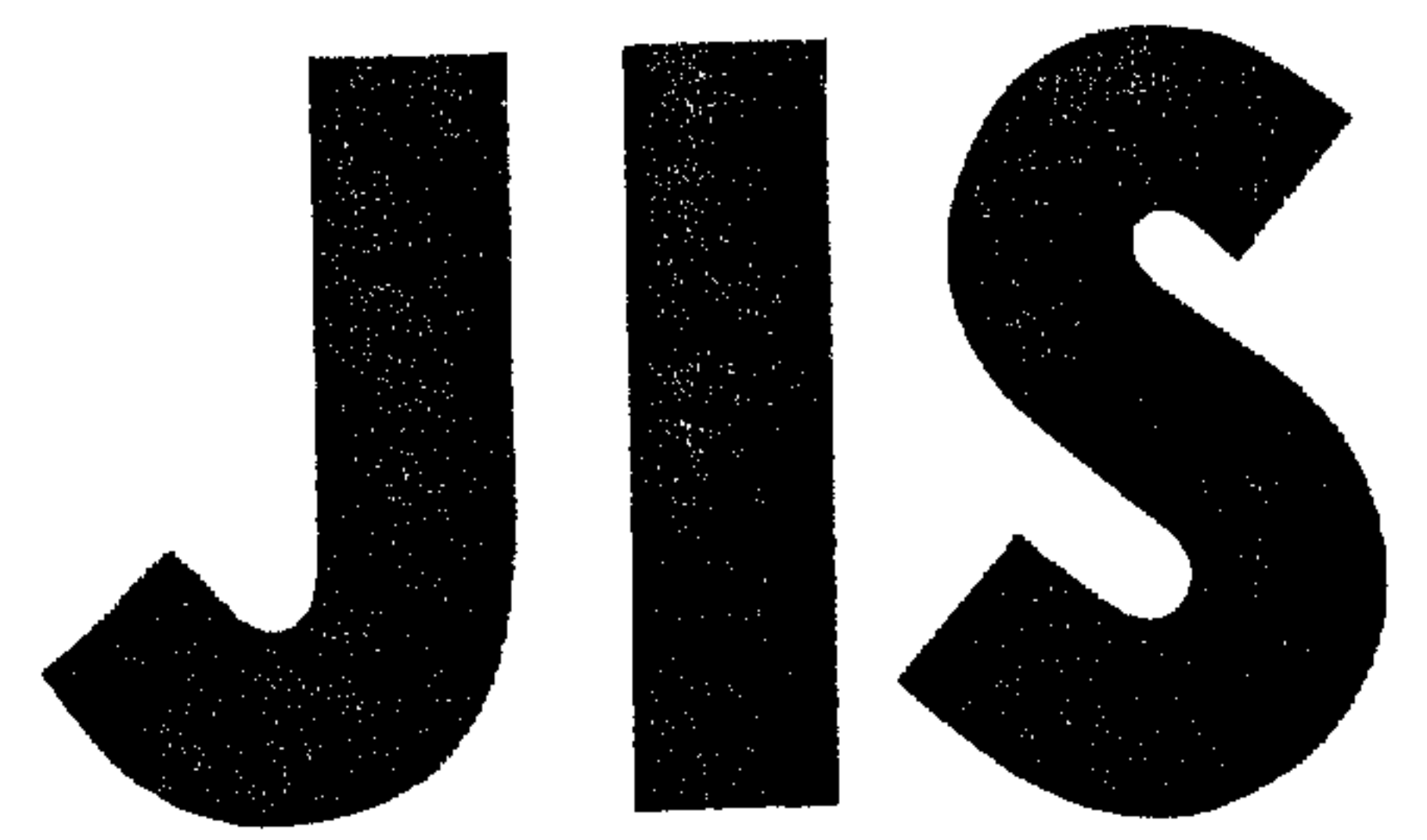




JAPANESE
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STANDARD

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JIS C 3003 : 1999

Methods of test for enamelled wires

ICS 29.060.10

Descriptors : enamelled wires, copper, electric wires, aluminium, insulated wires,
electric conductors, testing, electrical testing

Reference number : JIS C 3003 : 1999 (E)

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C 3003 : 1999

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS C 3003 : 1984** is replaced with **JIS C 3003 : 1999**.

In this revision, conformance with **IEC 60851** *Methods of test for winding wires* series (**IEC 60851-1** to **6**) was taken into consideration.

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Printed in Japan

- JIS K 8271 Xylene
- JIS K 8322 Chloroform
- JIS K 8891 Methanol
- JIS S 6006 Pencils and coloured pencils
- JIS Z 3282 Soft solders—Chemical compositions and forms
- JIS Z 8703 Standard atmospheric conditions for testing
- ISO 178 : 1975 Plastics—Determination of flexural properties

3 Classification of tests The classification of tests is as given in Table 1.

Table 1 Test items

Classification	Applicable clause for test method	Classification	Applicable clause for test method	Classification	Applicable clause for test method
Dimension	5	Resistance to softening	11	Conductor resistance	17
Continuity	6	Resistance to thermal shock	12	Elongation and tensile strength	18
Flexibility	7	Resistance to solvent	13	Springiness	19
Adherence	8	Solderability	14	Temperature index	20
Resistance to abrasion	9	Bonding	15	Resistance to transformer oil	21
Breakdown voltage	10	Resistance to refrigerant	16	—	—

4 Test conditions Unless otherwise specified, the tests shall be carried out under the ordinary temperature and ordinary humidity [temperature 20 °C ± 15 °C, humidity (65 ± 20) %] specified in JIS Z 8703.

5 Dimensions

5.1 Method A

5.1.1 Test equipment

5.1.1.1 Round and rectangular wire The equipment used shall have a precision better than 2 µm. If a micrometer is used the measuring force shall be as given in Table 2. The diameter of the spindle and the anvil shall also be as given in Table 2.

Methods of test for enamelled wires

Introduction This Japanese Industrial Standard has been prepared based on IEC 60172, *Test procedure for the determination of the temperature index of enamelled winding wires*, IEC 60851-1, *Methods of test for winding wires—Part 1 : General*, IEC 60851-2, *Methods of test for winding wires—Part 2 : Determination of dimensions*, IEC 60851-3, *Methods of test for winding wires—Part 3 : Mechanical properties*, IEC 60851-4, *Methods of test for winding wires—Part 4 : Chemical properties*, IEC 60851-5, *Methods of test for winding wires—Part 5 : Electrical properties* and IEC 60851-6, *Methods of test for winding wires—Part 6 : Thermal properties* published as the first editions in the respective years without any modification in the technical contents.

The portions underlined with dots or sidelined in this Standard are the items not included in the original International Standards.

1 Scope This Japanese Industrial Standard specifies methods of test for various enamelled copper wires and enamelled aluminum wires.

Remarks : The International Standards corresponding to this Standard are given below.

IEC 60172 : 1987 *Test procedure for the determination of the temperature index of enamelled winding wires*

IEC 60851 : 1996 *Methods of test for winding wires—*

IEC 60851-1 : 1996 *Part 1 : General*

IEC 60851-2 : 1996 *Part 2 : Determination of dimensions*

IEC 60851-3 : 1996 *Part 3 : Mechanical properties*

IEC 60851-4 : 1996 *Part 4 : Chemical properties*

IEC 60851-5 : 1996 *Part 5 : Electrical properties*

IEC 60851-6 : 1996 *Part 6 : Thermal properties*

Informative reference : The IEC Standard numbers are based on the new numbering system of IEC Standards put in force in January 1st 1997, and the standards published before the said date are numbered by adding 60000 to the former numbers. This is only the change in number and the contents remain unchanged.

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards indicated below shall be applied.

