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## A Comparison of Coated Paper Surfaces by Photomicrography

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A COMPARISON OF COATED PAPER SURFACES  
BY PHOTOMICROGRAPHY /

Thesis

Submitted to the Faculty  
Department of Paper Technology  
Western Michigan University

in Partial Fulfillment of the Requirements for  
the Degree of Bachelor of Science

by

Everett L. Potts, Jr.

June 1958

# A Comparison of Coated Paper Surfaces by Photomicrography

## TABLE OF CONTENTS

Abstract	iii
Survey of Literature	1
Photographic Techniques	1
General Defects of Paper	2
Raw Stock Defects	3
Coated Paper Defects	3
Patterns of Coated Papers	3
Literature Cited	5
Experimental Part	6
Experimental Procedure	6
Equipment and Techniques Used	6
Results of Experimental Work	9
Conclusions	18
Acknowledgement	19

# A Comparison of Coated Paper Surfaces by Photomicrography

## ABSTRACT

Five different types of coated papers were photomicrographed, namely cast coated, roll coated, trailing blade coated, air brush coated, and brush coated grades.

All cast coated papers were found to be extremely smooth and essentially free of pattern.

Roll coated papers displayed a microscopic pattern which resembled the magnified surface of an orange peel.

Trailing blade coated papers displayed sharp-edged pits and, in some cases, scuffed surfaces.

Air brush coated papers had a microscopic pattern which resembled the non-magnified surface of a pie crust.

Brush coated papers closely resembled air brush coated papers microscopically, however, they also carried a macroscopic pattern of brush marks which distinguished them from the air brush coated grades.

It was concluded that various types of coating processes leave typical patterns which may be used in conjunction with other characteristics of the paper to identify the particular coating process used.

# A Comparison of Coated Paper Surfaces by Photomicrography

## SURVEY OF LITERATURE

In recent years the study of surface defects and patterns of coated papers through the use of modern photography and photomicrography has become a valuable source of information applicable to technical work in the paper industry.

The increasing importance of photomicrography has brought about corresponding changes and advancements in techniques. Experiments have been performed to ascertain the most desirable types and arrangements of illumination. Advancements in photomicrographic equipment have been made along with developments in slide and field preparation (1).

### Photographic Techniques

J. C. Nelson (2) pointed out, that the evenness of paper surfaces is very important in the manufacture of reproduction papers, and that development of techniques for photographing paper surfaces was necessary to bring about improvements in production. Nelson used two different types of photomicrographic cameras in his study of paper surfaces, namely a model 39A and a model H, both manufactured by Bausch and Lomb.

Another method for studying paper surfaces with photography was proposed by R. L. Clark (3). This method, named photomacrog-raphy, was defined as surface photography at magnifications less than 25 diameters. Clark defined photomicrography as photography of surfaces magnified more than 25 diameters. Clark's

article included 22 pertinent photographs of surfaces, micro-sections, and formations of paper.

Willets and Georgevits (4) utilized a Polaroid camera in their study of coated paper surfaces. The camera was mounted with a 20 power, wide field, tube attachment. Illumination was from a parallel light source at an incident angle of 82 degrees.

H. L. Rohs (5) used a Bausch and Lomb photomicrographic camera (type K) and a dynoptic microscope. A Nicolas Illuminator was the source of parallel light.

Recent work was done by Majani and Crane (6) on the variables affecting the printability of coated papers. Their work included a photomicrographic survey of various types of coated paper surfaces. The details of their techniques were not disclosed.

There are two distinct types of surface imperfections encountered in coated papers. Those which are usually accidental and, therefore, avoidable; and those, such as coating pattern, which are or appear to be typical and unavoidable. Since there may be a certain degree of confusion between defects and patterns they are both included in this literature survey in order to make their individual distinctions more evident.

### General Defects of Paper

The Fourdrinier Papermaking Committee of TAPPI offered three general definitions at the Paper Defects Round-Table Meeting in 1951 (7).

1."Paper defects are localized flaws that may be seen or

felt or become apparent in subsequent converting operations.

2. Paper defects are imperfections that mar the sheet of paper for the converter or ultimate consumer.

3. Paper defects are those localized conditions which may or may not interfere with subsequent use of the sheet of paper."

### Raw Stock Defects

There are several raw stock defects which will produce imperfections in the final coated paper upon converting. Most of these defects were included in a list compiled at the TAPPI Paper Defects Round-Table Meeting (7). Outstanding examples are: stock lumps and slugs, slime spots, distorted surfaces, foam spots, wire impressions and thin streaks caused by ridged wires or water sprays.

