5-1-1925

Bulletin No. 141 - The Micrometer Caliper as an Instrument for Measuring the Diameter of Wool Fibers

University of Wyoming Agricultural Experiment Station

Follow this and additional works at: https://repository.uwyo.edu/ag_exp_sta_bulletins

Part of the Agriculture Commons

Publication Information

This Full Issue is brought to you for free and open access by the Agricultural Experiment Station at Wyoming Scholars Repository. It has been accepted for inclusion in Wyoming Agricultural Experiment Station Bulletins by an authorized administrator of Wyoming Scholars Repository. For more information, please contact scholcom@uwyo.edu.
UNIVERSITY OF WYOMING
AGRICULTURAL EXPERIMENT STATION

The Micrometer Caliper as an Instrument for Measuring the Diameter of Wool Fibers

Bulletin will be sent free upon request
Address: Director of Experiment Station, Laramie, Wyoming
UNIVERSITY OF WYOMING
Agricultural Experiment Station
LARAMIE, WYOMING

BOARD OF TRUSTEES

Officers

DEAN T. PROSSER...................................... President
JOSEPH A. ELLIOTT.................................... Vice President
FRED W. GEDDES...................................... Treasurer
FAY E. SMITH.......................................... Secretary
E. O. FULLER.......................................... Fiscal Agent

Executive Committee

DEAN T. PROSSER FRED W. GEDDES JOSEPH A. ELLIOTT

Members

Appointed Term Expires
1921 DEAN T. PROSSER 1927
1921 JOSEPH A. ELLIOTT 1927
1921 FRED W. GEDDES 1927
1922 ANNA B. HAGGARD 1929
1923 FRANK ALLAN HOLLIDAY 1929
1923 D. P. B. MARSHALL 1929
1923 P. J. QUEALY 1931
1925 BARBIE T. GRIEVE 1931
1925 J. M. SCHWOOB 1931
1923 NELLIE T. ROSS, Governor of Wyoming Ex Officio
KATHARINE A. MORTON, State Superintendent of Public Instruction Ex Officio
A. G. CRANE, Ph. D., President of the University Ex Officio

STATION STAFF

A. G. CRANE, Ph. D................................. President
J. A. HILL, B. S................................... Wool Specialist, Director
FAY E. SMITH........................................ Secretary
O. A. BEATH, M. A................................. Station Chemist
ROBERT H. BURNS, M. S........................ Assistant Wool Specialist
C. B. CLEVENGER, Ph. D........................ Assistant Chemist
A. T. CUNDY, A. R. C. Sc........................ Assistant Chemist
CECIL ELDER, D. V. M., M. Sc.................. Veterinarian
E. C. HARRAH, Ph. D.............................. Assistant Parasitologist
GLEN HARTMAN, B. S.............................. Assistant Agronomist
FRANK E. HEPNER, M. S........................ Head of Weather Station
FRED S. HULTZ, M. S.............................. Animal Husbandman
FRANK J. KOHN, B. S.............................. Assistant Poultry Specialist
EARL B. KRANTZ, M. S............................. Animal Husbandman in Charge United States-Wyoming Horse-Breeding Station
AUBREY M. LEE, D. V. M.......................... Assistant Veterinarian
AVEN NELSON, Ph. D.............................. Botanist and Horticulturist
W. L. QUAYLE, B. S.............................. Director of Experiment Farms
LEW P. REEVE, B. S............................... Assistant Animal Husbandman
JOHN W. SCOTT, Ph. D............................ Parasitologist
A. F. VASS, M. S.................................. Agronomist
H. S. WILLARD, M. S............................. Assistant Animal Husbandman
MARION V. HIGGINS............................... Librarian
AGNES M. BURNS................................. Clerk

*In cooperation with U. S. Department of Agriculture.
The Micrometer Caliper as an Instrument for Measuring the Diameter of Wool Fibers*

ROBERT H. BURNS—WYO. EXPERIMENT STATION
W. B. KOEHLER—GRADUATE STUDENT 1923-'24

INTRODUCTION

For a number of years the microscope has been the standard instrument for measuring the diameter of wool fibers. In 1921 Hill of this station reported on use of the machinist's micrometer caliper for measuring fibers in his student laboratory, in order that students might train themselves in the accurate judgment of the fineness of wool. At first it was thought that the micrometer caliper was not as accurate as the microscope but was accurate enough for teaching students the practical discrimination of fineness. However, as time went on and a large number of measurements were made with the micrometer caliper by various individuals, it appeared to be fairly accurate.

