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# Instrumental Method for the Determination of Hair Raspiness

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**Synopsis**—As comb teeth arrange hair fibers in a parallel manner and rub along hair scales, vibrational frequencies are emitted and play a role in the "feel" of hair. The audible frequencies, which denote raspiness, may be cosmetically undesirable. In an attempt to record and evaluate hair raspiness, an electronic comb, specifically designed to pick up frequencies by contact, was constructed. Several groups of hair tresses, which were treated with cosmetic chemicals, rinsed and dried, were combed with the instrument. Computer analysis of the data showed the expected differences between tresses; and some differences reflected excellent probabilities of test reproducibility. The method lends itself to rapid laboratory screening of agents designed to reduce friction during combing.

Hair raspiness, which is the property of a substance producing grating, harsh sounds and feel, is probably most noticeable during the combing process. As the comb moves through the hair and arranges it in a parallel manner, friction at the tooth-hair interface generates frequencies and conveys to the individual an impression of general hair condition. It has been shown (1) that subjective judgments of handle and combing ease correlate very well with frictional measurements. A literature survey (2) has revealed the existence of many fiber frictional measurement methods, some of which may be applied to human hair studies. Others (3, 4) have measured the spectral distribution of sound produced by fibers in friction.

In an attempt to investigate characteristics of hair sound and feel as experienced by an individual during the combing process, an electronic

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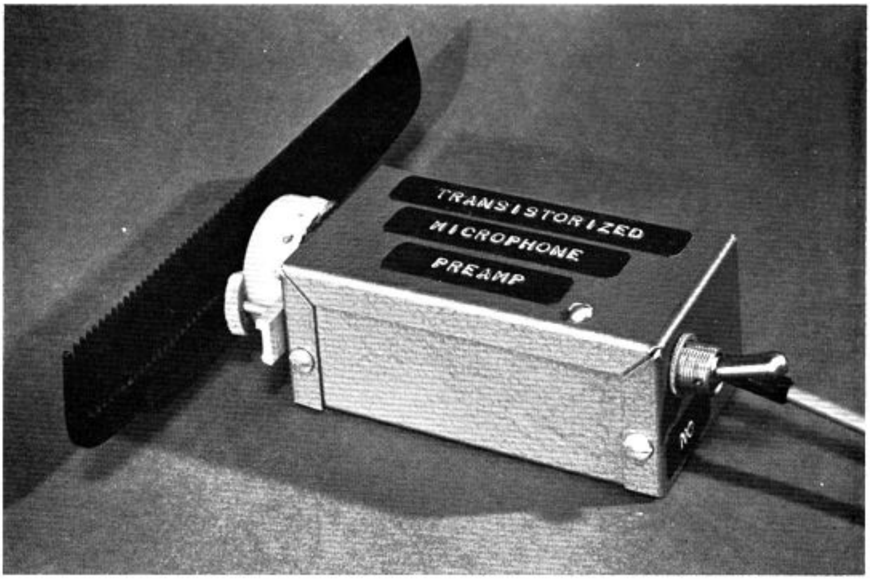


*Figure 1.* Comb, microphone, and pre-amplifier

comb which measures frequencies generated by tooth-hair interface friction was developed, with the following objectives:

a. The method should quantitatively compare product effects on hair raspiness.
b. The results should be in a form suitable for the application of statistics.
c. The method should be practical enough in test conditions to provide a routine evaluation of hair products.
d. The method should provide an additional parameter for tress quality control.

## Materials and Methods

A crystal contact microphone* which is specifically designed to pick up frequencies by contact and at the same time remains oblivious to extraneous noise was chosen for the study. An Ace Wavesetta hard rubber comb (#1033)† was affixed to the contact microphone (Fig. 1) by two small bolts. A third bolt, which had been placed through the comb

* Hamlin, Inc., Lake Mills, Wis.
† Ace Comb Co., Butler, N. J.

frame, served as a pressure adjustable contact bridge between the comb and microphone. In this situation, any sound frequencies received by the comb are carried to the contact microphone *via* the steel bolt. This complete assembly was mounted onto the end of a minibox. The microphone output was delivered to the single-ended input of a transistorized four stage pre-amplifier (Fig. 2) which has a self-contained power source, has an approximate gain of 100 and is contained within the aforesaid minibox. Signals from the complete unit were monitored on an oscilloscope during several tress combings. From the noise patterns on the

