Alfred Bader

Alfred Bader Fine Arts

Special Report by Dr. John Asmus
University of California, San Diego

1973


Print File
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COMTE LÉON VANDALIN MNISZECH

NATIONAL GALLERY OF ART
Washington

Observe the Comparisons

SELF-PORTRAIT
by Rembrandt van Ryn
Dutch, 1606-1669
Canvas, signed and dated 1659

The range of Rembrandt's self-portraits is unrivaled in the history of art. From the age of twenty until his death at sixty-three, the Dutch genius painted about sixty likenesses of himself, a body of work he expanded with over twenty etchings and about ten drawings. While self-portraits comprise roughly ten percent of Rembrandt's oeuvre, their numerical importance is heightened by their continuity, for there is hardly a phase of Rembrandt's life unaccounted for in his portraiture. When considered as a group, these varied portraits display tremendous pictorial inventiveness. At the same time, they consistently probe the artist's character. Perhaps the most intense psychological study is Rembrandt's Self-Portrait of 1659.

Seated in profile against a plain brown background, hands folded in his lap, the fifty-three-year-old Rembrandt turns full-face to the observer. The artist's unpretentious clothing enhances the simple, straightforward mood. He wears a gray-green doublet with a high velvet collar set off by the thin yellow lining of his undergarment and the deep red cloak which rests over his arm. His costume is completed by a black cap decorated with gold cord; underneath, his gray hair is massed in short curls.

Rembrandt's lined countenance--with its irregular features, loose flesh, and a trace of a moustache--reveals the artist's years of experience.

His large dominating eyes express a profound thoughtfulness that pervades the entire work. Indeed, the artist's keen self-observation is punctuated by his steady, candid self-analysis. Like many of his mature self-portraits, this work is powerful through its simplicity of style and utter concentration on character. There are no superficial ornaments to compete with the solitary, dignified figure of the artist; all trivia yields to the compelling reflection of the man. To sustain such a focus, Rembrandt arranged a dramatic illumination of his face by manipulating color and light.

While the artist employed many hues in painting his costume, they nevertheless were toned down, forming a somber palette that is further subdued by the brown background. Rembrandt designated livelier hues--variations of yellows, reds, and cream tones--to his face. Here the warm, bright colors command attention. Rembrandt's serious, penetrating gaze is further enhanced through light. Reserved almost entirely for the face, light seems to shine from within Rembrandt's visage. Broad shadow accents that play around his eyes and under his nose and lips intensify Rembrandt's persistent analysis of himself.

There is a sober quality here, a record of the artist's inner trials. Late in his career Rembrandt was haunted by dwindling popularity, bankruptcy, and personal disappointments. Yet this self-portrait traces the spiritual elements of character that survive such bitter experiences. It was just that expression of human consciousness which Rembrandt sought in his art. In his lifelong study of man's psyche, he proved to be his own best model.

B. S. M.

Height 84 cm., width 66 cm. (33 1/4 x 26 in.)
NGA No. 72. Andrew W. Mellon Collection GALLERY 48

REMBRANDT - SELF PORTRAIT

This painting was purchased by Robert Bernard Shaw (Rusty) of the Carriage House Galleries - 5611 University Way N.E. Seattle, Washington 98105. Phone-206-523-4960. He did not know, and does not presently know that it is a Rembrandt. Rusty purchased the painting in Venice, Italy in 1958 from a Polish Countess who was married to an Italian Count. This painting (according to Rusty) was from her own belongings, and not from the estate of her husband. Her first name was Stella, but Mr. Shaw is unable to recall her last name, and has lost track of any correspondence he had with her. He knows that she was born in Krakow, Poland, and that she died in Nice, France about 1960. at approximately 70 years of age. Rusty had met her incidentaly in a cafe in Venice. They struck up a conversation, and as a result, he purchased many items directly from her.

This is really all we know about the history of this painting, aside from the fact that it was at one time in the collection of an illustrious Polish Count - Count Leon Vandalin Mniszech. The collection of this man is well known, and he had many fine works of art. Count Mniszech died in 1901, and his collection was sold in Paris, France in 1902. This painting was not in his collection at that time. It left his collection, probably at a much earlier date. The painting was damaged and cut down in size at some time after it left Count Mniszechs' collection, since the collectors seal is presently partially wrapped around the stretcher board. It had been backed up with another canvas prior to its being cut down. The important part of the painting remains intact, and in good condition.

This is a very important Rembrandt painting, not only because it is one of the missing self portraits from the mid 1660's, but

(up-to-date x-rays could verify the following information about the underpainting!)

also because of what lies beneath the surface painting.

According to Seymour Slive, who is a noted American authority on Rembrandt, about one third of his self portraits are lost or missing. Most experts believe that he made approximately 90 self portraits - about 60 of them are in existence today. This is inclusive of the three mediums - painting-drawing and etching. Between the years 1662 and 1669 no self portraits exist that are known. This self portrait helps date itself, by the paintings that exist beneath the surface painting. I believe that the portrait is from 1663 or 64.

There are two oil studies for famous paintings by Rembrandt beneath this self portrait. This is also very important to the value of this painting, for the reason that no other oil study for a painting by Rembrandt exists anywhere in the world.

The oil study furthest beneath the surface, is upside down. It is an oil study for the very famous painting of "A Man in a Gold Helmet" supposedly Rembrandts brother. I think everyone has seen prints of this painting at some time. It was painted at some time in the late 1650's. Some date it 1657.

Over the top of this lower oil study, Rembrandt painted an oil study for the central figure in the very large painting- "The Conspiracy of Julius Civilis". This famous painting (cut down by Rembrandt himself) now hangs in the Stockholm National Museum in Sweden. This oil study is in the same position as the surface painting, and is directly beneath the surface painting. This hugh painting was painted in 1661 and 1662. Since this painting was not completed until 1662, it follows that the self paortrait is from one of the following years.

I should mention that in 1656, Rembrandt went through bankruptcy proceedings. He lost his house, and everything that he had was sold at a fraction of its worth to cover his debts. This undoubtedly explains why this canvas was used by him over and over, and not discarded.

Techniques typical of Rembrandt used on painting.

A. Hair made by scraping with the pointed handle of his brush.
B. Highlights in eyes picked out to light underbase.
C. Highlight on nose scraped down to light underbase.
D. Scattered isolated spots of strong color at various places.

These techniques could have been taught to students, but it is doubtful that a student painting a portrait of Rembrandt would have picked up on two things evident on this painting. There is a small scar on the neck of Rembrandt on this painting. This is the only portrait that this can be seen on, because this is the only portrait of Rembrandt with his head held back. Also, there is a small quirk in the upper eyelid of his left eye. This quirk is evident in other of his self portraits in old age. This is really very strong evidence that the surface painting was painted by Rembrandt also, and not by one of his students.

THE BOEING COMPANY

LABORATORY REPORT

ASM 28-002
NO. 2-4863-0000-048

Purpose ____ Model ____ Date March 24, 1972

To: ____ Org'n. ____ Part No. ____

Subject: Radiographs of Paintings

Source ____ Reinsp. Req. ____

Purchase Order Letter R.R. ____ Date Rec'd. 3/09/72 Quan. ____ Acc. ____ Rej. ____

Material ____ Spec. ____

☐ Chem. Lab. ____ ☐ Sonic ____ ☐ Met. Lab. ____ ☐ Mechanical ____

☒ X-Ray ____ ☐ Mag/Penetrant ____ ☐ ____

Reference: Accommodation Sale ASM 28-002 C.C. to:

The radiographic laboratory has completed an examination of a painting, suspected to be by Rembrandt. The purpose of the examination was to determine whether the painting is an original Rembrandt. Several good radiographs were obtained using x-ray techniques between ten and twenty kilovolts at ten milliamperes. A focal film distance of 48 inches was used with Eastman Type M film.

The radiograph of the painting said to be a self portrait of Rembrandt, plainly showed the feature of the visible (exterior) portrait as outlined by the various types and thicknesses of paint. There were also faint and confusing indications of sketches that had been covered over in the final painting. The under sketches seemed to show a bearded man rather than the clean shaven man shown on the final portrait but this conclusion required some imagination. Nothing really conclusive was noted except that the painting is an original and quite old. A really good interpretation of the radiograph will require a knowledge of the techniques of the artist.

Prepared by K. Bendschneider Approved by A. E. Freeman Org'n. 2-4863

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DEPARTMENT OF PRINTED MATTER
THE HEAD CURATOR

Paris, Feb. 23, 1972

Mr. Duane A. Lance
16843 Fremont Ave. No.
Seattle, Wash. 98133
(United States)

Sir:

The sale of the Leon Miniszech collection took place in Paris at the Georges Petit Gallery, on April 9, 10 and 11, 1902. The catalog describes 198 paintings, old pictures, especially portraits, of the German, English, Spanish and especially Italian, French, Flemish and Dutch schools. It includes numerous copies of pictures and facsimiles of signatures. A preface, signed L. Roger-Miles, calls attention to the portraits appearing in this collection. Some very great names in painting appear there: Goya, Guardi, Perugino, Tiepolo, Philippe de Champaigne, Largilliere, Hubert Robert, Breughel, Hals, Honthorst, Rubens, Ruysdael, etc. The catalog was completed by about a hundred items representing objects of art and furniture.

Count Leon Mniszech, the descendent of an illustrious Polish family, was the son of Count Andre Mniszech (b. November 21, 1824 - D. Paris, May 11 1905) and of the Countess, born Anna Marie Barbe Louise Potocka (b. 1827 - d. Paris, February 24, 1885). He had married, in Paris, on April 29 1876, Isaure de Montault, by whom he had no children, it would seem. The eldest son of Count Andre, Count Georges Mniszech (1823-1881) had married, on October 13 1846, Anna Hanska, daughter of Eveline Hanska who, on her second marriage, became in 1850, the wife of the great French novelist Honore de Balzac.

We have not been able to find the exact date of the death of Count Leon Mniszech, which must have taken place at the end of 1901 or at the beginning of 1902. He seems to have died in Paris. You will be able, if it interests you, to obtain an exact date by applying to the Archives of Paris, 30 quai Henri-IV, Paris-04.

Please accept, Sir, the expression of my most distinguished wishes.

/s/

Roger Pierrot.

58, Rue de Richelieu, Paris 02, Telephone 742-02-51

UNIVERSITÉ DE PARIS

BIBLIOTHÈQUE SAINTE-GENEVIÈVE

10, PLACE DU PANTHÉON - PARIS (Vᵉ)

TÉL. 633 05-15

Paris, 21 Février 1972

Monsieur,

Nous avons bien reçu votre lettre concernant le peintre collectionneur Mniszech.

Malheureusement la Bibliothèque Sainte Geneviève ne possède aucun ouvrage à son sujet et pas davantage le catalogue de vente de sa collection.

Je peux cependant vous communiquer le texte de la notice de E. Bénézit (Dictionnaire des peintres, sculpteurs, dessinateurs et graveurs. Paris, 1955. tome 6).

- "MNISZEK (Comte André de), peintre, travaillant à Paris, mort en 1905. Elève de Jean Gigoux. Le Musée de Besançon conserve de lui "le Portrait de Jean Gigoux" et celui de Lille "Nature morte". Le Comte Mniszek possédait une admirable collection de peintures dont la vente eut lieu le 9 avril 1902."

Vous noterez la différence de prénom. Cependant la date de vente est bien celle que vous signalez. Je n'ai trouvé trace d'aucun autre Comte Mniszek. Celle d'autres bibliothèques plus spécialisées pourront, peutêtre, vous donner quelques renseignements complémentaires.

- Musée du Louvre. Département des peintures. Service d'étude et de documentation. 75 - PARIS Ier.
- Bibliothèque FORNEY. 1, rue du Figuier. 75 - PARIS IVe.
- Bibliothèque d'Art et d'Archéologie de l'Université de Paris. 3, rue Michelet. 75 - PARIS VIe.
- Musée national d'art moderne. Bibliothèque. 2, rue de la Manutention. 75 - PARIS XV

Vous pouvez également vous adresser aux musées de Lille et de Besançon qui conservent des oeuvres de ce peintre.

Veuillez croire, Monsieur, à l'assurance de ma considération distinguée.

M. Blancherie

Melle M. Blancherie

Jean Grigoux 1810 - 1894

Painter

~~Report~~
Honors

Portraits of people

Romantic School

Lithographs

Collection in Besancon

Leon Mniszek

Andre Mniszek

Polish Painter

1905

Pupil of

Besancon, France (museum

has portrait of his of Jean Grigoux.

Lille, France (museum)

Still life of painting there

Her Portrait of a unidentified man in

1911 sold for 2200 francs

However, our familiarty with the human face is such that the split-face composite is a powerful analysis technique in such instances (Ref. 6). Consequently, in the following the split-face technique has been utilized. These image superpositions were performed on a digital computer image-enhancement system manufactured by Chorus Data Systems, Inc. It is known as the "Master Developer's System" and has a pixel field that is 512x484 with an 8-bit palette significance. Image-Pro (Ver. 1.5) image processing software from Media Cybernetics, Inc. was employed to execute the analyses.