### Coated Paper Defects

Even with theoretically perfect raw stock there are many defects which may occur in the coating conversion. Some of these imperfections, such as bubble craters, pinholes, "fish eyes", galvanizing and dusting, were mentioned in the article "Surface Defects Due to the Coating Process" (8).

### Patterns of Coated Papers

Webster (9) defines pattern as a design and, more specifically as an arrangement or composition that suggests or reveals a design. In the case of coating pattern, this design may be excessive and objectionable or minor and consequently acceptable.

The leveling index as proposed by Smith, Trelfa, and Ware (10) gives according to Gallagher (11), an indication of the pattern-forming characteristics of a coating color.

According to Majani and Crane (7), present day coating machinery produces a coated sheet with a characteristic pattern, and therefore it is possible to correlate each type of pattern with a specific method of coating.

During the course of the literature investigation it became apparent that additional information on coating pattern was needed; therefore, it was decided to undertake a photomicrographic study of coated paper surfaces.



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# A Comparison of Coated Paper Surfaces by Photomicrography

## EXPERIMENTAL PART

The objective of this thesis was to complement the presently available photographic records of coating patterns and defects which were limited in quantity. The work was confined to photomicrographic comparisons of coated paper surfaces.

### Experimental Procedure

Several examples of different types of coated papers were mounted on slides and observed with a binocular microscope in order to determine which slides were best suited to the photographic investigation.

The examples which seemed to characterize or typify best their own particular coating pattern were selected. These slides were then photographed at 30 diameters magnification with a photomicrographic camera on color transparency film.

Thirty examples were mounted and 140 photomicrographs were taken. From these, twelve were selected to illustrate characteristic patterns.

### Equipment and Techniques Used

The following equipment was used to take the photomicrographs for this thesis:

1. Bausch and Lomb monocular microscope with a five power eyepiece and a six power objective lens.
2. Bausch and Lomb Eyepiece Camera, Model N, with a 35

millimeter camera back.

3. Nicolas Illuminator, manufactured by Bausch and Lomb, as a source of parallel light for surface illumination, and equipped with a blue color compensating light filter.

4. Kodachrome, 35 millimeter, daylight type, color transparency film for projection.

5. Bausch and Lomb binocular microscope adjusted to 30 diameters magnification for preliminary scanning of samples.

6. A photographic darkroom, so that the light intensity for correct exposure could be duplicated.

7. Standard glass microscope slides for backing the paper samples.

8. Cellophane tape and rubber cement for mounting the paper samples on the glass slides.

9. Microscope slide box for storing samples when not in use.

10. Watch with sweep second hand for timing the exposure.

After the photomicrographs were taken and developed, standard viewing or projection equipment was used to inspect the transparencies for interpretation and descriptive analysis.

The set-up for taking the photomicrographs can best be explained by the labeled illustration in figure 1.

With the front lens of the Nicolas Illuminator two inches from the objective area and the angle of illumination less than ten degrees, the exposure time on Kodachrome daylight type film was 22 seconds. Daylight type film was used because the Nicolas Illuminator is factory equipped with a blue color compensating light filter.

All color film processing was done by the Eastman Kodak Company, Chicago, Illinois. The Kodachrome Transparencies were converted into Kodacolor negatives which were used to make black and white positive prints for use in this thesis.