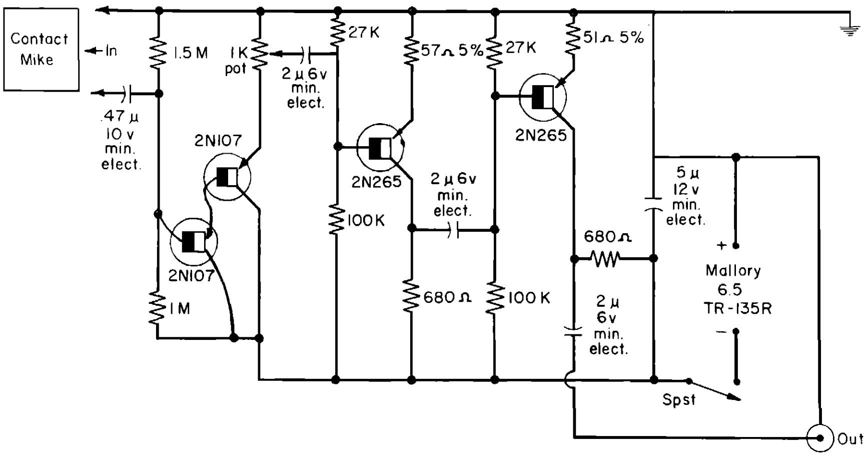


*Figure 2.* Diagram schematic of comb pre-amplifier

screen, the unit appeared to perform satisfactorily and provided a nucleus for all subsequent work. When the unit was monitored on a loudspeaker system, tress combings sounded similar to a rasping file on a sound board; hence the choice of the name, raspiness.

Initially, the transistorized pre-amplifier output was connected (single-ended) to a Grass 5B Polygraph* (Fig. 3) utilizing a 5P3 integrator pre-amplifier, which will integrate the complete incoming signal whether it is procured with a fast sweeping comb stroke or a slow methodical stroke; each record reveals the same area under the curve. As an option, the integrating pre-amplifier was monitored with a DuMont 411 oscilloscope.† A driver amplifier received the output of the integrating pre-amplifier and delivered the signal to an

* Grass Instrument Co., Quincy, Mass.

† DuMont Laboratories, Clifton, N. J.

oscillograph, where recordings were produced on strip-chart paper with curvilinear pens. Since the area under the curve has a direct relationship to frequency amplitude, chart curves were cut out with scissors and weighed on an analytical balance. Planimetering of the curves was found to be less accurate and, therefore, unsatisfactory. Integrator pre-amplifier calibration with a known input voltage makes possible comparisons between results taken at different times.

Secondly, the comb pre-amplifier was connected to an oscilloscope (Fig. 4) to which outside electronic capacitors had been applied to

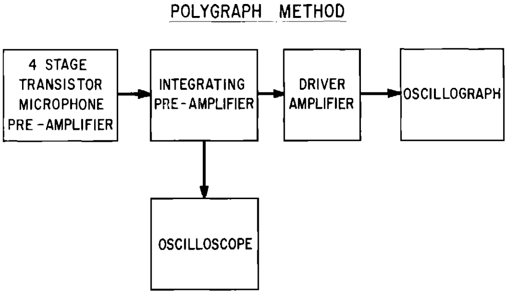


*Figure 3.* Block diagram of polygraph method

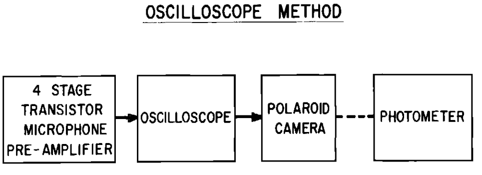


*Figure 4.* Block diagram of oscilloscope method

slow the sweep. Deviations of the electron beam were recorded on positive film using a Polaroid®* camera. After film development, a photometer reading of transmitted light through the film gave results relative to deflection amplitude of the electron beam.

For use, the transistorized pre-amplifier with the comb attached is held in the hand. A rigidly mounted tress or the subject's hair is combed with even strokes. Alternatively, tresses may be mounted on a constant speed rotating wheel and pulled through the rigidly mounted comb. Before the test combing is initiated, the comb is run through the hair several times to ensure no snarls and to establish timing.

* Polaroid is a trade mark of Polaroid Corp., Cambridge, Mass.

At least ten comb strokes at one-second intervals comprise the test. Tests have been run on wet and dry preparations. All tresses weighed 2.0 ($\pm$0.1) g.

Initially, damaged (bleached) and undamaged clean tresses were compared. In a second study, shampooed tresses were compared to tresses which had been shampooed and treated with a cationic rinse. Still further, in a third study, shampooed tresses were compared to tresses which had been treated with an experimental shampoo, which had been shown in previous subjective tests to increase hair manageability. A cross-over of the latter tress treatment supplemented this study. All results were analyzed by a Control Data® 160-A Computer,* using statistical FORTRAN† programs written by one of the authors (W. C. W.). Outcoming data from the hair combing device fit a normal distribution pattern.