In accordance with the above, original photographs of MR and comparison Rembrandt self-portraits were digitized and loaded into the computer. As any two original photographs will always be of sightly different magnifications, it was necessary to scale the computer-digitized image files to precisely the same size. This was accomplished by adjusting the vertical scales so that the eye-level to mouth distances were the same lengths in the two images. The horizontal scales were adjusted to make the eye-pupil separations the same in both images. Having made these adjustments the computer image for MR and the various self-portrait faces were split down the vertical bisectors through the noses. Then, the various facial halves from the self-portraits were connected to the appropriate half of MR. If a variety of these matches yield aesthetically acceptable faces, then it is quite plausible that MR is a portrait of Rembrandt, but not necessarily a self-portrait (to be addressed in subsequent sections). Usually, head orientation would be expected to be problematical when

trying to match faces from different pictures. Fortunately, the number of Rembrandt self-portraits is so vast that many different orientations are available to choose from in seeking a match to the face in MR.

Another complexity in forming split-face images of paintings is that of color. If the lighting in the two compositions represent quite different situations, then the match may look poor, aesthetically. Further, if the varnish has aged and yellowed a great deal more in one painting, then a good match may look improper. Consequently, the first comparisons presented are in monochrome and deal with the Rembrandt drawings and etchings.

The first of these facial matches appears in Figure 3. On the upper left is a 1628 self portrait in the Rijksmuseum. MR in the upper right has been adjusted in proportion as described above. Below these are the matchups taking one half of one together with one half of the other. The synthesis at the lower right is startling in several respects. First, the composite nose is virtually perfect in every detail. Second, the mouth and lips match in shape and proportion. Finally, creases in the cheeks extending from the nostrils to the corners of the mouth show considerable similarity even though Rembrandt would have been about 35 years older in MR. It is difficult to say much about the eyes as the lighting and shadow are so different.

Figure 4 employs the Rembrandt face from "Rembrandt and His Wife Saskia" of The Pierpont Morgan library. The match in the lower right again reveals an impressive match of nose, mouth, and cheek. In this instance the apparent age difference would still be substantial (25-30 years), yet the conformity in features is

dramatic.

A last rembrandt etching to be compared to MR in this manner is known as "Rembrandt Drawing at a Window" (1648) which is at the British Museum. This etching is reproduced in Figure 5 (upper left). The split-image match to MR in the lower right is quite interesting in that the chin is now beginning to match in addition to the nose, mouth, lips, and cheek creases. Evidently, by 1648 Rembrandt had begun developing the double chin that is so noticeable in his self-portrait paintings of the 1650s and 1660s. In fact it would have been quite surprising and disturbing if the MR portrait of an old man had matched the chins of the young Rembrandt in Figures 3 and 4 as the fleshy portions of a man's face would have to sag to a considerable degree in some 30 years. Thus, this modulation in facial match depicted by Figures 3, 4, and 5 conforms to the evident aging that would be expected if MR is in fact the face of Rembrandt.

The remainder of this investigation turns now to technical comparisons between the polychromatic Rembrandt painted self-portraits and MR. The Rembrandt works will be identified by number according to the system employed in Ref. 7.

Before proceeding with split-face matches in color it is appropriate to the continuity of Figures 3, 4, and 5 to match two polychrome portraits in black and white reproduction. This is presented in Figure 6. In this instance MR appears in the upper left and Rembrandt self-portrait painting 366 is in the upper right. The match formed in the lower left is especially interesting. All features including the double chin, the lips, the shape of the mouth, the creases, the nose, the eyes, and the

brow match perfectly. Noting the date of 366 (1658) makes the congruency of the match plausible as the faces being compared would now be of approximately the same age. If both are indeed by Rembrandt, the quality of the match may also be a consequence of both faces being oil portraits for the first time in this investigation. It is virtually certain that a great deal more care goes into the execution of a painting that into a sketch. Thus the geometrical accuracy may be greater in these two works.

The comparison of drawings and etchings is simplified by the fact that only the geometrical features come into play. Whereas paintings may be more realistic, differences in coloration (portraying lighting variations for instance) may make comparisons more difficult than for black and white. However, when MR is scaled to a split-screen match with Rembrandt self portraits 364 and 366 (Figures 7 and 8) the matches are acceptable, aesthetically. Even though the head positions are somewhat different suggesting differences in proportion, the facial details match remarkably well when scaled. In particular the brows, eyes, cheek bones, noses, mouths, mouth creases, lips, and chins match very well.

These split-face matches do not prove that the face in MR is that of Rembrandt. However, its geometrical characteristics are close enough to those in the known self portraits to indicate that it could be Rembrandt's face. Of course there is no geometrical way of proving that it is Rembrandt's face. The most that can be shown is that it is consistent feature by feature as indicated by Figures 3-8. On ocassion two different faces can be found that are quite similar, but this is a rare occurrence.

groups of vertical bars is a condensed histogram for the corresponding face in the portrait whose number appears immediately below that histogram. Each reveals the chiaroscuro characteristic of a cluster of pixels at the dark end (at the left of each histogram) and another cluster at the bright end (at the right of each histogram). The other interesting feature of the histogram set is the trend from a smooth uniform intensity distribution for the early portraits of a young face to the uneven distribution with a central feature exhibited by the aged faces. Evidently, this central feature characterizes Rembrandt's rendering of emerging wrinkles and other age marks.

Attention now turns to the small group of full-face self portraits by Rembrandt and to MR. These are presented in Figure 11. Again the established Rembrandt works are labeled by the individual catalogue number (39, 314, and 364). The MR face is identified as "TEST". The corresponding condensed histogram presentation for these appears in Figure 12. Again, the histogram for the young face is monotonically smooth. As the face ages, the intensity distribution becomes progressively more erratic. The two most aged (364 and test) quite clearly exhibit the emergence of the central as in the three-quarter face sequence. Thus, the aging sequence follows the same progression in the shading statistics for both the full-face and three-quarter face portraits. Although the individual histograms for the two facial angles are somewhat different (the shadows are deeper for the turned faces) the trends are the same. Significantly, the histogram for MR fits this trend. This in itself does not establish that MR was executed by Rembrandt, but it does reveal

that MR is consistent with his use of light and dark and his treatment of the portrayal of the aging process.

STATISTICAL ANALYSES (PALETTE)

There is a great deal more information in the polychromatic spectral character of paintings than in the simple distribution of light and dark analyzed in the preceeding section on albedo. Thus, the potential for developing definitive comparisons and contrasts between images is much greater, and the opportunity to uncover distinctive earmarks of Rembrandt self-portrait style and execution is enhanced through analyses of color. In this section we proceed to extract the histogram data for each individual primary color band (viz., red, green, and blue). Thus, the statistics of each face will be characterized by three, rather than one, individual histograms. To accomplish these analyses the individual RGB outputs of the video camera viewing the painting are digitized separately by the computer and independent histograms are calculated for each color band.

In order to develop a data base upon which to build comparison criteria, RGB histograms are presented for a diverse selection of portraits by other painters. These will demonstrate the range of variation to be expected between unrelated portraits by different artists of different faces. Four such sets of RGB histograms with the associated faces appear in Figures 13, 14, 15, and 16. Two are portraits by Stuart (13 and 16). One is a Goya self portrait (14). Figure 15 is a portrait by Raphael. Considering first Figures 13, 14, and 15 (all by different artists) it is evident that the individual corresponding

histograms are quite different.

Inspection of the red histograms (upper left) for the Stuart, Goya, and Raphael portraits (Figures 13, 14, and 15) reveal quite different forms. Figures 13 and 15 have peaks at low intensities while Figure 14 is highest at high intensities. Figure 13 has a secondary peak at a higher intensity while Figure 15 simply tapers off at the high end. Comparable differences are evident in the green-band histograms. Figure 13 has a fairly sharp band at low intensities and a lower uniform distribution extending to high intensities. Figure 14 has a strong broad peak at low intensities and a narrower peak at high intensities. Figure 15 has a sharp peak at low intensities with a "knee" extending up to intermediate intensities. Finally, the blue histograms also exhibit significant differences in character. Figure 13 has a sharp peak at low values that uniformly trails off to zero at mid range. Figure 14 has a major broad peak at low intensities and a secondary broad peak at the high end. Figure 15 has only a narrow peak at low values. In summary these three faces by different artists reveal very different distributions of red, green, and blue intensity values.

Comparing one Stuart portrait (Figure 13) with with another (Figure 16) is quite another matter. Whereas there are minor differences in the widths, heights, and positions of the peaks, valleys, and knees of the RGB histogram distributions, the global characteristics are the same for all three color bands.

The above exercises involving four portraits by three artists strongly suggests that there is scientific merit in exploiting primary color-band histograms to distinguish portraits

that were executed by an individual hand. However, before proceeding with an RGB analysis of MR within the context of Rembrandt's self portraits there is one further topic that must be considered. This is the issue of distinguishing original works from copies or forgeries.

In Figure 17 an authenticated Rembrandt self portrait is shown next to an authenticated copy. To the unaided eye there are subtle, but distinguishable, differences. Among these are the rendering of the hair as well as the shape and shading of the eyes. The situation is somewhat more distinct with reference to the corresponding histograms. The black and white (albedo) histograms and green-band histograms for these two paintings are shown for side-by-side comparison in Figure 18. The associated red-band and blue-band histograms may be compared in Figure 19. It appears that the individual histograms are closer to one another than are those of the different artists (Stuart, Goya, and Raphael) as discussed above. On the other hand they exhibit many more differences in character than do the histograms of two paintings by the same artist (Figures 13 and 16 by Stuart). Thus, this rather limited data base involving the statistics of six portraits lends some credence to the hypothesis that histogram comparisons may serve to aid in distinguishing those works by a particular hand from those by other artists, copists, and forgers. Without a doubt this is a small data base from which to generalize. However, it does represent a start in an area where new tools are much in need.

With the above as a starting point attention now turns to RGB comparisons between MR and a Rembrandt self portrait.

scribed earlier in this section, RGB histogram analyses are performed by scanning the images in each of the three primary colors and then computing independent histograms for each of the digitized bands. In analyzing the Stuart, Goya, and Raphael paintings earlier it emerged that these RGB histograms do correlate with the artist (for the limited statistical sample investigated). Consequently, attention will turn now to a comparison between the RGB histograms for MR and those of the 1659 "Self-Portrait with Palette and Brushes" (Kenwood House, #379). (In terms of head position and style the Metrolopitan's 1660 "Self-Portrait in a Large Beret", #381, would have been a better choice, however a high-quality photograph was unavailable for this investigation.)

Figures 20 and 21 display the facial images and the RGB histograms for Rembrandt self-portrait #379 and MR, respectively. The blue-band histograms are perfect matches of each other. The green-band histograms are nearly perfect matches as well. (They look guite different in magnitude because of auto scaling that plotted one on the x10 scale and the other on the x100 scale due to a very few low-value pixels with high counts.) The two red-band histograms have a similar overall character with a large peak at low intensity and a lower peak at high intensity. However, the low-value peak in #379 is somewhat broader than in MR. Also, the high-value peak in #379 is about twice the height of that in MR.

Referring back to the Stuart-Raphael-Goya and Rembrandt-Copy comparisons it is clear that MR is about as close to #379 as were the two Stuarts to each other. Further, MR and #379 appear closer

to each than did the Rembrandt to its copy or the Stuart to the Raphael or the Goya. From this result we move on to the issue of brush technique and in particular the degree of blending of the strokes.

STATISTICAL ANALYSES (BLENDING)

The foregoing analyses have focused on global aspects of the Rembrandt portraits. These features were the geometrical characteristics of the face, the degree of albedo (relating to shading and chiaroscuro), and chromatic RGB palette distribution. The final topic to be investigated here pertains to the statistics of the detailed brush strokes. Indeed, traditional inspection of paintings for the purpose of attribution relies heavily on brush technique. Often the directions of the strokes, their lengths, their widths, the degree of impasto, and the blending of the individual pigments yield important clues as to the identity of the artist. These characteristics are illustrated by Figure 22 where facial details are shown for MR, late and early Rembrandt self-portraits, and a work by Raphael. From these four examples it is clear that there is an enormous range in technique as to the parameters identified above.

The tools of computer IP can be applied to analyze and quantify such characteristics, statistically. One of these approaches involves measuring the frequency with which pixel values change a small amount when moving to a neighbor and how often the change is large. The statistics of such changes may be plotted in a histogram format. Four examples are presented in Figure 23.