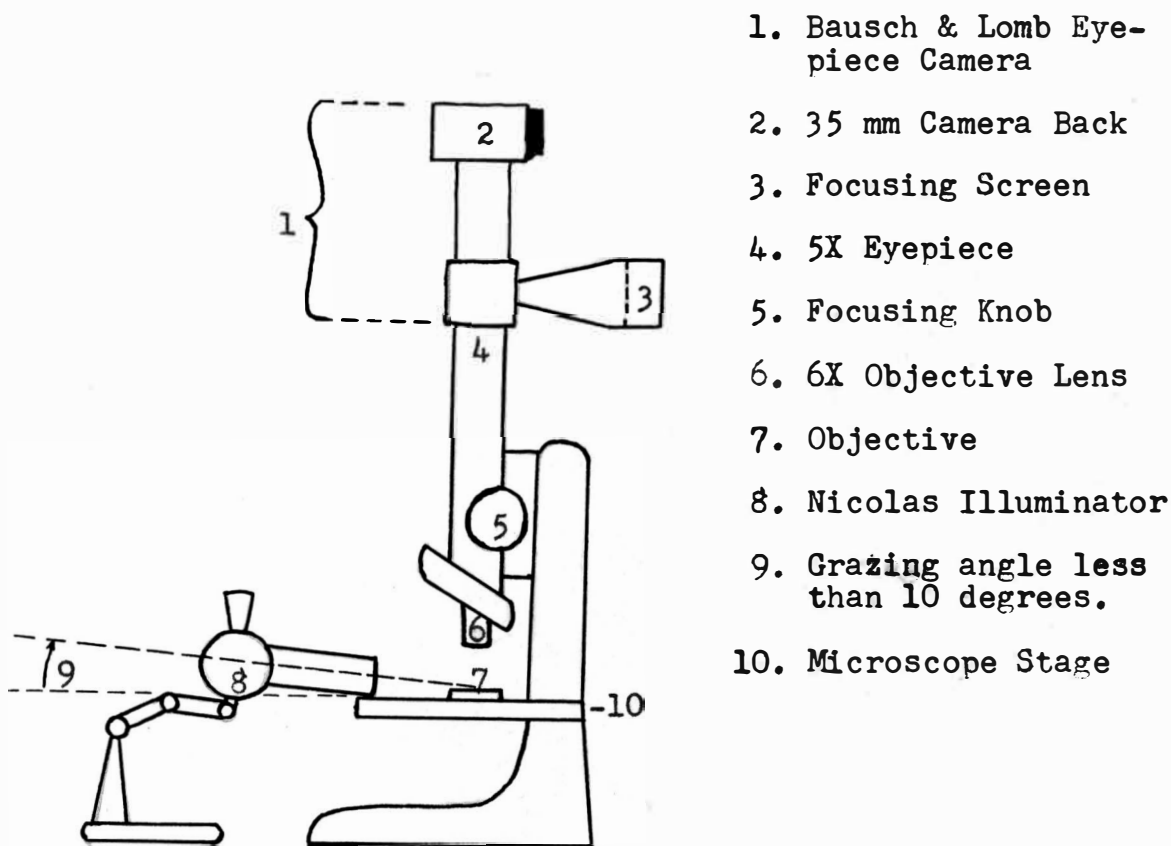
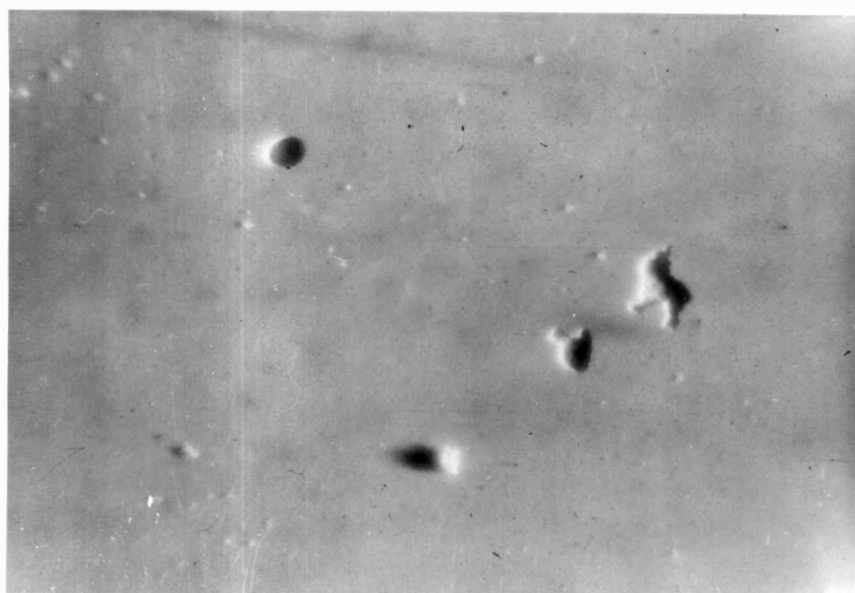


FIGURE 1

### Results of Experimental Work

The following photomicrographs were chosen because of their characteristic patterns to represent the various types of coating processes. Accompanying each photograph is a written discussion describing the surface characteristics which were used to identify the coating pattern and its corresponding process.