J. I. Hardy was the first to use the micrometer in the scientific study of wool.

Hill states that he found that an average student, after some practice is able to measure 100 fibers with a micrometer in less than 30 minutes, which agrees entirely with the writers' experience. Gordon asserts that one can make up the necessary amounts and measure the same number of fibers microscopically in an hour. Inasmuch as a student will probably acquire skill in measurement much more quickly with the micrometer than with the microscope the time-saving factor is very evident.

---

*Papers from the Wool Laboratory of the University of Wyoming Experiment Station—No. 10. This bulletin has been prepared from a thesis submitted by W. B. Koehler in partial fulfillment of the degree of Master of Science.

2. McMurtrie, Wm., Examination of Wool and other Animal Fibers, 1866, pp. 49, 543, 559.
6. Thoro T. Ztschr, Induktive Abstam. U. Vererbungslehre 32 (1923), No. (pp. 37-60 fig.).
As far as the writer's are aware, no comparison of micrometer and microscopic measurements of wool fibers has been made. Inasmuch as the micrometer is a very useful instrument in the wool laboratory for training students to discriminate fineness, it seemed desirable to test out its accuracy.

OBJECTS OF EXPERIMENT

1. To compare measurements of the same portion of a wool fiber, made first with a micrometer caliper, and then with a microscope with a measuring eyepiece.

2. To compare the variations between the measurements of the diameter of relatively fine fibers and relatively coarse fibers as influenced by the two methods of measurement.

METHOD OF EXPERIMENTATION

Instruments Used.

1. Machinist's Micrometer Caliper.

An ordinary machinist's micrometer caliper graduated in ten-thousandths of an inch was used. The micrometer caliper used in this study was made by the Brown & Sharpe Manufacturing Company. (See Fig. 1.)

![Micrometer caliper used for measuring wool fibers.](image-url)
2. Microscope.

A compound microscope and filar mikrometer (measuring eyepiece with movable crosshair) made by E. Leitz was used. An 8 mm. objective and 145 mm. tube length were used, which gave a magnification of 185 diameters.

The measuring eyepiece was calibrated with a stage micrometer reading in hundredths of a millimeter. One unit on the eyepiece was found to be equal to .02 mm.

The filar eyepiece which was used in this study has on its side a wheel graduated in 100 equal parts. A complete turn of this wheel moves the crosshair in the eyepiece over one division in the eyepiece. Therefore, one unit on the wheel equals .0002 mm.

These microscopic units were converted to ten-thousandths of an inch by dividing by 12.7.

**Fig. 2.** Filar eyepiece used on microscope for measuring wool fibers.

**Source of Samples.**

Twenty-seven samples of wool ranging from fine to braid were used in this study. They were divided into three series, A, B, and C, according to their origin.
Series A.

Sixteen of these samples were obtained from the U. S. Sheep Experiment Station at Dubois, Idaho. Their classification follows:

Seven Rambouillet samples ranging from 70's to 58's.

Four crossbred samples (Corriedale sire; Lincoln-Ramboulette crossbred dam) ranging from 56's to 50's.

Three crossbred samples (Lincoln sire; Rambouillet dam) ranging from 44's to 40's.

Two Corriedale samples classed as 48's to 46's.

One sample of fine in Series A was obtained from a large wool commission house in Boston.

Series B.

Five samples were from Australia and four of these came from the well-known Wanganella station of Australian Merinos. Their classification follows:

Four Wanganella samples ranging from 66's to 68's.

One sample of Australian hogget wool selected by W. T. Ritch, the Australian wool expert.

Series C.

Five samples of coarse wools all of United States origin. Their classification follows:

One Romney Marsh sample from University of Wyoming flock.

One Oxford Down sample from University of Wyoming flock.

One Low Quarter grade sample of U. S. origin.

One Common grade sample of U. S. origin.

One Braid grade sample of U. S. origin.

Preparation of Samples.

Small sub-samples from each of the large samples were washed in benzine, pressed between filter paper and exposed to the air for further drying. When the samples were dry both tip and base were clipped squarely off so as to have all the fibers as nearly the same length as possible.
Measurement of Samples.

