THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

BEHAVIOR OF FIBROUS AND NONFIBROUS COMPONENTS IN THE CORRUGATING OPERATION

PART IV-A. ANALYSIS OF FLUTE PROFILE OF ALUMINUM FOIL

Project 1108-22

Report Six

A Progress Report

to

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

March 26, 1962

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SUMMARY

The results of this limited study indicate that at slow corrugator speed and with low frictional drag between the medium and the fluted roll, the difference in consecutive flute height is somewhat more random, but still evident. The results obtained at the higher speeds, together with the data on silicone-treated board emphasizes the importance of friction. The results also strongly suggest that the periodicity noted in this and previous studies may be markedly influenced by what happens at the pressure roll nip.

INTRODUCTION

In Progress Report Four (Project 1108-22) to the Fourdrinier Kraft Board Institute, Inc., dated March 15, 1962, it was found that all samples of commercially made single-faced board exhibited a distinct pattern or periodicity of alternately high and low flutes. Further, it was hypothesized that the mechanism of corrugating or single-facing introduces a periodicity of high-low flutes; thus, the material and corrugating conditions effects on high-low corrugations may be superimposed on a basic high-low flute profile imposed by the corrugating or single-facing mechanism. There are indications that the mechanism of single-facing may play an important role in this connection because it is at this point that the fluted medium is translated from a "gear" form to a "rack" form. In order to accomplish this, there must be rotation of the flutes because when the flutes approach the pressure roll nip, the tips of the flutes are farther apart than the roots (due to curved surface of roll); however, on the discharge side of the nip, flute tips and roots are the same distance apart.

One way of testing the hypothesis that the mechanism of corrugating and single-facing imposed a high-low flute profile would be to corrugate a uniform material and observe the flute profile. The assumption is that, with an ideally uniform material, any periodicity would be associated with the mechanism of fabrication rather than material. Attention was, therefore, focused on obtaining a uniform material. A 0.0045 annealed aluminum foil was selected for this purpose. Previous examination of this particular foil indicated that its general characteristics were considerably more uniform than corrugating medium, although far short of ideal.

The aluminum foil selected above was fabricated into A-flute single-faced board on the Institute's experimental corrugator and the resulting board analyzed for flute height profile. Two regular corrugating mediums were also corrugated under various conditions for purpose of comparison.

MATERIALS AND PROCEDURE

The materials used in this phase of the study were as follows:

1. 0.0045 annealed aluminum foil
2. No. K6698, 26-lb. semichemical corrugating medium.
3. No. K6682, 26-lb. kraft corrugating medium.

The fabrication of the aluminum foil was carried out at 30 f.p.m. using a heavy application of silicone on each side of the foil to prevent fracture of the flutes. Higher speeds resulted in fractured flutes even with the silicone treatment. The other conditions of fabrication were the same as used in corrugating medium except that two-sided pressure-sensitive tape was applied to the single-face liner which provided a bond with the foil at the single-face pressure nip.

For comparison purposes, both the regular corrugating mediums were corrugated at 30 and 600 f.p.m. with and without silicone. The "without" samples were run first and the "with" samples last.

In addition, the regular corrugating mediums were run at 600 f.p.m. and the web tensions used were minimum, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 pounds per inch of width.

The flute height measurements were made in accordance with the Institute's normal procedure using the special caliper device.

DISCUSSION OF RESULTS

The results obtained on the various corrugating materials used are presented in Table I. A comparison of the flute height profile for the 0.0045 aluminum foil and the two commercial corrugating mediums may be seen in Fig. 1. It should be pointed out that only 50 flutes were measured for the commercial mediums whereas 141 flutes were used in the case of the slow speed of 30 feet per minute; the aluminum foil and commercial mediums treated with silicone exhibited generally less periodicity relative to consecutive flute height difference than the commercial mediums which did not have the silicone treatment. The flute height profile for the commercial mediums fabricated at 30 f.p.m. without silicone exhibited greater fluctuations in flute height and, in general, a more pronounced periodicity. When the fabrication speed is increased to 600 f.p.m., the difference in consecutive flute height increases markedly with and without silicone treatment. The silicone treatment appeared to be more effective in reducing "high-low" corrugations on Samples 6682 than 6698.

