

## Measurement of Resistance to Abrasion of Heavy Leather

### 1 Scope

The method is particularly applicable to all types of sole leather (including impregnated leather) used under dry and wet conditions and ranks leathers closely with the effects of actual wear<sup>1</sup>. It is also applicable to other types of heavy leather.

### 2 Principle

- 2.1 In normal wear the rotary component of the movements of the foot is the main cause of abrasion. To imitate this abrasion, two discs of sole leather are abraded by being rotated under pressure in a planetary orbit on the freshly surfaced flat face of a carborundum grinding disc which itself rotates in a horizontal plane and is fed with a specified volume of standardized sand. By this planetary motion sand particles abrade every part of each sample in all directions at varying velocities, while avoiding clogging the abrasive.

During the test, each leather disc is loaded with a mass of 35 kg, giving pressures of approximately  $15 \times$  and  $28 \times 10^4$  Pa for the diameters of 55 mm and 40 mm respectively.

After a fixed number of revolutions of the grinding disc, the decrease of mass of the specimens is determined. The procedure is repeated until 50% or more of the original mass has been abraded, and the number of revolutions of the grinding disc required to abrade exactly 50% of the mass of the specimens is calculated. A high figure indicates high abrasion resistance.

- 2.2 Conditions in practical wear vary widely. They depend on the wearer, the type of feet, the flexibility of the combination of the sole and the bottom of the shoe, and whether the conditions are wet or dry. These result in different pressures during wear, varying compression of the leather, dry and wet abrasion and leaching of water solubles.

### 3 Apparatus

The following apparatus is required.

Abrasion resistance test apparatus, see Figs 1, 2 and 3.

The essential parts of the machine<sup>1</sup> are as follows:

- (a) a disc (1) of internal diameter 403 mm rotating horizontally anti-clockwise at  $30 \pm 0.5$  r/min;
- (b) a carborundum stone (2);

Originally the abrasion resistance was expressed as  $100 \times$  the number of abrasion periods of 450 revolutions, that is approximately 15 min (see 2.1) required to abrade unit thickness. In the formula, therefore, the constant number  $0.222 = 100/450$ .

## 7.2 Assessment of thickness loss

Depending on its compressibility, sole leather will be compressed more or less during the abrasion test and it is not possible therefore to assess the thickness loss exactly by measurement of thickness. It is assumed therefore that a 50% loss in mass is equal to a 50% loss in thickness.

## 8 Test report

The test report shall include the following information:

- (a) the method of abrasion, that is wet or dry and the pressure applied;
- (b) the calculated abrasion resistance  $R$ ;
- (c) the thickness of the specimens  $t$ , in mm;
- (d) the sampling position in the bend<sup>1</sup>;
- (e) the apparent density of the specimen, in  $\text{kN/m}^3$  <sup>1</sup>.

The machine and test method were developed by the former Government Institute of the Leather and Shoe Industry in the Netherlands (JN Gerssen, *Collegium* 1936, 440) and brought to their ultimate form by the Leather Research Institute TNO.

Only a simplified description of the machine is given in Section 3 and Figs 1, 2 and 3. A detailed description and working drawings for its construction can be obtained from Lederinstituut TNO, Waalwijk, Netherlands.

See also *Journal of the Society of Leather Technologists and Chemists*, 1961, 45, ibid 130; 1967, 51, ibid 80; 1969, 53, ibid 12.

Testing can be carried out by Lederinstituut TNO, either by contacting them directly or by making arrangements through the British Leather Confederation, Leather Trades House, Kings Park Road, Moulton Park, Northampton, NN3 1JD, or Satra, Satra House, Rockingham Road, Kettering, Northamptonshire.

Stones made and delivered by Slijpsteenindustrie 'De Mass', Cuyk, Netherlands, have been found to be suitable.

Type 'Laxo' S 40, made and supplied by AB Statens, Skog-Industrier, Sweden, has been found to be suitable.

