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CARE AND ADJUSTMENT OF FOLDING TESTERS OF THE SCHOPPER TYPE

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CARE AND ADJUSTMENT OF FOLDING TESTERS OF THE SCHOPPER TYPE[1]

ABSTRACT

Because of the importance of the folding test as a criterion of the durability of papers and the difficulty of keeping folding testers of the Schopper type in proper condition considerable attention has been given to their care and adjustment. Brief reference is made to a previous publication in which was described a device designed to facilitate adjusting the tension on the specimen. This device, which is a dead-weight tester involving the use of a balanced bell-crank lever, has been improved and has been adapted to the measurement of the friction of the rollers. This method of measuring roller friction is described, and a number of suggestions are made concerning the care and adjustment of the folding tester. A procedure is outlined for the periodic inspection and adjustment of the tester.

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I. INTRODUCTION

The folding test is widely regarded as the most valuable test for those papers which undergo considerable bending and creasing and similar types of wear. Folding testers of the Schopper type have for many years been generally used for making such tests throughout the world wherever paper is tested. In the United States this type of tester is specified by the Technical Association of the Pulp and Paper Industry in its official folding test method.[2] Nevertheless, this tester occasions considerable trouble because of the several working parts driven by the specimen. From Figure 1, which is a diagrammatic representation of the principal working parts immediately affecting the specimen, it is evident that the folding endurance of the specimen P is conditioned by the tension of the springs S, by the condition of the folding blade F, and by the friction and alignment of the rollers R between which the paper is creased. When these parts wear or get out of adjustment, their condition is reflected in erroneous test results. It is often difficult to locate exactly the source of the trouble, even when erroneous results are suspected. The considerable effect upon test data produced by comparatively small changes in certain mechanical adjustments makes imperative a frequent inspection and adjustment of these testers in order that trustworthy results may be obtained.

A previous publication[3] of the Bureau of Standards, issued in 1927, discussed the relation of some of the mechanical variables to the test results in the light of data then available and described a newly developed device for adjusting the tension on the specimen.

[1] Supplementary report to B. S. Tech. Paper, No. 357.
[2] Paper Testing Methods, p. 58, 1928; Lockwood Trade Journal Co., New York, N. Y.
[3] B. S. Tech. Paper, No. 357, Calibration and Adjustment of the Schopper Folding Tester. Government Printing Office, Price, 10 cents.

The emphasis was placed on the accurate adjustment of the springs by means of which this tension is applied, since it is known that considerable differences in tests are brought about by comparatively small changes in the tension on the specimen. The adjustment of the springs, however, does not alone determine the effective tension on the specimen. The condition of the four vertical rollers quadrantally situated about the central position of the slot in the folding blade is an important contributing factor to both the amount of the effective tension and the distribution of this tension over the width of the specimen. Excessive friction or poor alignment of these quadrantal rollers will give rise to low folding results, because in the one case the effective tension on the specimen is increased and in the other it is unevenly applied so that one side or the other of the specimen begins to tear prematurely. In this publication a simple means is described of measuring the friction of these rollers by means of an adaptation of the bell-crank lever calibrating apparatus previously described [4] for adjusting the spring tension, and a procedure

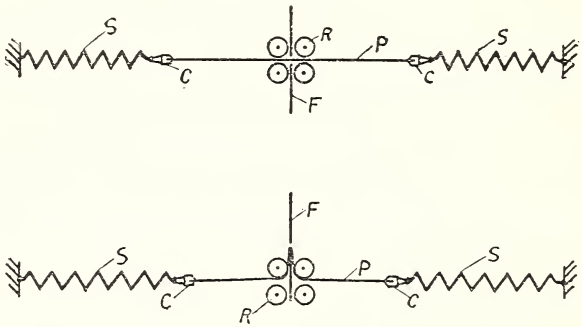

FIGURE 1.—*Diagrammatic representation of the working principle of the Schopper folding tester*

is outlined for the periodic inspection and adjustment of the Schopper folding tester.

II. RÉSUMÉ OF PREVIOUS WORK

In the Schopper folding tester a strip of paper is folded, as illustrated in Figure 1, by means of a thin, slotted blade which passes back and forth between two pairs of rollers arranged quadrantally about the central position of the slot in the folding blade. The specimen is kept under spring tension varying from about 0.8 to 1 kilogram and is folded until rupture occurs. The effect on the folding results of the condition of the essential working parts, such as the folding blade and its linkage, the rollers supporting the clamps, the quadrantal rollers, and the tension springs, was discussed in the previous report. Differences arising from the condition of parts driven by the specimen were estimated in terms of effective tension on the specimen, since the only available pertinent data had to do with the effect of altering this tension. Because of the great variability of individual results and the time required to make a test no attempt was made to study directly the effect of these different

[4] See footnote 3, p. 1.

variables. According to available data, a given change in the effective tension on the specimen is followed by a much greater percentage error in the folding results, so that the necessity for careful adjustment of the working parts was stressed in the discussion.