The above results, although limited, indicate that even a relatively uniform material such as aluminum foil exhibits a certain degree of periodicity, i.e., alternate "highs" and "lows"--when corrugated into a single-faced structure at a low speed of 30 f.p.m. The difference in the height of consecutive flutes appears to be a function of corrugator speed and medium quality, particularly the interaction between the mechanism of corrugating and single-facing and the ability of the medium to slip, slide, or rotate as the stress demands. The lower the frictional drag against the fluted roll, the lower is the tension in the medium in the labyrinth. Undoubtedly, the variation in caliper, tension, and compression moduli, etc., from point to point as well as the variation in the "bounce" of the top corrugating roll all play a part; however, the frictional characteristics appear to have the major role relative to flute height differences.

TABLE I

SINGLE-FACED BOARD FLUTE HEIGHT RESULTS

Trial No.	Material	Corrugating Conditions: Speed, f.p.m.	Corrugating Conditions: Tension, lb./in.	Corrugating Conditions: Silicone Treatment	Flute Height, pt.: Av.	Flute Height, pt.: Max.	Flute Height, pt.: Min.	Difference in Consecutive Flute Height, pt.: Av.	Difference in Consecutive Flute Height, pt.: Max.	Difference in Consecutive Flute Height, pt.: Min.
1	0.0045 aluminum foil	30	Min.	Yes		200.0	196.6	0.5	1.8	0.0
2	6682	30	Min.	Yes	196.0	197.2	194.5	0.8	2.3	0.0
3	6682	30	Min.	No	195.4	196.8	193.8	1.0	3.0	0.0
4	6698	30	Min.	Yes	196.0	198.2	194.5	1.0	4.2	0.0
5	6698	30	Min.	No	195.6	197.4	193.8	1.4	3.4	0.0
6	6682	600	Min.	Yes	198.3	200.0	196.2	1.5	3.6	0.0
7	6682	600	Min.	No	197.6	200.5	194.5	2.4	6.0	0.0
8	6698	600	Min.	Yes	198.0	200.8	194.8	1.6	4.3	0.0
9	6698	600	Min.	No	197.7	200.4	195.0	2.4	4.5	0.1
10	6682	600	Min.	No	197.8	201.1	194.0	3.6	7.0	0.6
11	6682	600	0.5	No	197.6	200.2	195.0	1.8	4.0	0.0
12	6682	600	1.0	No	197.7	202.1	194.9	2.4	7.2	0.3
13	6682	600	1.5	No	196.5	200.4	193.5	2.0	6.3	0.0
14	6682	600	2.0	No	196.2	198.5	191.7	1.9	6.5	0.0
15	6682	600	2.5	No	195.2	198.1	192.8	1.6	5.4	0.0
16	6682	600	3.0	No	194.2	197.7	191.0	2.6	5.3	0.1
17	6698	600	Min.	No	197.8	200.0	195.5	1.9	4.5	0.0
18	6698	600	0.5	No	197.5	200.5	195.1	2.2	5.6	0.0
19	6698	600	1.0	No	197.0	100.5	192.8	1.6	7.7	0.0
20	6698	600	1.5	No	196.4	200.2	193.0	3.0	7.2	0.8
21	6698	600	2.0	No	195.6	198.8	191.6	2.6	7.2	0.3
22	6698	600	2.5	No	195.7	199.1	191.1	3.0	8.0	0.0