In Figure 23 are the four spatial-frequency histograms for MR (upper left), Rembrandt late self-portrait #499 (upper right), the Rembrandt "Portrait of a Scholar", #67 (lower left), and an early Rembrandt self-portrait #29 (lower right). The origin of each histogram is at its lower left corner. The horizontal scale of each (abscissa) represents the change in intensity when moving from a particular pixel to its neighbor. The height of each vertical bar represents the numbers of jumps in intensity in the scene of that particular magnitude. Thus, it is evident in each of the four histograms that most of the pixel value jumps are small (e.g., 0, 1, 2) as the vertical bars are longest near the respective origins. The tapering off of the distributions toward larger values of pixel jumps may be interpreted as a measure of the smoothness or blending of the brush strokes. When the fall off is rapid (i.e., #67 and #29) then the blending is smooth. On the other hand, a slower fall off as in "Test" and #499 is an indication of a degree of abruptness that is indicative of poor blending. It is interesting to note that the spatial histograms for MR and self-portrait #499 are comparable. They fall off at about the same rate and both reach to about half of full scale. This is in contrast to the early Rembrandt works (#67 and #29) that exhibit truncated distributions toward the higher levels. Thus, the spatial statistics of the brush stroke blending of MR are consistent with those in the Rembrant self-portrait of the appropriate period in Rembrandt's career.

It is evident to the unaided eye in inspecting Figure 22 that the blending is smoother in the early Rembrandt works. It may be asked how the computer analysis adds anything to this

obvious conclusion? The answer is that spatial-frequency histogram analysis facilitates the quantification of this blending artifact allowing a more rigorous mathematical comparison. Further, as more paintings are scrutinized in this manner, the data base will grow and automated computer searches may be instituted to seek out matches and relationships that at present are largely uncovered as a matter of chance.

CONCLUSIONS

The computer IP analyses reported here have expanded considerably the body of information pertaining to the spectral, chiaroscuro/albedo, and brush-stroke characteristics of the Rembrandt self-portraits. Although several paintings have been examined in this study, it is still something of a probative effort in contrast to an exhaustive statistical sampling. As further years pass and computer IP becomes commonplace the data base on the unique Rembrandt "fingerprint" will emerge in due course. However, the shear magnitude of Rembrandt's output makes this an enormous task.

Whereas the statistical analyses performed on MR and the Rembrandt portraits were not exhaustive, they are more extensive than those performed on any other collection of paintings. The work focused on the facial features rather than on such other areas as hair, neck, shoulders, or background. Clearly, the artist would have concentrated his attention on the face, and the ancillary features probably exhibit less attention to personal features. Thus, these investigations probably represent a sensible attack in terms of a reasonable expenditure of time and

energy at this stage in the development of IP technology for authentication.

The study reported in this report does not probe each and every possible avenue of investigation as was mentioned above. However, a very considerable range was covered, and interesting and important results emerged. First, the split-face investigations involving Rembrandt drawings, etchings, and paintings show that the face in the painting identified as MR could be that of Rembrandt. Second, the chiaroscuro/albedo measurements indicate that MR is consistent with the properties of Rembrandt self-portraits and especially with those of the 1660s. Third, the RGB color distribution of MR is also consistent with that of the self-portraits (and inconsistent with that of the one copy considered). Finally, the spatial frequency characteristics of MR indicate a brush technique very close to that of the self-portraits and quite different from those of several other artists.

Each of the above findings alone could be a coincidence. Taking these four "coincidences" together shifts the overall probability toward the position that MR is closely related to the body of Rembrandt's ninety self-portraits. These results are consistent with the conclusion that MR is one of the thirty missing works. Statistical analyses of the type reported here can not prove that MR was executed by the hand of Rembrandt. However, if X-ray and materials analyses also point in this direction, then the evidence becomes overwhelming and surely much stronger than the bases for many of the generally accepted Rembrandt attributions.

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DOUGLAS C. WILLIAMS • 10830 - 1st Dr. S.E. • Everett, Washington 98208 (U.S.A.)
Phone: Area Code (206) 347-8643

June 13, 1989

Dr. Alfred Bader
President,
ALDRICH CHEMICAL

Dear Dr. Bader,

First, let me introduce myself to you. My name is Douglas Williams and I represent the owners of a very important old master painting...a self portrait oil painting of the famous Dutch artist Rembrandt, in his later years. New evidence concludes that this painting is one of the approximately 30 missing self portraits of Rembrandt, and was once in the collection of Count Leon Vandalin Mniszech, an illustrious Polish Count who lived in France in the 1800's.

Recently, an associate of yours and ours, Dr. John Asmus of the University of California, San Diego, completed a series of scientific tests using computer image processing and enhancement to analyze this Rembrandt self portrait. The results of the tests by Dr. Asmus, which took over one year to complete, show very strong evidence that this portrait was painted by Rembrandt himself. Also, Dr. Giancarlo Calcgno of the Soprintendenza Beni Ombientalia di Venezia, an associate of Dr. Asmus, concluded that the painting is in an excellent state of conservation and was skillfully executed by the artist.

Our purpose in writing you, on the referral of Dr. Asmus, is to inform you that this self portrait of Rembrandt is now available for purchase. Enclosed with this letter is a color photo of the portrait, and a copy of the test results performed by Dr. Asmus. All technical information is available for viewing with Dr. Asmus at his facility in California.

If you are interested in this painting please contact either myself at the above address or phone number or Dr. Asmus (address/phone listed below), for further details:

Dr. John F. Asmus
8239 Sugarman Dr.
LaJolla, California 92037 (U.S.A.)
Phone: Area Code (619) 452-1839

Very sincerely yours,

Douglas C. Williams

Douglas C. Williams
Representative

DCW/jd

Enclosures

COMPUTER IMAGE STUDIES OF REMBRANDT SELF PORTRAITS

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BACKGROUND

There is a great deal of uncertainty and controversy surrounding the artwork legacy of Rembrandt van Rijn. Much of the difficulty stems from the dearth of reliable contemporary documentation covering the artist's activities and the great number of students who painted in his studio. Consequently, attributions have rested heavily upon subjective assessments of style and execution, together with whatever historical evidence can be uncovered. The dilemma associated with selecting those works which should be asigned to Rembrandt is complicated further by his fame and the potential for great financial return from the discovery of new pieces. In recent decades this dilemma has been alleviated to a considerable degree by the introduction analytical scientific methods for analyzing (and, in some cases, dating) the materials of an artwork. However, the greatest impact of materials analyses has been to throw out many style-based attributions after finding that the materials were inconsistent with the artist's legacy. Thus, materials analyses typically play a negative role in showing that an attribution is impossible rather than proving that the work in question was by a particular hand.

On the other hand a new opportunity has emerged as a consequence of NASA's pioneering development of computer image processing (IP) throughout the early years of the space program. During

the past 10-15 years many of these techniques have been advanced and simplified for medical diagnostics, television special effects, and several other applications in science and industry. Consequently, it is now possible to apply this tool to the direct attribution of a painting through analyses of various statistical properties of a painting (Ref. 1). This report describes the first efforts at investigating the properties and statistics of Rembrandt portraits so as to provide a basis for determining which should be included in the body of his works, rather than which should be excluded.

TECHNICAL ANALYSES OF ARTWORKS

Much of the practice of art scholarship involves the inspection and interpretation of photographs and radiographs. Quite often such materials leave something to be desired in clarity, contrast, or detail. Consequently, in more recent years computer image processing (IP) technology has begun appearing in art conservation activities pertaining to such images. For instance James, et. al. (Ref. 2) adapted digital radiography to the analysis of paintings and did achieve higher contrast, but at a cost of lower spatial resolution. Further, Druzik, et. al. (Ref. 3) tackled the problems of interferences in radiographs, and Asmus, et. al. (Ref. 4) applied IP to ultrasonic images of artwork interiors.

THE REMBRANDT PAINTINGS

It is difficult to imagine another artist in Western Civilization who is as universally known and admired as Rembrandt. His

"Night Watch" is one of the most widely recognized paintings in the world. "Danae", located in the Hermitage is often cited as one of the most beautiful paintings in existence (Ref. 5). However, Rembrandt's most stunning accomplishment may be the series of self-portraits that span his adult life. It is generally believed that the total number of these that he executed was about ninety. Of this number only 50-60 have been located and attributed with reasonable certainty. Nevertheless, this portion of his output has provided art historians with an extraordinary insight into the artist's psycological, artistic, and emotional development as well as into his biological aging. In recent years a portrait from a Polish collection has been brought forward as a candidate for one of the 30-40 missing self-portraits. It is an especially interesting candidate as it may fill a gap in Rembrandt's latter life (1660-1664) that is not covered by any of the other known self-portraits.

THE MNISZECH REMBRANDT

This portrait, which for convenience will be referred to as the "Mniszech Rembrandt" (MR), was purchased in Venice, Italy by Mr. Robert B. Shaw in 1958. At the time of the sale the owner was evidently one of the heirs to the estate of the late Count Leon Vandalin Mniszech of Poland. Apparently, it had not been sold in Paris with the rest of the Count's collection in 1902.

The painting has been damaged in that it has been cut down in size. This must have taken place after it left the Mniszech collection as his seal is presently wrapped around the stretcher board. It is clear that it was relined with a new canvas prior to

its being cut down. It was inspected by Dr. Giancarlo Calcagno of the Soprintendenza Beni Ambientali di Venezia who concluded that the remaining important central portion is in an excellent state of conservation and was skillfully executed by the artist.

A photographic reproduction of the "Mniszech Rembrandt" (MR) to be employed in the computer IP investigations is reproduced in Figure 1. The sections that follow illustrate various approaches that were explored in applying the technology of computer IP to the authentication of this artwork.

GEOMETRICAL FEATURES

A most important issue to be resolved first pertains to the identity of the face portrayed in Figure 1. Put directly, if it is not Rembrandt's face, then it can not be a Rembrandt self-portrait. Thus, a plausible starting point in investigating this painting is to compare the geometrical features of the face in MR with those of the generally accepted self-portrait paintings, drawings, and etchings (which may have to be reversed as etchings involve a transfer process that yields a mirror image).

Technically, the flicker technique, photogrammetry, 3D-video viewing, and side by side inspection are found suitable quite frequently for geometrical image comparisons. When the differences are major and a hard-copy presentation is desired juxtaposed images as in Figure 2 are both convenient and satisfactory.

For images that are rather close in appearance small differences are more easily discerned by means of an overlay. For instance in comparing two faces one could form a photographic double exposure with one shown in green and the other in red.

PHOTO

(Self Portrait At Front of Report)

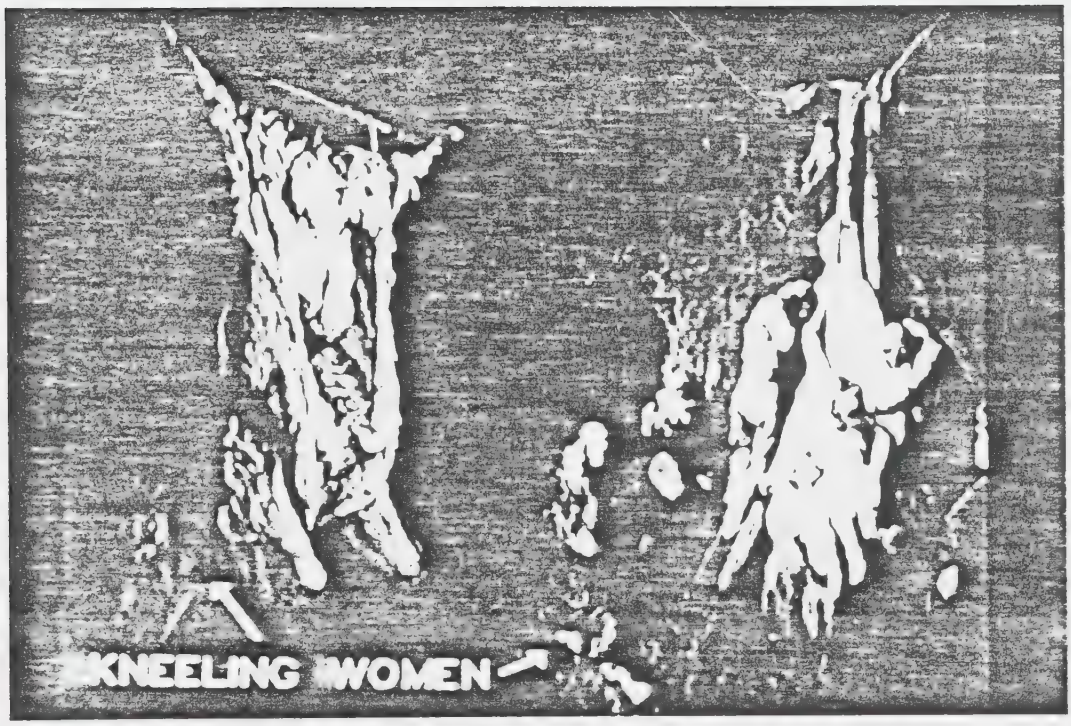

Figure 2. Split-screen display of "The Descent from The Cross" and "The Flayed Oxen", both by Rembrandt. This type of comparison offers a convenient way to compare compositional features of two artworks. However, the spatial separation makes it difficult to detect subtle differences between very similar scenes.

However, our familiarty with the human face is such that the split-face composite is a powerful analysis technique in such instances (Ref. 6). Consequently, in the following the split-face technique has been utilized. These image superpositions were performed on a digital computer image-enhancement system manufactured by Chorus Data Systems, Inc. It is known as the "Master Developer's System" and has a pixel field that is 512x484 with an 8-bit palette significance. Image-Pro (Ver. 1.5) image processing software from Media Cybernetics, Inc. was employed to execute the analyses.

