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Wool — Determination of fibre length distribution parameters — Electronic method

Laine — Détermination des paramètres de distribution de longueur des fibres — Méthode électronique

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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2648 was drawn up by Technical Committee ISO/TC 38, *Textiles* and circulated to the Member Bodies in July 1972.

It has been approved by the Member Bodies of the following countries :

Austria	India	South Africa, Rep. of
Belgium	Iran	Spain
Bulgaria	Ireland	Sweden
Canada	Israel	Switzerland
Czechoslovakia	Japan	Thailand
Denmark	Mexico	Turkey
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Finland	Poland	U.S.A.
Germany	Portugal	U.S.S.R.
Hungary	Romania	

The Member Body of the following country expressed disapproval of the document on technical grounds :

France

This International Standard is based on the IWTO test method 17-67, drawn up by the International Wool Secretariat (IWS).

Three successive interlaboratory tests have enabled the progressive development of the standard test method and the control and calibration method described in this International Standard.

The favourable results of the last two experiments led to the adoption of the standard method of test and the calibration and control methods using a series of plastic calibrators, specially prepared for the participants in these experiments.

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Wool — Determination of fibre length distribution parameters — Electronic method

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method for the determination of fibre length distribution parameters, principally mean length and the coefficient of variation of length, for all-wool slivers and rovings.

The method is not directly applicable to slivers made up of a blend of two or more fibres.

Selection of the test specimen is effected using an auxiliary machine, called "mechanical grip"; it may be used on top sliver, on worsted drawing slivers and rovings, and on slivers from the semi-worsted system.

2 PRINCIPLE AND DEFINITION OF THE TEST PARAMETERS

2.1 Principle

The electronic machine tests the length of textile fibres, using a specimen of fibres made up with the aid of the mechanical grip.

This grip, fed with slivers or rovings, prepares a numerical specimen of fibres, i.e. one in which the number of fibres in each length class are represented in the same proportion as in the original sliver.

This specimen is in the form of a draw of parallel fibres, all these fibres having their ends approximately on a line perpendicular to the direction of the fibres.

The specimen formed in this way is then transferred from the grip to an electronic instrument, where it is placed in a slide between two thin plastic sheets.

The slide containing the test specimen moves at constant speed, through a measuring condenser. The variation in capacity caused in this way (due to the partial replacement of the "air" dielectric by the "wool" dielectric) is proportional to the mass of the portion of the draw of fibres situated in the condenser. In view of the constitution of the specimen, it is easily shown that the record of changes in the signal proportional to the changes in capacity is equivalent to a diagram of "hauteur" *H* (see references 1 and 2, annex A).

This diagram is automatically traced by a recorder connected to the main machine.

2.2 Test parameters

An electronic calculator that is incorporated automatically evaluates the following length distribution parameters during test :

1) mean cross-section biased length or hauteur *H* : (*a, l*) in Palmer's notation;

2) coefficient of variation of hauteur, CV_H;

3) mean length X cross-section biased length, or barbe *B* : (*al, l*) in Palmer's notation. As the density of the fibres may be regarded as constant, the barbe *B* is also the mean weight biased : (*w, l*) in Palmer's notation.

3 APPARATUS

The apparatus comprises three parts :

1) the mechanical grip;

2) the main electronic instrument;

3) the recorder.

A suitable machine is described in annex C.

3.1 The mechanical grip

The grip works in the same way as the nip of a rectilinear comb. With each movement it extracts from the sliver a numerical sample containing all the fibres having their ends within a short length of the sliver, between two cross-sections perpendicular to the sliver axis about 2,5 to 3,7 mm apart. The complete specimen is made up of a collection of about ten to sixteen of these samples.

3.2 The main electronic instrument

The main electronic instrument consists of two parts :

1) a device for measuring the local mass of the fibre specimen, and

2) a calculator, automatically evaluating the length distribution parameters during the test.

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3.3 The recorder

A galvanometric or potentiometric recorder automatically traces the cumulative diagram of hauteur on squared paper during the test (see figure 1). The diagram ordinate gives the percentage (linear density biased) of fibres, the length of which is greater than the length shown by the corresponding abscissa. (The linear density biased percentage is very near to the numerical percentage.) The lengths in abscissa are actual lengths (scale 1/1).

4 TEST SPECIMENS

4.1 In the case of wool top slivers, the mass of which is between 15 and 30 g/m, a length of 1,20 m of sliver is broken off from the ball or bump top. Immediately after drawing this sample, it is held under slight tension and given 24 turns of twist; held taut in this state, it is then gripped at its centre, the two ends placed together and held there. It then suffices to release the centre progressively, turn by turn, keeping it slightly tensioned, to form a very uniform compact hank.

In this form, the sample may be kept indefinitely; it may easily be sent by post in a plastic bag to the testing laboratory.

This twisting operation is absolutely essential in order to obtain accurate test results

The twisting operation may be omitted only in the case when the ball of sliver or roving is available at the time of testing, or when the test is carried out within 4 h of sampling. It is, however, preferable in all cases to work according to the instructions above.

4.2 In the case of rovings or drawing slivers with a mass less than 15 g/m, a sufficient number of successive samples of 1,20 m are broken off to constitute, by juxtaposition, a sliver whose mass per metre is about 22 g (30 g maximum). In the juxtaposition, the slivers are always placed in the same direction (for example the leading end always to the left). Then, without delay, this made-up sliver is subjected to the twisting and hanking operation described in 4.1.

4.3 Samples must not be drawn from the outer layer (generally damaged by handling), nor from too near the centre of the ball.

4.4 Slivers having adventitious thickness faults (especially abnormal thick or thin places) are to be discarded. Also, slivers coming directly from the comb, "cut" or "chopped" slivers, and those containing fibre bundles (sometimes only apparent by examination of the sliver against the light) cannot be used in the test. In all these cases, the variation in fibre length between successive specimens is very great and very large errors may result.

5 CONDITIONING AND TESTING ATMOSPHERE

Under normal conditions, the electronic testing instrument is affected neither by the moisture content of the sliver nor by the temperature and humidity of the room where the test takes place.

However, the preparation of the specimen by the mechanical grip and the operations of transferring the specimen from the mechanical grip to the Almeter are much more easily performed with a sliver having a sufficiently high moisture content, corresponding to its regain in an atmosphere of between 55 and 75 % relative humidity. (In this way difficulties due to static electricity are avoided.)

Furthermore, the test is sensitive to sudden large variations in the local moisture content along the sliver, such as for example from the application of fibre lubricants in drop form followed almost immediately by testing. Also, slivers that have undergone treatment involving soaking (dyeing, backwashing, etc.) and those coming from a dryer should only be tested after a delay sufficient for moisture content variations to come to equilibrium.

In the case of samples of which the moisture content and particularly its homogeneity along the sliver are unknown, it is thus preferable to carry out a preliminary conditioning.

The instructions that follow are based on these considerations.

5.1 Conditioning atmosphere

5.1.1 *Test in a testing laboratory*

The sample, kept in the form of a twisted hank, is exposed to the conditioning atmosphere for a minimum period as indicated below. This period may possibly vary according to the type of material and the sampling conditions.

Generally, regardless of the origin of the sample of sliver, the preliminary conditioning period is 24 h in the standard atmosphere for testing as defined in ISO 139.

5.1.1.1 In the most frequent case of tops sampled in the normal way at a passage following combing, and all drawing slivers and rovings sampled from a machine where fibre lubricant is not applied, the period of conditioning in standard atmosphere can be reduced to a minimum of 4 h.

In some circumstances this period can be reduced still further — for instance, if a rapid conditioning enclosure is available in which the sample hank can be placed for half an hour. followed by a further half hour in the standard atmosphere.

Finally, the conditioning period may be omitted or reduced to a precautionary half hour when a combination of the following conditions occurs :

a) Sampling has taken place recently (approximately within the 4 h preceeding the test) during processing or from balls stored in a satisfactory atmosphere (of the order of 55 to 75 % relative humidity).