The relative merits and disadvantages of the different methods of adjusting the tension on the specimen were considered, and a new device was described for making this adjustment in a very simple and convenient manner. This apparatus (shown in fig. 2) consists, essentially, of a bell-crank lever having similar arms at right angles and supported by a knife-edge at the center of gravity. A 1-kilogram weight suspended from the horizontal arm serves to balance the tension of the spring attached by a link to the vertical arm, thus insuring a tension of 1 kilogram for the required deflection of the spring.

The measurement of the friction of the quadrantal rollers and the consideration of it in the inspection and adjustment of the folding tester were suggested. A few measurements were made by means of a pulley supported on a knife-edge with which the dead-weight equivalent of the friction could be evaluated, so as to show the magnitude of the possible error due to neglecting this friction. More recently the bell-crank lever apparatus, in addition to some improvement in design, has been provided with a means of attaching the supporting bracket to the roller housing in such a manner as to enable one to make the roller-friction measurements very easily and quickly.

III. METHOD OF MEASURING ROLLER FRICTION

With the bell-crank lever device attached to the folding tester in the manner shown in Figure 3, a ribbon is fastened in the clamp at the end of one of the calibrated springs and is passed around one of the rollers and attached at the other end to the vertical lever. A kilogram weight is then hung at the end of the horizontal lever, and weights are added until the spring shows a deflection corresponding to a tension of 1 kilogram as determined by the previous calibration. The weight added in excess of 1 kilogram represents the friction of that roller in terms of effective tension on the specimen. By shifting the ribbon from one clamp to the other or by attaching the supporting bracket to one side or the other of the roller housing the friction of each of the four rollers can be measured. This procedure measures the friction of the roller on the outstroke of the folding blade. The friction on the instroke may be measured in a similar manner except that the weight suspended from the horizontal arm is decreased until the spring draws together to a position corresponding to a tension of 1 kilogram. The amount by which the weight on the horizontal arm is less than 1 kilogram represents the friction for the instroke. The results for the instroke measurements are usually somewhat less than those for the outstroke, as shown by some 1,800 determinations made over a period of a year. The friction on the outstroke is the more important, since in this case the effective tension is increased, resulting in a tendency for the specimen to break prematurely. Hence, it seems necessary to consider only the roller friction on the outstroke of the folding blade.

The roller friction has been observed to vary from 25 to 220 grams equivalent tension and is usually from 50 to 80 grams for rollers in

good condition. An arbitrary value of 100 grams has been found a practical limit below which the friction can be kept with reasonable care. Even a variation between the limits of 25 and 100 grams is objectionable, but this is about the best that can be done, considering the limitations of the tester.

An increase in the roller friction usually results from lack of oil, or from the use of inferior oil, or from the bearings being gummed up because of the collection of dust or of lint from the specimen. It is sometimes necessary to remove the rollers and clean the shafts and bearings. However, this is to be done only as a last resort because of the difficulty of realigning the rollers when they are replaced. Poor alignment may be more serious than too much friction. Although the bearing plates are doweled in place, there is usually enough play so that in tightening down the screws the rollers may be thrown out of parallel far enough to cause unequal distribution of the tension along the width of the specimen. An excellent test for this defect is a simple one suggested by E. O. Reed, of the Government Printing Office. A strip of paper with a fairly low fold is cut in the machine direction, clamped in the folding tester, and folded just short of its folding endurance; that is, so that it is almost ready to break. The strip is taken out and examined. Incipient tearing at either the top or bottom edge of the strip indicates more tension on that edge than on the other, which is probably brought about by poor alignment of the rollers.

IV. PERIODIC INSPECTION AND ADJUSTMENT

About once a month, in the ordinary use of the folding tester, it should be carefully inspected, oiled, and adjusted if necessary. A tester in continuous use may require attention more often than this.