JIS B 1501 *Steel balls for ball bearings*

JIS B 7502 *Micrometer callipers*

JIS B 7721 *Verification of the force measuring system of the tensile testing machine*

JIS G 3522 *Piano wires*

Table 2 Spindle and anvil diameters and measuring force

Type of wire	Nominal conductor diameter mm	Spindle and anvil diameter mm	Measuring force N
Enamelled round wire	< 0.100	2 to 8	0.1 to 1.0
	≥ 0.100	5 to 8	1 to 8
Enamelled rectangular wire	—	5 to 8	4 to 10

5.1.1.2 Bunched wire The measurement shall be made with a polished conical mandrel having dimensions as shown in Fig. 1.

Unit : mm

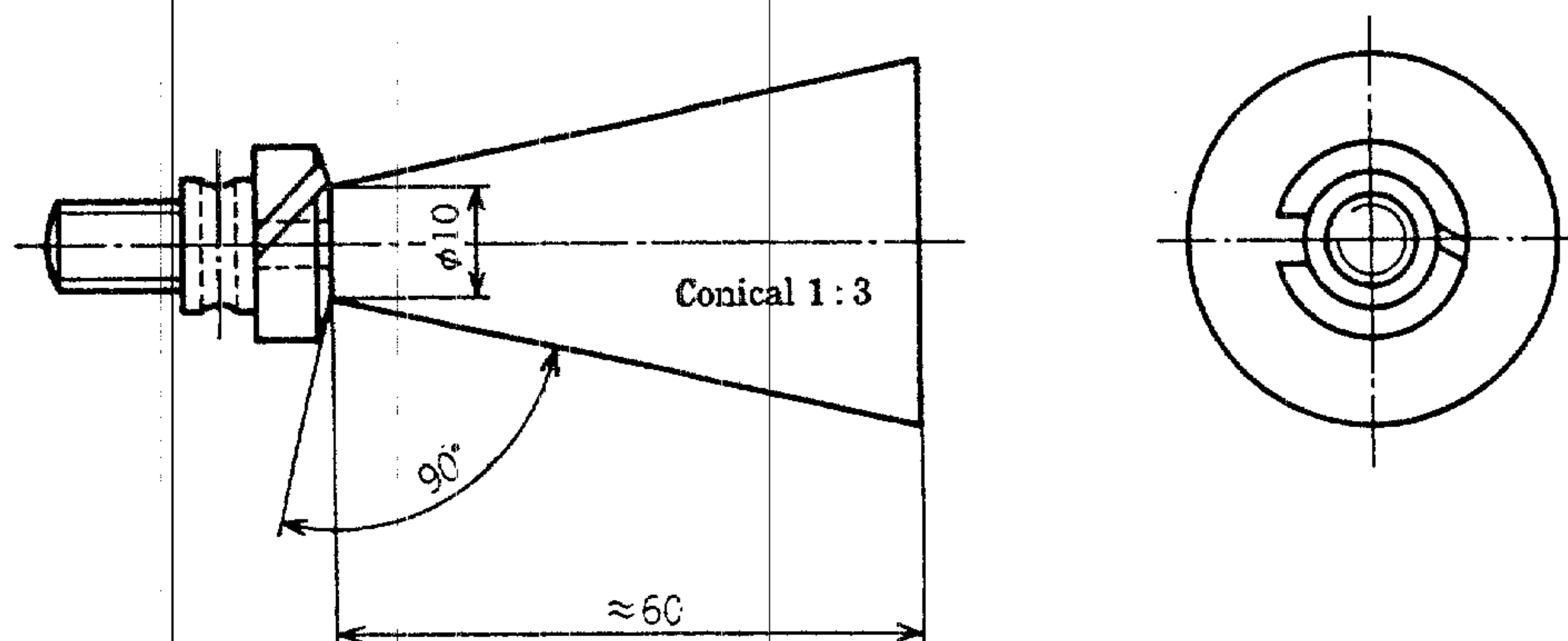


Fig. 1 Conical mandrel

5.1.2 Procedure

5.1.2.1 Conductor dimension

5.1.2.1.1 Round wire (see Table 3) From a straight piece of wire the insulation shall be removed by any method that does not damage the conductor. Three measurements of the bare conductor diameter shall be made at points evenly distributed around the circumference of the conductor. For determination of the conductor diameter as given in the relevant standards, the following applies:

Table 3 Determination of the conductor diameter

Nominal conductor diameter	Measurement	Clause or subclause
$D \leq 0.063$ mm	Resistance	17
$D > 0.063$ mm	Dimension	5.1.2.1.1

Note : By agreement between purchaser and supplier, resistance measurements may be made in the range of nominal conductor diameters over 0.063 mm and up to and including 1.000 mm.

The three single values shall be reported. The mean value represents the conductor diameter.

5.1.2.1.2 Rectangular wire The insulation shall be removed at the three places used for measurements in 5.1.6.2 by any method that does not damage the conductor. At each place one measurement of the two dimensions of the conductor shall be made. The three single values shall be reported for each dimension of the conductor. The mean represents the conductor width or the conductor thickness respectively.

5.1.3 Out-of-roundness of the conductor Out-of-roundness is the maximum value of the difference between any two readings of the conductor diameter at each cross-section. The measurement shall be made in accordance with 5.1.2.1.1. The out-of-roundness shall be reported.

5.1.4 Rounding of corners of rectangular wire For the purpose of this test, a cross-section of the wire shall be prepared and then examined under a sufficient magnification. Three straight pieces of wire shall be cast in a suitable resinous compound, that will not affect the insulation. After curing, the colour of the resinous compound shall contrast with the colour of the insulation. The specimen consisting of the three pieces of wire embedded in the cured resinous compound shall be cut at right angles to the length of the wire pieces and the cross-section shall be carefully ground and polished by suitable means. The polished surface shall be examined under a magnification which allows a correct judgement of the rounding of corners. It shall be reported how the arc merges into the flat surface of the conductor. Any sharp, rough and projecting edges shall also be reported.

5.1.5 Increase in dimension due to the insulation (film thickness on both sides) The increase in dimension due to the insulation is the difference between the overall dimension and the conductor dimension.

- a) **Round wire** The measurement shall be made in accordance with 5.1.2.1.1 and 5.1.6.1. The difference between the overall diameter and the conductor diameter shall be reported as increase in diameter.
- b) **Rectangular wire** The measurement shall be made in accordance with 5.1.2.1.2 and 5.1.6.2. The difference between the overall width and the conductor width shall be reported as the increase in width. The difference between the overall thickness and the conductor thickness shall be reported as increase in thickness.

5.1.6 Overall dimension

5.1.6.1 Round wire On a straight piece of wire, three measurements of the overall diameter shall be made at points evenly distributed around the circumference of the wire. The three single values shall be reported. The mean value represents the overall diameter.

5.1.6.2 Rectangular wire On a straight piece of wire at each of three places at least 100 mm apart, one measurement shall be made of the two dimensions of the wire. Where the dimension of the specimen is greater than the diameter of the micrometer spindle, measurements shall be made both at the centre of the face of the specimen and over the edges. If these values differ, only the highest value shall be noted.

The three single values shall be reported for each dimension of the wire. The mean values represent the overall width or the overall thickness respectively.

5.1.6.3 Bunched wire

Note : The method indicated below gives useful values in practice, but not an accurate overall diameter.

The overall diameter is the width of a layer wound on a mandrel divided by the number of turns. The bunched wire shall be wound closely on a mandrel according to Fig. 1 and under a tension in newtons, which is 65 times the total nominal cross-section of the conductors in square millimetres. The width of the layer shall be not less than 10 mm for bunched wires with overall diameters up to and including 0.5 mm, and be not less than 20 mm for larger diameters and shall be measured with a precision of 0.5 mm.