Individual fibers were drawn from the small sample, taking large and small fibers without discrimination and always drawing from the same side of the sample.

The fiber was straightened between the fingers, one end held by the thumb and third finger and the other end held by the first and second fingers and was then placed between the jaws of the micrometer. The micrometer was turned up slowly until the fiber lay snugly between the jaws and the ratchet clicked twice. One soon learns the right amount of speed to use in closing the jaws of the micrometer and should use the same relative speed in measuring the wool fibers as in checking the zero point of the micrometer.

After the fiber had been measured by the micrometer and the size recorded, the ends of the fiber were cut off as close to the jaws of the micrometer as is possible with a safety razor blade. The portion of the fiber remaining between the jaws of the micrometer was then removed and placed on a glass slide. A cover glass was placed over it to keep the fiber flat (in one plane). No mounting medium was used. Holden having found that glycerine, Canadian balsam, and air gave identical results within the limits of experimental error.

The slide with the fiber on it was placed under the microscope and three measurements were taken at various parts of the fiber. Inasmuch as the length of the fiber when clipped on either side of the micrometer jaws was about one-quarter of an inch and the visible microscopic field was about one-seventh as large, it was necessary to move the slide and follow the outline of the fiber, taking measurements at typical portions of the fiber at each end and in the middle.

One hundred fibers from each small sample were measured in this way.

TABLE I.—Showing a comparison of the average thickness of 100 fibers from various samples of wool as measured by the microscope and by the micrometer caliper

<table>
<thead>
<tr>
<th>Sample</th>
<th>Microscopic Mean</th>
<th>Caliper Mean</th>
<th>Corrected Caliper Mean</th>
<th>Percent of Caliper Mean Represented by Microscope</th>
<th>Percent of Corrected Caliper Mean Represented by Microscope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>6.74±.08</td>
<td>5.69±.07</td>
<td>6.69</td>
<td>118.5</td>
<td>100.7</td>
</tr>
<tr>
<td>56s</td>
<td>7.20±.11</td>
<td>5.91±.12</td>
<td>6.91</td>
<td>121.8</td>
<td>104.2</td>
</tr>
<tr>
<td>66s</td>
<td>7.46±.09</td>
<td>6.29±.07</td>
<td>7.29</td>
<td>119.2</td>
<td>102.8</td>
</tr>
<tr>
<td>Wang, Ram</td>
<td>7.56±.07</td>
<td>6.54±.09</td>
<td>7.54</td>
<td>115.6</td>
<td>100.7</td>
</tr>
<tr>
<td>66s</td>
<td>7.82±.11</td>
<td>6.59±.10</td>
<td>7.59</td>
<td>118.7</td>
<td>103.0</td>
</tr>
<tr>
<td>60s</td>
<td>7.93±.08</td>
<td>6.77±.10</td>
<td>7.77</td>
<td>117.1</td>
<td>102.1</td>
</tr>
<tr>
<td>70s</td>
<td>7.97±.06</td>
<td>6.72±.07</td>
<td>7.72</td>
<td>118.6</td>
<td>103.2</td>
</tr>
<tr>
<td>Hoggett</td>
<td>8.81±.11</td>
<td>8.87±.07</td>
<td>8.87</td>
<td>113.6</td>
<td>99.2</td>
</tr>
<tr>
<td>Wang. R. 68s</td>
<td>7.93±.08</td>
<td>6.98±.08</td>
<td>7.98</td>
<td>113.6</td>
<td>99.2</td>
</tr>
<tr>
<td>Wang. R. 66s</td>
<td>8.07±.09</td>
<td>6.93±.09</td>
<td>7.93</td>
<td>116.5</td>
<td>101.8</td>
</tr>
<tr>
<td>Wang. E. 68s</td>
<td>8.31±.07</td>
<td>6.99±.06</td>
<td>7.99</td>
<td>118.9</td>
<td>104.0</td>
</tr>
<tr>
<td>64s</td>
<td>8.86±.12</td>
<td>7.48±.10</td>
<td>8.48</td>
<td>114.7</td>
<td>101.2</td>
</tr>
<tr>
<td>56s</td>
<td>8.83±.11</td>
<td>7.82±.10</td>
<td>8.82</td>
<td>112.9</td>
<td>100.1</td>
</tr>
<tr>
<td>54s</td>
<td>9.51±.10</td>
<td>8.37±.13</td>
<td>9.37</td>
<td>113.6</td>
<td>101.5</td>
</tr>
<tr>
<td>48s</td>
<td>9.90±.10</td>
<td>8.80±.14</td>
<td>9.80</td>
<td>112.5</td>
<td>101.0</td>
</tr>
<tr>
<td>42s</td>
<td>10.39±.13</td>
<td>9.20±.12</td>
<td>10.20</td>
<td>112.2</td>
<td>101.2</td>
</tr>
<tr>
<td>52s</td>
<td>10.45±.17</td>
<td>9.56±.16</td>
<td>10.56</td>
<td>109.3</td>
<td>99.0</td>
</tr>
<tr>
<td>56s</td>
<td>11.02±.13</td>
<td>9.90±.12</td>
<td>10.98</td>
<td>111.0</td>
<td>100.4</td>
</tr>
<tr>
<td>48s</td>
<td>11.45±.16</td>
<td>9.98±.16</td>
<td>10.98</td>
<td>114.5</td>
<td>104.0</td>
</tr>
<tr>
<td>46s</td>
<td>12.12±.17</td>
<td>11.79±.20</td>
<td>12.79</td>
<td>105.3</td>
<td>97.1</td>
</tr>
<tr>
<td>Low '4</td>
<td>13.32±.22</td>
<td>11.57±.20</td>
<td>12.57</td>
<td>115.1</td>
<td>106.0</td>
</tr>
<tr>
<td>Oxford</td>
<td>13.15±.06</td>
<td>12.44±.09</td>
<td>12.44</td>
<td>105.5</td>
<td>97.7</td>
</tr>
<tr>
<td>Romney</td>
<td>13.75±.14</td>
<td>13.00±.15</td>
<td>13.00</td>
<td>105.8</td>
<td>98.2</td>
</tr>
<tr>
<td>Braid</td>
<td>14.84±.16</td>
<td>13.37±.14</td>
<td>13.37</td>
<td>111.0</td>
<td>103.3</td>
</tr>
<tr>
<td>Common</td>
<td>15.76±.21</td>
<td>14.35±.20</td>
<td>14.35</td>
<td>111.0</td>
<td>102.8</td>
</tr>
</tbody>
</table>