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b) The sample hank has been transported in a sufficiently airtight plastic bag, avoiding any excessive heat or cold.

5.1.1.2 For slivers coming from a process involving soaking, drying or oiling, a conditioning period of 24 h in standard atmosphere is to be observed.

In order to standardize the procedure, this period of 24 h may be adopted for all cases where no urgency exists.

5.1.2 *Tests in the laboratory of a mill or merchant*

The same rules for conditioning as given in 5.1.1 are to be observed. The standard atmosphere is, however, not essential; it is sufficient if the room atmosphere is of satisfactory relative humidity, between 55 and 75 %, and has a temperature between 18 and 28 °C. (A conditioning cabinet may be used if necessary.)

In mill laboratories conditioning may generally be omitted according to the indications in 5.1.1.1; however, when using a machine applying fibre lubricant it must not be forgotten that the applicator must be put out of use during the production of the sample.

5.2 Testing atmosphere

5.2.1 *Testing laboratory*

The test is to be performed in the standard atmosphere for testing : 65 ± 2 % and 20 ± 2 °C as defined in ISO 139. The machine must be situated sufficiently far from the humidification points (at least 1 m; if possible 1,5 m).

5.2.2 *Laboratory of a mill or merchant*

Standard atmosphere is advisable but not essential. Preferably, the same atmosphere should be used for testing as for conditioning (55 to 75 % relative humidity, temperature 18 to 28 °C).

Provided that the sample has been kept for a suitable period in a humid atmosphere (55 to 75 % relative humidity) according to the recommendations made in 5.1.1 and 5.1.2, and that the test is performed quickly, shortly after this period, it is sufficient for the atmosphere in the testing room to be fairly stable in temperature and humidity, having a relative humidity of between 30 and 75 % and a temperature between 15 and 30 °C.

The machine must be sufficiently far from any possible ventilation or humidification points (at least 1 to 1,5 m).

6 PREPARATION OF SAMPLES FOR TESTING

The sample, kept in hank form, is untwisted immediately before performing the test. Holding an end in each hand, the sliver is then straightened out by holding it taut and shaking it lightly.

If the sliver or roving sample available is in ball form, the drawing of the sample of 1,20 m takes place immediately before testing, after unwinding a few outer turns that have low tension.

The sliver sample is then introduced into the mechanical grip. (The procedure is described in annex B).

7 PROCEDURE

Transfer the specimen to the slide, set the machine, and start up the movement of the transporter slide and the recorder. Take readings l_1 and l_2 within 10 s after the stopping of the slide. Detailed procedure on the use of the instrument is given in annex C.

8 CALCULATION AND EXPRESSION OF RESULTS

After carrying out a test as described in clause 7 and after recording readings l_1 and l_2 taken from the microammeter with the "FUNCTION" switch in the first integral and double integral positions respectively, the hauteur, barbe and coefficient of variation are calculated as follows.

8.1 Calculation of hauteur *H* and barbe *B*

The hauteur, expressed in millimetres, is equal to reading l_1 multiplied by a coefficient α which depends on the range used, as shown in the table below.

$$H = l_1 \alpha$$

The barbe, expressed in millimetres, is equal to the quotient of reading l_2 by reading l_1 multiplied by a coefficient β which depends on the range used, as shown in the table below.

$$B = (l_2/l_1)\beta$$

TABLE — **Values of coefficients α and β used to calculate *H* and *B***

Range	α	β
1	$\frac{1}{2}$	75
2	$\frac{2}{3}$	100
3	1	150
4	$\frac{4}{3}$	200

8.2 Calculation of coefficient of variation of hauteur

The coefficient of variation of hauteur is given by the following formula :

$$CV_H = \sqrt{\frac{B-H}{H}}$$

or, expressed in %

$$CV_H = \sqrt{\frac{B-H}{H}} \times 100$$

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This calculation may be very easily carried out on a slide rule, putting the difference of $B-H$ on the squaring scale of the rule, and opposite this difference putting the H value lined up on the slider. The value of the coefficient of variation is then found opposite the 1 mark of the slider on the normal scale of the slide rule.

This calculation may also be performed very easily by means of nomograms as described in 8.4. However, it is preferable to use a calculating machine.

8.3 Percentage of short fibres

The percentage of fibres shorter or longer than a given length may be estimated either from the diagram traced by the recorder or directly on the instrument by reading the graduated scale.

This latter method is the more accurate : do not forget, however, to check at each test the verification indicated in C.2.2.3.3, annex C, before making the summary of the percentage.

8.4 Use of the nomograms[1)]

A set of nomograms is supplied with each instrument, enabling the hauteur, barbe and coefficient of variation to be calculated very easily.

There is a nomogram for each measuring range.

Calculation of hauteur : Select the nomogram corresponding to the measuring range used, then mark the value of the first integral (I_1) on scale C and read the hauteur value on scale B opposite the mark.

Calculation of barbe : Mark the value of the first integral (I_1) on scale C, mark the value of the second integral (I_2) on scale F, join these two points and the intersection with the axis of the barbes gives the value of the barbe.

Calculation of the coefficient of variation of hauteur : Mark the value of the first integral (I_1) on scale A, mark the value of the second integral (I_2) on scale F, join these two points, and the intersection with scale CV gives the coefficient of variation of hauteur.

A calculation example is given on each nomogram.

9 DEFINITION OF THE TEST ON TOP SLIVER – NOTES ON SAMPLING

9.1 Sliver asymmetry

The top sliver is slightly asymmetrical as a result of the presence, in unequal proportions in both directions, of fibre hooks.

For the sake of uniformity, the test is used to indicate the mean result for H, B and CV_H, obtained on both ends of the sliver.

9.1.1 In the case of the semi-automatic grip, a single test on the left-hand end of the sample of sliver and a single test on the right-hand end are to be performed following the instructions in clauses 7 and 8. The arithmetic mean of the results obtained on both ends of the sliver for H, B, CV_H, etc. is calculated.

9.1.2 In the case of the automatic motorised grip, the sliver is inserted folded and the draws are taken simultaneously from the left and right ends of the sliver. In this case, the results of a single test for H, B, CV_H, etc. made on the left and right average sample are designated "an Almeter test".

9.2 Suggestions regarding sampling

9.2.1 *Testing in a testing laboratory*

To characterise a lot, less than or equal to 5 tonnes (5 000 kg), three samples should preferably be drawn, each of 1,20 m of sliver from three different balls chosen at random.

After conditioning, two of these samples are kept for testing; on each of these "an Almeter test" as defined in 9.1 is performed.

If the difference between the two H tests of these first two slivers is greater than 2 %, the third sample is also tested. For greater masses, one sample per 5 tonnes portion is added, these samples being taken as production proceeds.

On each of these additional samples of sliver, "an Almeter test" as defined in 9.1 is performed.

9.2.2 *Testing in a mill laboratory*

In this case, several successive samples obtained in the course of production are tested : at least two (at the rate of one per portion of 1 to 5 tonnes (1 000 to 5 000 kg) for example) and preferably three, if the difference between the first two H tests is greater than 2 %.

For large lots, an additional sample for each 5 tonnes portion may also be taken. It is to be remembered that one H test is defined here as the mean of two single tests, one left-hand and one right-hand.

IMPORTANT NOTE — The recommendations given in 9.2 regarding sampling are not of an obligatory nature. They are suggestions based on actual experience (very fragmentary) of variations of fibre length within a lot of top.

Wider experience, obtained through collaboration between national testing laboratories and national industrial associations, will be required in order to definitely standardize this sampling procedure.

1) Large size nomogram (42 cm × 60 cm) are available.

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ANNEX A

LITERATURE REFERENCES

References 1 and 2 below explain the conception and working of the machine.

References 3, 4 and 5 describe experiments and inter-laboratory tests carried out on the Almeter.

Reference 5, among other things, analyses the causes of error in the use of the Almeter.