One measurement shall be made. The overall diameter rounded off to 0.01 mm shall be reported.

5.1.7 Increase in diameter due to the bonding layer of enamelled round wire (thickness of bonding layers on both sides) The increase in diameter due to the bonding layer is the difference of the overall diameter with and without the bonding layer.

The overall diameter of the wire shall be measured according to 5.1.6.1. After removal of the bonding layer by means of a solvent or any other suitable agent or by any other method which does not damage the underlying coating, the measurement shall be repeated. The difference of the two mean values shall be reported as the increase in diameter due to the bonding layer.

5.2 Method B The measurement of dimensions shall be carried out with a measuring instrument having a minimum scale of $\frac{1}{1000}$ mm. For a dimension with a specified value in the place of $\frac{1}{100}$ mm, the micrometer specified in **JIS B 7502** may be used (measuring force 3.9 N to 5.9 N). The measurements of overall diameter or overall dimensions, conductor diameter or conductor dimensions and thickness of film shall be made as stated below.

- a) **Round wire** A specimen of about 15 cm in length is taken and the diameter is measured at three positions evenly distributed on the same plane perpendicular to conductor axis, and the mean value of these values represents the overall diameter. Next, the conductor diameter is measured in such a manner that the film is removed at the portion where the overall diameter has been measured by any method that does not damage the conductor, then the diameter is measured in the same way as that for overall diameter, and the mean value represents the diameter. The thickness of film shall be expressed by $\frac{1}{2}$ of the difference between the overall diameter and the conductor diameter.
- b) **Rectangular wire** A specimen of about 30 cm in length is taken and the two dimensions are measured at each of three places about 10 cm apart, and the respective mean values represent the overall dimensions. Next, the conductor dimensions are measured in such a manner that the film is removed at the portions where the overall dimensions have been measured by any method that does not damage the conductor then the measurements are made in the same way as those for the overall dimensions, and the respective mean values represent the

dimensions. The thickness of film in the direction of wire thickness and that in the direction of wire width shall be expressed by $\frac{1}{2}$ of the difference between the overall thickness and the conductor thickness and by $\frac{1}{2}$ of the difference between the overall width and the conductor width, respectively.

6 Continuity of insulation The continuity of insulation shall be checked by low-voltage method for wires of conductor diameter up to and including 0.050 mm, and by high-voltage method for wires of conductor diameter over 0.050 mm up to and including 1.600 mm or may be checked by pin-hole method.

Continuity of insulation is checked by attaching the specimen to a tester which provides electrodes for application of voltage to the film and an electric circuit capable of detecting the fault of the insulating film, and is expressed by the defected number of faults per length.

- a) **Low-voltage method** A wire sample shall be pulled with a speed of (275 ± 25) mm/s between two felt pads, which shall be immersed in an electrolytic solution of sodium sulphate in water (30 g/l) with the conductor of the wire and the solution connected to an electrical circuit with an open-circuit d.c. test voltage of (50 ± 3) V (see Fig. 2). The force applied to the wire shall not exceed 0.03 N. Faults shall be detected by means of a suitable relay along with a counter. The counter shall operate when the wire coating has a resistance of less than 10 k Ω for a period of 0.04 s. The counter shall not operate when the resistance is 15 k Ω or more. The counter shall not indicate more than 10 faults per second.

A continuous fault shall be indicated by a pilot lamp.

One test shall be made. The number of faults per 30 m of wire length shall be reported.

- b) **High-voltage method** The specimen is travelled over a "V" shaped electrode sheave made of stainless steel at a speed of (275 ± 25) mm/s.

The conductor is earthed and in positive polarity.

For wires of conductor diameter over 0.050 mm up to and including 0.250 mm, the electrode sheave as shown in Fig. 3 b) shall be used and the length of contact of the wire and the sheave shall be 22.5 mm to 25.0 mm. For wires of conductor diameter over 0.250 mm up to and including 1.600 mm, the electrode sheave as shown in Fig. 3 a) shall be used and the length of contact of the wire and the sheave shall be 25 mm to 30 mm.

Two guide sheaves shall be used as arranged in Fig. 3, and the dimensions of the sheaves are same as those of the electrode sheave.

The fault display circuit shall operate at the appropriate fault current in Table 5 with a speed of response of $5 \text{ ms} \pm 1 \text{ ms}$ when the appropriate voltage shown in Table 4 is applied between the conductor and the electrode sheave. The tolerance of the said voltage is $\pm 5 \%$. The circuit shall have a counting ability of (500 ± 25) counts per minute when a bare wire is tested, and shall be capable of recording the number of faults.

One test is made, and the number of faults per 30 m is reported.

The high voltage power supply shall feed a smooth d.c. and the short circuit current shall be $25 \mu\text{A} \pm 5 \mu\text{A}$. The voltage shall not drop more than 75 % when the resistance of fault is 50 M Ω . The surge damping resistor installed in the high-voltage circuit shall be $4.7 \text{ M}\Omega \pm 10 \%$.

Note : The earth insulation for the high-voltage electrode should be a high-resistivity material, non-hygroscopic, non-tracking and easily cleaned, having a clearance for maintaining a continuous voltage of 3 000 V. No shielding should be used on the high-voltage lead since a minimum capacitance to ground is required during switching and counting events. The drive motor should be the brushless type and should have sufficient power to maintain the required speed to pull 1.600 mm wire.

Table 4 Test voltages

Type of conductor	Nominal conductor diameter		Voltage (d.c.)						
	mm		V						
	Over	Up to and including	Grade 1	Grade 2	Grade 3	<u>Class 3</u>	<u>Class 2</u>	<u>Class 1</u>	<u>Class 0</u>
Copper	0.050	0.125	350	500	750	—			
	0.125	0.250	500	750	1 000				
	0.250	0.500	750	1 000	1 500	<u>350</u>		<u>500</u>	
	0.500	1.600	1 000	1 500	2 000				
Aluminium	0.400	1.600	500	1 500	—				

Table 5 Fault currents (detected)

Test voltage (d.c.) V	Fault current (detected) µA
2 000	12
1 500	10
1 000	8
750	7
500	6
350	5