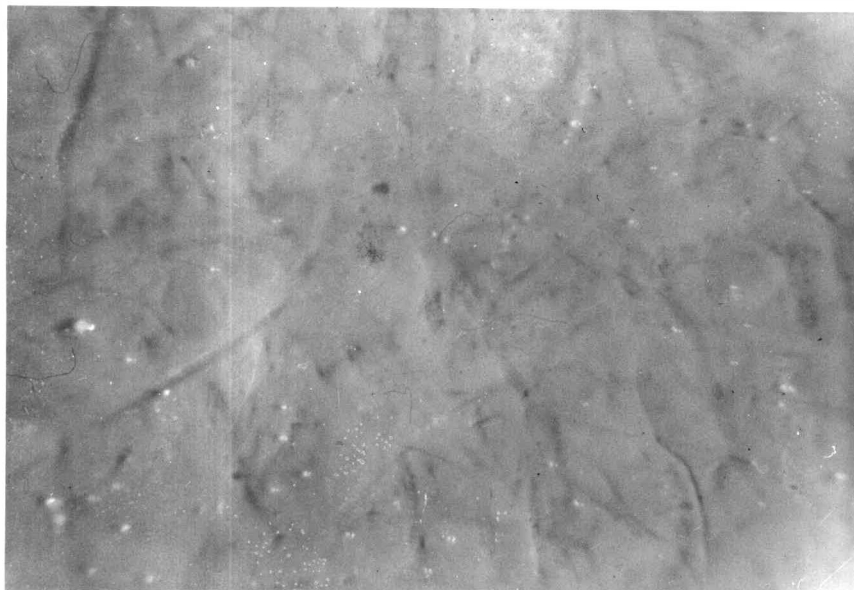
Figure 2; Heavy Weight Cast Coated Paperboard



The surface of this cast coated sheet is extremely smooth and the coverage of the raw stock is excellent. There are three relatively large pits which penetrate deeply into the coating and have irregular shapes.

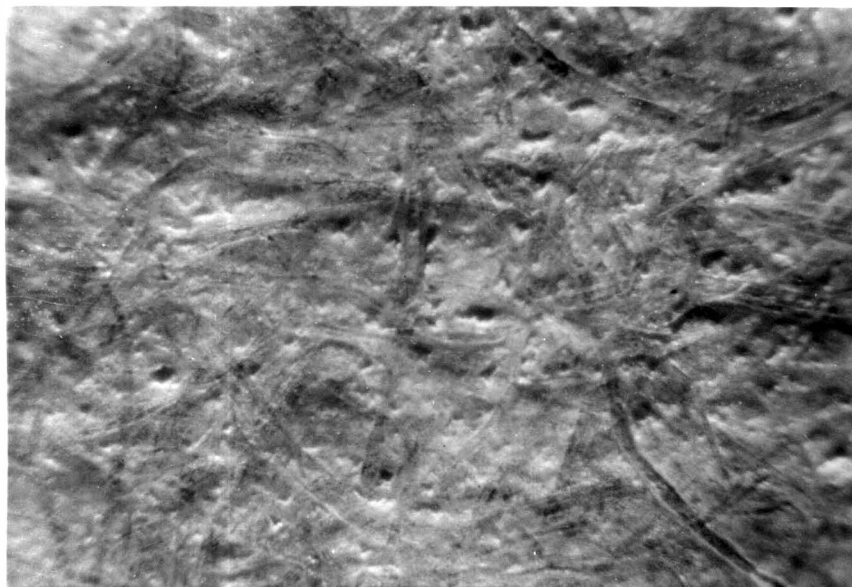
The light source is from the right or east side of the photograph and therefore, all shadows are cast to the left or west. There is a dust particle in the six o'clock position on the photograph which casts a long shadow to the left.

Figure 3; Light Weight Cast Coated Paper



The coating is very smooth and the coverage of the raw stock is good. However, there is a mild degree of roughness caused by the moderate fiber show through. The illumination is from the right or east side of the photograph.

Figure 4; Medium Weight Trailing Blade Coated Paper



The trailing blade coated paper of figure 4 has been supercalendered, and therefore, since the coating weight is relatively light there is a great deal of fiber show-through. There are several clearly defined, sharp-edged pits visible between the fibers. These particular kinds of pits are characteristic of the trailing blade process. Illumination is from the north side of the photograph.