References 6 and 7 contain regression equations relating Almeter results to Schlumberger Analyser results.

References 8 and 9 are specially recommended to the reader wishing to acquaint himself with fibre length measurement (exact definitions and relationships between the various parameters, correlation with evaluation by experts, etc.).

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6) DILLIES H., MAZINGUE G. and VAN OVERBEKE M. : "Regression Almeter/Schlumberger dans le compte rendu des discussions du C.T. de la F.L.I. réunion de Paris, décembre, 1963." [Comparison of the Almeter and Schlumberger machines.] *Bull. Inst. Text. France,* 1965, **117**, 191; or *Bulletin C.T.C.R.S.* (Roubaix), 1964, **64**, 385.

7) MONFORT F. : "Information expérimentale relative au fonctionnement de l'appareil Almeter." [Experimental information regarding the operation of the Almeter.] *Ann. Sci. Text. Belges,* No. 1, March, 1964.

8) MONFORT F. : *Aspects Scientifiques de l'industrie Lainière*. [Scientific aspects of the wool industry.] Editions DUNOD, Paris, 1960.

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ANNEX B

SPECIMEN PREPARATION USING THE SEMI-AUTOMATIC GRIP

B.1 OPERATION OF THE GRIP

The test specimen is to be made up of a certain number of successive fibre draws extracted from a sliver of parallel fibres from one original base line.

The draws are assembled so as to make a specimen of sufficient size, representative of the lot being tested, and weighing about 1 g. This specimen is placed in a pinned device called a "specimen holder" consisting of a series of fallers connecting two aluminium chassis, forming handles.

The grouping of the draws is by both superposition and juxtaposition. For instance, in the case of wool, the specimen is made up of on the average ten to sixteen draws, with two tufts of five to eight superimposed draws placed side by side.

In order to make the functioning of the grip clear, the operation to be performed for making the draw on a prepared machine will first be explained (sliver inserted and prepared for squaring). Then a detailed examination will follow, in their chronological sequence, of the various steps to be carried out in the preparation of a specimen :

- insertion of the sliver;
- squaring;
- making the actual draws;
- transfer to the electronic apparatus.

The operation of the grip may be split up into four successive stages. At the start of the operation it is assumed that the grip is in position D (starting position) characterised as follows (see figures 2, 3 and 4) :

1) The left-hand lever (4) is in position b, to the right of vertical, the jaws of the grip itself are separated (the grip is said to be "open"); the embedding device (3) is raised in position a (figure 2).

2) The carriage (7) is in the extreme right position against the stop, the right-hand lever (8) is inclined towards the right in position b. The combing brush (15) is raised (swung to the right).

Stage I — Advancing the carriage towards the grip

With the left hand resting without pressure on the knob of lever (4), pull the whole of the carriage towards the left by means of the right hand holding the knob of lever (8). In carrying out this movement, lever (8) passes firstly from position b (inclined to the right) to position a (inclined to the left). This pulling movement must be carried out fairly quickly so that the carriage reaches the left-hand end of its track with sufficient force to switch off the various controls at the track end.

On arrival at the end of the track, pressure towards the left must be maintained on lever (8) so as to keep a well defined stopping position (lower end 8_L of lever (8) pressed against the stop).

Stage II — Closing the grip on the left-hand end of the sliver

With the right hand still pressing lever (8) to the left, lever (4) is swung to the left into position a by means of the left hand. The jaws of the grip close onto the ends of the fibres projecting from the pins of the first row of retaining combs.

Stage III — Extraction of a fibre draw and return of the carriage

With the left hand resting on lever (4) without it exerting pressure), the right hand pushes lever (8) back to the right so as to move the carriage to the right up to the stop.

This third stage is divided into two parts.

Stage III/1 — The right hand moves lever (8) gradually from position a (inclined to the left) to position b (inclined to the right). During this first part, the lower part 8_L of the lever is supported on the front stop to reduce the force exerted for the extraction of the gripped fibres from the sliver.

The operation must be performed at a fairly slow speed according to the number of fibres in the cross-section : more slowly for a fine merino sliver, more quickly for a cross-bred sliver. As soon as lever (8) has swung to b, movement is speeded up for the next phase.

Stage III/2 — With lever (8) remaining blocked in position b, the pressure exerted to the right by the hand continues to move the carriage until its stop at the right-hand end of the track. The operation according to this second part of stage III may be carried out very quickly, but not so excessively as to strike the stop violently.

Stage IV — Release of the draw from the jaws of the grip and embedding into the pins of the specimen holder.

With the right hand resting on lever (8) (no pressure required) the left hand moves lever (4) from its left-hand position a to its right-hand positions c, passing through the intermediate position b (do not exert any axial force during this movement).

This fourth stage may also be divided into two parts.

Stage IV/1 — Opening of the grip — During the passage of the lever from position a to position b, the jaws of the grip open and the fibre draw is released.

Stage IV/2 — Embedding the draw — During the passage of the lever from position b to the position c, the plate on which the specimen holder rests is swung downwards to the right and the embedding unit is lowered from position a to position b.

At the end of this downward movement, pressure with the left hand is released and lever (4) is allowed to return to its rest position b by the action of a spring.

The tuft of fibres is thus embedded at some depth in the pins.

During this second part of stage IV, the sequence counter, situated on the left, advances one unit.

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B.2 SEQUENCE OF OPERATIONS FOR THE PREPARATION OF A SPECIMEN

B.2.1 Insertion of the sliver

When it is out of use, the semi-automatic grip is left in position A (normal rest position), preferably protected by a cover.

The rest position A is characterised as follows :

- lever (4) in position b;
- retaining combs (11) swung to the right (i.e. horizontal);
- levers (12A, 12B) horizontal;
- yoke (13) horizontal;
- carriage (7) 4 or 6 cm from its right-hand stop;
- brass plate (14) below the retaining combs;
- specimen holder (6) at the side of the grip.

Before the insertion of the sliver, the semi-automatic grip is put in position B : for this, the two transporter levers (12A, 12B) are raised vertically with the right hand and simultaneously the retaining comb (11) is swung to the left with the left hand. The feed roller (10) is then raised by swinging the yoke (13) to the left, as shown in figure 3.

The sliver, of suitable length, is then passed under the feed roller by first holding it in the right hand, then taking it with the left hand to the left of the roller.

It is then guided with the left hand in the chrome channel until its left-hand end projects about 20 cm beyond the end of the channel.

The left-hand end of the sliver is compressed by hand so that it only occupies the centre (3 to 4 cm) of the grooved part and is not trapped when the plate (14) is lowered.

With the right hand, the grooved brass plate (14) is placed on the sliver, positioning it in the guide studs at both sides of the channel.

The retaining comb is swung to the right by holding it by the cylinder (28), taking care that the teeth of the comb do not catch the brass plate. The brush (15) lifts automatically.

Swing the yoke (13) back to the right.

Replace the levers (12) horizontally.

The automatic grip is thus in position C, ready for the next operation.

B.2.2 Squaring the sliver

Squaring is commenced by hand, by removing fairly large tufts of fibres from the end of the sliver by successive draws between the thumb and index finger of the left hand placed perpendicular to the direction of the fibres to remove large tufts. The fibre bundles are kept in the palm of the hand until a bulky accumulation is formed, which is discarded before continuing.

On reaching about 20 mm from the end of the channel, the size of the tufts removed must be reduced by making small extractions between the ends of the thumb and index finger over a sliver width of about 5 mm at a time.

Squaring by hand stops when the end line of the sliver is about 5 mm in front of the first row of pins of the retaining comb.

Take care not to catch the fingers in the first row of teeth of the retaining comb.

The operation is then continued with the semi-automatic grip by successively performing the movements corresponding to stages I to IV/1 of the complete operation described in B.1, omitting stage IV/2. The complete cycle of drawing movements (excepting IV/2) is repeated about five to eight times until a perfectly squared base line is obtained. The draws collected in the jaws of the grip are removed every three to four times for examples, as they form a bulky mass liable to hinder gripping.