In accordance with the above, original photographs of MR and comparison Rembrandt self-portraits were digitized and loaded into the computer. As any two original photographs will always be of sightly different magnifications, it was necessary to scale the computer-digitized image files to precisely the same size. This was accomplished by adjusting the vertical scales so that the eye-level to mouth distances were the same lengths in the two images. The horizontal scales were adjusted to make the eye-pupil separations the same in both images. Having made these adjustments the computer image for MR and the various self-portrait faces were split down the vertical bisectors through the noses. Then, the various facial halves from the self-portraits were connected to the appropriate half of MR. If a variety of these matches yield aesthetically acceptable faces, then it is quite plausible that MR is a portrait of Rembrandt, but not necessarily a self-portrait (to be addressed in subsequent sections). Usually, head orientation would be expected to be problematical when

trying to match faces from different pictures. Fortunately, the number of Rembrandt self-portraits is so vast that many different orientations are available to choose from in seeking a match to the face in MR.

Another complexity in forming split-face images of paintings is that of color. If the lighting in the two compositions represent quite different situations, then the match may look poor, aesthetically. Further, if the varnish has aged and yellowed a great deal more in one painting, then a good match may look improper. Consequently, the first comparisons presented are in monochrome and deal with the Rembrandt drawings and etchings.

The first of these facial matches appears in Figure 3. On the upper left is a 1628 self portrait in the Rijksmuseum. MR in the upper right has been adjusted in proportion as described above. Below these are the matchups taking one half of one together with one half of the other. The synthesis at the lower right is startling in several respects. First, the composite nose is virtually perfect in every detail. Second, the mouth and lips match in shape and proportion. Finally, creases in the cheeks extending from the nostrils to the corners of the mouth show considerable similarity even though Rembrandt would have been about 35 years older in MR. It is difficult to say much about the eyes as the lighting and shadow are so different.

Figure 4 employs the Rembrandt face from "Rembrandt and His Wife Saskia" of The Pierpont Morgan library. The match in the lower right again reveals an impressive match of nose, mouth, and cheek. In this instance the apparent age difference would still be substantial (25-30 years), yet the conformity in features is

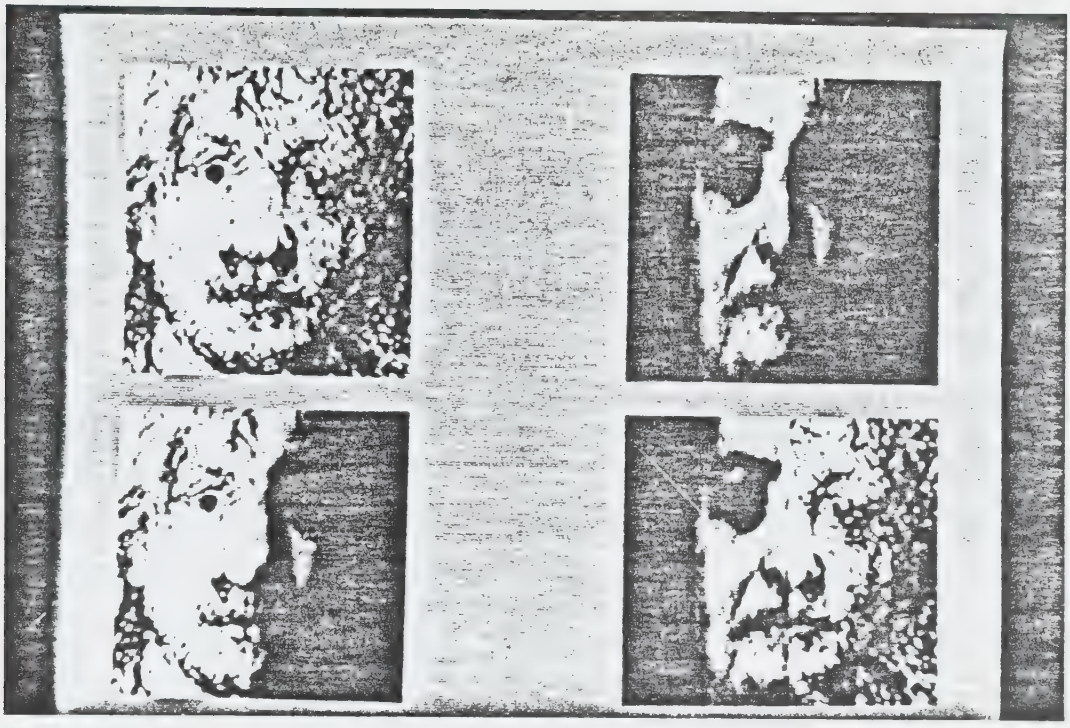

Figure 3. Split-face syntheses employing a 1628 Rembrandt self-portrait (Rijksmuseum) shown in the upper left and MR (right).

Figure 4. Split-face synthesis employing a 1636 Rembrandt self-portrait (Morgan Lib.) shown in the upper left and MR (right).

dramatic.

A last rembrandt etching to be compared to MR in this manner is known as "Rembrandt Drawing at a Window" (1648) which is at the British Museum. This etching is reproduced in Figure 5 (upper left). The split-image match to MR in the lower right is quite interesting in that the chin is now beginning to match in addition to the nose, mouth, lips, and cheek creases. Evidently, by 1648 Rembrandt had begun developing the double chin that is so noticeable in his self-portrait paintings of the 1650s and 1660s. In fact it would have been quite surprising and disturbing if the MR portrait of an old man had matched the chins of the young Rembrandt in Figures 3 and 4 as the fleshy portions of a man's face would have to sag to a considerable degree in some 30 years. Thus, this modulation in facial match depicted by Figures 3, 4, and 5 conforms to the evident aging that would be expected if MR is in fact the face of Rembrandt.

The remainder of this investigation turns now to technical comparisons between the polychromatic Rembrandt painted self-portraits and MR. The Rembrandt works will be identified by number according to the system employed in Ref. 7.

Before proceeding with split-face matches in color it is appropriate to the continuity of Figures 3, 4, and 5 to match two polychrome portraits in black and white reproduction. This is presented in Figure 6. In this instance MR appears in the upper left and Rembrandt self-portrait painting 366 is in the upper right. The match formed in the lower left is especially interesting. All features including the double chin, the lips, the shape of the mouth, the creases, the nose, the eyes, and the

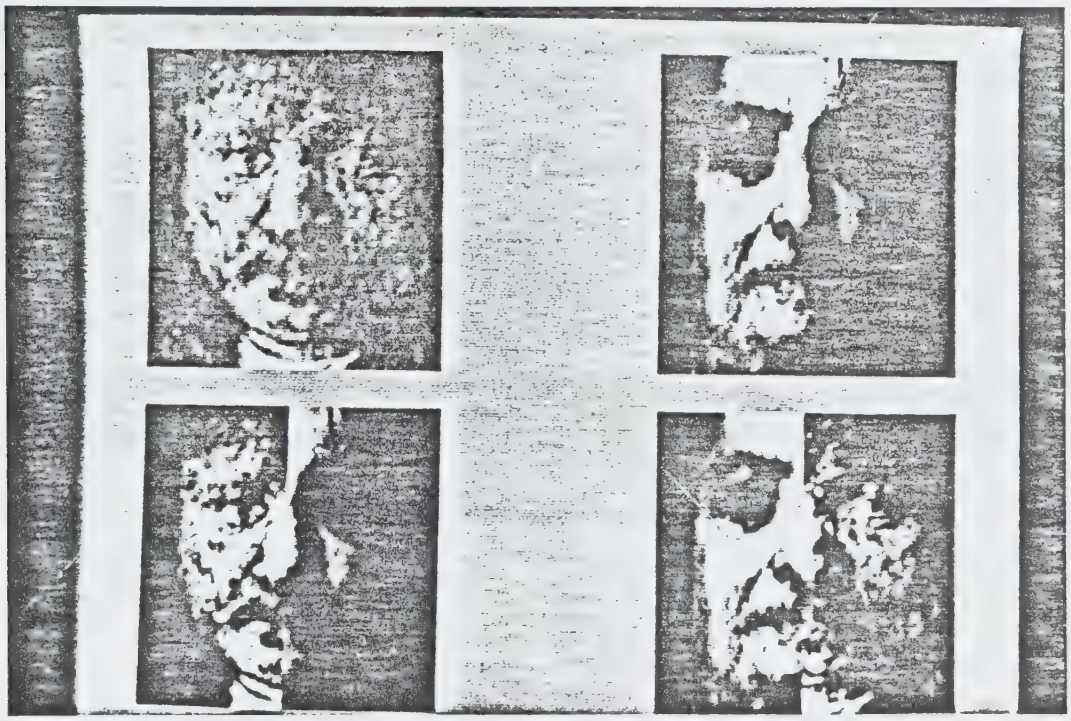

Figure 5. Split-face systhesis employing a 1648 Rembrandt etching (British Museum) shown in the upper left and MR (upper right).

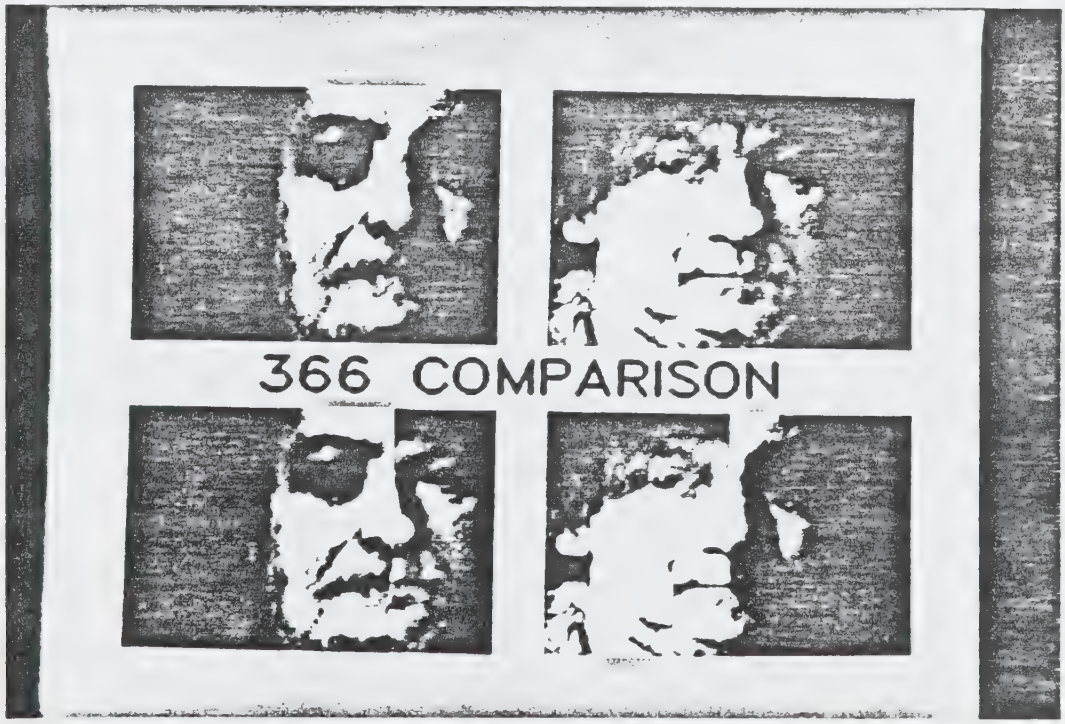

Figure 6. Split-face synthesis employing 1658 Rembrandt painting 366 (Frick Collection) shown in upper right and MR (upper left).

brow match perfectly. Noting the date of 366 (1658) makes the congruency of the match plausible as the faces being compared would now be of approximately the same age. If both are indeed by Rembrandt, the quality of the match may also be a consequence of both faces being oil portraits for the first time in this investigation. It is virtually certain that a great deal more care goes into the execution of a painting that into a sketch. Thus the geometrical accuracy may be greater in these two works.

The comparison of drawings and etchings is simplified by the fact that only the geometrical features come into play. Whereas paintings may be more realistic, differences in coloration (portraying lighting variations for instance) may make comparisons more difficult than for black and white. However, when MR is scaled to a split-screen match with Rembrandt self portraits 364 and 366 (Figures 7 and 8) the matches are acceptable, aesthetically. Even though the head positions are somewhat different suggesting differences in proportion, the facial details match remarkably well when scaled. In particular the brows, eyes, cheek bones, noses, mouths, mouth creases, lips, and chins match very well.

These split-face matches do not prove that the face in MR is that of Rembrandt. However, its geometrical characteristics are close enough to those in the known self portraits to indicate that it could be Rembrandt's face. Of course there is no geometrical way of proving that it is Rembrandt's face. The most that can be shown is that it is consistent feature by feature as indicated by Figures 3-8. On ocassion two different faces can be found that are quite similar, but this is a rare occurrence.