In case several testers are being used in a laboratory, one can readily tell from test data if one or more are consistently giving low results, especially if the specimens of each sample tested are divided up among the several testers. In this case one can express each individual result as a percentage of the average for that sample and tabulate these values for the different testers somewhat in the manner of Table 1, which shows the comparative performance of six folding testers. The data for this table were calculated from the results of all routine tests made during the preceding month; that is, since the last calibration of the tester. The six testers are indicated by the letters A, B, C, etc. The mean of these percentage values for each tester is found, and from these average values the relative performance of the different testers may be judged, perfect concordance being indicated by a mean value of 100 for all testers. Two of the testers gave results somewhat lower than the average for the six testers. If the adjustment of the spring tension is correct, there is little that might change in the operation of the tester in such a way as to increase the folding values. Therefore, it is the testers which consistently give results below the average for all the testers toward which suspicion should be directed. In the case illustrated by the data in Table 1, two of the testers, C and D, invite the most suspicion among these six testers. On inspection the rollers in these two testers were found to be in poor condition. The bearings were worn, and the rollers were out of alignment as a consequence. It was necessary to repair these two testers.

TABLE 1.—*Relative performance of six folding testers, the data being percentage of average result for each sample tested*

Sample No.	Folding tester											
	Machine direction						Cross direction					
	A	B	C	D	G	H	A	B	C	D	G	H
15	119	143	93	105	135	107	109	130	74	83	147	78
	64	69	76	90	-----	-----	-----	-----	100	53	96	131
16	124	108	95	94	67	127	115	157	116	84	69	70
	93	-----	-----	90	104	99	-----	143	112	61	-----	73
17	111	126	107	111	96	98	76	98	76	106	87	----
	-----	-----	78	94	-----	73	142	-----	135	103	93	----
	-----	-----	-----	-----	-----	107	-----	-----	-----	83	-----	----
18	118	97	78	67	162	83	123	115	68	60	122	----
	-----	103	89	82	-----	121	104	151	62	-----	82	----
	-----	-----	-----	-----	-----	-----	-----	-----	113	-----	-----	----
19	120	153	95	107	130	74	129	99	128	96	69	61
	-----	-----	61	95	88	79	69	-----	-----	106	82	162
20	106	-----	96	-----	88	103	74	116	-----	85	88	114
	91	-----	95	-----	100	-----	-----	-----	-----	76	-----	149
	138	-----	106	-----	76	-----	-----	-----	-----	106	-----	----
	-----	-----	-----	-----	-----	-----	-----	-----	-----	93	-----	----
21	122	90	109	94	85	126	98	110	-----	101	76	115
	93	93	-----	-----	83	-----	102	63	-----	102	89	141
	-----	-----	-----	-----	103	-----	-----	-----	-----	-----	-----	----
26	98	82	87	84	87	121	95	157	94	70	84	142
	120	-----	79	117	125	-----	-----	111	96	-----	82	68
27	130	96	99	101	97	117	86	122	54	65	133	123
	-----	96	-----	95	76	92	134	-----	64	156	-----	----
	-----	-----	-----	-----	-----	-----	-----	-----	62	-----	-----	----
28	101	89	55	114	86	117	129	66	79	145	134	110
	90	124	112	-----	112	-----	98	78	84	-----	77	----
29	91	132	70	86	123	123	137	84	101	73	90	128
	79	-----	-----	102	104	-----	-----	96	108	87	-----	98
	89	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
Mean	105	107	88	96	101	104	107	112	91	91	94	110

Before proceeding to adjust the springs or determine the roller friction one should make a general inspection of the working parts of the tester, seeing that the folding blades are in good condition and parallel with each other; that there is no undue play in the driving linkage; that the spring housings move freely; that the supporting rollers are round and move freely; and that all bearing surfaces are clean and well oiled. The oil used on the bearings of the rollers should be clock oil or similar high-grade thin oil. Care must be taken that no oil is left on the surface of the rollers which might be absorbed by the specimen and affect the folding value.

The quadrantal rollers should be inspected for proper clearances. The clearance between the folding blade and the rollers on each side should be 0.015 inch, and the clearance between rollers in the space initially occupied by the specimen should be about 0.020 inch. A few thousandths of an inch more or less in the latter clearance appears to make no difference in the folding results, provided the rollers are in proper condition in all other respects. There is no adjustment provided for this clearance, but when new bearings are put in the clearance should be made about 0.020 inch.

A test should next be made to determine if the rollers are in proper alignment. A specimen, cut in the machine direction from a sample of paper which has a folding number of about 100 or less, is folded

in the tester by hand just short of rupture. By a little practice one can usually determine when to stop the folding by attending closely with the ear until a sound of breaking fibers is heard, when the folding blade is stopped in its outer position and the tension is released gently, without shock to the specimen. The strip is taken out and inspected for tendency to tear on one side more than on the other. Several strips should be folded and inspected in this way. If the fold at this advanced stage in the fatigue test appears to be uniform from side to side of the specimen, the rollers may be considered in proper alignment.