B.2.3 Drawing and formation of the specimen

At the end of the 8th squaring movement (I to IV/1), the plate (5) is placed in its bottom right-hand position and the specimen holder (6) is inserted into the grooves of the plate (5) until the front edge of the handle (that turned towards the operator) (reference mark 16B) reaches the red reference mark (16A). The counter is set to zero by means of the knurled wheel, a series of complete movements is then executed (stages I to IV) in order to superimpose the draws constituting the first half of the specimen. The specimen holder is then slid towards the operator until the second red reference mark (16C) reaches reference mark (16A).

The second half of the draws are then superimposed by a series of complete movements. The second tuft thus formed is in this way juxtaposed to the first.

B.2.4 Transfer of the specimen

When the selected number of draws has been reached, the specimen holder (6) is pulled towards the operator, out of the plate (5) and holding it with both hands by the handles at either side it is held above the carriage of the electronic apparatus after turning it over with pins downwards. The subsequent operations are described in clause 7 of the standard method of test.

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ANNEX C

THE ALMETER[1]

C.1 CHARACTERISTICS

The apparatus comprises three parts :

C.1.1 The mechanical grip

The mechanical grip is as described in 3.1.

C.1.2 The main instrument

The Almeter consists of two parts, assembled within one chassis :

1) a device for measuring the local mass of the fibre specimen;

2) a calculator, automatically evaluating the length distribution parameters during the test.

The device for measuring the local mass is made up of a specially designed condenser in the shape of an elongated rectangle measuring 1,8 mm × 175 mm. The small dimension (1,8 mm) of the condenser which is in the direction of the fibres enables a detailed examination of local mass to be made from the tip of the specimen to the line of the common origin of the fibres.

A slide automatically traverses the test specimen at a constant rate between the electrodes of the measuring condenser.

C.1.3 The recorder

The recorder is as described in 3.3.

C.2 METHOD OF OPERATION

C.2.1 Starting-up the machine

C.2.1.1 *Switching-on*

The machine is switched on by means of the "On-Off" switch (figure 1) or, if a stabiliser is used, by means of the Start/Stop switch.

Never leave the stabiliser switched on (red lamp lit) with the Almeter out of use.

C.2.1.2 *Warming up periods*

After 10 min warming up the Almeter is ready for carrying out tests. A slight drift from zero and from 100 on the recorder may be observed during the first half hour, but does not affect the accuracy of tests performed on the Almeter.

C.2.1.3 *Recommendations regarding the switching-on periods*

Successive switching-on and off of the machine is more harmful to the life of the valves and the stability than prolonged continuous use. There is thus no advantage in switching off the machine for periods of less than 3 h for example.

C.2.2 Test procedure

C.2.2.1 *Transfer of the specimen*

C.2.2.1.1 With the "FUNCTION" knob (10, figure 1) in the "Ampli" position, the lever (12) is placed at "0". The slide is then withdrawn completely by hand, then opened by raising the upper part to the vertical position.

C.2.2.1.2 The specimen holder is inserted above the lower cover of the slide with the pins facing downwards and the base of the specimen (aligned ends of fibres) towards the operator. The two locating studs on the side of the operator are inserted into the corresponding holes on the lateral rails of the slide.

NOTE — In order to limit as far as possible the risk of piercing the plastic cover with the pins of the specimen holder, it is recommended that the following method is used.

1) Insert the specimen holder above the plastic cover in such a way that the left-hand locating stud towards the operator is slightly lower than the other stud. Only this stud will engage in its stocket.

2) Next, the right-hand locating stud is inserted in its socket, keeping the specimen holder inclined so as to keep the pins as far as possible from the plastic cover.

3) Only when the two locating studs are engaged in their sockets lower the specimen holder slowly onto the slide.

C.2.2.1.3 The extractor system (18, figure 3) consisting of parallel steel rods is then inserted between the fallers of the specimen holder with only one rod in front of the first faller on the side of the operator.

Pushing the extractor, fully downwards, the specimen is extracted from the pins and deposited on the lower cover of the slide. The clamp bar (19, figure 3) is then lowered on to the cover as a precautionary measure, against the first rod, until it rests flat on the cover, its forepart clamping the aligned ends of the fibres. Next, taking the specimen holder by its two handles, it is lifted slightly on the side facing the operator only, in order to disengage the locating studs.

Then keeping it supported on the rails, it is moved gently towards the front edge, pushing lightly to the right.

1) The information given on this machine is not intended to favour its use or to give preference to this apparatus. Other apparatus giving equivalent results may be used.

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On the right of the specimen holder, on the side of the machine, there is a guide stud against the edge of the lower rail of the slide.

This movement continues for about 15 mm until the specimen holder comes to rest against the rails of the upper part of the slide raised to the vertical. Then the whole of the specimen holder and extractor is raised vertically and placed on the table beside the machine.

The clamp bar is then removed by pivoting it gently on its edge supported on the cover on the side of the operator. Great care is to be taken not to displace the specimen during this operation.

C.2.2.1.4 The upper cover is then lowered, at first rapidly until it is about 2 cm above the lower cover, then very slowly to avoid spreading out the specimen. Light pressure is applied to the upper part of the slide to check that closure is complete.

C.2.2.2 *Preliminary machine settings*

C.2.2.2.1 ZERO ADJUSTMENT

The slide is pushed by hand until it is completely in the machine and left in this position. The knob "Meter 0" (3 figure 1) is moved until perfect coincidence of the microammeter needle, the reference mark 0 on the scale, and the image of the needle in the mirror of the microammeter (close one eye for this adjustment).

VERY IMPORTANT NOTE — Incorrect setting of the electric zero can produce very great differences in the l_1 and l_2 values, as the zero-setting error is integrated throughout the test. This adjustment must therefore be carried out very carefully.

C.2.2.2.2 LOCATION OF MAXIMUM (corresponding to the base of the specimen)

Place the lever (12) in the "MAN" (Manual) position, and move knob (13) situated on the right-hand side of the machine anti-clockwise to remove the slide slowly. The scale needle rises to a maximum, then descends. Then go back, moving the transport knob (13) in the reverse direction, then by successive short forward and backward movements, progressively slower, make quite sure that the maximum has been reached. (The maximum reading is generally stable within a zone of a few millimetres.) If during this operation the needle passes the 100 mark on the scale, bring it back to the 70 to 100 region by turning the "Meter 100" knob (8, figure 1) anti-clockwise.

C.2.2.2.3 100 SETTING

When the carrier position corresponding to the maximum reading has been positively reached, move the "Meter 100" knob to bring this reading to exactly 100 (observe the coincidence as in the zero-setting).

If the reading remains to the left of the 100 mark with the "Meter 100" knob turned completely to the right, the size of the specimen is insufficient. It must be discarded and a new specimen must be made with a greater number of draws.

If the needle remains to the right of the 100 mark with the "Meter 100" knob turned completely to the left, the specimen is too large. Prepare a new specimen with fewer draws.

C.2.2.2.4 SELECTION OF RANGE

The machine has 3 or 4 test ranges selected by position "1-2-3-4" on the "RANGE" switch (11, figure 1). The following is the procedure for selecting the suitable test range :

With the "FUNCTION" switch (10) in the "Ampli" position and the lever (12) in the "MAN" position, by moving the transport knob (13) anti-clockwise bring the scale reading to 50 %. Read off the corresponding length "l" opposite the mark on the scale (15).

If "l" is less than or equal to 45 mm, switch to range 1.

If "l" is between 45 and 60 mm, switch to range 2.

If "l" is between 60 and 90 mm, switch to range 3.

If "l" is greater than 90 mm, switch to range 4.

If, however, at the end of the test, one of the l_1 or l_2 readings exceeds 100, recommence the test selecting the higher range (3 instead of 2 for instance).