1All measurements in units of ten-thousandths of an inch.
2Addition of one ten-thousandths of an inch to caliper mean.
<table>
<thead>
<tr>
<th>Caliper Group</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Mean</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government Coarse</td>
<td>1</td>
<td>33</td>
<td>187</td>
<td>266</td>
<td>200</td>
<td>235</td>
<td>186</td>
<td>150</td>
<td></td>
<td>104</td>
<td>50</td>
<td>63</td>
<td>50</td>
<td>33</td>
<td>8</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australian Coarse</td>
<td>3</td>
<td>43</td>
<td>151</td>
<td>164</td>
<td>103</td>
<td>26</td>
<td>8</td>
<td>2</td>
<td></td>
<td>50</td>
<td>70</td>
<td>93</td>
<td>61</td>
<td>67</td>
<td>35</td>
<td>23</td>
<td>19</td>
<td>9</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Average Micro.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount which</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro. which exceeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caliper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government Coarse</td>
<td>1.55</td>
<td>1.42</td>
<td>1.23</td>
<td>1.12</td>
<td>1.14</td>
<td>1.12</td>
<td>1.02</td>
<td>0.90</td>
<td></td>
<td>1.10</td>
<td>0.95</td>
<td>0.94</td>
<td>0.63</td>
<td>0.75</td>
<td>0.39</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australian Coarse</td>
<td>0.92</td>
<td>1.35</td>
<td>1.13</td>
<td>1.04</td>
<td>0.95</td>
<td>0.81</td>
<td>0.61</td>
<td>0.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage which</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro. which exceeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caliper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government Coarse</td>
<td>51.7</td>
<td>35.5</td>
<td>24.6</td>
<td>18.7</td>
<td>16.3</td>
<td>14.9</td>
<td>11.3</td>
<td>9.0</td>
<td></td>
<td>10.0</td>
<td>7.9</td>
<td>7.2</td>
<td>4.5</td>
<td>5.0</td>
<td>2.4</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australian Coarse</td>
<td>23.0</td>
<td>27.0</td>
<td>18.8</td>
<td>14.9</td>
<td>11.9</td>
<td>9.0</td>
<td>6.1</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>1</td>
<td>36</td>
<td>230</td>
<td>450</td>
<td>464</td>
<td>350</td>
<td>224</td>
<td>190</td>
<td></td>
<td>156</td>
<td>129</td>
<td>156</td>
<td>111</td>
<td>100</td>
<td>43</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1.55</td>
<td>1.38</td>
<td>1.25</td>
<td>1.13</td>
<td>1.11</td>
<td>1.08</td>
<td>1.01</td>
<td>0.96</td>
<td></td>
<td>1.17</td>
<td>1.11</td>
<td>1.04</td>
<td>0.94</td>
<td>1.22</td>
<td>1.21</td>
<td>1.01</td>
<td>1.13</td>
<td>0.74</td>
<td>1.46</td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>51.7</td>
<td>34.5</td>
<td>25.0</td>
<td>18.8</td>
<td>15.9</td>
<td>13.5</td>
<td>11.2</td>
<td>9.6</td>
<td></td>
<td>10.6</td>
<td>9.3</td>
<td>8.0</td>
<td>6.7</td>
<td>8.1</td>
<td>7.6</td>
<td>5.9</td>
<td>6.3</td>
<td>3.9</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>Corrected caliper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>diameter</td>
<td>4.00</td>
<td>5.00</td>
<td>6.00</td>
<td>7.00</td>
<td>8.00</td>
<td>9.00</td>
<td>10.00</td>
<td>11.00</td>
<td></td>
<td>12.00</td>
<td>13.00</td>
<td>14.00</td>
<td>15.00</td>
<td>16.00</td>
<td>17.00</td>
<td>18.00</td>
<td>19.00</td>
<td>20.00</td>
<td>21.00</td>
<td></td>
</tr>
<tr>
<td>Percent of corrected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>caliper mean</td>
<td>113.7</td>
<td>107.6</td>
<td>104.2</td>
<td>101.9</td>
<td>101.4</td>
<td>100.9</td>
<td>100.1</td>
<td>99.6</td>
<td></td>
<td>103.7</td>
<td>101.4</td>
<td>100.9</td>
<td>100.3</td>
<td>99.6</td>
<td>101.4</td>
<td>101.2</td>
<td>100.1</td>
<td>100.7</td>
<td>98.7</td>
<td>102.2</td>
</tr>
</tbody>
</table>