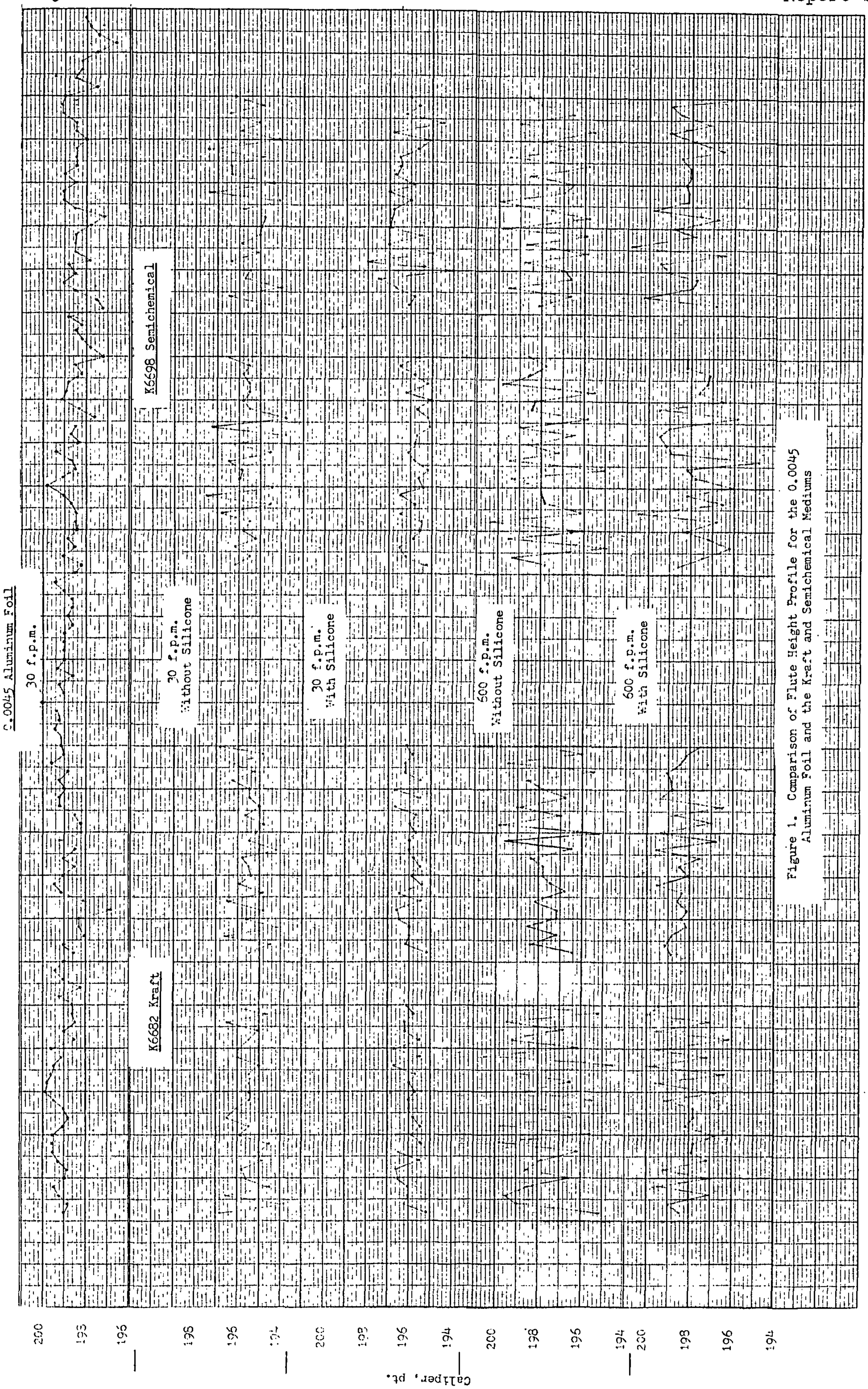

Figure 1. Comparison of Flute Height Profile for the 0.0045 Aluminum Foil and the Kraft and Semichemical Mediums

When the average flute heights are considered for the samples made at 30 f.p.m. with and without silicone treatment, it may be noted that the 0.0045 aluminum foil exhibited equal or higher caliper than the corresponding samples fabricated with 0.009 to 0.010-inch mediums. Also, the average difference in consecutive flute height was lower for the foil. When the regular board samples, fabricated at 30 and 600 f.p.m., are compared, it may be seen that the average flute height increased with increase in speed for both with and without silicone samples. The increase varied from 2.0 to 2.3 points. The average as well as maximum difference in consecutive flute height increased with speed although the increase was less for the samples having the silicone treatment. These results indicate the importance of the frictional drag of the medium against the corrugating roll.

The results for the two mediums fabricated at 600 f.p.m. using increasing web tension are also presented in Table I and are graphically illustrated in Fig. 2 and 3. The results indicate that the higher the web tension, the lower the flute height or board caliper. In the case of Sample 6682, the average and maximum difference in flute height appear to be independent of web tension, whereas in the case of 6698, the average and maximum difference increased with increase in web tension. Web or transport tension would, of course, have an effect only up to the center of the labyrinth, inasmuch as the transport tension beyond this point is essentially zero. The lower caliper at the higher web tensions indicate that the web tension increases the stiffness of the medium and may tend to "float" the top roll more at the higher web tension levels.