## Results

Figure 5 gives representative recording examples. At the top left (*A*) is a compressed direct readout of three tress combings using the polygraph method. It is a series of positive and negative deflections; and although not utilizable for quantitative interpretation, it is evidence of noise generation. However, pen response time prevents recording frequencies above 60 cycles/sec. If the three previous signals are each electrically integrated, the record at the top right (*B*) is obtained. To increase sensitivity of the method, paper speed of the strip chart recorder may be accelerated to give an expanded integrated readout, as seen in recording *C*.

Records of control and treated tresses appear in the lower recordings of Fig. 5. Recording *D* is that of a clean, dry tress examined with the polygraph method (1 comb stroke). Record *F* is obtained from a similar tress examined by the oscilloscope method (4 comb strokes). If a dry tress which has been treated with a cationic rinse after shampooing is combed at the same amplifier settings used with control tresses, it may be readily observed from records *E* and *G* that the signal drop from the controls (*D* and *F*) is considerable with both methods of recording.

As seen in Table I (polygraph method), control tresses were compared to cationic rinse treated tresses, which when combed with the coarse

* Control Data is a trade mark of Control Data Corp., Minneapolis, Minn.

† FORTRAN is an abbreviation for FORmula TRANslation and was originally developed for International Business Machine equipment.

comb teeth showed a 77.72% drop in sound levels. Statistically, on the basis of the null hypothesis, there was a 5% chance that the control and experimental tresses were from the same population as a result of treatment. When the tresses were combed with the fine comb teeth and the results compared, there was an 84.31% drop in sound levels of the treated tress group. Here, there was only a 1% chance that the control and experimental tresses were from the same population as a result of treatment.

Table II (oscilloscope method) compares two groups of tresses which were treated with a control shampoo and an experimental shampoo, respectively. The experimental shampoo had the same detergent base as the control shampoo; however, it contained two additives which have been shown subjectively to increase hair manageability. The tresses which were washed in the experimental shampoo showed an 11.87% drop in sound levels when compared to the control group. Accompanying this is a 30% probability that the two groups are from the same population as a result of treatment. When the tress groups are crossed over, as seen in the bottom half of Table II, the experimental shampoo group exhibits only a 4.73% drop in sound levels when compared to the control group. However, there is a 60% probability that

Table I
Control Tresses and Cationic-Treated Tresses (Polygraph Method)

| Tress | N | Mean | Std. dev. | $t$ Value | Level of Sig. | % Change |
|---|---|---|---|---|---|---|
| | | | *A. Coarse teeth* | | | |
| Control | 3 | 4.09 | 1.98 | ... | ... | ... |
| Cationic | 3 | 0.91 | 0.24 | 3.70 | .95 | −77.72 |
| | | | *B. Fine teeth* | | | |
| Control | 3 | 14.98 | 3.55 | ... | ... | ... |
| Cationic | 3 | 2.84 | 0.47 | 5.87 | .99 | −84.31 |

Table II
Control Shampoo Tresses and Experimental Shampoo Tresses (Oscilloscope Method)

| Tress | N | Mean | Std. Dev. | $t$ Value | Level of Sig. | % Change |
|---|---|---|---|---|---|---|
| Control (A) | 6 | 40.81 | 7.21 | ... | ... | ... |
| Experimental (B) | 6 | 36.02 | 5.88 | 1.261 | .70 | −11.87 |
| Control (B) | 5 | 54.23 | 9.78 | ... | ... | ... |
| Experimental (A) | 6 | 51.67 | 4.27 | 0.545 | .40 | − 4.73 |