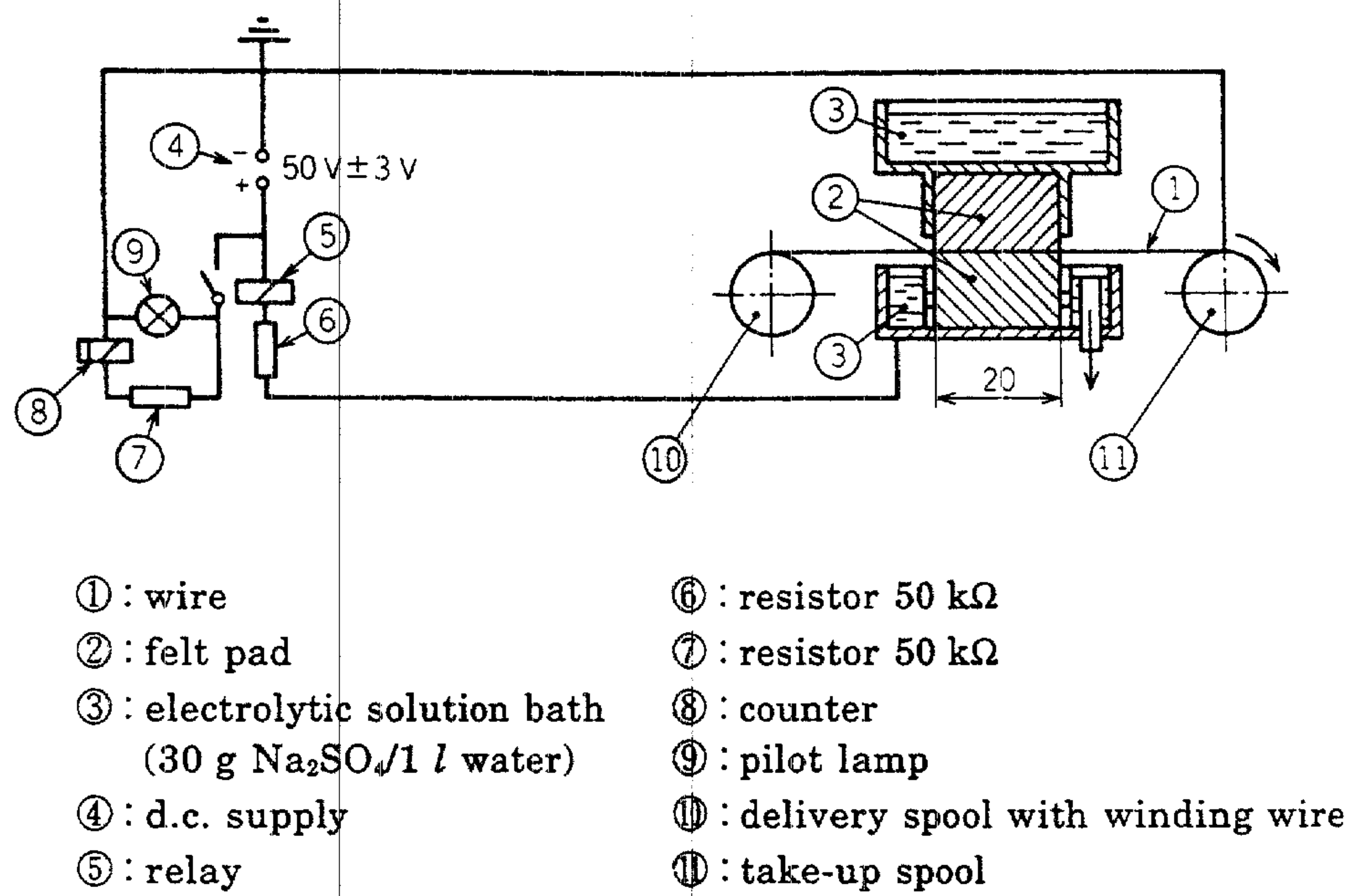
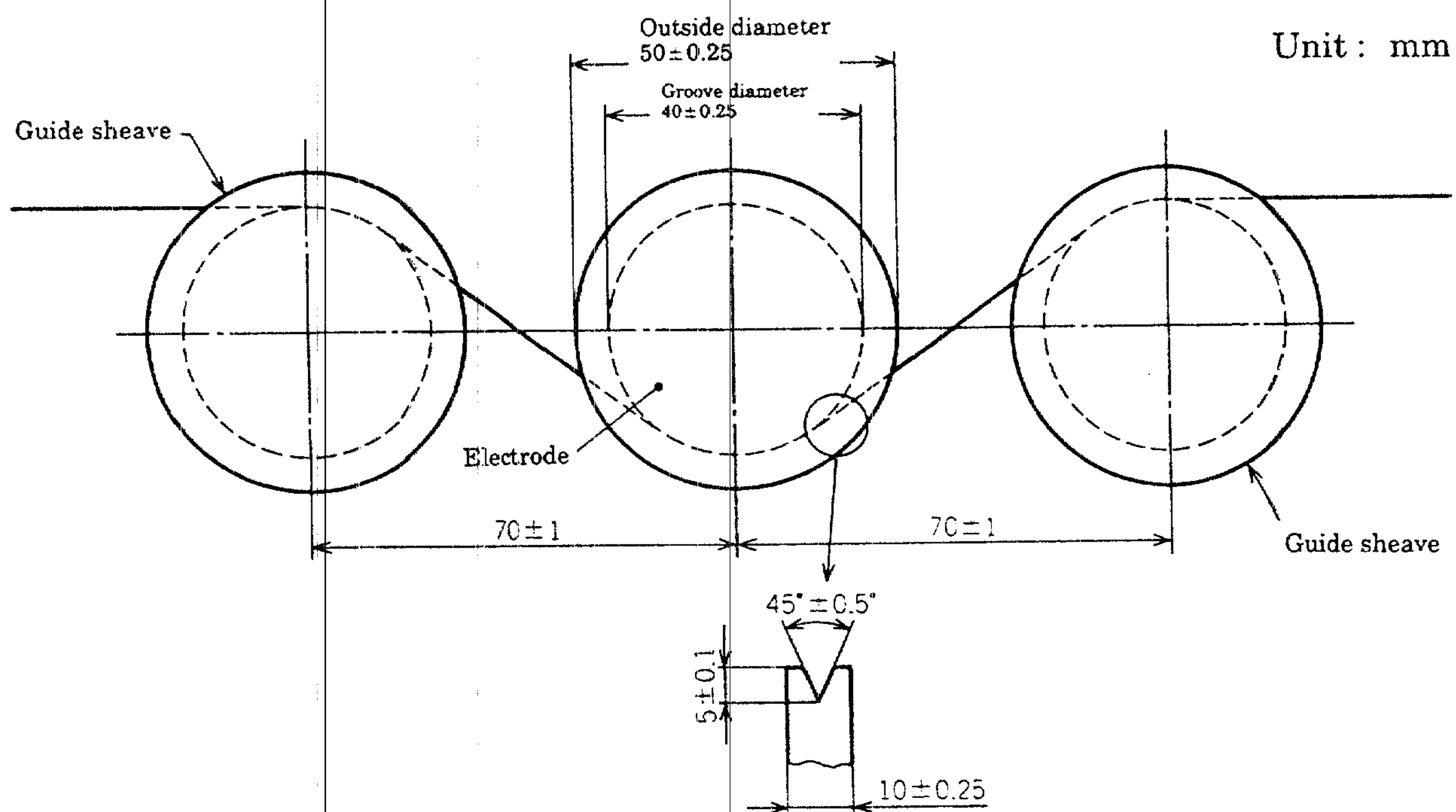
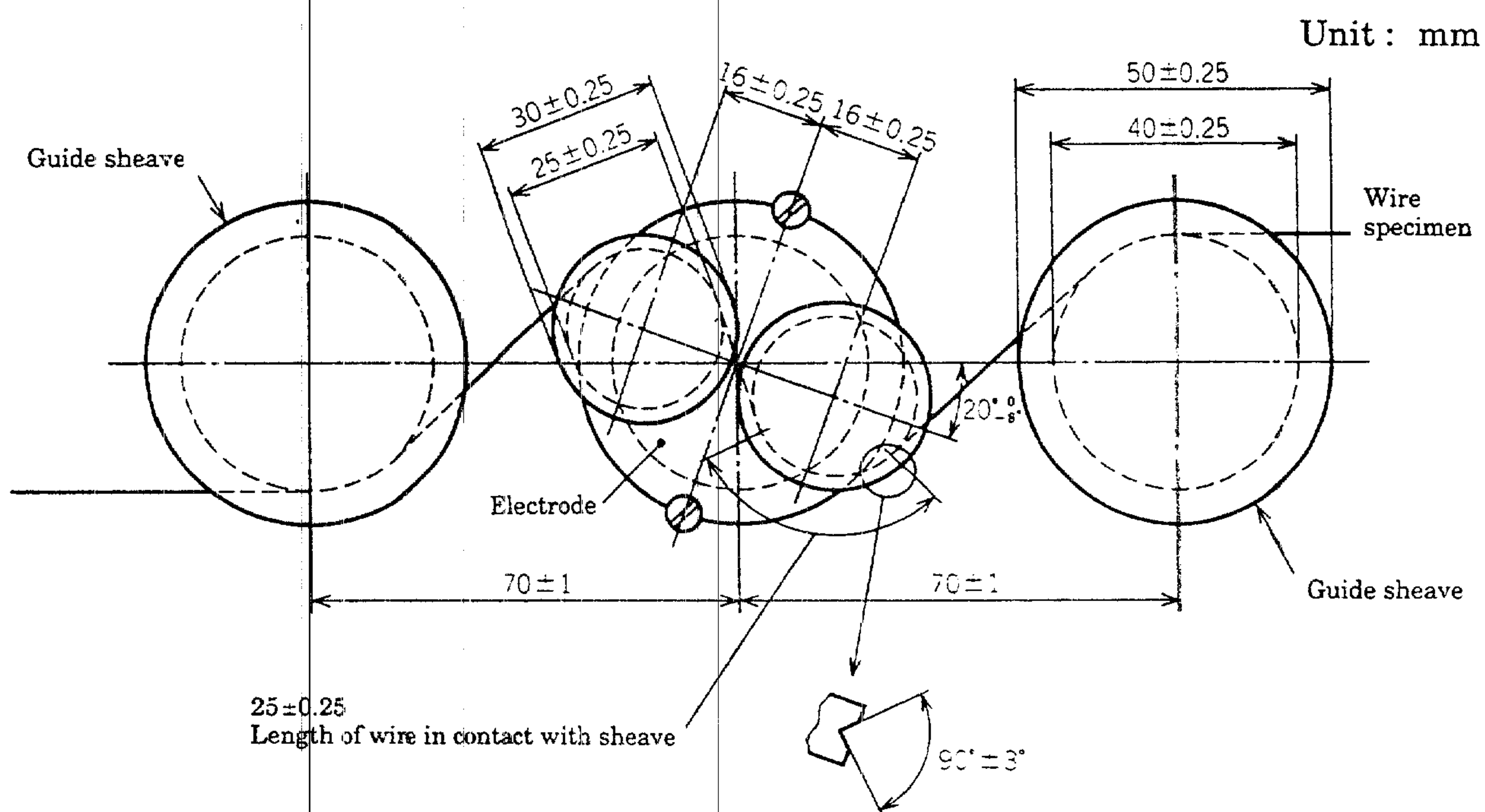