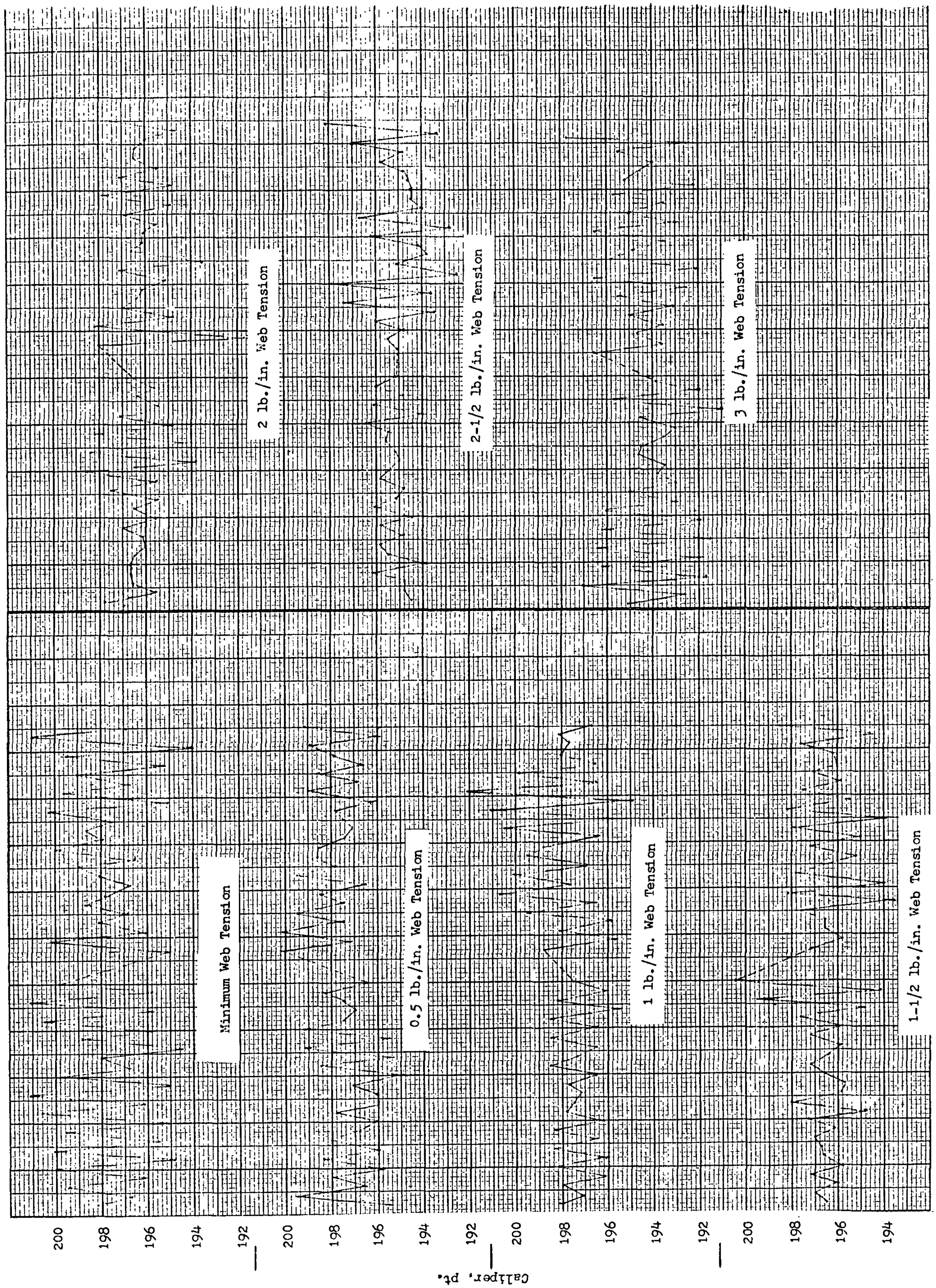

Figure 2. Flute Height Profile for Sample 6682
(Run at 600 f.p.m.)