1 All measurements stated in units of ten-thousandths of an inch.
2 Average microscopic diameter.
3 Amount which microscope exceeds caliper.
4 Percentage which microscope exceeds caliper.
5 Addition of one ten-thousandths of an inch to caliper mean.
TABLE III.—Showing correlation between measurements obtained by the microscope and those obtained by the micrometer caliper on the same wool fibers.

FREQUENCY OF MICROSCOPIC MEASUREMENTS

<table>
<thead>
<tr>
<th>Caliper Group</th>
<th>Frequency</th>
<th>Microscopic Mean</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>10.06±.04</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>10.02±.02</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>10.08±.08</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>10.14±.10</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>10.20±.12</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>10.26±.14</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>10.32±.16</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>10.38±.18</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
</tbody>
</table>

1 All measurements in units of ten-thousandths of an inch.
**Chart Two**

- **Corrected Diameter Micrometer**
- **Mean Diameter Microscope**
- **Actual Diameter Micrometer**

*Data arranged by micrometer units.*
The two methods of measurement are compared in Tables I, II and III and in Charts One and Two.

In Table I the average diameter of each sample as measured by the micrometer caliper is compared with the average diameter obtained with the microscope. This comparison is shown graphically in Chart One.

The relation between the measurements obtained by the microscope is shown more in detail in Table II. The fibers are grouped according to their diameters measured on the micrometer caliper. This average microscopic measurements for each group is then used as a basis of comparison. For example, there were only 33 fibers among all those measured in the Government series that measured 4 ten-thousandths of an inch by the caliper and only 3 fibers of the Australian series. The average diameter of these groups measured by the microscope was 5.42 and 4.92 ten-thousandths, respectively, and the mean of the combined group of 36 fibers was 5.38. It is on this basis that the comparisons in the column headed "4" in Table II are made. The comparisons of Table II are shown graphically in Chart Two.