C.2.2.3 *The actual test*

C.2.2.3.1 The lever (12) is placed at position "0" and the slide is withdrawn by hand until the longest fibres are flush with the stainless steel plate above the upper cover.

The lever is then lowered into the "MOT" (motor) position, and the "FUNCTION" commutator turned to position "$\int$" (first integral).

NOTE — Before moving the "FUNCTION" commutator to "$\int$", wait for the scale needle to come to rest in the immediate vicinity of zero.

The "Start" button (5) is then pressed for a moment to start up the movement of the transporter slide and the recorder.

C.2.2.3.2 When the base of the specimen passes into the measuring head, the slide automatically stops, a slight click being heard. (The recorder stops simultaneously.) At this moment, the first reading l_1 on the scale is taken (to 0,1 division approx.) — (observe as for the zero setting). Pass immediately to position "$\int\int$" (double integral) on the "FUNCTION" commutator and also take the second reading l_2.

NOTE — The l_1 and l_2 values are removed from the memory of the calculator when the "FUNCTION" switch is switched to the "Ampli" position.

These readings must be taken within the 10 s after the stopping of the slide.

C.2.2.3.3 The "FUNCTION" switch is then put back to the "Ampli" position and the microammeter must read between 46 and 50. This means that the condenser is exactly at the theoretical base of the specimen (halfway between maximum and zero).

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After the automatic stopping of the slide, check whether the first mark (zero) on the scale (15) coincides with the reference mark on the stainless steel plate, with a maximum tolerance of ± 1 mm. If the displacement is greater, it is probable that the specimen has slipped during transfer. In this case, recommence the sampling procedure and test, or make allowance for the displacement of the zero of the scale for l (5 %), l (1 %), l_3 and l_4. If the displacement is repeated, readjust the position of the scale.

C.2.2.3.4 With the "FUNCTION" switch still in the "Ampli" position and the lever (12) in the "MAN" position, the transporter knob (13) is turned until graduation 2,5 cm on the scale (15) is reached. Reading l_3 (percentage of fibres longer than 2,5 cm) is then read from the scale.

Continuing to move the transporter knob, the 4 cm graduation on the scale (15) is brought to the edge of the stainless steel plate. Reading l_4 (percentage of fibres longer than 4 cm) is then read from the scale.

The percentage of fibres shorter than 2,5 (or 4) cm is the difference between 100 and reading l_3 (or l_4).

C.2.2.3.5 Continuing to move the transporter knob, the scale reading is brought exactly to 5. Reading l (5 %), (length of or length exceeded by only 5 % of the fibres) is read from the scale (15).

Next, the transporter knob is moved to bring the scale reading exactly to 1.

Then, on the scale opposite the edge of the stainless steel plate, length l (1 %) is read off, which is to be regarded as the maximum fibre length (exceeded by only 1 %).

C.2.2.3.6 To obtain a second diagram (copy), move the lever (12) to the "0" position, withdraw the slide until the longest fibres are flush with the stainless steel plate, put lever 12 back in the "MOT" position and press the "START" button.

C.2.2.3.7 Lever (12) is then put back to the "0" position and the slide withdrawn fully forward by hand, the upper part of the slide is raised to the vertical and the specimen is removed after using it to pick up the fibres adhering to the cover.

The machine is then ready for the next test.

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ANNEX D

CONTROL OF THE MACHINE

COMPLETE TEST OF THE ALMETER

The series of tests described below enables the correct working of the machine to be fully checked. The tests must be carried out in the order indicated.

A complete test is to be carried out every month, and before a series of tests requiring great accuracy (interlaboratory tests for example).

D.1 CHECKING THE MECHANICAL ZERO OF THE MICROAMMETER

This check must be carried out before switching on current to the machine; if the machine is switched on, switch it off (switch at "off") and wait for 10 min.

Then stand in front of the microammeter (scale), close one eye and check that the microammeter needle, the zero reference mark on the scale, and the image of the needle in the mirror are perfectly superimposed. Tap the screen lightly during this check.

If coincidence is not perfect, make the required correction by means of the screw on the front face of the microammeter. Only turn a small fraction of a turn to the left or right (do not turn the screw a full turn).

D.2 CHECKING THE ABSENCE OF FRICTION IN THE MICROAMMETER

Normal wear of the pivots of the spindle carrying the scale needle can in the long run cause friction, reducing the accuracy of the reading and in particular affecting the zero-setting before testing. To check this, a calibration lozenge test is performed according to D.5, but with range 3 switched on. When the automatic stop has operated, note reading l_1. Then tap the screen and note the new l'_1 reading, which as a result of friction will be greater than l_1. (Note the readings to the nearest 0,1 division.)

Carry out the test five times.

If the mean difference between l'_1 and l_1 is greater than 0,4 division, the microammeter must be overhauled.

D.3 CONTROL OF THE GAIN BY THE CALIBRATION RECTANGLE TEST

The current is first switched on to the machine (switch at ON). After half an hour (or more) the calibration rectangle test is carried out according to the following instructions :

The calibration rectangle is supplied in a small case attached to each machine. This case also contains the calibration lozenge for the lozenge test described later.

These calibrators must be handled carefully with clean hands and not be scratched or damaged in any way.

The control using the plastic rectangle is intended to check the gain of the amplifier with respect to the output level of the oscillator. As a result of the gradual ageing of the valves in this circuit, the gain normally diminishes during the life of the valves. Moreover, a fairly rapid variation in oscillator output level may be produced at the start of the life of the valves.

The gain must remain higher than a set minimum value so that the corresponding circuits operate under good conditions and that the number of draws required to make up a specimen does not become too high.

D.3.1 Method of operation

D.3.1.1 After opening the slide and removing the adhering fibres, the calibration rectangle is placed centrally on the width of the cover, its long side parallel to the edges of the cover and the short front side (opposite the operator) about on a line passing through the 13 mark on the lateral scale (at ± 1 cm approx.).

D.3.1.2 After pushing the slide fully into the machine and leaving it in this position, zero-setting is carried out as for a normal test.

D.3.1.3 The "Meter 100" knob is then turned fully to the right (there is no actual stop, but higher friction stops its rotation).

D.3.1.4 The slide is then withdrawn by hand, with the lever still in the "0" position, until the short side of the rectangle facing towards the operator is flush against the stainless steel plate above the cover, on the front face of the machine.

D.3.1.5 With the "FUNCTION" switch still in the "Ampli" position, normally the reading on the scale of the microammeter is greater than 80 and less than 100 divisions. If the reading obtained is outside these limits, it must be moved to 90 divisions ± 2 by changing the oscillator output level, then, if necessary, the gain of the amplifier.

This adjustment is preferably left to the manufacturer's service engineer. The calibration rectangle test must be carried out approximately every month when the machine is being used an average of 8 h a day.

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D.4 CHECK OF THE SPECIMEN COVER

The original cover, subjected to a strict check, normally has a long life. The small folds, streaks and scratches of various kinds appearing during normal operating conditions have no appreciable effect.

However, some faulty movements are likely to seriously damage the uniformity of the cover. Amongst the faults that may be mentioned that affect the accuracy of the test are deep impressions or even holes made by the pins of the specimen holder, a localised dent caused by a heavy object falling, deep wide folds (of the order of 1 cm) due to over-tension, burns caused by cigarette ash, etc.

It is therefore necessary to inspect the state of the cover regularly by means of a test described below.

It is also recommended that a diagram be recorded during the test described. This will show whether any small localised faults (lumps or hollows) greater than ± 1 % exist.

These localised faults have not much effect on the results of the test but can influence the form of the length diagram.

D.4.1 Method of operation

The check is preferably carried out half an hour (or more) after beginning to use the machine.

D.4.1.1 Remove all fibres on the cover. Check carefully that the cover is clean, without soil or dust and free from grease; in case of doubt clean it, using a cloth impregnated with an anti-static agent. Take care to spread a very thin uniform layer over the four surfaces, wait for about 10 min for the solvent to evaporate fully before closing the slide and carrying out the test.