When abrasion resistances are compared for leathers with considerable differences in thickness and/or apparent density and/or taken from

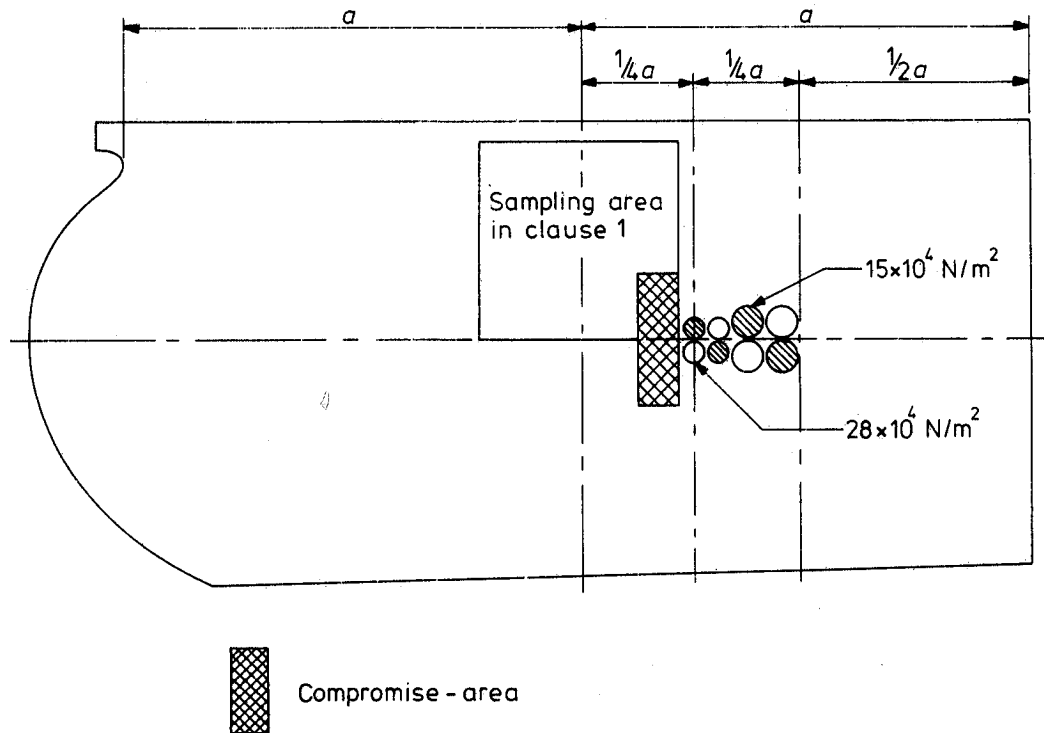
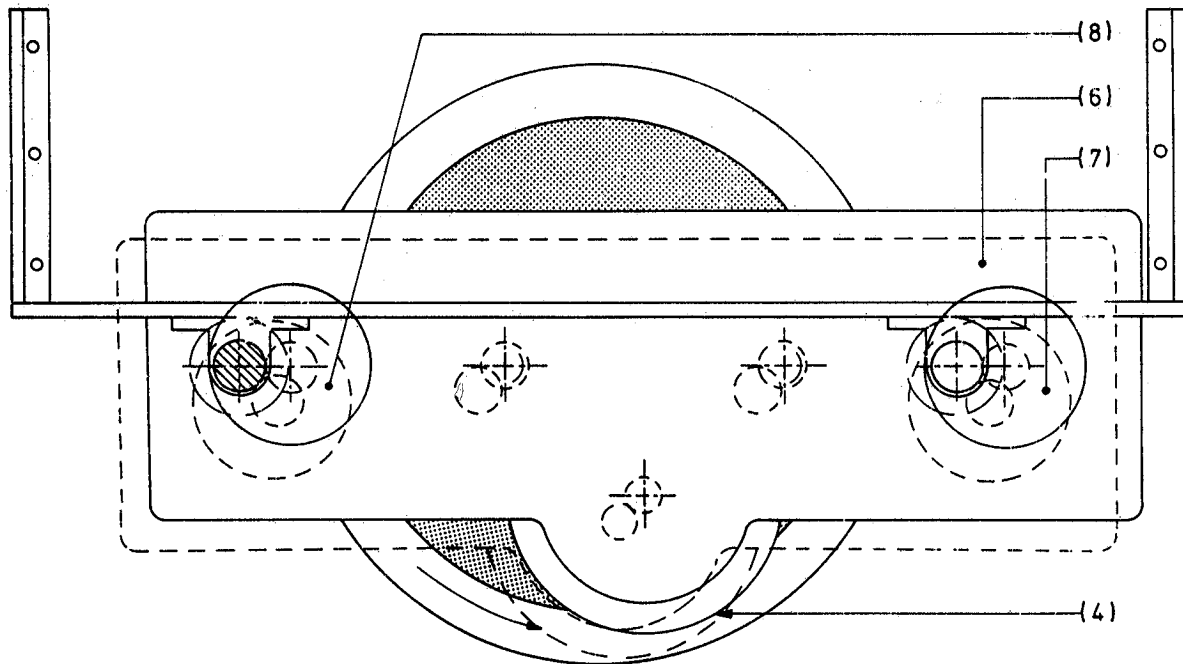