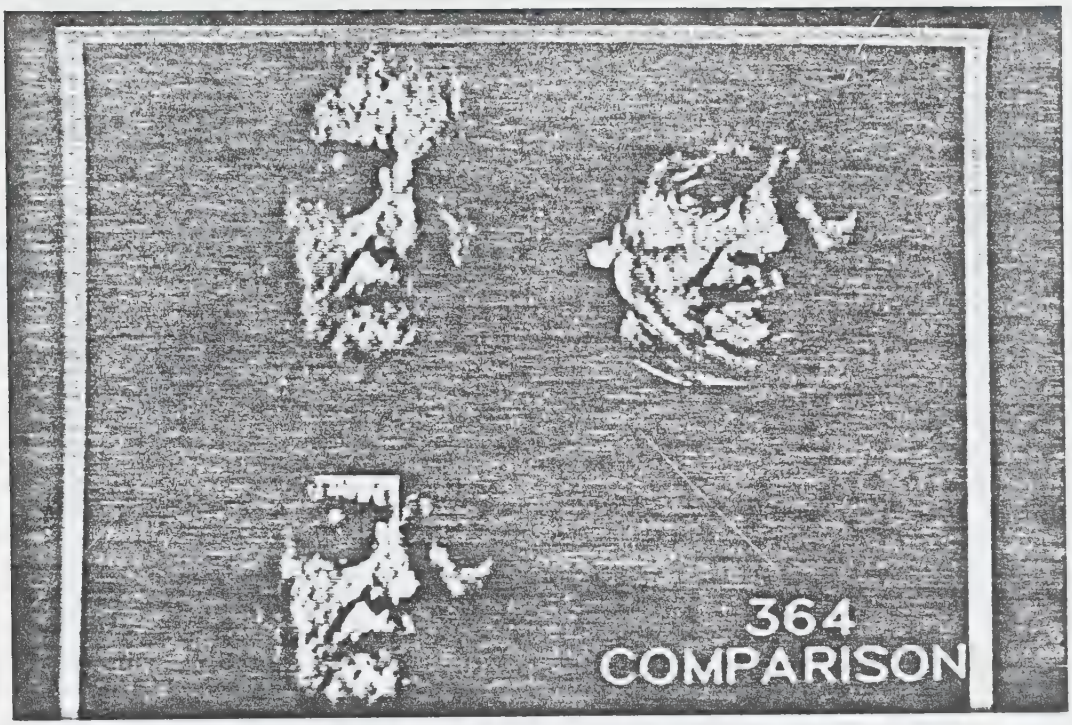

Figure 7. Split-face polychromatic synthesis employing MR (upper left) and Rembrandt self portrait 364 (upper right).

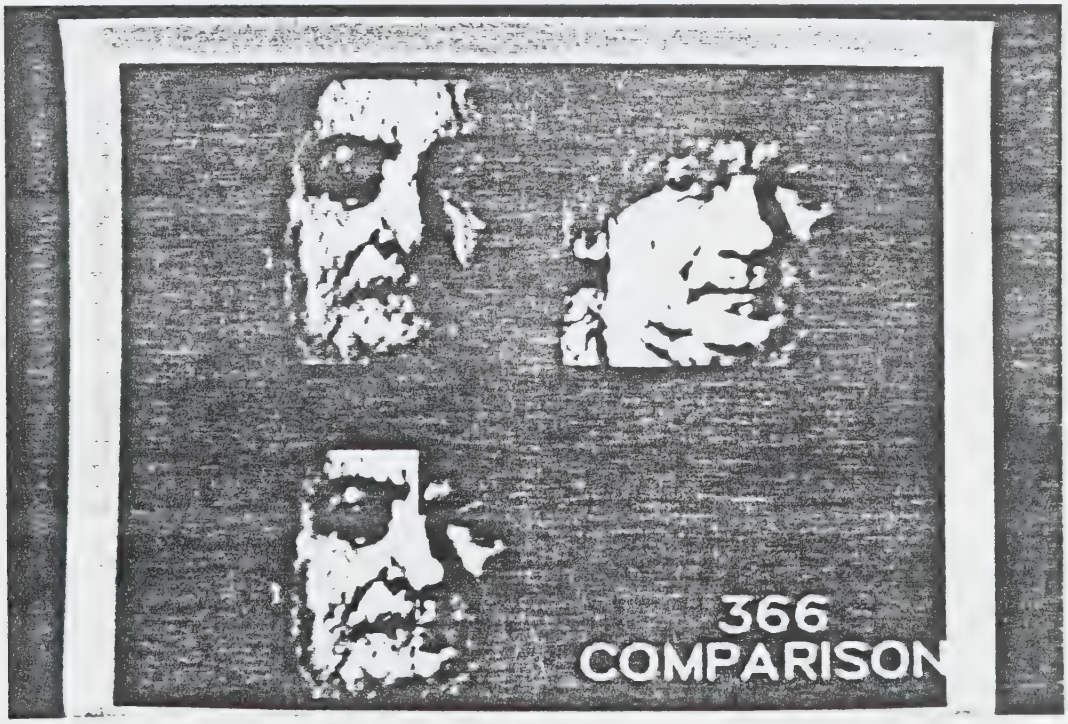

Figure 8. Split-face polychromatic systhesis employing MR (upper left) and Rembrandt self portrait painting 366 (upper right).

HISTOGRAM STATISTICAL ANALYSES[2]

Complex bodies of information will have certain statistical properties. Such information forms the bases of numerous analyses in fields such at voice recognition, cryptographics, ocean waves, and quantum mechanics, just to name a few. As a painting requires a great many brush strokes in its execution, if follows that the resulting surface will have surface and spectral morphologies that are characteristic of the length and direction of the artist's brushing technique, the types of brushes used, the palette, the mixing technique, the speed of execution, the use of glazes, the care in blending, and the viscosity of the medium.

One way of portraying the statistical characteristics of an image is through an amplitude histogram. An amplitude histogram is a graphical plot that indicates the distribution of brightness levels throughout a pictorial scene. Histograms are essentially "fingerprints" of the distributions of light and dark shading in the scenes. In other words it is a quantification of "chiaro-scuro" which is of such central significance in the works of Rembrandt. It is possible that every artist in executing his works develops an envelope of shadings that are characteristic of his hand. On the other hand such stylistic mannerisms may be so deeply embedded in the overall geometrical and chromatic characteristics of each particular composition so as to be essentially invisible in the histograms. The only way of determining the efficacy of the histogram approach to identifying an individual hand in the execution of a painting is to develop a substantial data base for the purposes of comparison. Then, by comparing histograms for various paintings by the same artist

with each other as well as with those for other artists and especially with histograms for known copies it may be possible to identify histogram artifacts that are unique to the artist in question.

In order to interpret the histograms that are presented in the following pages it is necessary to understand something about the computer/digitization system that was employed in the study. At the onset the painting (or its photograph) is viewed by a CCD television video camera. Its electrical output is transmitted to a computer input device known as a frame grabber or digitizer board. It divides the video camera scene into a grid of small dots or points of light known as pixels (PICTURE ELEMENTS). The system utilized in this study employed a matrix of 512 pixels across the image by 484 vertical elements. Thus, the image can be thought of as being made up of 512 vertical columns and 484 horizontal lines. Consequently, there are a total of 512 X 484 = 247,808 pixels in the image. As is the case with most computer IP systems, each pixel is assigned one of 256 intensity levels (called 8-bit digitizing). The amplitude histogram is a graphical plot that displays the numbers of pixels in the digitized image having each of the 256 possible intensity values (or shades of gray). For polychromatic images each pixel is represented by three independent files, each with 256 intensity levels for the red, green, and blue portions of the spectrum, respectively. In such cases it takes three histograms (red, green, and blue) to describe the statistics of the image.

In summary an amplitude histogram is a graphical way of

displaying contrast and brightness. For instance if most of the pixels have very high intensities (near 255), then the image is bright. If most of the pixels have very low intensities (near 0), then the image is dark. If the pixel distribution is in a narrow band, then the image has low contrast. When the pixel distribution spans the 256-level range, the image has high contrast. With this as background we proceed with the comparison of the statistics of MR and the known Rembrandt self portraits.

STATISTICAL ANALYSES (ALBEDO)

The first step in determining whether the statistics of MR match those of Rembrandt paintings must be to develop a data base. As with the split-face comparisons, for simplicity black and white (monochrome) images are considered first. In this instance the histograms portray the degree of whiteness (albedo) that Rembrandt paints into his faces.

In contrast to the full-faced MR painting the majority of the Rembrandt self portraits present a three-quarter attitude. Consequently, in order to develop a broad statistical basis for the characteristics of his face through the years we shall begin by analyzing the three-quarter-face portraits and then generalize to a full-face situation and determine whether MR falls in place. Four of the three-quarter Rembrandt faces are reproduced in Figure 9. By the catalogue numbers 8, 31, 207, and 450 it is evident that this selection spans the artists life from youth to his final years.

The for histograms corresponding to the faces in Figure 9 appear in an alligned presentation in Figure 10. Each of the four

Figure 9. Four representative three-quarter-face Rembrandt self portraits shown in monochrome for albedo analyses (Figure 10).

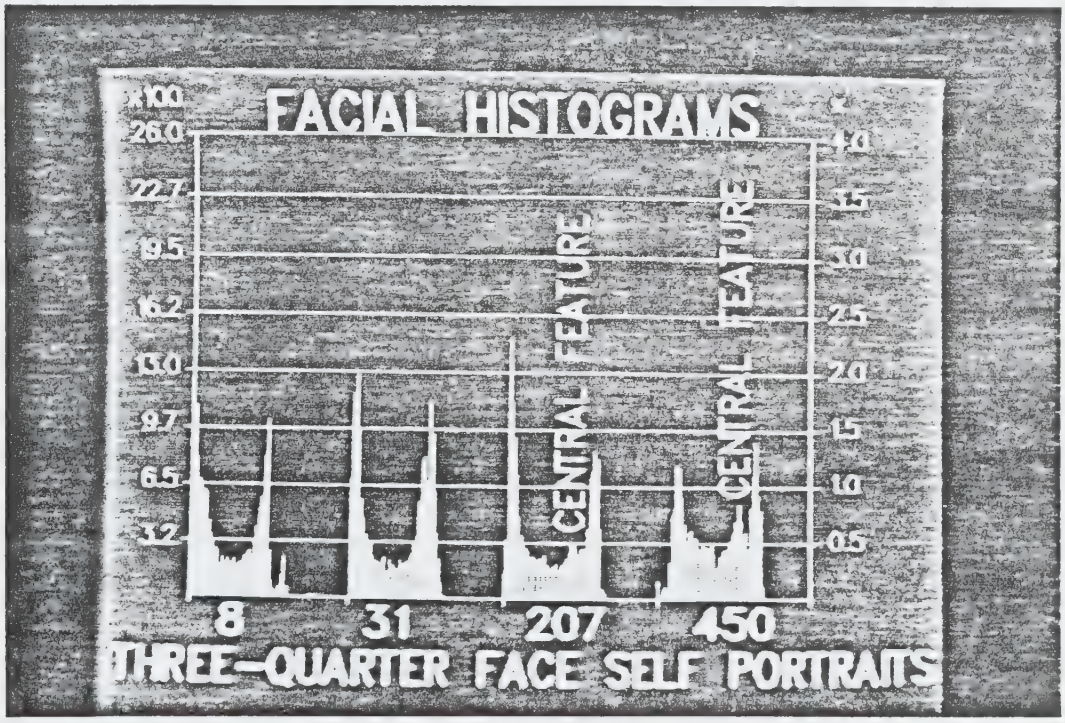

Figure 10. The four condensed histograms corresponding to the four three-quarter-face self portraits of Figure 9.

groups of vertical bars is a condensed histogram for the corresponding face in the portrait whose number appears immediately below that histogram. Each reveals the chiaroscuro characteristic of a cluster of pixels at the dark end (at the left of each histogram) and another cluster at the bright end (at the right of each histogram). The other interesting feature of the histogram set is the trend from a smooth uniform intensity distribution for the early portraits of a young face to the uneven distribution with a central feature exhibited by the aged faces. Evidently, this central feature characterizes Rembrandt's rendering of emerging wrinkles and other age marks.

Attention now turns to the small group of full-face self portraits by Rembrandt and to MR. These are presented in Figure 11. Again the established Rembrandt works are labeled by the individual catalogue number (39, 314, and 364). The MR face is identified as "TEST". The corresponding condensed histogram presentation for these appears in Figure 12. Again, the histogram for the young face is monotonically smooth. As the face ages, the intensity distribution becomes progressively more erratic. The two most aged (364 and test) quite clearly exhibit the emergence of the central as in the three-quarter face sequence. Thus, the aging sequence follows the same progression in the shading statistics for both the full-face and three-quarter face portraits. Although the individual histograms for the two facial angles are somewhat different (the shadows are deeper for the turned faces) the trends are the same. Significantly, the histogram for MR fits this trend. This in itself does not establish that MR was executed by Rembrandt, but it does reveal

Figure 11. Four representative full-face portraits (three by Rembrandt together with MR) analyzed for albedo in Figure 12.