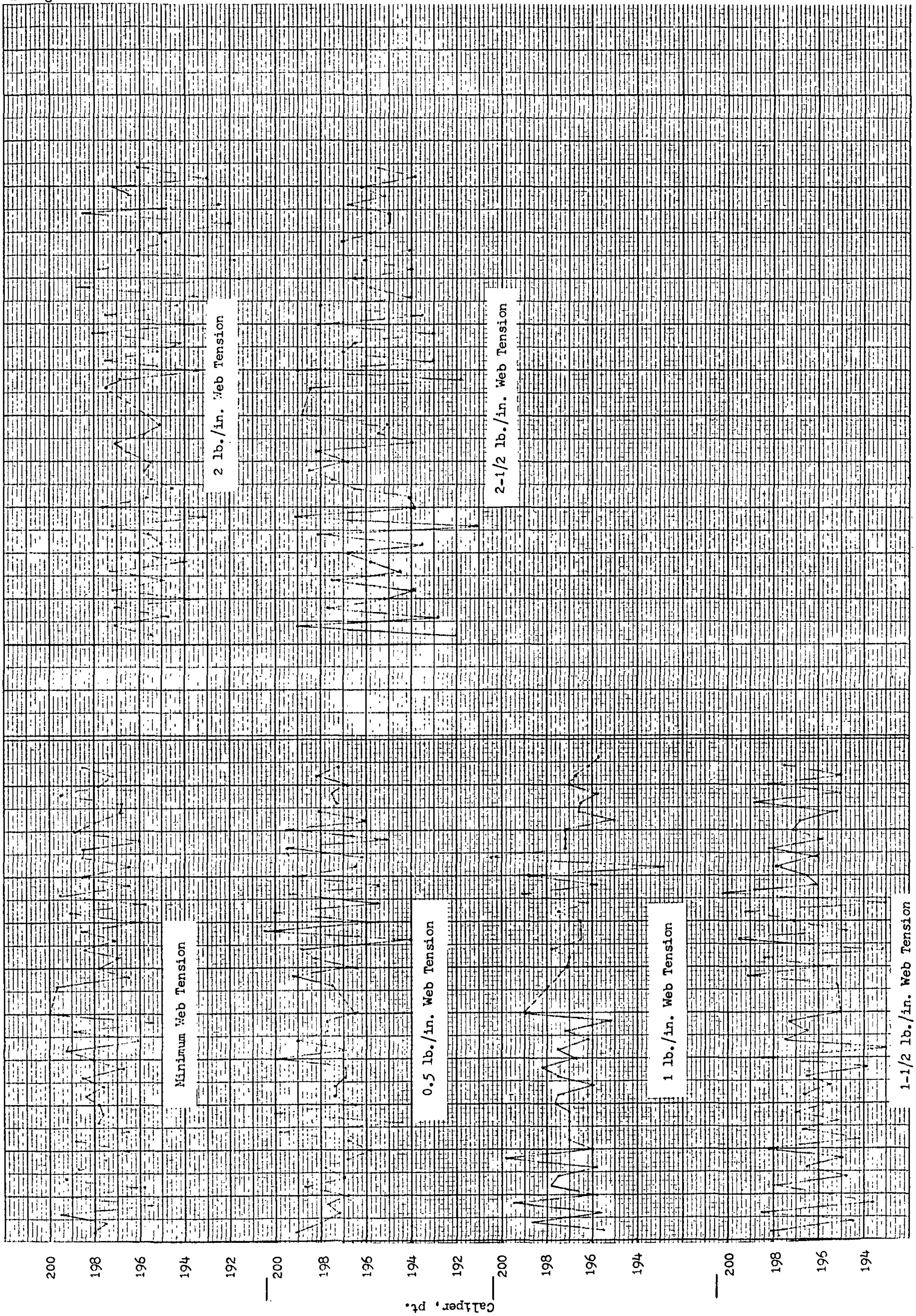

Figure 3. Flute Height Profile for Sample 5698
(Run at 600 f.p.m.)

LITERATURE CITED

1. The Institute of Paper Chemistry. Behavior of fibrous and nonfibrous components in the corrugating operation. Part IV. Analysis of commercial boards for high-low corrugations. Progress Report Four to Fourdrinier Kraft Board Institute, Inc., Project 1108-22, March 15, 1962.

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