Fig. 2 Apparatus for testing low voltage continuity of covering



a) Sheave dimensions and spacing for wire size
0.250 mm to 1.600 mm



b) High voltage continuity-sheave for wire size
0.050 mm to 0.250 mm

Fig. 3 Sheave for high voltage continuity

c) **Pin-hole method** In the pin-hole method, the procedure shall be as stated below.

Take a specimen of about 1.5 m in length for conductor diameter of 0.060 mm or less and about 6 m in length for conductor diameter of 0.070 mm or more, carry out heat treatment for about 10 min in a thermostatic oven kept at a specified temperature (if not specified, the temperature shall be $125^{\circ}\text{C} \pm 3^{\circ}\text{C}$). After heat treatment, without bending nor stretching, dip the specimen in 0.2 % brine added with proper quantity of alcohol solution of 3 % phenolphthalein, by a length of 1 m or more for conductor diameter of 0.060 mm or less, or a length of 5 m or more for conductor diameter of 0.070 mm or more, apply d.c. 12 V for 1 min, by making the solution as positive and conductor of test piece as negative, and then examine the number of pin-holes generated.

7 Flexibility

7.1 Method A

7.1.1 Round wire The test shall be carried out as stated in "mandrel winding test" for wires with conductor diameter up to and including 1.600 mm, and as stated in "stretching test" for wires with conductor diameter over 1.600 mm.

a) **Mandrel winding test** A straight piece of wire shall be wound for 10 continuous and adjacent turns around a polished mandrel of the diameter given in the relevant standard. The mandrel shall be rotated with a rate of 1 r/s to 3 r/s with a tension applied to the wire which is just sufficient to keep it in contact with the mandrel. Elongating or twisting the wire shall be avoided. Any suitable equipment shall be used.

If the relevant standard calls for pre-stretching before winding, the wire shall be elongated according to sub-clause 18.1 to the specified percentage. After winding, the specimen shall be examined for cracks with the magnification as given in Table 6.

Table 6 Magnification to detect cracks

Nominal conductor diameter mm		Magnification*
Over	Up to and including	
—	0.040	10 to 15 times
0.040	0.500	6 to 10 times
0.500	1.600	1 to 6 times

* One time expresses normal vision.

Three specimens shall be tested. Any cracks detected shall be reported.

b) **Stretching test** A straight piece of wire shall be elongated according to sub-clause 18.1 to the percentage specified in the relevant standard. After elongation, the specimen shall be examined for cracks or loss of adhesion with normal vision or with a magnification of up to six times.

Three specimens shall be tested. It shall be reported, if the wire shows cracks and/or loss of adhesion.

7.1.2 Rectangular wire A straight piece of wire approximately 400 mm in length shall be bent through 180° round a polished mandrel of the diameter given in the relevant standard in two directions to form an elongated S-shape. The straight part between the U-shape bends shall be at least 150 mm. Care should be taken to ensure that the specimen does not buckle or depart from a uniform bend. A suitable apparatus is shown in Fig. 4.

After bending, the insulation shall be examined for cracks on insulating film under a magnification of six to ten times.

Six specimens shall be bent, three flatwise (on the thickness) and three edgewise (on the width). It shall be reported, if the wire shows cracks.