Fig 4 Ideal sampling position in the bend to be used for comparative abrasion tests on standardised materials

- (c) leather holders with leather discs (3), both rotating anti-clockwise and moving in a horizontal circular path imparted by the movement of gear box (6);
- (d) cast iron disc (4) for surfacing the carborundum stone with steel grit;
- (e) weight pieces (5), total mass on each specimen 35 kg;
- (f) gear box (6) having a circular motion of radius 40 mm produced by two synchronous crank shafts (7) and (8), whose speeds are  $52/25 \times$  speed of disc (1) (Fig 3). The gear box houses the two vertical shafts which revolve at  $60/58 \times 52/25 \times$  speed of disc (1) and to which are attached at their lower ends the leather holders and at their upper portions weight pieces (5);
- (g) adjustable automatic switches;
- (h) sand distributor;
- (i) gutter for catching the steel sand;
- (j) adaptors with a recess (corresponding to the diameters of the specimen) into which the specimens are fixed to prevent lateral displacement relative to the holders.

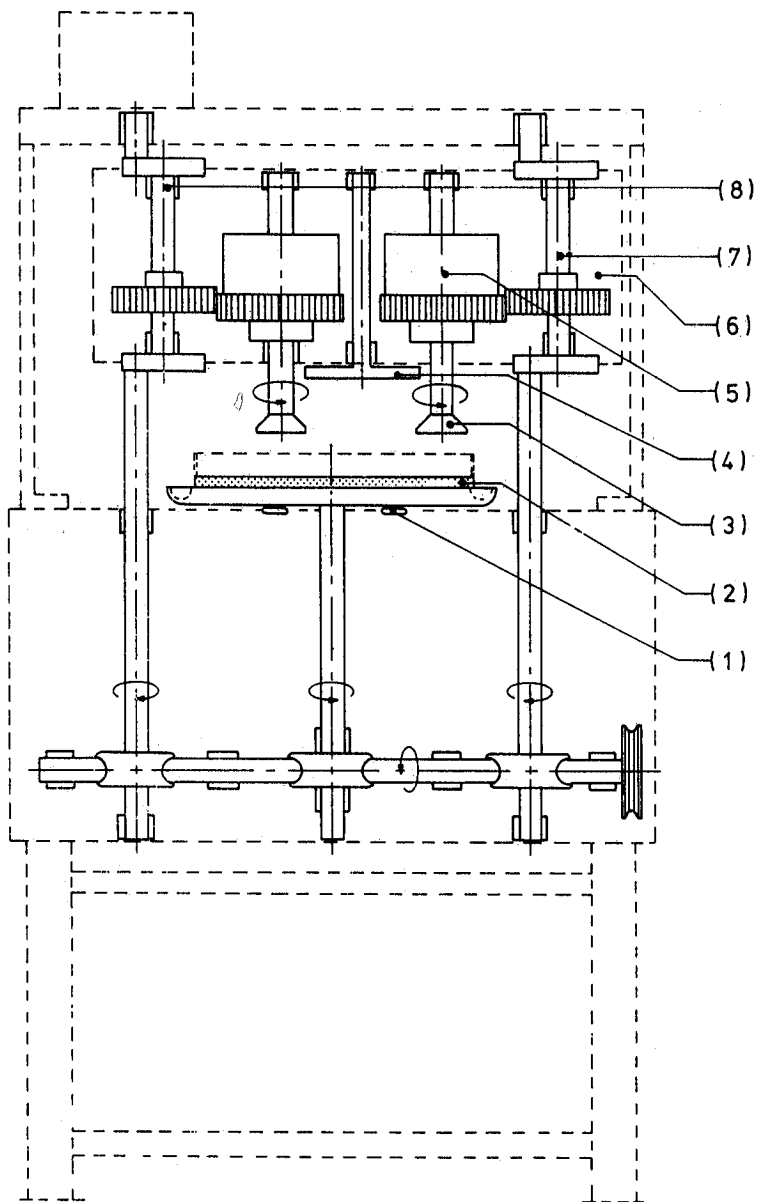
#### Note

No material has been found with a constant composition and which approximates sufficiently to the properties and fibre structure of leather to be usable as a standard for calibrating the machine but reproducible results can be maintained by robust and stable construction of the machine and by standardising the composition and characteristics of the grinding disc, type of steel grit used for surfacing the grinding disc, the procedure for surfacing the grinding disc, the grain size of the river sand and conditions during the tests themselves. While the leather specimens need to be conditioned before test, it is not necessary to place the machine in a conditioned room.



- Key**
- (4) cast iron disc
  - (6) gear box
  - (7) synchronous crank shaft
  - (8) synchronous crank shaft

**Fig 2** Plan view of the eccentric movement of the gear box sketched in two positions after a rotation of  $45^\circ$



**Key**

- (1) disc
- (2) carborundum stone
- (3) leather holder with leather disc
- (4) cast iron disc
- (5) weight pieces
- (6) gear box
- (7) synchronous crank shaft
- (8) synchronous crank shaft

**Fig 3** Essential parts of abrasion machine

## 4 Abrasives

4.1 Carborundum stone, with the following dimensions and properties<sup>1</sup>.

- (a) Dimensions:
  - diameter 400 mm;
  - thickness 25 mm;
  - diameter of spindle hole 25 mm.
- (b) Central recess:
  - diameter 60 mm;
  - depth 17 mm to 20 mm.
- (c) Composition:
  - carborundum
  - grain 40 to 60;
  - hardness Qu 4;
  - bond ceramic.