Also check that the measuring condenser is quite clean : remove any fibres or dust, using the small special brush.

This operation must be performed with great care, exactly as follows : with the slide closed and pulled out about 15 cm, insert the brush between the upper cover and the stainless steel guard plate, just above the right-hand side of the cover, without going more than 5 mm to the right of the cover.

Insert the brush gently until it is level with the steel guard plate (avoid inserting the metal handle below the guard plate). Now move the brush from right to left until it comes against the condenser mounting, about 15 mm beyond the left-hand side of the cover.

Withdraw the brush towards the operator.

Repeat the operation below the lower cover, between this and the lower brass mounting of the condenser. (Keep the small brush clean by rinsing in alcohol.)

D.4.1.2 Put the "FUNCTION" commutator in the "Ampli" position. Turn the "Meter 100" knob fully to the right, until greater friction resists its rotation. Using the "Meter 0" knob, bring the scale reading exactly to 0, checking the coincidence in the mirror.

D.4.1.3 Withdraw the slide (by hand) to the 15 cm mark on the scale. Switch the "Range" switch to range 1, turn the "FUNCTION" knob to the "$\int$" position, lower the lever to the "MOT" position, and press the "Start" button.

D.4.1.4 Wait for the carriage to stop automatically at the end of the track, then take the two readings I_1 on "$\int$" and I_2 on "$\int\int$" (FUNCTION knob).

I_1 must be between $-0{,}8$ and $+0{,}8$ divisions; and I_2 between $-1{,}5$ and $+1{,}5$ divisions (either side of zero).

D.4.1.5 Return the lever to "0" and the "FUNCTION" knob to "Ampli". Re-check the "0" very exactly, and if necessary readjust it with the "Meter 0" knob, with the slide pushed fully in. Then pull the slide forward by hand to the 30 cm mark on the scale.

D.4.1.6 Turn the Range switch to range 3, the "FUNCTION" to "$\int$", the lever to "MOT", and press the "Start" button.

D.4.1.7 When the carriage stops, read I_1 at "$\int$" and I_2 at "$\int\int$".

I_1 must be between $-0{,}8$ and $+0{,}8$ divisions; and

I_2 between $-1{,}5$ and $+1{,}5$ divisions.

NOTES

1 When the I_1 and I_2 values are positive, check whether the zero setting has been made slightly too high.

On the other hand, when the I_1 and I_2 values are negative, check whether the zero setting has been made slightly too low.

If the I_1 and I_2 values are between the set limits, no importance should be attached to any faults in the cover.

2 The test is normally performed once a week, whenever a fault is noticed on the cover, and immediately after any operation wrongly carried out or any important visible fault.

When a cover no longer satisfies any of the conditions mentioned (I_1 and I_2 outside the specified limits, or isolated differences of readings greater than ± 1 %) it must be replaced; sometimes it is possible to repair the cover.

These operations, which are normally fairly delicate, should preferably be entrusted to a service engineer.

D.5 CALIBRATION LOZENGE TEST

The test using the calibration lozenge is intended to check the correct functioning of the whole of the electronic machine, that is to check the measuring tension amplifier and the analogue computors simultaneously.

The principal role of the test is to warn the operator of any sudden breakdown that may occur (sudden failure of a component in the electronic circuits). Secondly, it enables an approximate check to be made of the calibration of the machine, thus ensuring the accuracy of tests.

The check should preferably be carried out after half an hour (or more) of the machine being put into service (between two series of tests for instance).

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D.5.1 With the "FUNCTION" knob in the "Ampli" position, the "Range" switch at range 1, and the lever at "0", the transporter slide of the electronic machine is withdrawn *completely* by hand, then opened by raising the upper part almost to the vertical.

D.5.2 All fibres on the cover are carefully removed. Then a calibration lozenge is placed centrally on the width of the cover, its long axis in the direction of travel of the slide, that is *parallel to the edges of the cover,* the front edge approximately on a line passing through the 13 cm mark on the lateral rule, and the end of the lozenge marked by a reference mark or number turned towards the operator.

The transporter slide is then closed.

D.5.3 Preliminary adjustments are then made as for a normal test on a wool sample : set the zero, find the maximum, and set to 100. Then, leaving the slide in the position corresponding to maximum, with a consequent scale reading of 100, button (9) "Recorder Test" is pressed, *the recorder motor thus being switched on* (check that the recorder switch is in the position ensuring paper transport).

While the recorder paper is running, the 100 reading on the scale must not vary by more than 0,3 division (for example 99,7 instead of 100). (A machine in perfect condition will show a reduction of 0,1 to 0,2 division : 99,8 to 99,9 instead of 100.)

If this is not the case, the two valves of the high-frequency amplifier must be replaced. This is best carried out by the service engineer. When this check has been completed, stop pressing the "Recorder Test" button. The slide is then withdrawn by hand until the front edge of the lozenge is level with the stainless steel plate above the upper cover, then the actual test is performed as on wool sample.

D.5.4 Value l_1 is read, and must be within ± 1,5 of its nominal value; value l_2 within ± 3; and the relationship $100\frac{l_2}{l_1}$ within ± 2.

Mean nominal values

	l_1	l_2
Range 1	98,2	85,8
	73,8	48,4
	49	21,7
	36,8	12,2

The specific values for each lozenge may differ slightly from those given above; they are given separately.

D.5.5 With the lever in the "MOT" position, place the "FUNCTION" switch in the "Ampli" position and note the "*Aa*" (automatic stop) reading on the scale.

Aa must be between 49 and 51.

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ANNEX E

CALIBRATION CHECK OF THE MACHINE

E.1 On request, the maker supplies a collection of five calibration trapeziums, enabling a very accurate and complete calibration of the machine to be carried out on its four ranges.

This type of calibration has been developed as a result of observations made by the "Fibre Length" sub-committee of the I.W.T.O.

Calibration trapezium No. 1 (the smallest) is measured ten times on each of ranges 1 and 2.

Calibration trapezium No. 2 : ten times on each of ranges 1, 2 and 3.

Calibration trapezium No. 3 : ten times on each of ranges 2, 3 and 4.

Calibration trapezium No. 4 : ten times on ranges 3 and 4.

Calibration trapezium No. 5 : ten times on range 4.

IMPORTANT NOTE – In carrying out the zero and 100 settings before each test, tap the microammeter scale lightly.

Thus a total of eleven check values is obtained.

The mean of ten readings, l_1, l_2 and l_2/l_1 for each of these eleven values is then compared with the nominal values : the tolerance for the mean of the ten l_1 readings and the ten 100 l_2/l_1 relationships is ± 0,6 division (i.e. ± 0,3 mm in length on range 1).

If the admissible deviations are exceeded, the maker's service engineer should carry out readjustment, range by range.

Using a recorded values/nominal values regression for these calibration trapeziums, "reduced" values may also be obtained from recorded values on wool specimens.

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ANNEX F

ACCURACY OF THE METHOD

An interlaboratory experiment, involving 32 participants in 5 countries, comprising 5 official testing or research laboratories and 27 mill laboratories, has permitted the determination of confidence limits for Almeter length measurements in normal industrial usage. The results were analysed for 26 manual sampling grips and 11 automatic grips, some participants having performed tests with both types.

From each of five commercial lots of top that had not been subjected to any special treatment and covering a range of hauteur between 46 and 94 mm, samples drawn from a single ball of top were distributed to the participants.

The coefficient of variation of tests within a laboratory (CV_0) and between laboratories (CV_1) for each of the five lots examined was obtained by an analysis of variance.

The values obtained thus take into account not only the variance due to apparatus (which is generally negligible within a laboratory) but also the variance of length distribution within a ball of top sliver.

However the variance of length distribution during the production of a lot, which is translated into an inter-ball variance, is not included. An estimation of this variance, obtained by an industrial investigation, will be published later.