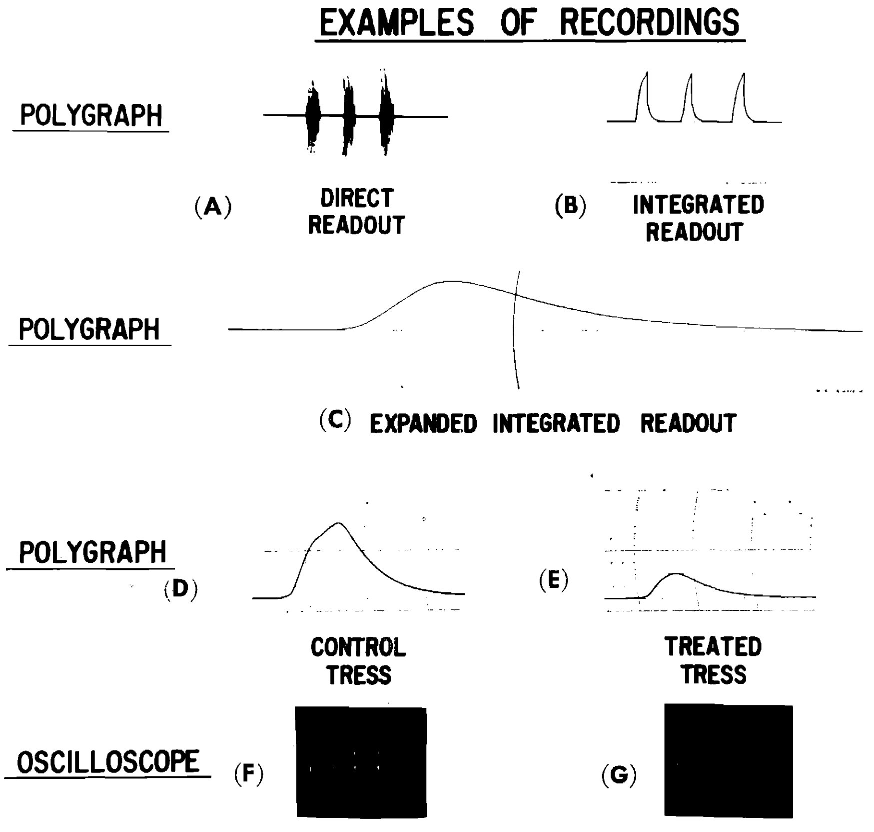


*Figure 5.* Representative examples of tress recordings

the two groups are from the same population as a result of treatment. In the cross-over, one tress was eliminated in group *B* due to obvious contamination.

In addition, when dry bleached hair was compared to dry unbleached hair in early studies, there were greater sound levels during combing of the former based on subjective evaluation of the records. Some holding sprays tend to increase combing sound levels. Furthermore, it is difficult to differentiate between similar control and experimental products on wet hair.

## Discussion

The method as shown in Fig. 5 and monitored on audio output appears to reflect sound levels (raspiness) as a result of comb-tooth and frame interface friction during the combing process. The method appears to be practical for use in both tress and *in vivo* work, since the initial sensing element is a common hard rubber comb.

The polygraph method and oscilloscope method give comparable results. The former method appears to have advantages from an *a priori* standpoint because the integration system will more faithfully register complete signals; whereas the oscilloscope photos register only those points in the flying spot path for which residence time is sufficient to affect film emulsion. However, the polygraph method is more time consuming in cutting and weighing of records. A digital voltmeter which would display the integrated signal would rectify this situation.

From the data in Table I, tresses treated with a cationic rinse gave about one-fifth the raspiness levels as those recorded in the control tresses; and this change was significant at the 0.05% level with the coarse comb teeth and significant at the 0.01% level with the fine comb teeth. This is in contrast to previous work (1), which found a cationic rinse to have relatively little effect on dry friction of hair.

Table II compares two groups of tresses, which were treated with a control shampoo and an experimental shampoo, respectively. The experimental shampoo contains two ingredients which have been shown subjectively to increase hair manageability. In the first test, the 12% drop in raspiness values is not significant at an acceptable level. After the cross-over, the experimental group again shows a raspiness value drop, which is not significant at an acceptable level. However, a trend is noticeable, and the data of the first experiment in Table II show enough promise to warrant increasing the degrees of freedom (numbers of tresses) to anticipate better confidence limits of probability. In the second experiment, tress group *B* may have had some carry-over from the first treatment, as reflected in the lower relative changes in sound levels.

The finding that bleached hair gives much higher raspiness levels than unbleached hair correlates with other studies (1). These present tests were examined subjectively by strip-chart recorder and audio outputs; however, the difference was highly discernible.

In addition, electronic comb measurement is now being used as another parameter for selection of homogeneous tress groups, thereby establishing better tress quality control.

In conclusion, the method presented appears to offer the hair investigator a tool for the exploration of the parameter, raspiness. It is possible that the method may find better use after further development. It has an advantage in that the primary probe is the common comb and the electrical integrating system is designed to normalize readings independent of sampling technique. The disadvantages lie in the inability to sample a standard tress after different treatments. In one case the hair may be highly charged with static, spread out, and representative combings difficult to obtain; and with other treatments the hair fibers may tend to mat together and involve more fibers than in the first case. However, this may be a blessing in disguise for these situations do more closely depict actual user conditions.

Several other aspects can be considered in future studies. The effects of materials of construction of combs would be of interest to comb manufacturers. This study would be feasible if the combs were produced in similar molds. The hair-on-hair *versus* comb-on-hair noise ratio should be explored. Our assumption that the major noise component is a result of tooth-hair interface friction may be vulnerable. In spite of apparent shortcomings the method appears to have some potential which will be borne out by future studies.

## Summary

1. A method to evaluate frequencies, which are produced during hair combing, has been developed.
2. Data from the output devices may be handled statistically.
3. The method provides a basis for routine screening of hair products.
4. The method provides an additional parameter for tress quality control.

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