Figure 5; Light Weight Trailing Blade Coated Paper

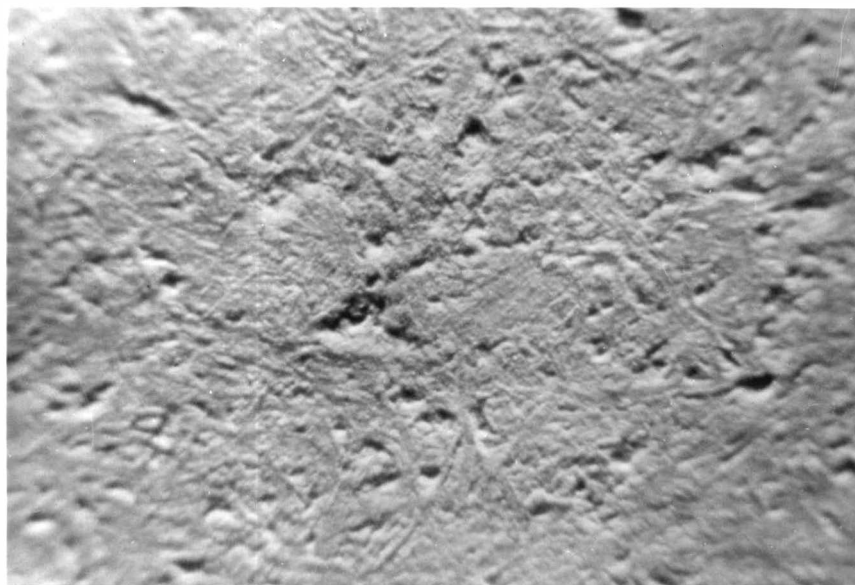
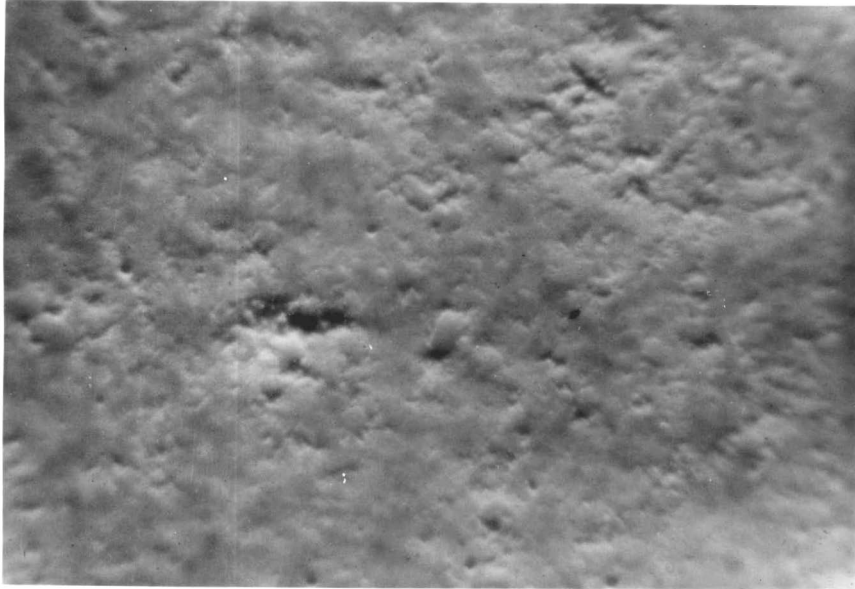


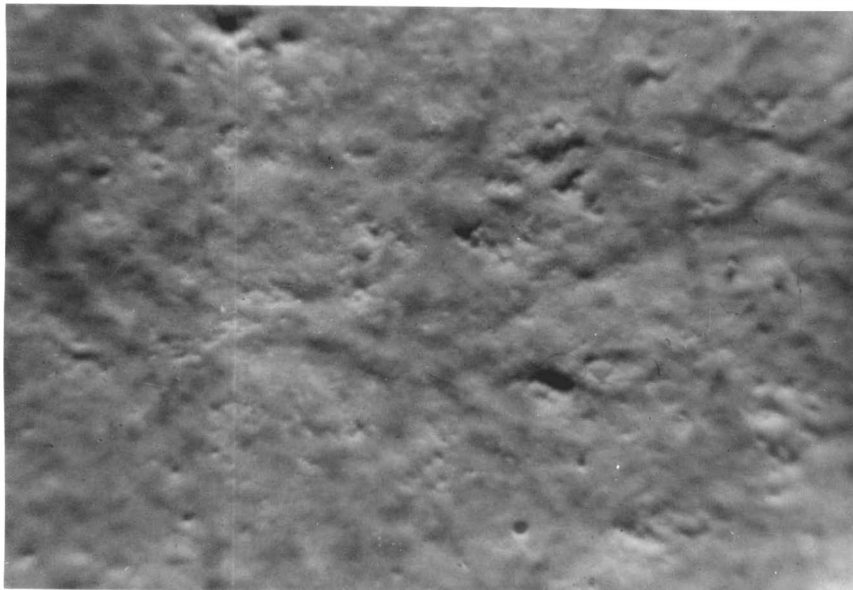
Figure 5, shows an un-calendered light weight trailing blade coated paper. The raw stock for this sheet was also light weight. The fiber matrix is readily visible and the surface appears to have been scuffed during the coating process. The sharp-edged pits are visible even though the sheet has not been supercalendered. Illumination is from the north.