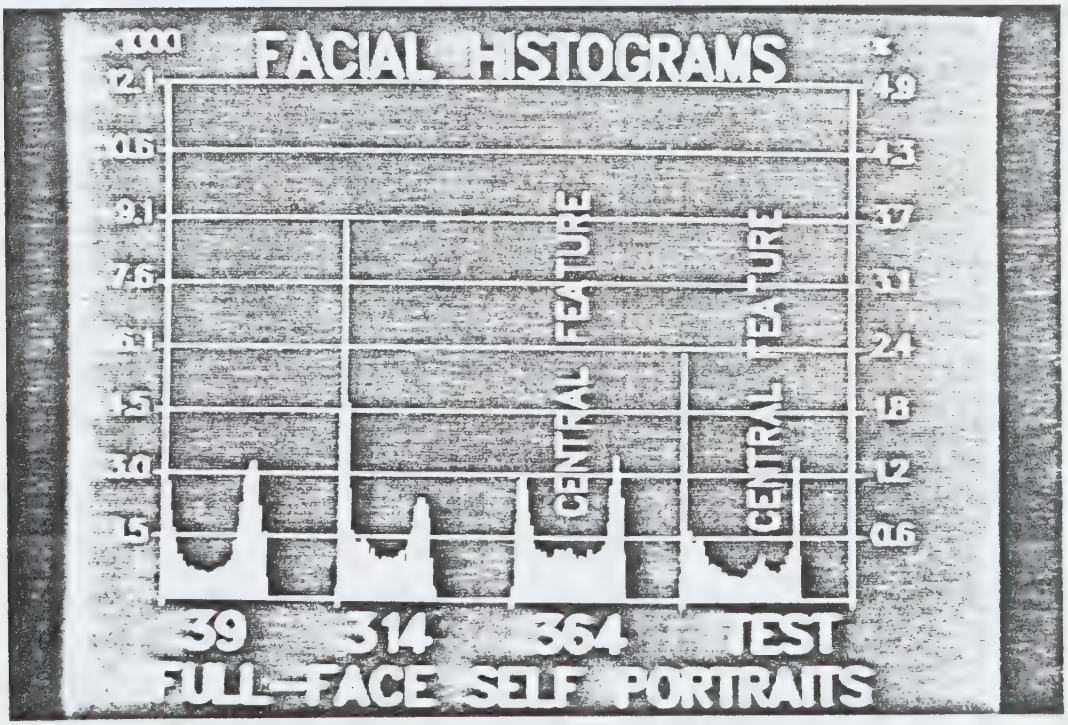

Figure 12. The four condensed histograms corresponding to the four full-face portraits of Figure 11.

that MR is consistent with his use of light and dark and his treatment of the portrayal of the aging process.

STATISTICAL ANALYSES (PALETTE)

There is a great deal more information in the polychromatic spectral character of paintings than in the simple distribution of light and dark analyzed in the preceeding section on albedo. Thus, the potential for developing definitive comparisons and contrasts between images is much greater, and the opportunity to uncover distinctive earmarks of Rembrandt self-portrait style and execution is enhanced through analyses of color. In this section we proceed to extract the histogram data for each individual primary color band (viz., red, green, and blue). Thus, the statistics of each face will be characterized by three, rather than one, individual histograms. To accomplish these analyses the individual RGB outputs of the video camera viewing the painting are digitized separately by the computer and independent histograms are calculated for each color band.

In order to develop a data base upon which to build comparison criteria, RGB histograms are presented for a diverse selection of portraits by other painters. These will demonstrate the range of variation to be expected between unrelated portraits by different artists of different faces. Four such sets of RGB histograms with the associated faces appear in Figures 13, 14, 15, and 16. Two are portraits by Stuart (13 and 16). One is a Goya self portrait (14). Figure 15 is a portrait by Raphael. Considering first Figures 13, 14, and 15 (all by different artists) it is evident that the individual corresponding

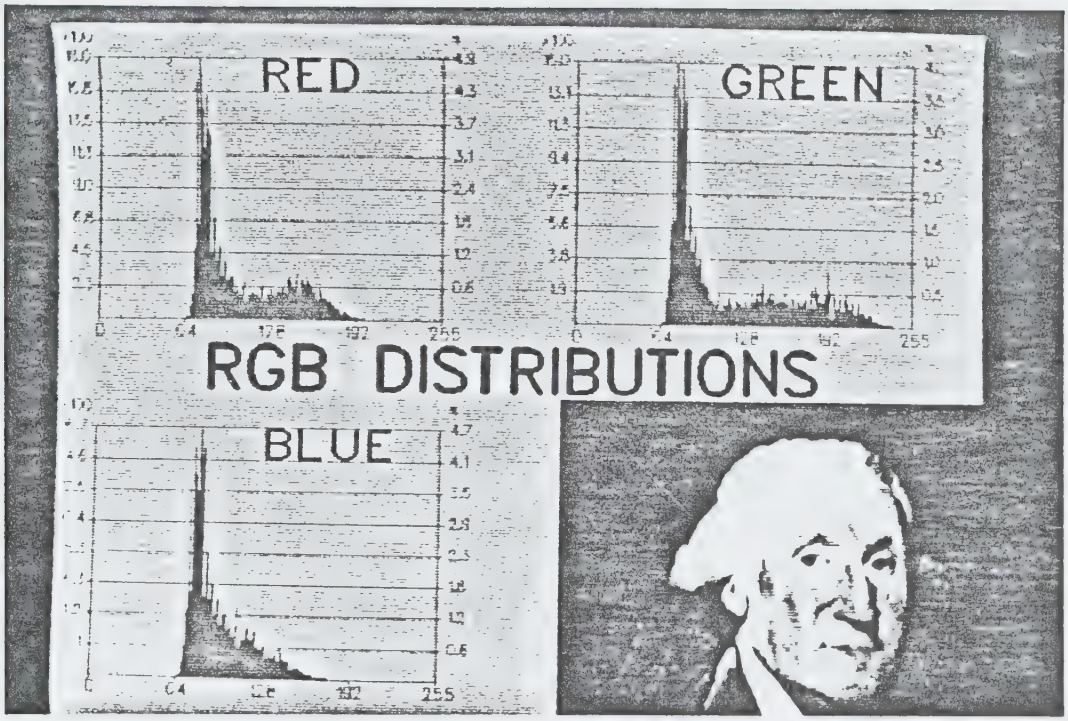

Figure 13. Stuart portrait together with the intensity histograms for the red, green, and blue bands.

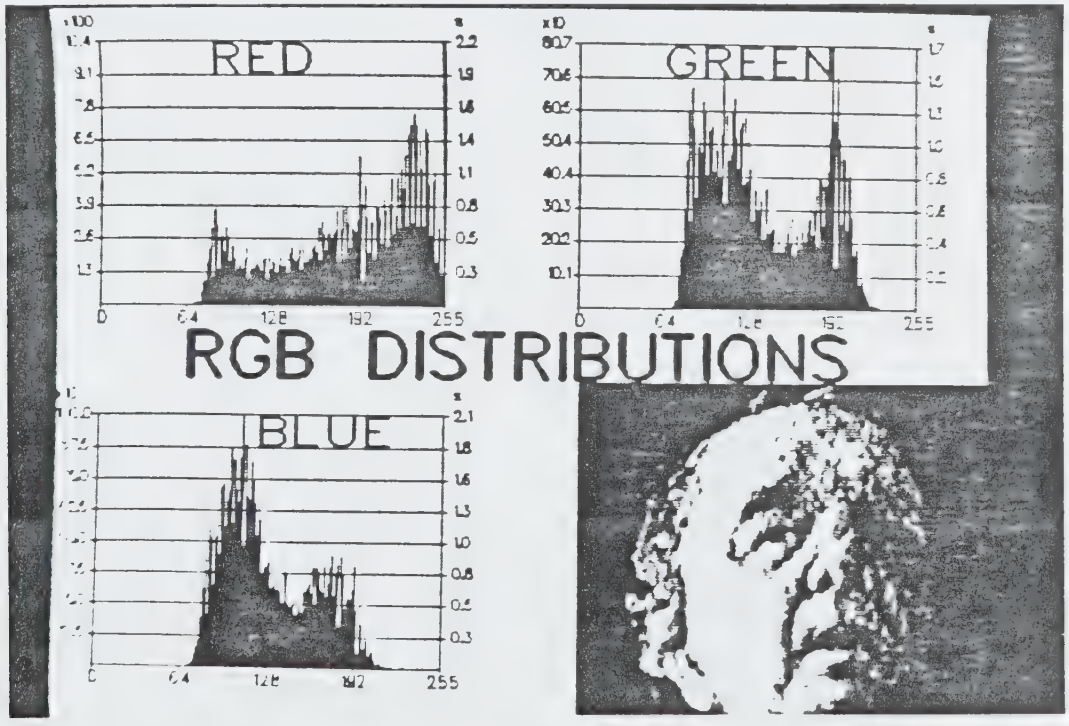

Figure 14. Goya self portrait together with the intensity histograms for the red, green, and blue bands.

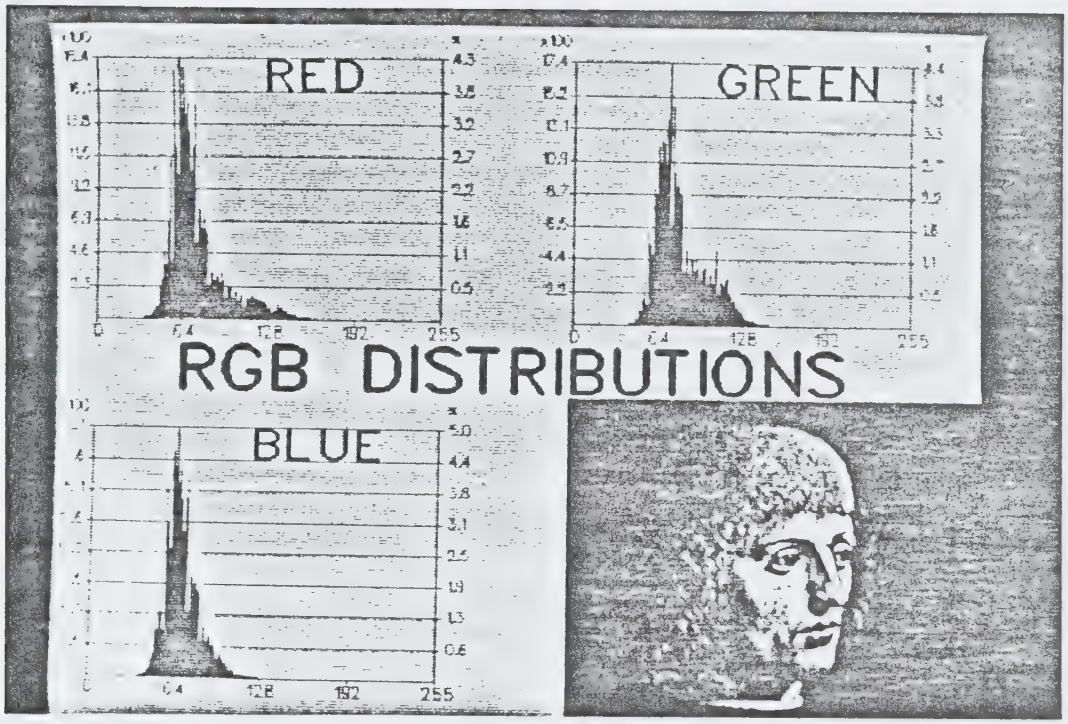

Figure 15. Raphael portrait together with the intensity histograms for the red, green, and blue bands.

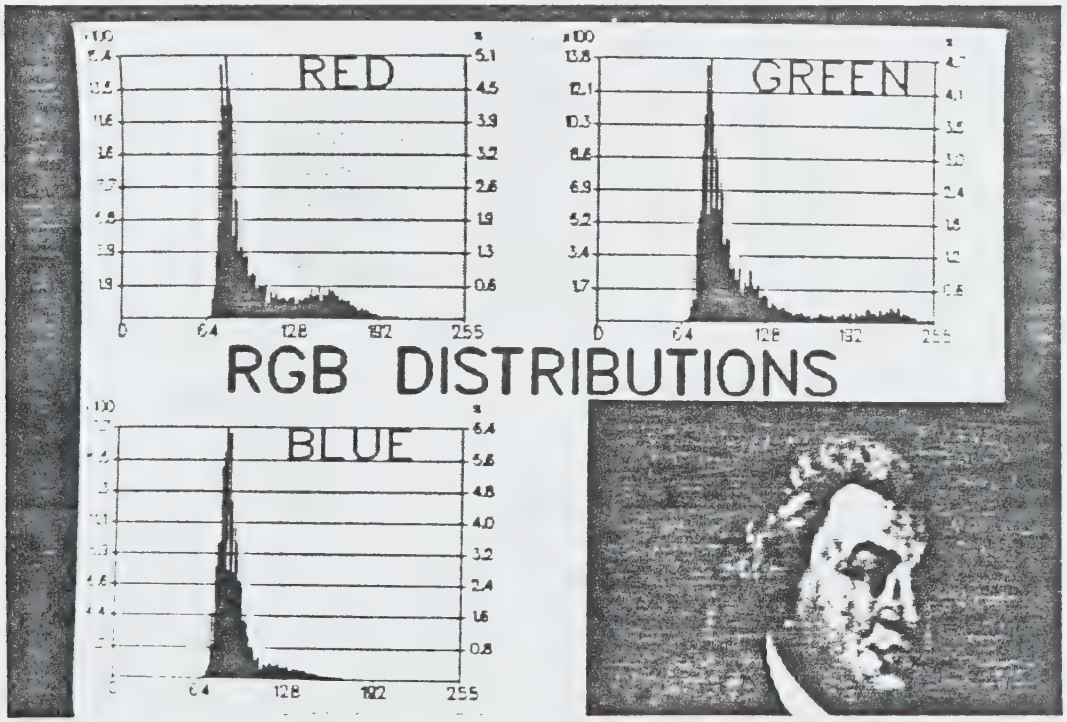

Figure 16. Stuart portrait together with the intensity histograms for the red, green, and blue bands.

histograms are quite different.