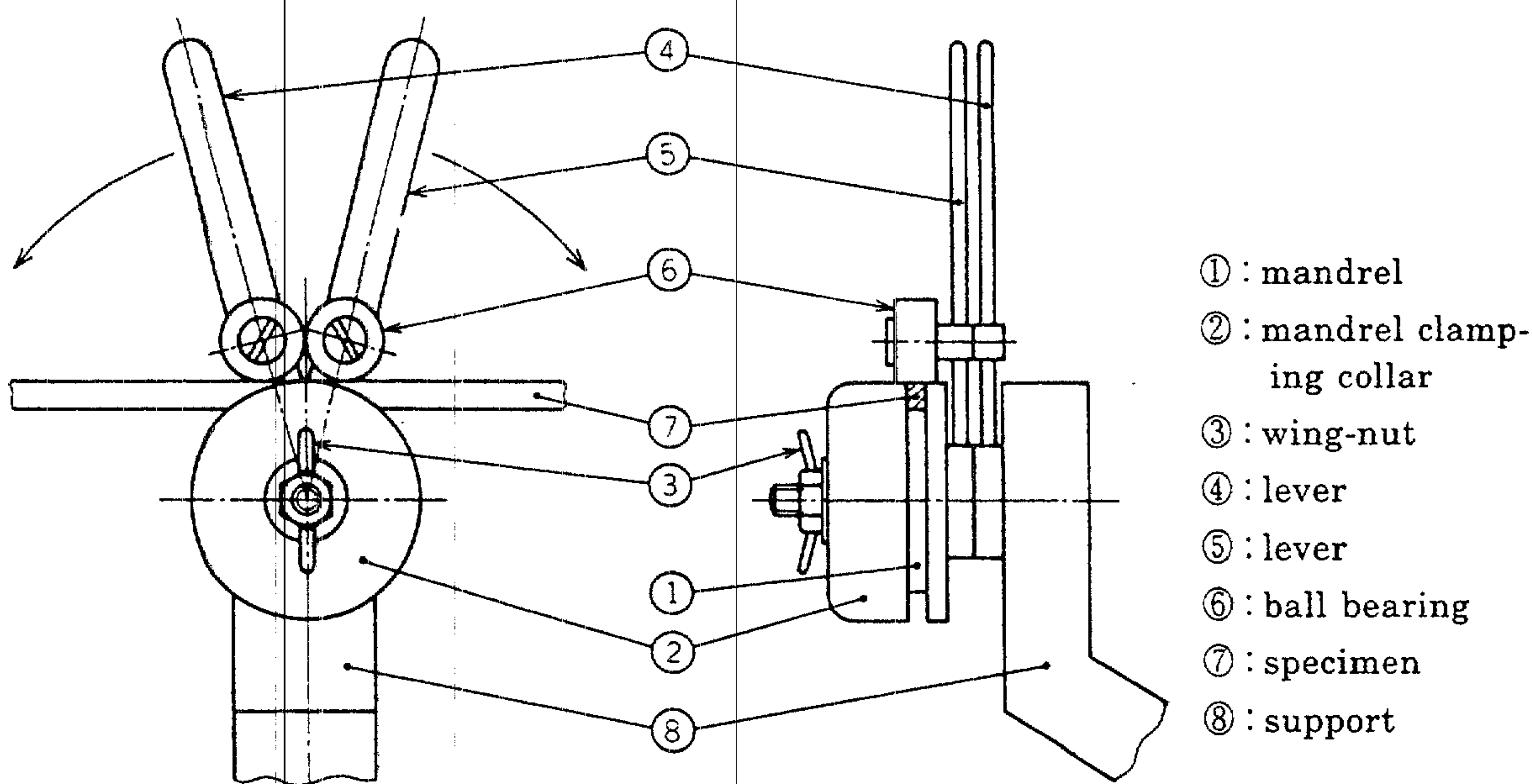


Fig. 4 Test equipment for mandrel winding test

7.2 Method B

7.2.1 Round wire The flexibility of round wires shall be investigated by stretching for conductor diameter of 0.35 mm or less, and by mandrel winding for that of 0.37 mm or more.

- a) **Stretching** Take three specimens of about 35 cm in length from the same bobbin, on each specimen mark lines with a gauge length of 250 mm, elongate the specimen to a specified value at a rate of not more than 300 mm/min and then investigate whether visible cracks appear or not, on the film using a magnifying glass of about 15 magnifications (value of least distance of distinct vision divided by focal length of the magnifying glass).
- b) **Mandrel winding** Take three specimens of proper length from the same bobbin, concerning each specimen, wound the specimen on its own circumference or on a round bar of smooth surface having a specified diameter for 10 turns in order that the wire will contact closely each other, and then visually check whether visible cracks appear or not on the film.

7.2.2 Rectangular wire For the rectangular wire, the test shall be carried out as follows:

- a) **Stretching** Take three specimens of about 35 cm in length, from the same bobbin, on each specimen mark lines with a gauge length of 250 mm, elongate the specimen to a specified value at a rate of not more than 300 mm/min, and then visually check whether visible cracks appear or not on the film.
- b) **Bending** Take two specimens of about 20 cm in length from the same bobbin, bend one specimen at the central part through an angle of 180° flatwise and the other edgewise along the circumference of round bar having a specified diameter, while the specimen is in the same plane, and then visually check whether visible cracks appear or not on the film.

8 Adherence

8.1 Round wire Round wires shall be tested as follows:

a) Jerk test

- 1) **Test equipment** The test equipment for jerk test shown in Fig. 5 or an equipment which is capable of stretching the specimen at a stretching speed of about 4 m/s shall be used.
- 2) **Test procedure** A straight piece of wire shall be rapidly stretched to the breaking point or to an elongation given in the relevant standard. The gauge length shall be between 200 mm and 250 mm.

After elongation, the specimen shall be examined for cracks or loss of adherence under a magnification as given in Table 6. A distance of 2 mm from the broken ends shall be disregarded.

Three specimens shall be tested. It shall be reported, if the wire shows cracks and/or loss of adherence.

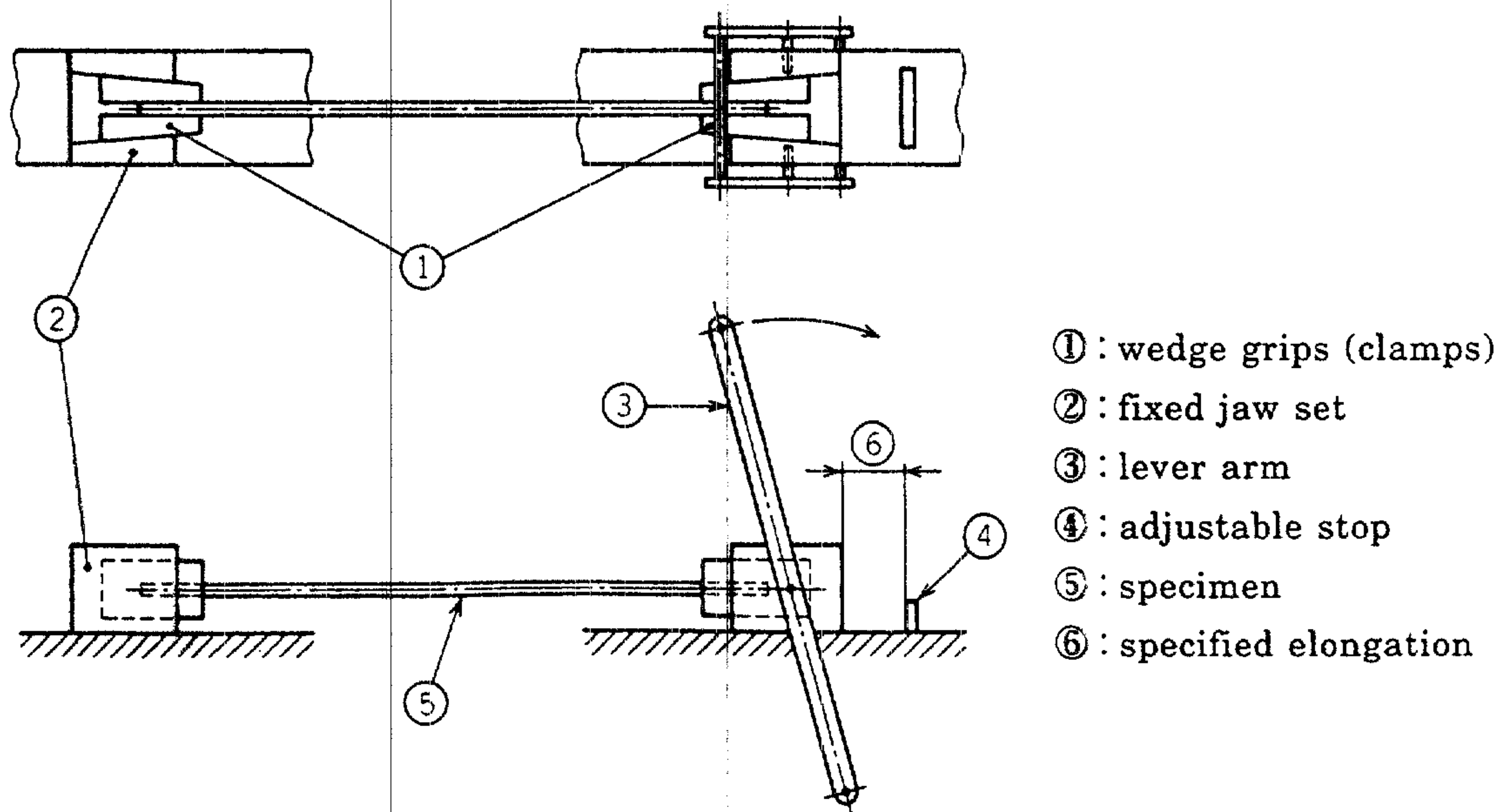


Fig. 5 Test equipment for jerk test

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- b) **Peel test (by twisting)** A straight piece of wire shall be placed in the test equipment shown in Fig. 6 consisting of two fixing devices 500 mm apart on the same axis. One of these is free to rotate. The other is not but can be displaced axially and is loaded according to Table 7 to apply a tension to the rotating wire.