4.2 River sand

Sharp building sand sieved with silk sieves of 10, 20 and 30 wires/cm, with openings of approximately 0.8, 0.35 and 0.24 mm respectively. Equal volumes of grain sizes between 10 to 20 wires/cm and 20 to 30 wires/cm are mixed and used as abrasive.

4.3 Steel grit

Sharp steel grit with a particle size of 0.3 mm to 0.4 mm.<sup>1</sup>

### Note

The evaluation of the suitability of alternative materials and sampling methods is given in Appendix A.

## 5 Preparation of test specimens

5.1 Cut circular specimens of 40 mm and 55 mm diameter.

5.2 For the dry abrasion test, condition the specimens in accordance with Clause 2, measure their thickness ( $t$ ), in mm, in accordance with Clause 3 and determine their mass ( $m$ ), in g.

5.3 For the wet abrasion test, wet specimens of 55 mm diameter with 30 ml to 35 ml water in glass or porcelain dishes of 60 mm to 65 mm diameter. Place the dishes in a desiccator or suitable other vessel and evacuate the air to a pressure of not more than 25 mm of mercury. After approximately 3 minutes, break the vacuum and leave the specimens in the water for approximately 30 minutes. Take the specimens from the water, blot them, weigh them and test immediately.

5.4 For the abrasion test after leaching, drying and compression, put specimens of 40 mm diameter in approximately 5 times their mass of water for 24 h. Blot them, dry in a stream of air at room temperature and condition as in Clause 2 for at least 96 h. Roll or press the specimens to an apparent density of 1100 kg/m<sup>3</sup>. Weigh the specimens.

### Note

Alternatively, samples with diameter greater than 40 mm can be treated as follows. After rolling to an apparent density of  $11 \text{ kN/m}^3$ , specimens of 40 mm are cut out. This method is recommended for leathers whose area increases substantially during rolling.

## 6 Procedure

### 6.1 Attaching a new carborundum grinding disc

Before placing a new grinding disc on the dish, carefully remove any labels and glue so that the back of the grinding disc is plane. The dish should also be clean. Attach the grinding disc with a flange screw and fill the recess in the grinding disc with a tightly fitting cork disc 60 mm in diameter and 15 mm thick.

### 6.2 Pre-treatment for the grinding disc

6.2.1 Lower the cast iron disc without fixing it. Put a piece of paper 100 mm x 100 mm and 0.08 mm to 1 mm thick on the grindstone under the iron disc. Lift the dish by means of the handle until the grindstone and the paper touch the iron disc. Raise the dish slightly more, by which the iron disc is lifted. Clamp first the dish and then the iron disc in position.