In order to summarise the results of the five commercial lots used (selected at random from the ordinary production of two combing establishments) and also to take account of cases corresponding to lots more heterogeneous within a ball than those used in the experiment, the following hypothesis has been made : the five lots examined were regarded as coming from a population of lots of normal distribution as far as the variation of Almeter measurements is concerned, and the variation for a limit lot corresponding to a probability threshold of 10 % has been calculated.

The values given below (tables 1, 2 and 3) have therefore been calculated in this way from the experimental results obtained from the five lots. Consequently they give an estimate of the maximum values that will be obtained from the coefficients of variation CV_0 and CV_1, and also for the confidence limits and maximum probable differences (M.P.D.) between laboratories, in the case of samples drawn from a single ball of top.

Definition of a "measurement" on the Almeter

In order to avoid the influence of any possible asymmetry between the two directions of the sliver, an Almeter "measurement" is defined as the result of an evaluation of the length distribution on both "left" and "right" ends of the sliver.

1) In the case of the manual sampling grip, a "measurement" is thus defined as the arithmetic means of two "readings", the first reading relating to the left end of the sliver and the second to the right end.

One "measurement" with the manual grip thus requires two specimens to be taken, one from the left and the other from the right, and two passages on the Almeter apparatus.

2) In the case of the automatic sampling grip, a "measurement" is defined as corresponding to a single reading on a single specimen, but with the introduction of the folded sliver into the faller field of the grip : sampling thus takes place simultaneously on the "left" and "right" ends. One "measurement" thus corresponds to one specimen being taken with a single passage on the Almeter.

The CV_0 and CV_1 values in table 1 are given for "one measurement" as defined above, and thus for two specimens and two Almeter passages in the case of the manual grip, and a single specimen with a single Almeter passage in the case of the automatic grip.

Similarly, the values of the confidence limits (C.L.) and the maximum probable difference (M.P.D.) are given in tables 2 and 3 as a function of the number of "measurements" as defined above, and thus corresponding in each case to twice the number of specimens and twice the number of Almeter passages when the manual grip is used.

The variance within a laboratory is characterised by the "intra" coefficient of variation CV_0. It is therefore practically the same for a single specimen (folded) and a single Almeter passage with the automatic grip as for the mean of two specimens (left and right) and two Almeter passages with the manual grip.

The variance between laboratories is characterised by the "inter" coefficient of variation CV_1. It is therefore lower for a single folded specimen with the automatic grip than that obtained for two specimens and two passages with the manual grip.

The confidence limits (C.L.) given in table 2 are established on the basis of the "intra" coefficient of variation CV_0. They thus take into account the variance due to apparatus within a laboratory, and the variation of length distribution throughout a sample drawn from a ball of top. The limits do not take into account the variation during production of the lot (between balls, for example), nor the inter-laboratory variation.

The maximum probable difference (M.P.D.) given in table 3 expresses the difference that may be expected between the results (means of k "measurements") of two laboratories testing samples drawn from the same ball. This difference, calculated at the probability threshold of 95 %, will on average only be exceeded 5 times out of 100.

The M.P.D. thus take into account the variance within laboratory and the variance between laboratories testing samples from the same ball, but not the possible variation between balls throughout the lot.

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TABLE 1

	CV_0 % Variation within a laboratory		CV_1 % Variation between laboratories	
	automatic grip	manual grip	automatic grip	manual grip
Hauteur	1,80	1,80	1,30	1,59
Barbe	1,36	1,36	1,08	1,53

TABLE 2

Number of measurements k	$\text{C.L.} = \pm \frac{2\,CV_0}{\sqrt{k}}$			
	Hauteur		**Barbe**	
	automatic grip	manual grip	automatic grip	manual grip
1	3,60	3,60	2,72	2,72
2	2,54	2,54	1,92	1,92
3	2,08	2,08	1,57	1,57
4	1,80	1,80	1,36	1,36
5	1,61		1,22	
6	1,47		1,11	
7	1,36		1,03	
8	1,27		0,96	

TABLE 3

Number of measurements k	$\text{M.P.D. \%} = 2\sqrt{2}\sqrt{CV_1^2 + \frac{CV_0^2}{k}}$			
	Hauteur		**Barbe**	
	automatic grip	manual grip	automatic grip	manual grip
1	6,28	6,79	4,91	5,79
2	5,15	5,76	4,09	5,11
3	4,71	5,37	3,78	4,86
4	4,47	5,17	3,61	4,73
5	4,32		3,51	
6	4,22		3,43	
7	4,15		3,38	
8	4,09		3,34	

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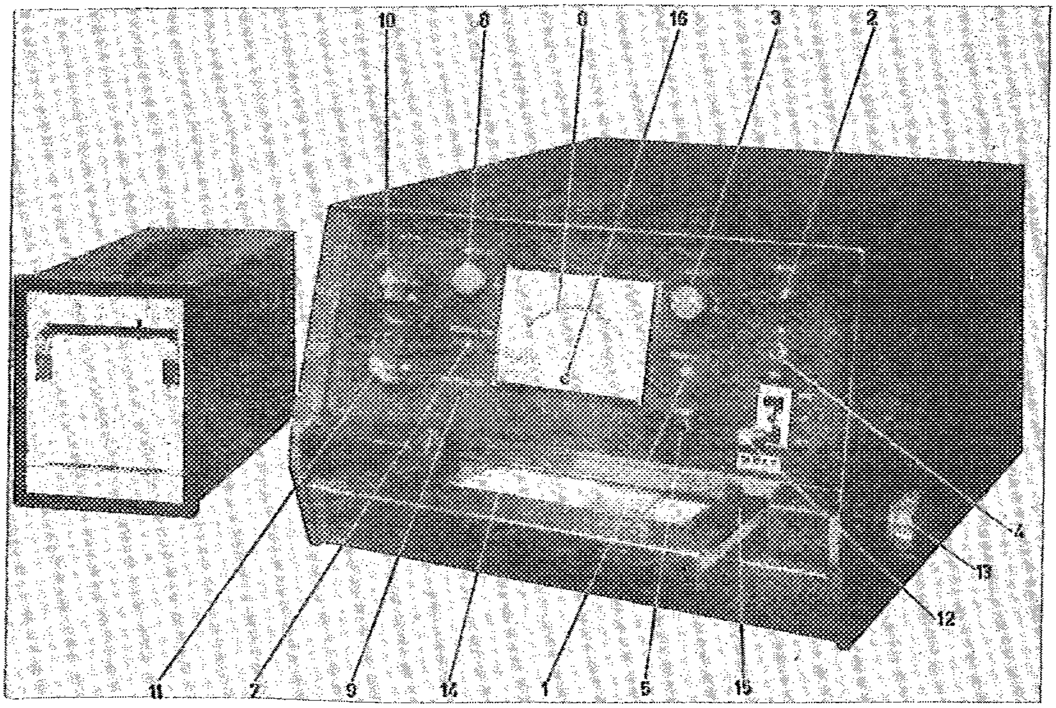