Figure 6; Heavy Weight Air Brush Coated Paper



This air brush coated sample has a coat weight of 15 pounds, and consequently fiber show-through is at a minimum. The surface has an appearance similar to that of a pie crust. Illumination is from the north side of the photograph.

Figure 7; Medium Weight Air Brush Coated Paper





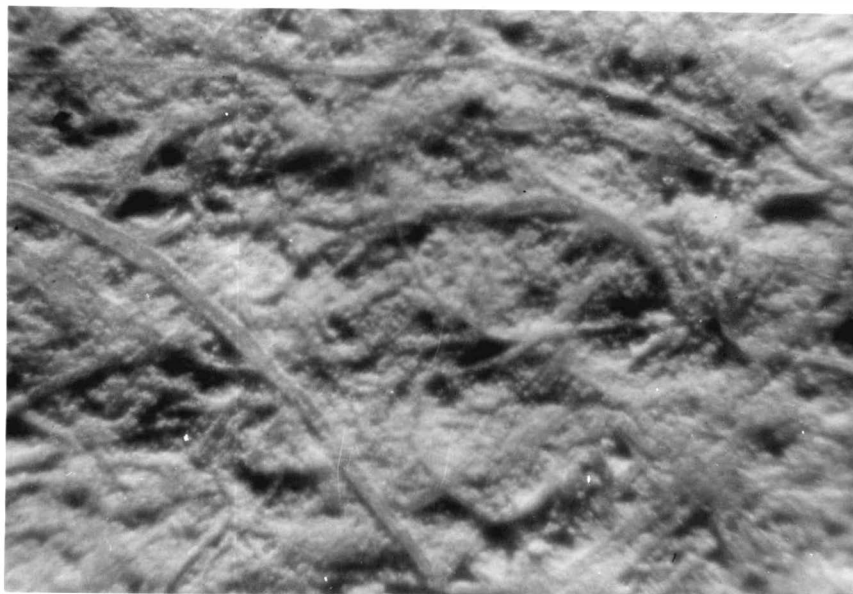
The air knife coated specimen of figure 7 has a 11.5 pound coat weight, therefore, there are a few fibers visible through the coating. This sheet has been supercalendered. The pie crust appearance is still readily discernible. The illumination is from the north side of the photograph.

Figure 8; Un-calendered Air Brush Coated Paperboard



This air brush coated paperboard sample has not been calendered as is evident by the prominent display of fibers. Coverage of individual fibers is good but the coating followed very closely the contours of the fibers. There is a great deal of similarity between this air brush sample and the trailing blade un-calendered sample; and a very striking similarity between this air brush sample and regular un-calendered hair brush coated samples. There are essentially no pits with the exception of area where the coating has not filled up the spaces between the surface fibers. The illumination is from the north side of the photograph.

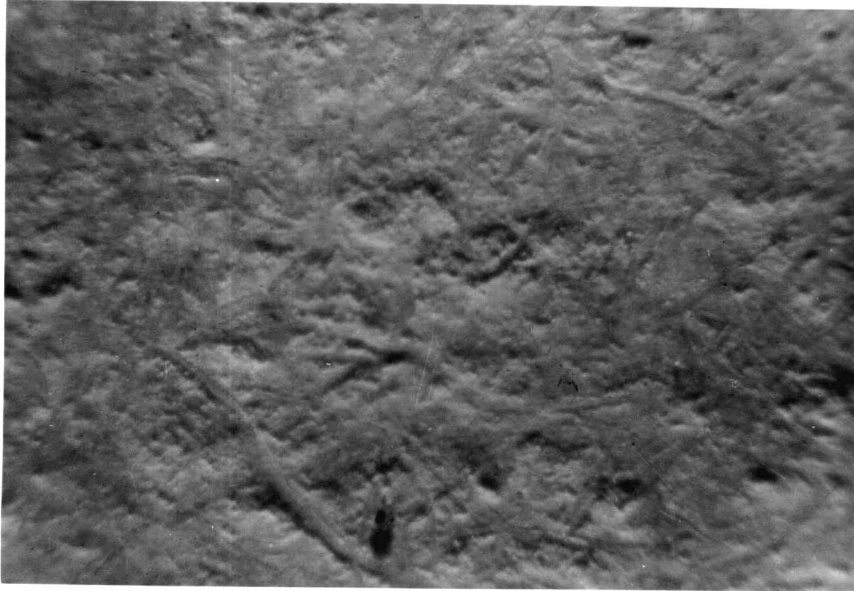
Figure 9; Light Weight Un-calendered Brush Coated Paper