6.2.2 Set the revolution counter on zero. Strew about 100 g of steel grit on the grinding disc. Switch on the machine; the iron disc will throw the steel grit into the gutter. With a little shovel, bring the steel grit from the gutter on the rotating grinding disc, at the right hand side of the iron disc. Take 5 seconds for each shovelling and throwing. Do this continuously until the dish has made about 100 revolutions, after which the machine is switched off by hand or automatically.

6.2.3 Lift the iron disc again and lower the dish, both to their extreme positions. Remove the used steel grit from the grinding disc and from the gutter by brushing and vacuum cleaning (mouth-piece, diameter 5 cm, of heavy rubber tube). For this purpose, the dish is rotated with a hand wheel. Finally the machine is rotated in such a way that the box with the leather holders is in the extreme backward position. Put the ring on the dish and the sand distributor above the dish on its supports. Put the revolution counter of the automatic switch on zero. The machine is then ready for the abrasion test.

Before a new grinding disc is put into use, subject three pairs of samples to 450 revolutions of abrasion without measurement and re-surface the grinding disc after each pair has been abraded; a total of three surfacings of the grinding disc.

### 6.3 Abrasion test

6.3.1 Attach each specimen, prepared in the manner described in Section 5, into the recess of the adaptors, by means of 3 microtacks of length 7 mm.



- 6.3.2 Place the adaptors with the leather discs under the pressure holders of the machine in such a way that the pins of the adaptors fit into the holes in the pressure holders. Keep the adaptors in place by means of spring clips.
- 6.3.3 Lift the dish with the grinding disc on to the clips and remove the clips. Lift the dish higher, so that the specimens and the adaptors are correctly in place. Lift the dish with the loaded specimens by 2 mm to 6 mm, as read on the gauges, dependent on the thickness of the leather. When the height of the sand distributor is adjusted correctly, the distance between the grinding disc and the sand distributor is approximately 3 mm and the weight pieces exert their full pressure on the specimens.
- 6.3.4 Fix the dish in this position.
- 6.3.5 Scatter 500 ml of the sand (see 4.2) on the grinding disc, approximately half of it at each side of the sand distributor.
- 6.3.6 Set the revolution counter to zero and the automatic switch to the required number of revolutions, that is 75 revolutions for 40 mm diameter specimens and 225 revolutions for 55 mm specimens.
- 6.3.7 Switch on the machine and switch on the vacuum cleaner. The action of the vacuum cleaner shall be such that only dust floating in the air over the grinding disc is sucked off and not the sand on the stone itself. Continue until the machine switches off automatically. Lower the dish and remove the sand distributor only when the grinding disc needs to be surfaced.
- 6.3.8 Remove the leather specimens from the adaptors and clean them by dusting with the mouth-piece of the vacuum cleaner. Weigh the specimens.

Note

Reconditioning of the specimens before weighing is not necessary, because the loss of moisture during the test is negligible.

- 6.3.9 The test is continued using the same sand, but the specimen which was first abraded in the left hand part of the machine is transferred to the right hand part and vice versa. In this way differences in the abrading action between the left and right hand parts of the machine can be neutralised. Continue the test until 50% or more of each specimen is abraded. The used sand is removed after every 450 revolutions and the grinding disc surfaced and dusted and 500 ml of fresh sand put on the disc. If the test is finished in less than 450 revolutions, the grinding disc shall nevertheless be surfaced and supplied with fresh sand before new specimens are tested.

In the wet abrasion test, the leather discs are placed in water for about 5 min at a pressure of approximately 305 kPa (air pressure or mains water pressure) after every abrasion test and before they are weighed, then blotted and weighed. In the wet abrasion test brass adaptors are used in place of steel.

6.3.10 Assess the abrasion resistance under any of the following five sets of experimental conditions, in order to cover completely the range of factors affecting the durability of the soles.

- (a) Under a pressure of  $15 \times 10^4$  Pa, which corresponds to the normal pressure on the abraded portion of the sole.
- (b) Under a pressure of  $28 \times 10^4$  Pa which can occur when a non-uniformly distributed pressure is applied to a sole.
- (c) In a wet state, under normal pressure as in (a).
- (d) After leaching, drying and compressing to an apparent density of  $11 \text{ kN/m}^3$  under high pressure as in (b).
- (e) When the conditions of distribution of pressure and/or soil are very mild, a pressure lower than normal can be used, that is  $7.5 \times 10^4$  Pa.