Inspection of the red histograms (upper left) for the Stuart, Goya, and Raphael portraits (Figures 13, 14, and 15) reveal quite different forms. Figures 13 and 15 have peaks at low intensities while Figure 14 is highest at high intensities. Figure 13 has a secondary peak at a higher intensity while Figure 15 simply tapers off at the high end. Comparable differences are evident in the green-band histograms. Figure 13 has a fairly sharp band at low intensities and a lower uniform distribution extending to high intensities. Figure 14 has a strong broad peak at low intensities and a narrower peak at high intensities. Figure 15 has a sharp peak at low intensities with a "knee" extending up to intermediate intensities. Finally, the blue histograms also exhibit significant differences in character. Figure 13 has a sharp peak at low values that uniformly trails off to zero at mid range. Figure 14 has a major broad peak at low intensities and a secondary broad peak at the high end. Figure 15 has only a narrow peak at low values. In summary these three faces by different artists reveal very different distributions of red, green, and blue intensity values.

Comparing one Stuart portrait (Figure 13) with with another (Figure 16) is quite another matter. Whereas there are minor differences in the widths, heights, and positions of the peaks, valleys, and knees of the RGB histogram distributions, the global characteristics are the same for all three color bands.

The above exercises involving four portraits by three artists strongly suggests that there is scientific merit in exploiting primary color-band histograms to distinguish portraits

that were executed by an individual hand. However, before proceeding with an RGB analysis of MR within the context of Rembrandt's self portraits there is one further topic that must be considered. This is the issue of distinguishing original works from copies or forgeries.

In Figure 17 an authenticated Rembrandt self portrait is shown next to an authenticated copy. To the unaided eye there are subtle, but distinguishable, differences. Among these are the rendering of the hair as well as the shape and shading of the eyes. The situation is somewhat more distinct with reference to the corresponding histograms. The black and white (albedo) histograms and green-band histograms for these two paintings are shown for side-by-side comparison in Figure 18. The associated red-band and blue-band histograms may be compared in Figure 19. It appears that the individual histograms are closer to one another than are those of the different artists (Stuart, Goya, and Raphael) as discussed above. On the other hand they exhibit many more differences in character than do the histograms of two paintings by the same artist (Figures 13 and 16 by Stuart). Thus, this rather limited data base involving the statistics of six portraits lends some credence to the hypothesis that histogram comparisons may serve to aid in distinguishing those works by a particular hand from those by other artists, copists, and forgers. Without a doubt this is a small data base from which to generalize. However, it does represent a start in an area where new tools are much in need.

With the above as a starting point attention now turns to RGB comparisons between MR and a Rembrandt self portrait.

Figure 17. Rembrandt self portrait (left) and a known copy (right).

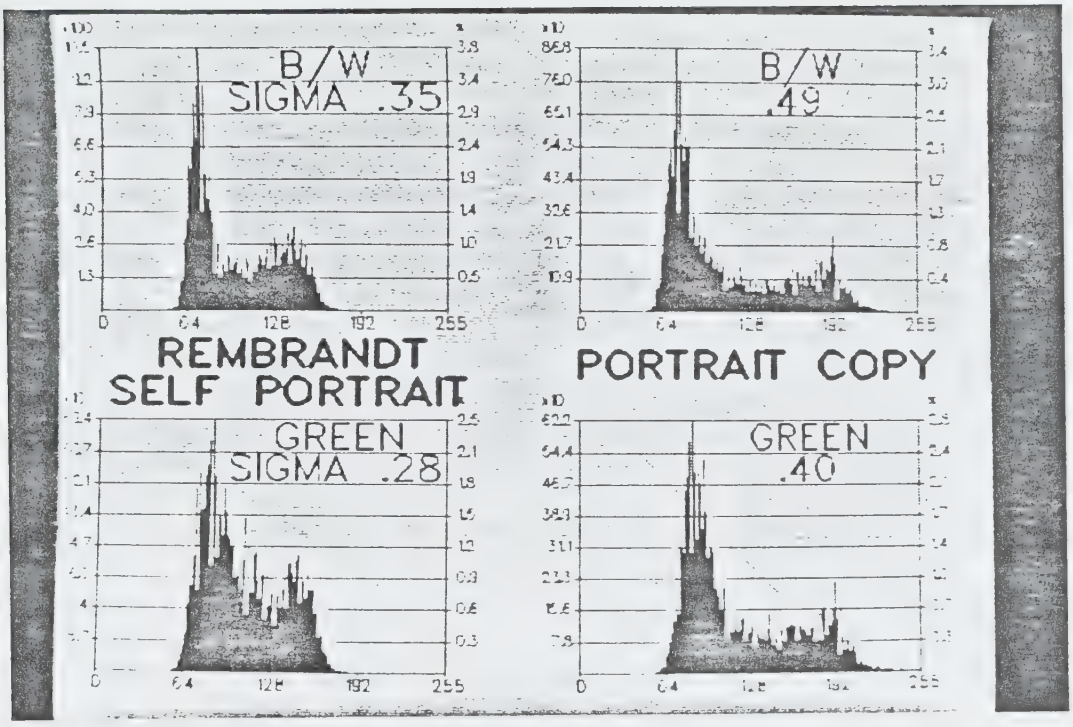

Figure 18. Comparison of the black/white and green histograms for the Rembrandt self portrait and its copy (Figure 17).

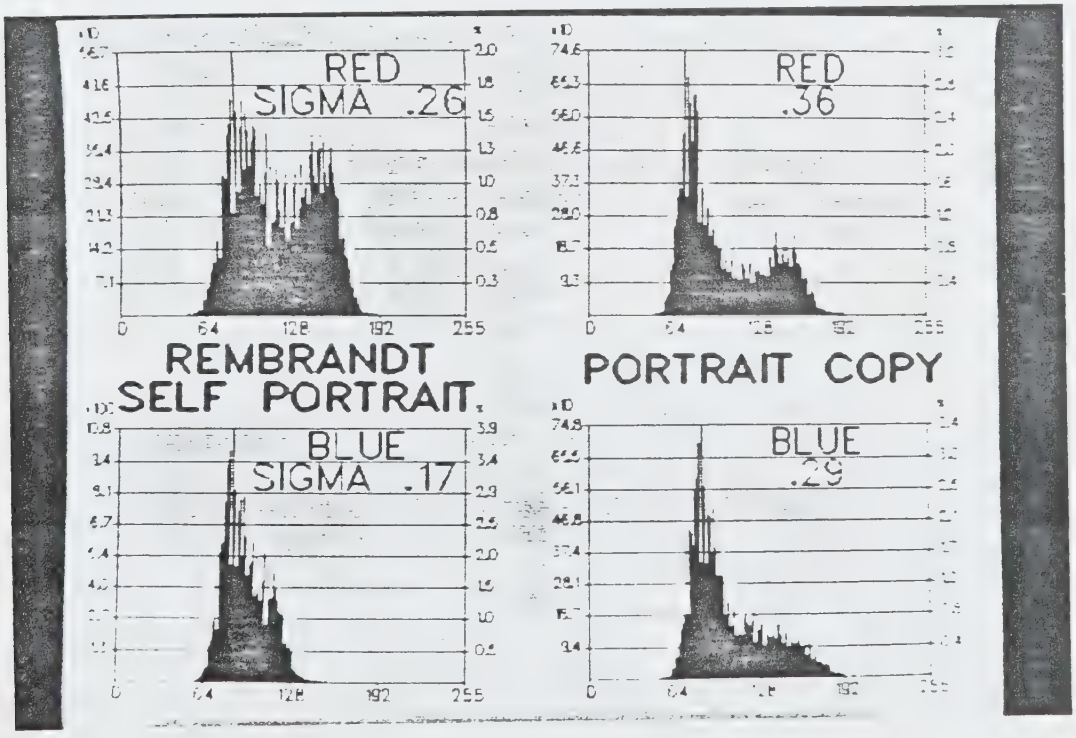

Figure 19. Comparison of the red and blue histograms for the Rembrandt self portrait and its copy (Figure 17).

scribed earlier in this section, RGB histogram analyses are performed by scanning the images in each of the three primary colors and then computing independent histograms for each of the digitized bands. In analyzing the Stuart, Goya, and Raphael paintings earlier it emerged that these RGB histograms do correlate with the artist (for the limited statistical sample investigated). Consequently, attention will turn now to a comparison between the RGB histograms for MR and those of the 1659 "Self-Portrait with Palette and Brushes" (Kenwood House, #379). (In terms of head position and style the Metrolopitan's 1660 "Self-Portrait in a Large Beret", #381, would have been a better choice, however a high-quality photograph was unavailable for this investigation.)

Figures 20 and 21 display the facial images and the RGB histograms for Rembrandt self-portrait #379 and MR, respectively. The blue-band histograms are perfect matches of each other. The green-band histograms are nearly perfect matches as well. (They look guite different in magnitude because of auto scaling that plotted one on the x10 scale and the other on the x100 scale due to a very few low-value pixels with high counts.) The two red-band histograms have a similar overall character with a large peak at low intensity and a lower peak at high intensity. However, the low-value peak in #379 is somewhat broader than in MR. Also, the high-value peak in #379 is about twice the height of that in MR.

Referring back to the Stuart-Raphael-Goya and Rembrandt-Copy comparisons it is clear that MR is about as close to #379 as were the two Stuarts to each other. Further, MR and #379 appear closer

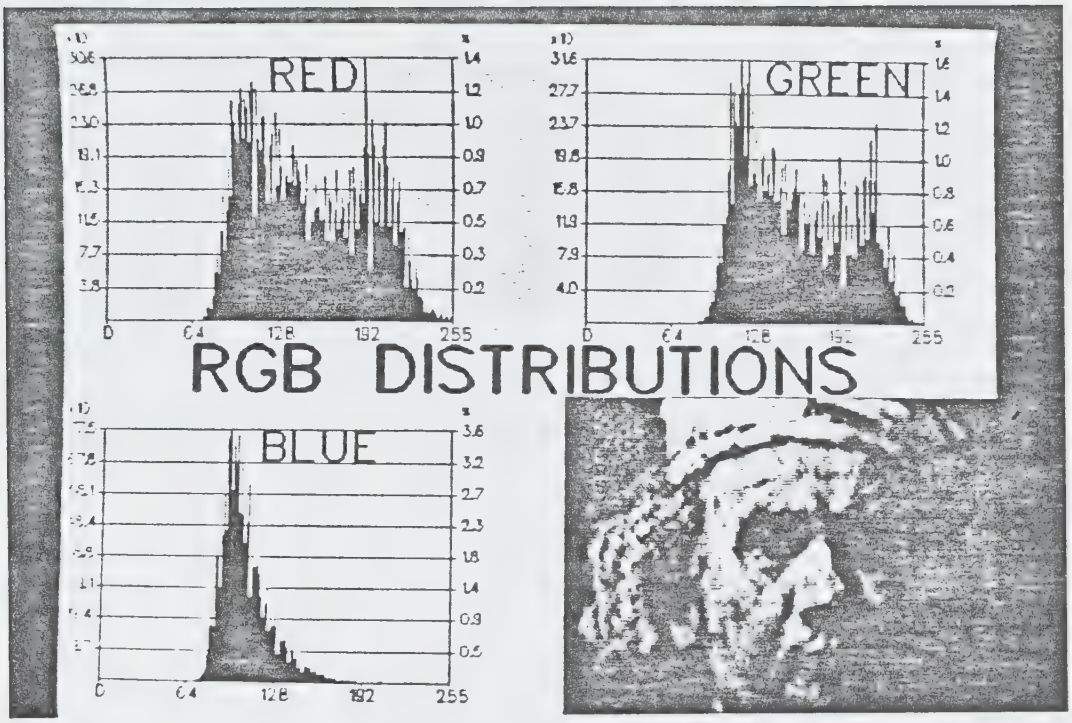

Figure 20. The face of the Rembrandt self-portrait #379 together with its RGB-band histograms.