On this brush coated sheet the coating appears to follow the contours of the fibers very closely. That is to say, the individual fibers are relatively well covered but their outlines are quite prominent. However, the locality immediately below the surface is well filled with coating. There are no individual pits evident, but there are many open areas between the surface fibers. The general appearance of this sample is very similar to the previously described air brush coated surfaces; however, the brush coating process leaves a macroscopic brush mark pattern which makes its identification relatively easy.

Illumination is from the northern side of the photograph, and it should also be mentioned that the high and low areas on this surface are approximately equal in distribution.

Figure 10; Light Weight Calendered Brush Coated Paper



The fibers closest to the surface on this sample are quite evident; however the main body of the sheet has been well covered with coating. The recesses in the surface are comparatively shallow. The macroscopic brush pattern previously mentioned is present but not visible under magnification. Illumination is from the north side of the photograph.

Figure 11; Un-calendered Roll Coated Paper

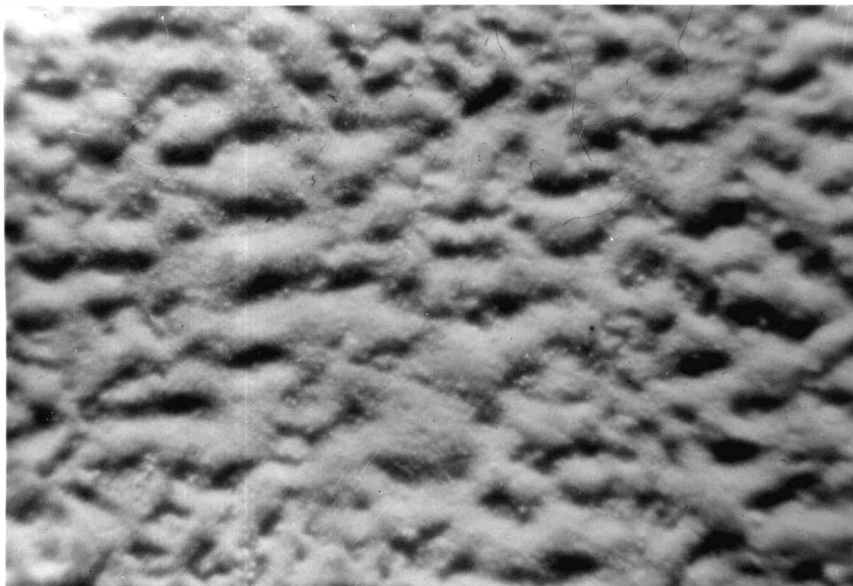
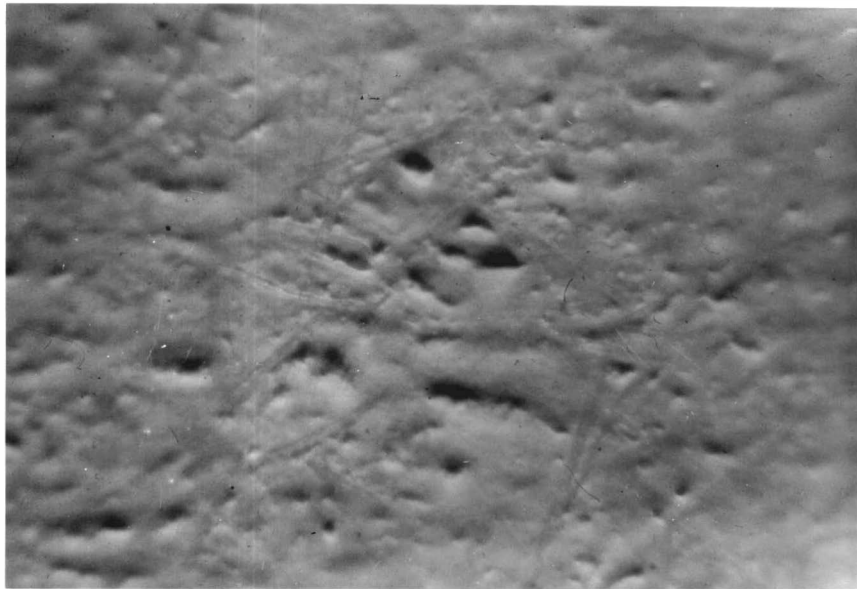