Table III shows in detail the frequency distributions of the microscopic measurements from which the means in Table II were obtained. Thus it is shown that the 36 fibers that measured 4 ten-thousandths in the caliper and had an average diameter of 5.38 ten-thousandths by the microscope, contained 22 fibers in the 5 group and 14 fibers in the 6 group, this grouping being on the basis of microscopic measurement to the nearest ten-thousandth of an inch.

RESULTS

Object No. 1.

The number of samples was relatively small (27) and so the results of this experiment are not to be taken as entirely conclusive, but are representative of only a relatively small number of samples.

The microscopic measurements were larger than the micrometer measurements in practically every fiber. This would be expected, for the micrometer has a slight crushing action on the
fiber. Moreover, the fiber, when put between the glass slides, will tend to lie on its flat side and thus present its greatest diameter in the microscopic field. There is also a tendency for oval fibers to twist when the jaws of the micrometer are closed upon them and thus the smallest diameter is obtained when measuring fibers with the micrometer.  

All of these factors would seem to add more reliability to the results obtained in this experiment.

There were some variations in the difference between micrometer and microscopic measurements in the different samples, but, as shown by the table, the relation is fairly uniform.

Table I shows that the microscopic measurements of the entire series of samples average 113.8±.6 per cent larger than the micrometer caliper measurements. However, it can be seen from Chart One that if one ten-thousandth of an inch is added to the micrometer caliper reading, it will closely approximate the microscopic reading.

In the last column of Table I this addition has been made and in this case the microscopic measurements are 101.4±.3 per cent of the micrometer caliper measurements so adjusted. Thus the microscopic measurements are only 1.4 per cent greater than the micrometer caliper measurements corrected by the addition of one ten-thousandth of an inch.

Object No. 2.

If all of the fibers having a certain micrometer measurement are gathered together we have the results given in Tables II and III and in Chart Two.

Now, if these fibers are divided into two, large groups placing all fibers measuring from 3 to 10 ten-thousandths of an inch, inclusive, in diameter in one group, and all those measuring from 11 to 20 ten-thousandths of an inch in diameter, inclusive, in the other group, some interesting facts are disclosed.

If the correction of one ten-thousandth of an inch is added to the micrometer caliper measurements the resulting figure is very close to the microscopic measurement. To be fairly accurate so far as the results of this experiment go the corrected

micrometer caliper mean if between 1 and 10 ten-thousandths would have to be multiplied by 103.7 per cent and if between 10 and 20 it would have to be multiplied by 100.7 per cent.

Thus the fact is brought out that there is less variation between the two methods of measuring diameter in the large fibers than in the small fibers. This difference is expressed in percentage and thus would naturally be larger in the smaller fibers. Then also the larger fiber has more area in contact with the jaws of the micrometer than the smaller fiber.

_Effect of softness on the accuracy of the micrometer._

Since it seems evident that one of the sources of error in the use of the micrometer is the compression of the fiber between its jaws, the question arose whether fibers from wool that feels soft to the touch would be compressed more than fibers of wool that lack the feeling of softness. The samples of Australian wool used in these experiments had been kept in the laboratory to illustrate the softness of certain types of Australian wool.

But the Australian samples did not show as much variation in diameter between the two methods of measurement as did American wools of corresponding fineness. Hence it would seem that soft Australian wools do not yield to a crushing force any more readily than American wools of similar fineness, and that any special softness of Australian wools is not caused by a weak-celled fiber that is easily compressed. It may be the gloss and oiliness of the surface or some other characteristic of the fiber which gives it its reputation for softness in the manufacturing trade.

In this connection it must be remembered that only five samples of Australian wools were used, which is a small number, but, nevertheless, was about the same number as was used of similar American grades.

**SUMMARY**

Object. 1.

A. The average microscopic measurements of any sample were always larger than the average caliper measurements.

B. For all practical purposes this difference amounts to 1 ten-thousandth of an inch.
Object No. 2.

Larger fibers do not give us as great a proportionate difference of diameters measured by the two instruments as do the smaller fibers. No important difference was found that could be attributed to the difference in the softness of the samples measured.

CONCLUSION

The micrometer caliper is much easier for students to use than the microscope for measuring wool. It has been proved to be fairly accurate, and the measurements obtained by it bear a rather close relationship to the microscopic measurement. For all practical purposes this relationship may be expressed as follows:

The diameter as measured by the caliper + 1 ten-thousandth of an inch equals the diameter measured by the microscope.