If this test shows poor alignment of the rollers, there is trouble ahead. It seems likely that the proper alignment of the quadrantal rollers is of even more importance than the precise adjustment of the tension on the specimen. Very small differences between the top and bottom clearances which are scarcely detectable with feeler gages are likely to show up in the folding results. It is difficult to impress upon a machinist the precision with which his adjustments must be made when these rollers and their bearings need his attention. Something can be done toward correcting poor alignment by placing paper shims under the ends of the roller mountings so as to change slightly their angle; but if the trouble is very serious, the services of a skilled machinist or instrument maker are necessary. He will probably have to replace the bearings of the roller, giving careful attention to their alignment.

One may now proceed to the adjustment of the tension springs in substantially the manner described in the previous publication and to the measurement of the roller friction. The bell-crank lever has been improved in design, and one or two details of the procedure have been somewhat modified. The ends of the two arms of the bell-crank lever have been made just alike so that the device can be reversed. This is an advantage in that any maladjustment of the bell-crank lever itself is made immediately evident by reversing the device and repeating the calibration. If the two results do not agree, one should look for unequal lever arms or lack of balance in the bell-crank lever. Trouble from this source should not occur except by an accident to the apparatus, but it is well to confirm the condition of the bell-crank lever itself each time it is used.

A strip of strong paper or celluloid about 0.005 inch thick is clamped in the tester, tension is put on the springs by pulling out their housings, and the driving wheel is revolved until the folding blade has traveled its greatest distance from the central position. The distance between small punch marks placed on the shoulders of the clamp and its guide is spanned with bow dividers, a separate pair being used for each clamp. The hand wheel is turned 180° until the blade is again in its outermost position, and the deflection interval is again spanned with the bow dividers. If this test should show the folding blade to travel farther on one side of its stroke than on the other, it can be remedied by moving the whole central block backward or forward until the the two strokes are equalized.

The procedure for adjusting the spring tension, which was described in the previous publication, should be used in its entirety only as a means of equalizing the deflection intervals previous to making the final adjustment of the springs with which tension is applied to the specimen. This preliminary adjustment is necessary only in case the spring tension is badly out of adjustment or the deflection inter-