FIGURE 1

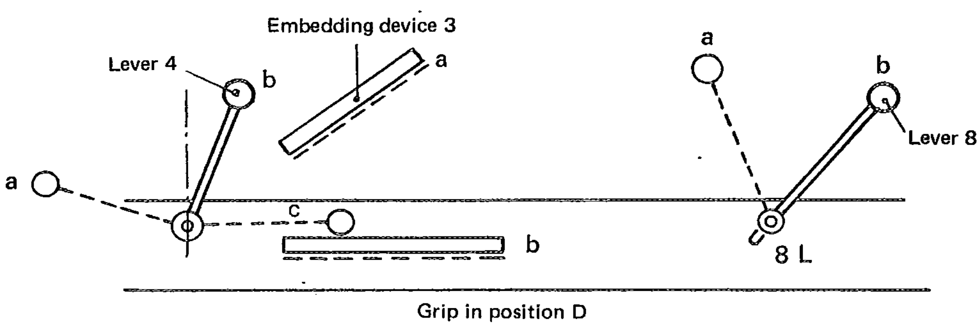

FIGURE 2

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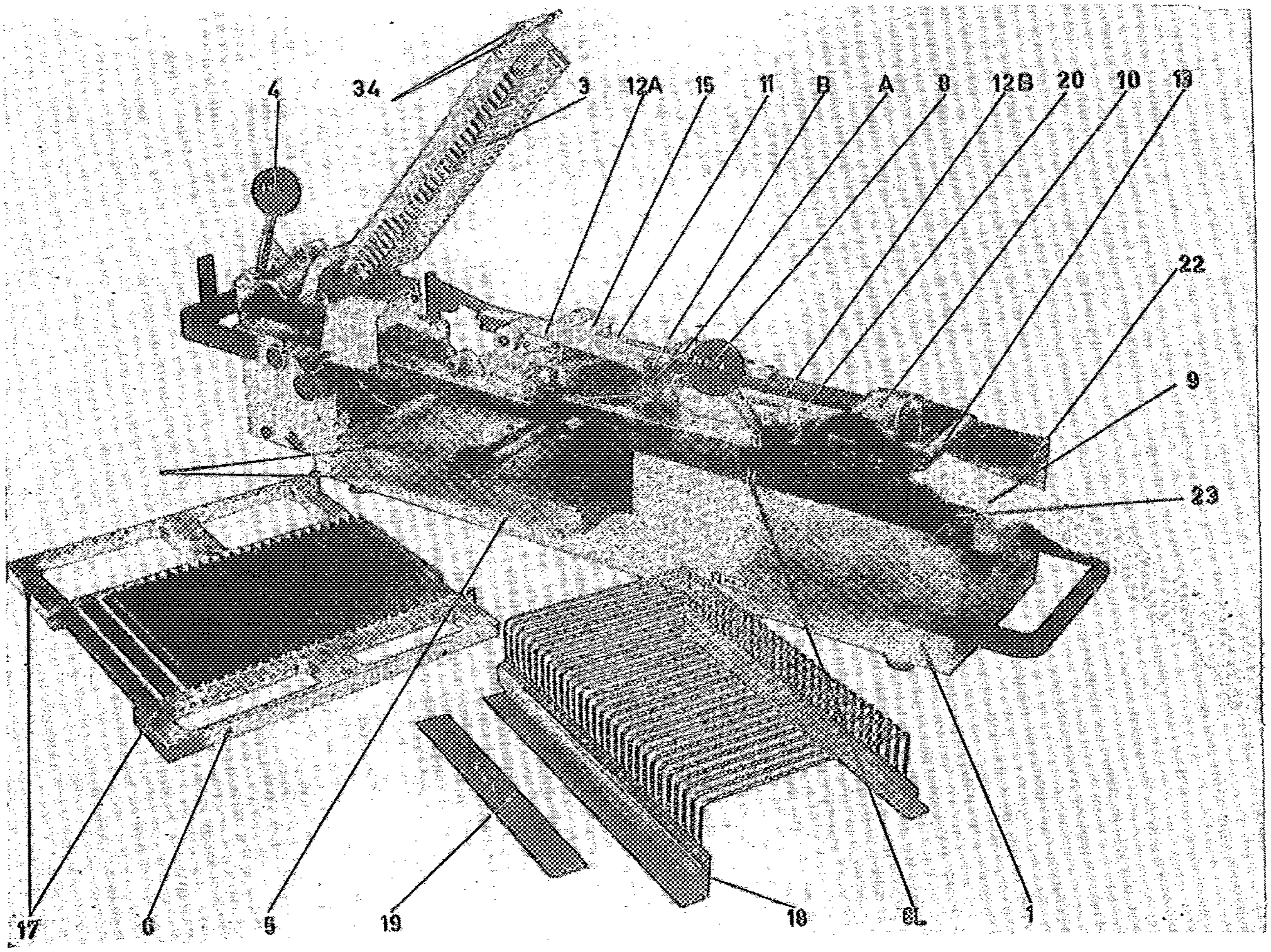

FIGURE 3

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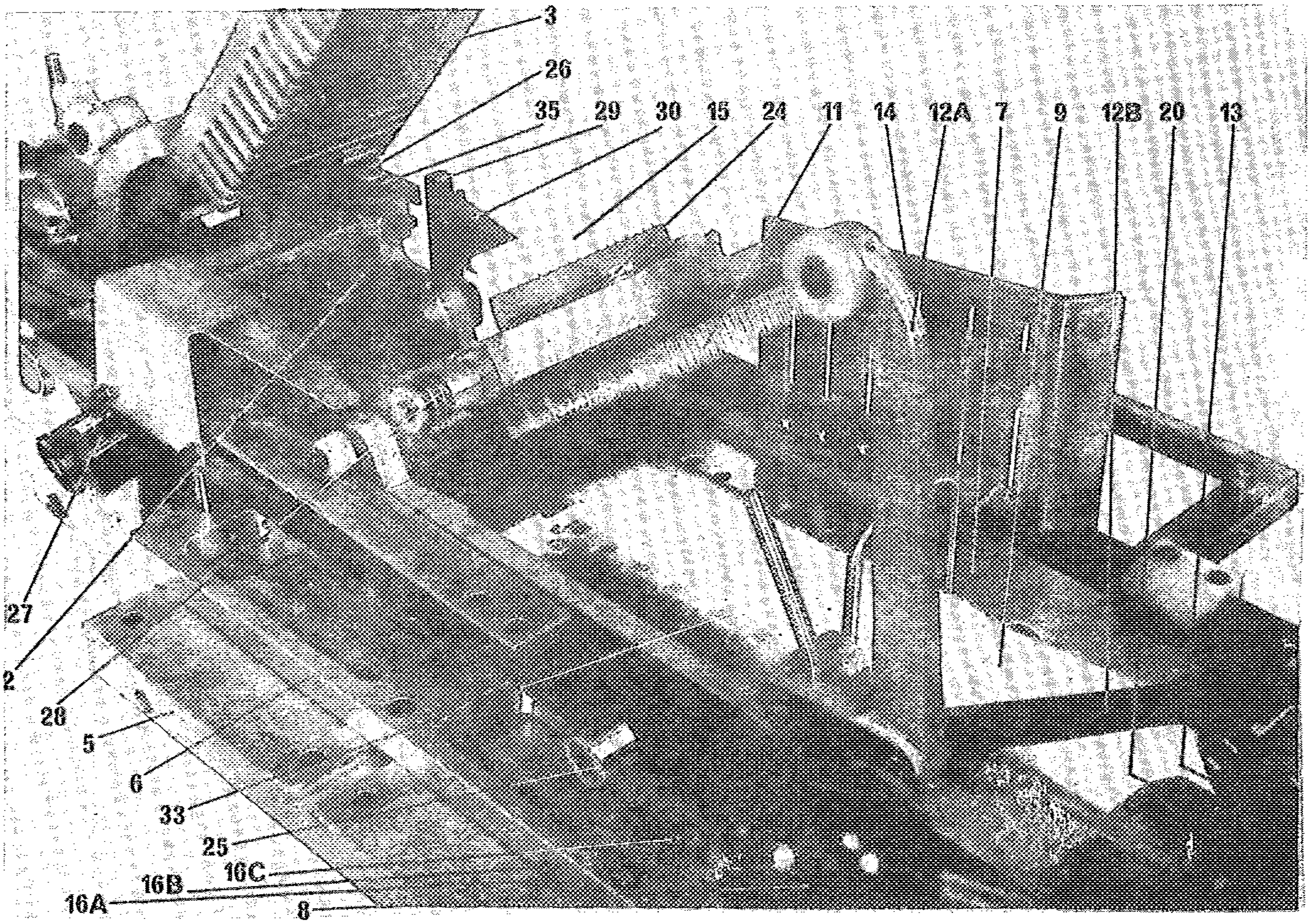

FIGURE 4

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