#### Note

For routine tests of abrasion resistance, comparison with wear trials has shown that it will normally be sufficient to test dry under normal pressure of  $15 \times 10^4$  Pa, but for research and development purposes or exceptional leathers and/or conditions, any or all of the four additional sets of experimental conditions, ie, (b) to (e), may provide information which justifies the extra work involved.

## 7 Calculation of results

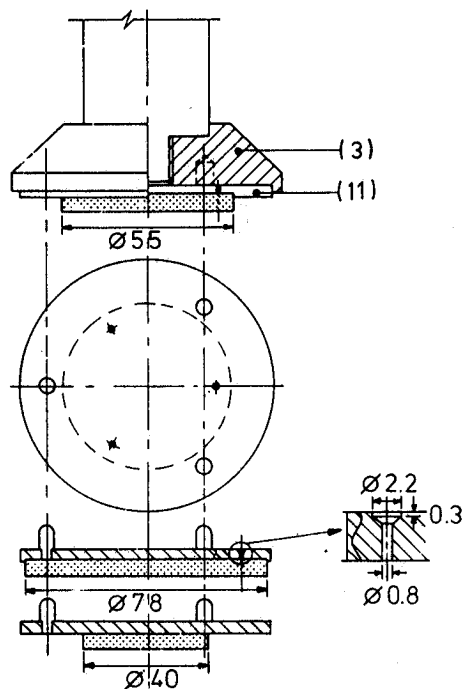
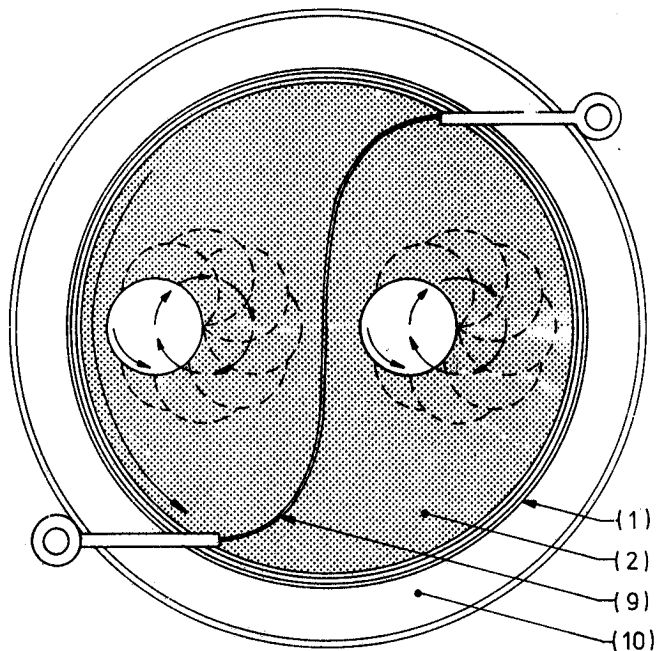
### 7.1 Assessment of abrasion resistance

For the assessment of the abrasion resistance, the number of revolutions of the grinding disc required to abrade a certain thickness of the leather is recorded.

The abrasion resistance is 0.222 times the mean number of revolutions required to abrade unit thickness, when the averaging is made over that half of the leather thickness which lies nearer to the grain side, and the thickness losses are estimated indirectly from the mass losses, as indicated in 7.2.

Let  $t$  be the initial thickness, in mm, and  $r$  the number of revolutions which reduces the initial mass of the two specimens (see 5.2) to 0.5 mg; then the abrasion resistance  $R$  is defined as:

For normal sole leather, the abrasion resistance of half the leather thickness from the grain side is about the same as for half the leather thickness from the flesh side. It is sufficient therefore to abrade half the thickness from the grain side in order to know the abrasion resistance of the whole leather. If the grain or flesh side of the leather has been split off, the numbers of revolutions both from the grain and from the flesh sides shall be determined and the mean value used in calculating the abrasion factor.



#### Key

- (1) disc
- (2) carborundum stone
- (3) leather holder with leather disc
- (9) sand distributor
- (10) gutter for catching steel sand
- (11) adaptor

Dimensions are in millimetres.

Fig 1 Movement of leather samples over grindstone