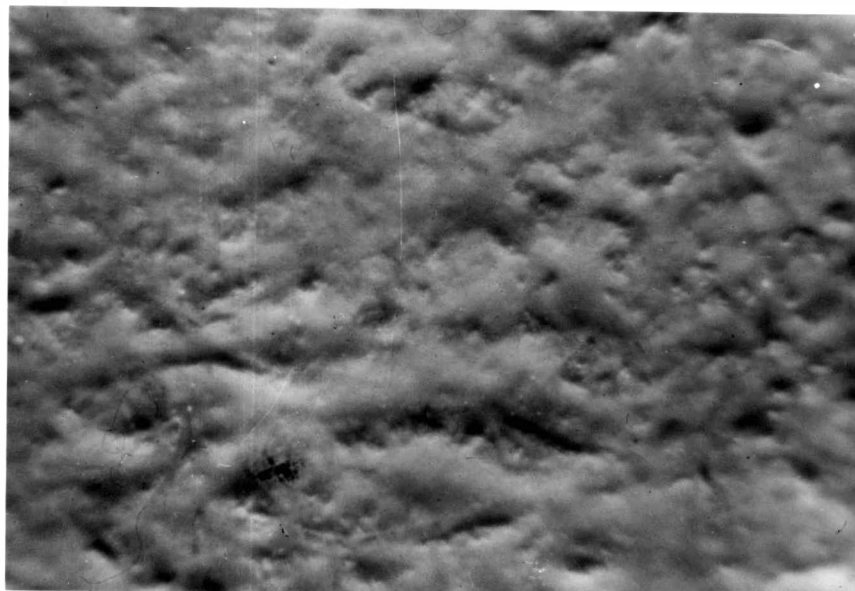
Figure 11 is an un-calendered roll coated paper. It has a rough surface which closely resembles the magnified surface of an orange and its pattern is commonly called an orange peel pattern. The illumination is from the north side of the photograph.

Figure 12; Supercalendered Roll Coated Paper



The surface of this roll coated sample is relatively smooth and displays several round-edged pits. The coverage is good, even though many surface fibers are still visible. The orange peel pattern has been flattened out due to the action of the supercalender. The pits that are visible appear to be caused by the fiber matrix not being sufficiently filled with coating. There is a slight similarity between this sample and the pie crust pattern of air brush coated paper. Illumination is from the north side of the photograph.

Figure 13; Duplex Roll Coated Paper



This duplex roll coated sample has been lightly supercalendered. The coverage of the surface fibers is good due to the second layer of coating which was applied. The orange peel pattern is present but partially disguised by the double layer of coating. This sample also resembles the pie crust pattern of air brush coated paper. Apparently the supercalendering did not adequately flatten the surface. The illumination is from the north side of the photograph.

## CONCLUSIONS

Each coating process leaves a characteristic pattern. These patterns may be used to identify what process was utilized. If the paper has not been supercalendered, the pattern will be readily identifiable. However, if the paper has been supercalendered, identification of pattern becomes more difficult. The actual degree of supercalendering necessary to completely disguise a pattern was not determined. Double coated papers were not readily recognizable due to the cancelation of pattern by the second coat.

The unusually smooth surface of cast coated papers and the orange peel pattern of roll coated papers were easily identified by photomicrography. Therefore, it was not difficult to distinguish these two types of coated papers from air brush, brush, and trailing blade coated grades. However, identification of air brush, brush, and trailing blade patterns by the use of photomicrography alone was not always satisfactory. Consequently, separation and identification were accomplished by combining microscopic techniques with other observations. Air brush coated papers under magnification closely resembled the surface of a pie crust. The trailing blade coated papers displayed characteristic sharp-edged pits. Neither the air brush nor the trailing blade coated papers showed a significant macroscopic pattern. However, the brush coated papers displayed macroscopic brush marks which aided greatly in their identification.

## ACKNOWLEDGEMENT

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