Table 7 Load for peel test

Nominal conductor diameter mm		Load N
Over	Up to and including	
1.000	1.400	25
1.400	1.800	40
1.800	2.240	60
2.240	2.800	100
2.800	3.550	160
3.550	4.500	250
4.500	5.000	400

By means of scraper as shown in Fig. 7 a), the coating shall be removed on opposite sides of the wire and along the wire axis down to the bare conductor as shown in Fig. 7 b). The pressure on the scraper shall be sufficient to remove the coating and leave a clean smooth surface at the coating/conductor interface without scraping off a significant quantity of conductor material. The removal of the coating shall commence about 10 mm from the fixing devices. The rotating device shall be driven at a speed of between 60 r/min and 100 r/min until the number of revolutions R as specified in the relevant standard has been reached. After peeling and rotating, the specimen shall be examined for loss of adhesion. If the coating can be removed from the wire without difficulty (for example with the thumbnail), it shall be considered to have lost its adhesion even if it has not become completely detached from the wire.

One specimen shall be tested. It shall be reported, if loss of adhesion is observed.

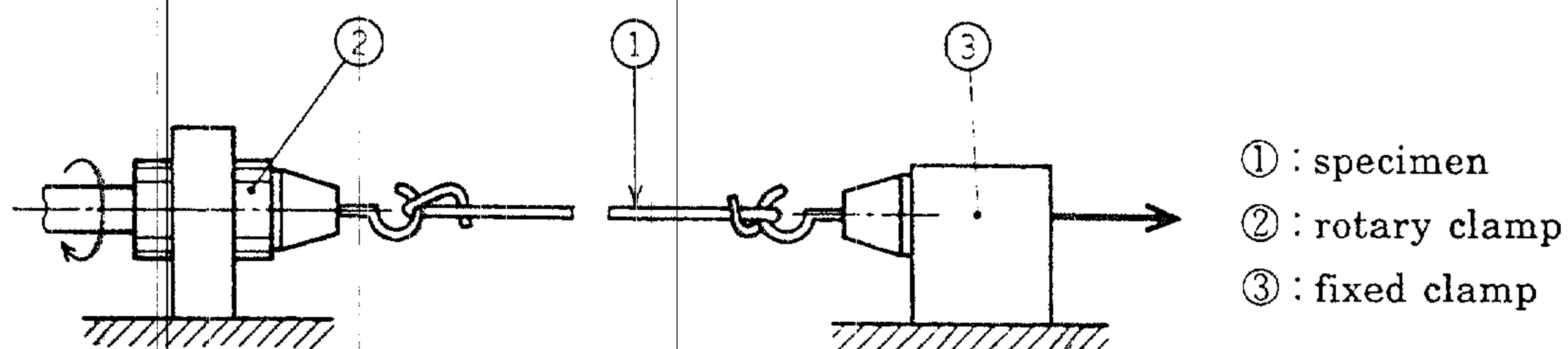


Fig. 6 Test equipment for peel test (by twisting)

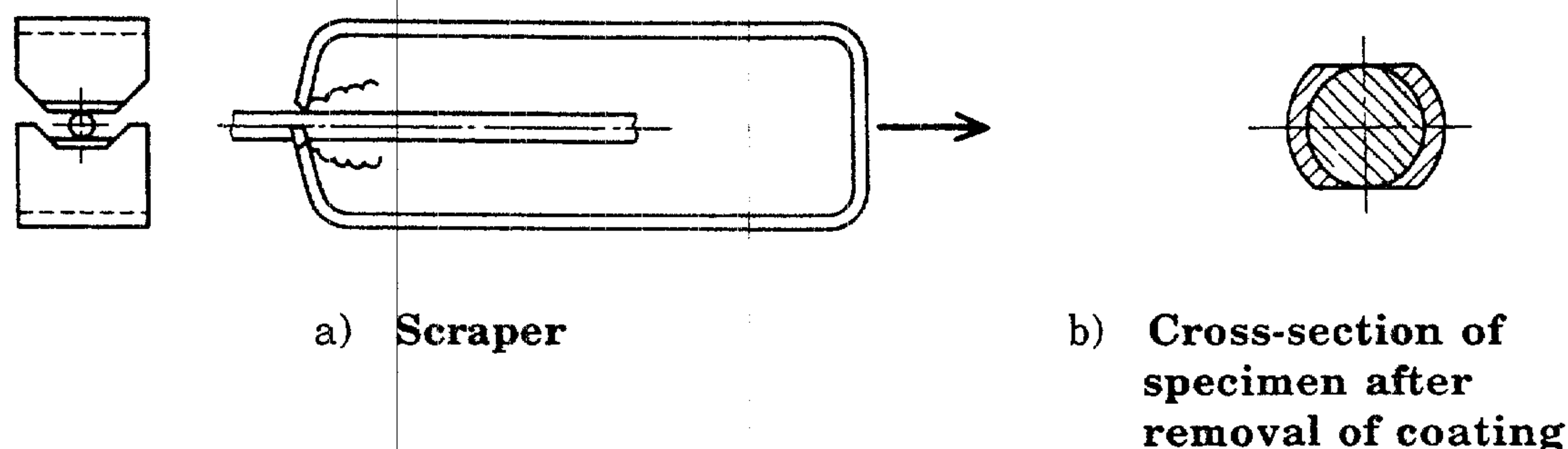


Fig. 7 Scraper and cross-section of specimen

8.2 Rectangular wire A straight piece of wire of about 300 mm length, shall be elongated in accordance with sub-clause 18.1 to the percentage specified in the relevant standard.

Before elongation, the coating shall be cut circumferentially through to the conductor at a point approximately in the centre of the measured length. After elongation, the specimen shall be examined for loss of adhesion.

One specimen shall be tested. It shall be reported, if loss of adhesion is observed, measured longitudinally from the cut. If so, the length of loss of adhesion shall be measured in one direction from the cut. The maximum value observed shall be reported after examining all sides of the specimen.

9 Resistance to abrasion (applicable to round wire) Resistance to abrasion is determined as the maximum force which can be sustained when a needle scrapes along the wire under a progressively increasing force.

- a) **Principle** A straight piece of wire is subjected to a unidirectional scrape test, by a needle to which a progressively increasing load is applied and which scrapes along the wire surface. The load which causes an electrical contact of the needle with the conductor is called the load-to-failure.
- b) **Equipment** Test equipment as shown in Fig. 8 shall be used. It shall be provided with a mechanism to produce scraping action in one direction at a rate of (400 ± 40) mm/min. The scraping device shall contain a polished piano wire or a needle of (0.23 ± 0.01) mm diameter, located between two jaws which hold the piano wire or needle rigidly, without sagging or curvature and at right angles to the direction of stroke which shall be in the direction of the axis of the wire under test. For placing the specimen, the test equipment shall be provided with two clamping jaws over a supporting anvil which can be lowered while a wire is inserted into the jaws and straightened. The test equipment shall provide a d.c. voltage of (6.5 ± 0.5) V to be applied between the conductor and the piano wire or the needle scraper. The short-circuit current shall be limited to 20 mA, for example by means of a series resistor or a relay. The circuit shall be designed to detect a short circuit and stop the equipment after the scraper is in contact with the conductor of the wire for about 3 mm.

The test equipment shall be provided with a graduated scale over the lower edge of the lever, which indicates the factor by which the initial load applied to the piano wire or to the needle has to be multiplied to determine the force-to-failure.