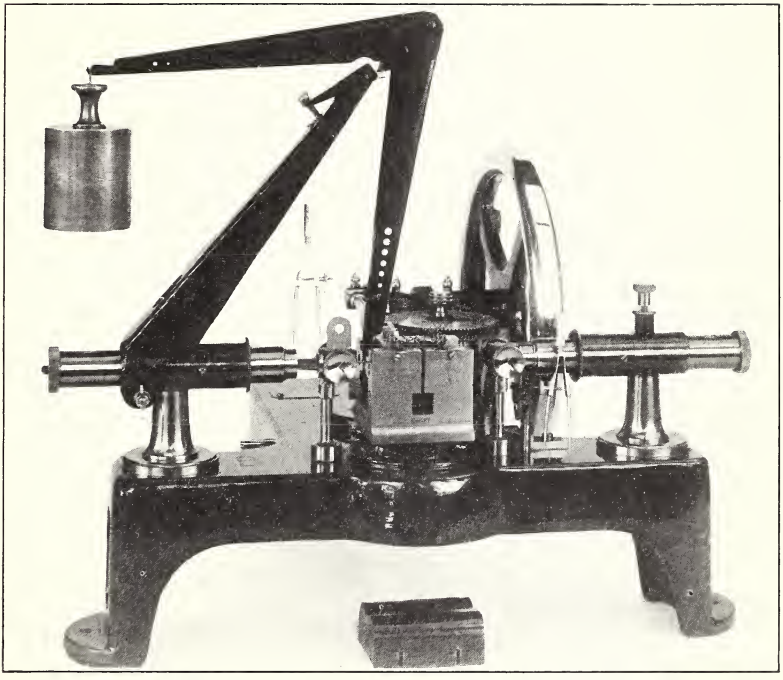

FIGURE 2.—*Balanced bell-crank lever used in calibrating folding testers*

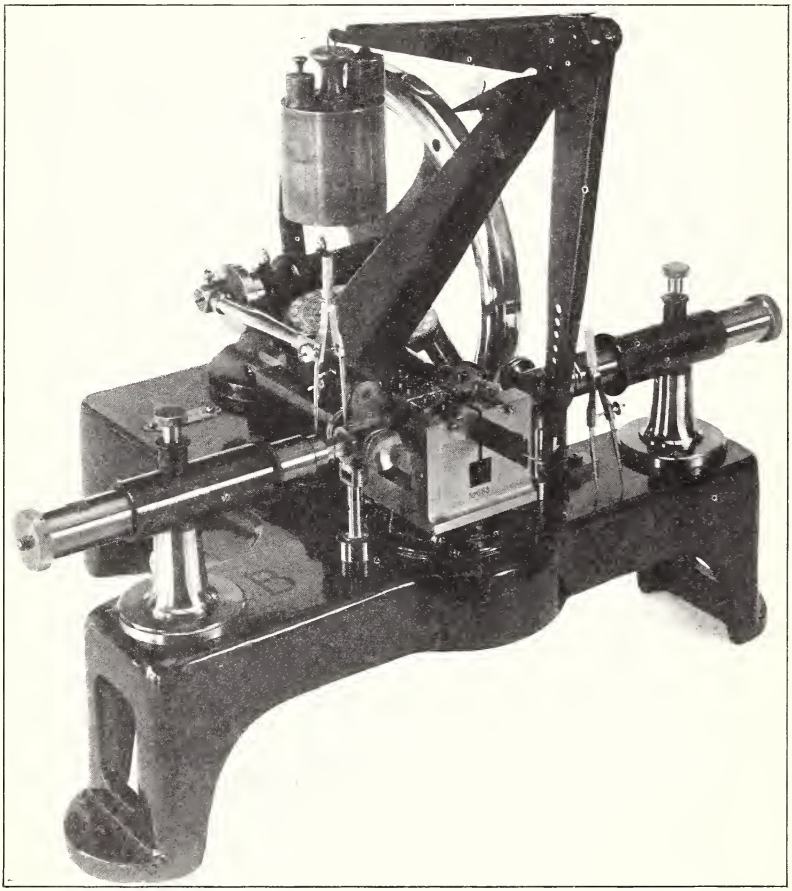

FIGURE 3.—*Method of measuring roller friction with bell-crank lever device*

vals are much different. Should it be regarded as final, there is some danger of a faulty adjustment resulting from one of the jaw stems sticking slightly in its guide as the folding blade is moved out of its central position before the specimen is put under tension. This preliminary adjustment differs from the final one only in that the spring housings are moved out after the maximum blade travel is attained, rather than before, so as to compel the two jaws to move approximately the same distance.

In order to adjust the tension of the springs attached to the jaws so that they will exert a tension of 1 kilogram on the specimen when the folding blade has reached its farthest outward position, a specimen of paper or celluloid is clamped in the jaws, the spring housings are pulled out to their operating positions, and then the driving wheel is turned until the folding blade is in its outermost position. Each interval is spanned between punch marks on clamp and stem with the bow dividers which are left set as a means of reproducing the respective intervals. The bell-crank lever device is put in place as illustrated in Figure 2, and the height of the knife-edge bearing is adjusted so that the supporting rollers touch the jaws lightly. With a 1-kilogram weight at the end of the horizontal arm, each spring is adjusted so that the deflection interval corresponds to the setting of the bow dividers; that is, so that the spring exerts a tension of 1 kilogram when the folding blade is in the outermost position.

The friction of the quandrantal rollers may next be measured with the bell-crank lever device attached as illustrated in Figure 3. The bow dividers are used as before as a means of reproducing the deflection interval corresponding to a tension of 1 kilogram. With the 1-kilogram weight attached to the horizontal arm, more weights are added until the spring is extended an amount corresponding with a tension of 1 kilogram as determined with the aid of the bow dividers. The weights on the lever arm should be lifted slightly and lowered very gently, so as to allow the apparatus to come to equilibrium without the effect of shock. The weight which it has been necessary to add represents the friction of the roller in terms of effective tension on the specimen. The friction of all four rollers is determined in this manner. If the friction of any roller exceeds 100 grams effective tension, an effort should be made to reduce the friction by oiling or cleaning the bearing surfaces. If it is necessary to remove any roller, the whole calibration procedure should be repeated, including the test for alignment of the rollers.

The various adjustments are interdependent. For example, the adjustment of the central block containing the rollers in order to equalize the travel of the folding blade in each direction also affects the maximum spring tension, and realignment of the rollers may affect their friction. It is necessary to have a fairly definite and systematic procedure for the calibration and adjustment in order to cover the situation adequately without unnecessary repetition in the procedure. Considerable attention to these testers is required in order to obtain reliable results, and a careful, periodic inspection and adjustment is essential to the best results.

WASHINGTON, April 3, 1929.