- c) **Procedure** A straight piece of wire shall be wiped clean, placed in the apparatus and straightened by a maximum of 1 % elongation. The specimen shall then be secured in the clamping jaws and the supporting anvil adjusted to contact the specimen. The initial force applied to the scraping device shall not exceed 90 % of the minimum force to failure specified in the relevant standard and shall lead to short circuit between scraper and conductor at a point between 200 mm and 150 mm from the fixed pivot point. The weighted scraping device shall be lowered slowly to the surface of the wire and the scraping action started. The value at which the scraper stops shall be read on the graduated scale on the lower edge of the lever. The product of this value and the initial load applied shall be recorded as load-to-failure. The procedure shall be repeated twice on the same specimen, indexing around the periphery of the wire, once at 120° and once at 240° from the original position and the same information recorded.

One specimen shall be tested. The three single values shall be reported. The mean value represents the average force-to-failure.

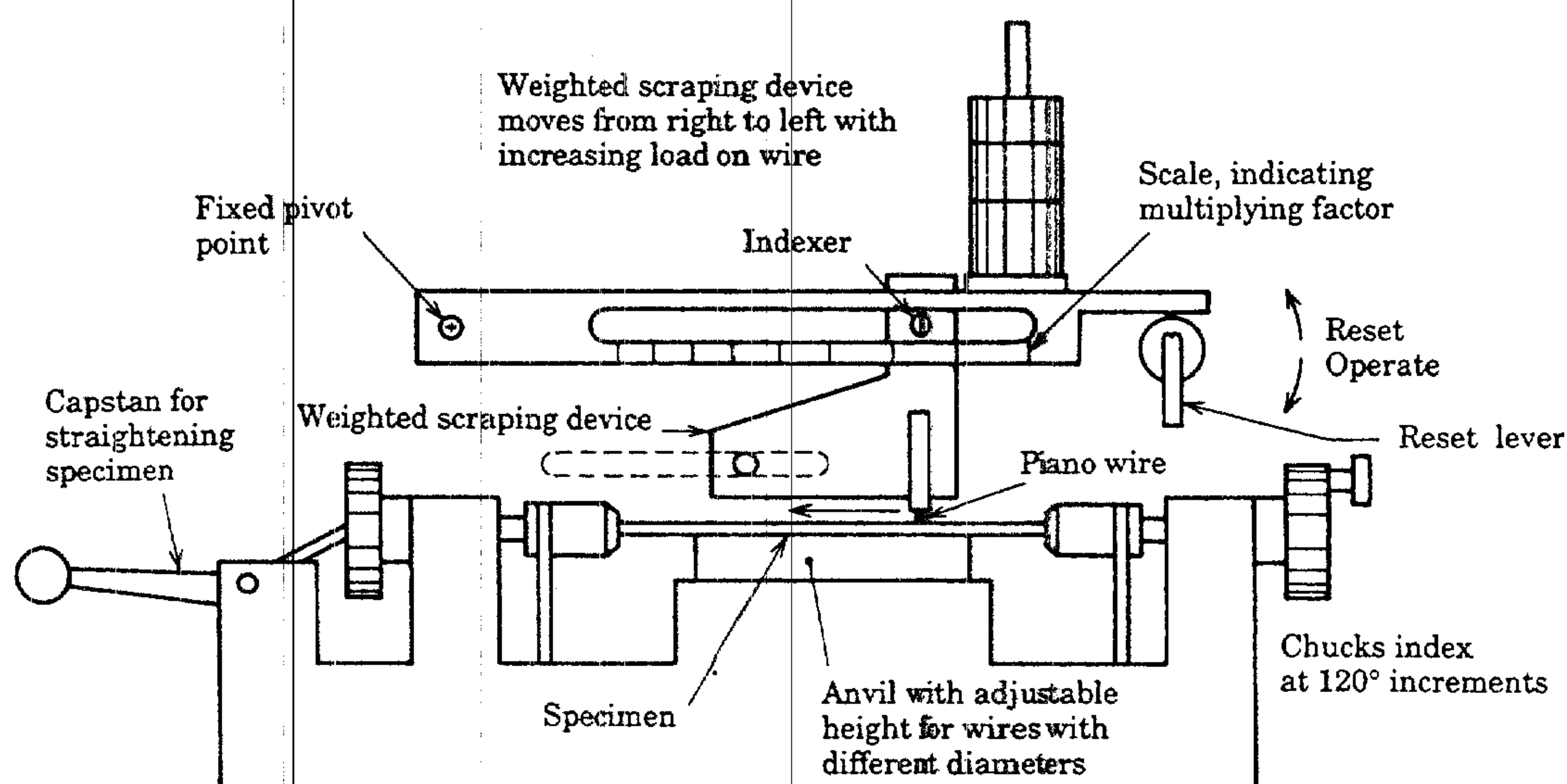


Fig. 8 Test equipment for unidirectional scrape test

10 Breakdown voltage

10.1 Method A The breakdown voltage shall be checked by metal cylinder method for round wires with a conductor diameter up to and including 0.100 mm, by twisting (of two pieces) method for round wires with a conductor diameter over 0.100 mm up to and including 2.500 mm, or by metal foil method for round wires with a conductor diameter over 2.500 mm, and by metal shot method for rectangular wires. An a.c. voltage at a frequency 50 Hz or 60 Hz shall be used as the test voltage which shall be applied at zero and increased at a uniform rate specified in Table 8 and the breakdown voltage shall be measured. The breakdown detecting current shall be 5 mA.

The transformer used for this test shall have a capacity not less than 500 VA, and shall be capable of supplying undistorted sine wave voltage, with a peak factor being $\sqrt{2} \pm 5\%$ and with a maximum voltage drop of 2 % at 5 mA.

The test shall be carried out at the room temperature and the elevated temperature specified in the relevant standards. The test at elevated is excluded in the metal cylinder method.

a) **Test at room temperature**

- 1) **Metal cylinder method** A straight piece of wire with the insulation removed at one end shall be connected to the upper terminal as shown in Fig. 9 and wound once around the cylinder with a diameter of 25 mm. A load as specified in Table 9 shall be applied to the lower end of the wire to keep the specimen in close contact with the cylinder. The test voltage shall be applied between the conductor of the wire and the cylinder. Five specimens shall be tested. The five single values shall be reported.
- 2) **Twisting (of two pieces) method** A straight piece of wire, approximately 400 mm in length, with the insulation removed at both ends, shall be twisted back on itself for a distance of (125 ± 5) mm on the twisting device as shown in Fig. 10 with a load applied to the wire pair, and with the number of twists, as given in Table 10. The loop at the end of the twisted section shall be cut at two places to provide a maximum spacing between the cut ends. Any bending to ensure adequate separation between the two wire ends shall avoid sharp bends or damage to the coating. The test voltage shall be applied between the conductors of the wires. Five specimens shall be tested. The five single values shall be reported.

Table 8 Rate of test voltage increase

Breakdown voltage V		Rate of test voltage increase V/s
Over	Up to and including	
—	500	20
500	2 500	100
2 500	—	500

Table 9 Load

Nominal conductor diameter mm		Load N
Over	Up to and including	
—	0.018	0.013
0.018	0.020	0.015
0.020	0.022	0.020
0.022	0.025	0.025
0.025	0.028	0.030
0.028	0.032	0.040
0.032	0.036	0.050
0.036	0.040	0.060
0.040	0.045	0.080
0.045	0.050	0.100
0.050	0.056	0.120
0.056	0.063	0.150
0.063	0.071	0.200
0.071	0.080	0.250
0.080	0.090	0.300
0.090	0.100	0.400

Table 10 Load and number of twists

Nominal conductor diameter mm		Load N	Number of twists
Over	Up to and including		
0.100	0.250	0.85	33
0.250	0.355	1.70	23
0.355	0.500	3.40	16
0.500	0.710	7.00	12
0.710	1.060	13.50	8
1.060	1.400	27.00	6
1.400	2.000	54.00	4
2.000	2.500	108.00	3