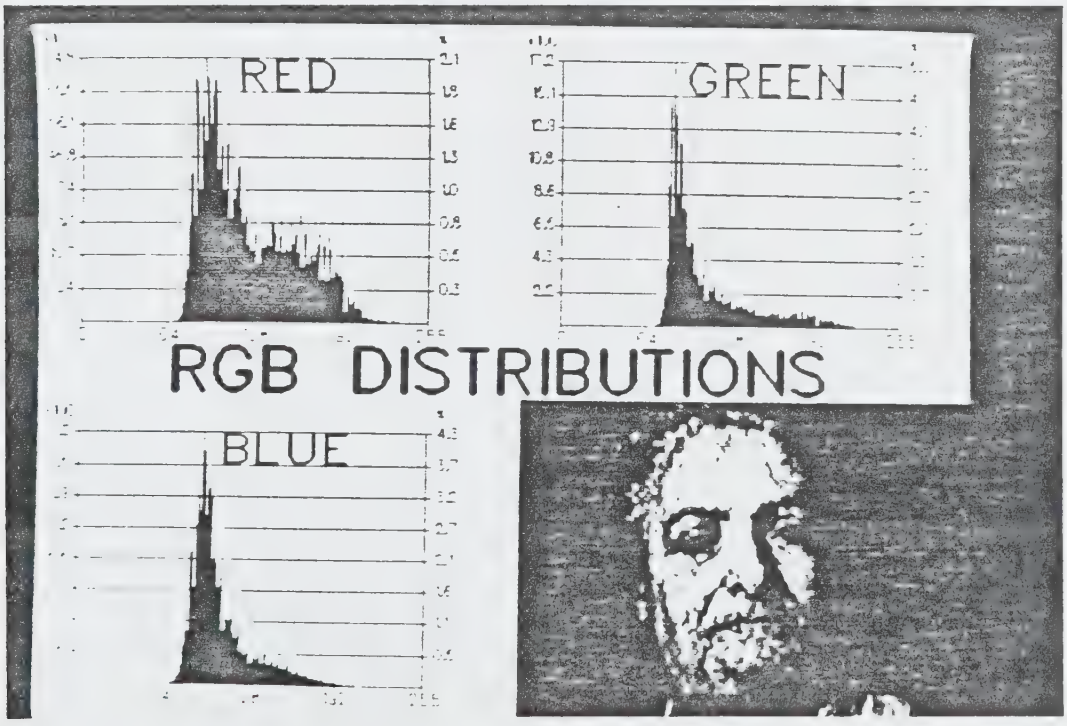

Figure 21. The face from the test portrait MR together with its RGB-band histograms for comparison with those of Figure 20.

to each than did the Rembrandt to its copy or the Stuart to the Raphael or the Goya. From this result we move on to the issue of brush technique and in particular the degree of blending of the strokes.

STATISTICAL ANALYSES (BLENDING)

The foregoing analyses have focused on global aspects of the Rembrandt portraits. These features were the geometrical characteristics of the face, the degree of albedo (relating to shading and chiaroscuro), and chromatic RGB palette distribution. The final topic to be investigated here pertains to the statistics of the detailed brush strokes. Indeed, traditional inspection of paintings for the purpose of attribution relies heavily on brush technique. Often the directions of the strokes, their lengths, their widths, the degree of impasto, and the blending of the individual pigments yield important clues as to the identity of the artist. These characteristics are illustrated by Figure 22 where facial details are shown for MR, late and early Rembrandt self-portraits, and a work by Raphael. From these four examples it is clear that there is an enormous range in technique as to the parameters identified above.

The tools of computer IP can be applied to analyze and quantify such characteristics, statistically. One of these approaches involves measuring the frequency with which pixel values change a small amount when moving to a neighbor and how often the change is large. The statistics of such changes may be plotted in a histogram format. Four examples are presented in Figure 23.

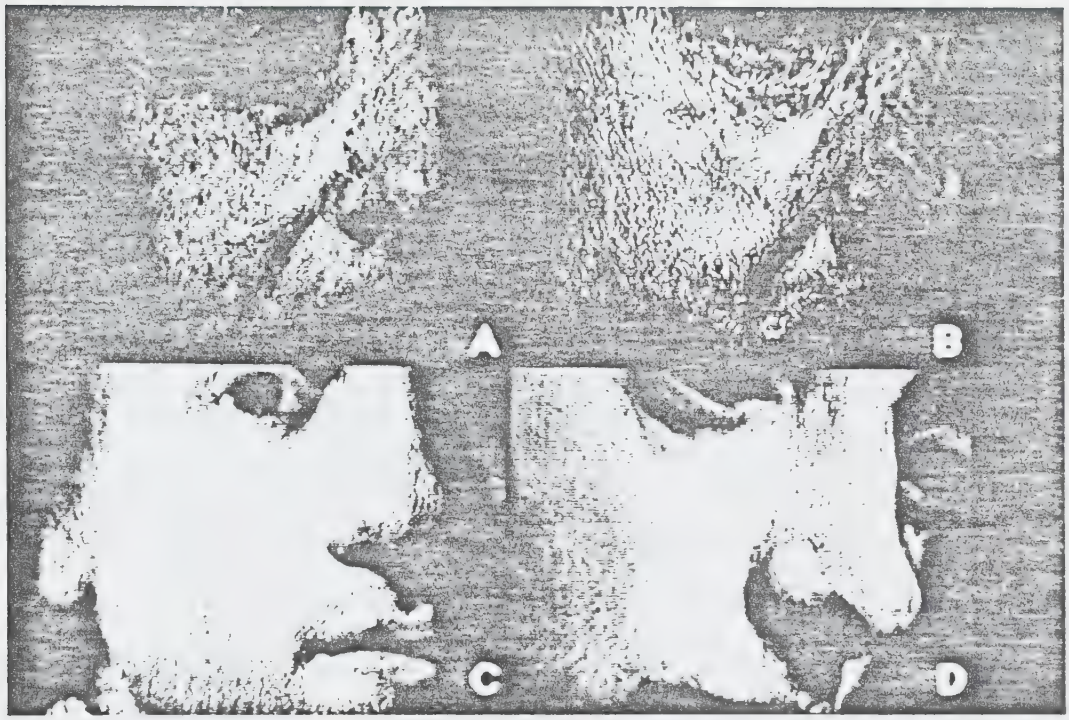

Figure 22. Details from the faces of MR (A), late Rembrandt (B), early Rembrandt (C), and Raphael (D) showing brush technique.

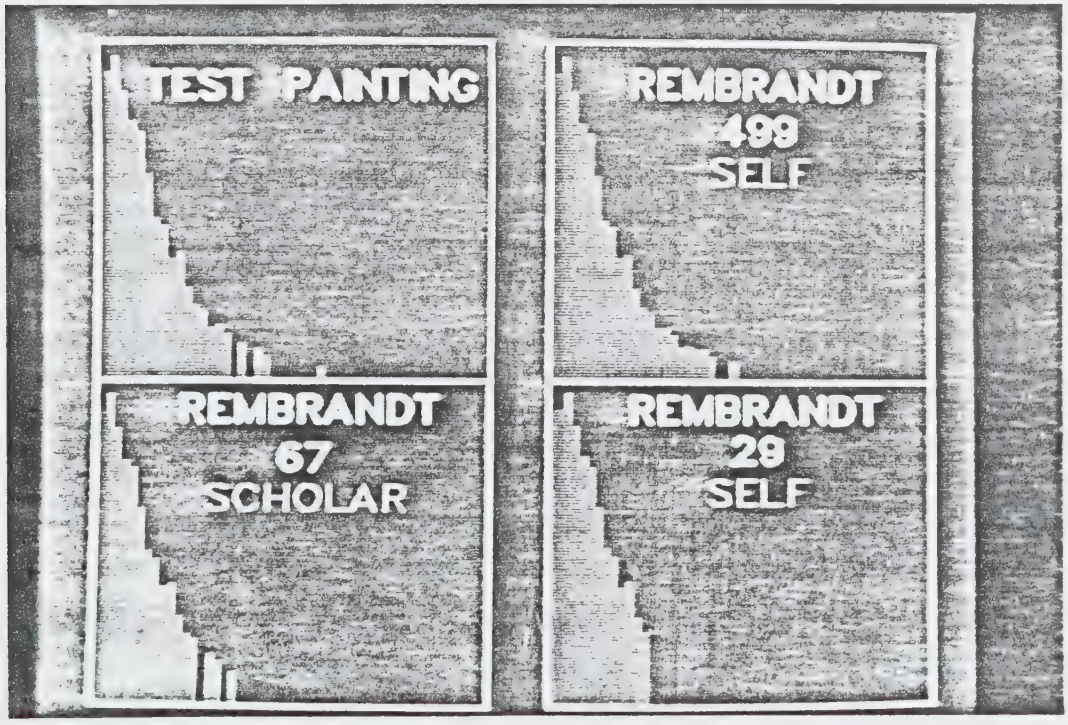

Figure 23. Spatial frequency spectra for MR ("Test"), Rembrandt's self-portraits 29 and 499, and "Portrait of a Scholar" (67).

In Figure 23 are the four spatial-frequency histograms for MR (upper left), Rembrandt late self-portrait #499 (upper right), the Rembrandt "Portrait of a Scholar", #67 (lower left), and an early Rembrandt self-portrait #29 (lower right). The origin of each histogram is at its lower left corner. The horizontal scale of each (abscissa) represents the change in intensity when moving from a particular pixel to its neighbor. The height of each vertical bar represents the numbers of jumps in intensity in the scene of that particular magnitude. Thus, it is evident in each of the four histograms that most of the pixel value jumps are small (e.g., 0, 1, 2) as the vertical bars are longest near the respective origins. The tapering off of the distributions toward larger values of pixel jumps may be interpreted as a measure of the smoothness or blending of the brush strokes. When the fall off is rapid (i.e., #67 and #29) then the blending is smooth. On the other hand, a slower fall off as in "Test" and #499 is an indication of a degree of abruptness that is indicative of poor blending. It is interesting to note that the spatial histograms for MR and self-portrait #499 are comparable. They fall off at about the same rate and both reach to about half of full scale. This is in contrast to the early Rembrandt works (#67 and #29) that exhibit truncated distributions toward the higher levels. Thus, the spatial statistics of the brush stroke blending of MR are consistent with those in the Rembrant self-portrait of the appropriate period in Rembrandt's career.

It is evident to the unaided eye in inspecting Figure 22 that the blending is smoother in the early Rembrandt works. It may be asked how the computer analysis adds anything to this

obvious conclusion? The answer is that spatial-frequency histogram analysis facilitates the quantification of this blending artifact allowing a more rigorous mathematical comparison. Further, as more paintings are scrutinized in this manner, the data base will grow and automated computer searches may be instituted to seek out matches and relationships that at present are largely uncovered as a matter of chance.

CONCLUSIONS

The computer IP analyses reported here have expanded considerably the body of information pertaining to the spectral, chiaroscuro/albedo, and brush-stroke characteristics of the Rembrandt self-portraits. Although several paintings have been examined in this study, it is still something of a probative effort in contrast to an exhaustive statistical sampling. As further years pass and computer IP becomes commonplace the data base on the unique Rembrandt "fingerprint" will emerge in due course. However, the shear magnitude of Rembrandt's output makes this an enormous task.

Whereas the statistical analyses performed on MR and the Rembrandt portraits were not exhaustive, they are more extensive than those performed on any other collection of paintings. The work focused on the facial features rather than on such other areas as hair, neck, shoulders, or background. Clearly, the artist would have concentrated his attention on the face, and the ancillary features probably exhibit less attention to personal features. Thus, these investigations probably represent a sensible attack in terms of a reasonable expenditure of time and

energy at this stage in the development of IP technology for authentication.

The study reported in this report does not probe each and every possible avenue of investigation as was mentioned above. However, a very considerable range was covered, and interesting and important results emerged. First, the split-face investigations involving Rembrandt drawings, etchings, and paintings show that the face in the painting identified as MR could be that of Rembrandt. Second, the chiaroscuro/albedo measurements indicate that MR is consistent with the properties of Rembrandt self-portraits and especially with those of the 1660s. Third, the RGB color distribution of MR is also consistent with that of the self-portraits (and inconsistent with that of the one copy considered). Finally, the spatial frequency characteristics of MR indicate a brush technique very close to that of the self-portraits and quite different from those of several other artists.

Each of the above findings alone could be a coincidence. Taking these four "coincidences" together shifts the overall probability toward the position that MR is closely related to the body of Rembrandt's ninety self-portraits. These results are consistent with the conclusion that MR is one of the thirty missing works. Statistical analyses of the type reported here can not prove that MR was executed by the hand of Rembrandt. However, if X-ray and materials analyses also point in this direction, then the evidence becomes overwhelming and surely much stronger than the bases for many of the generally accepted Rembrandt attributions.

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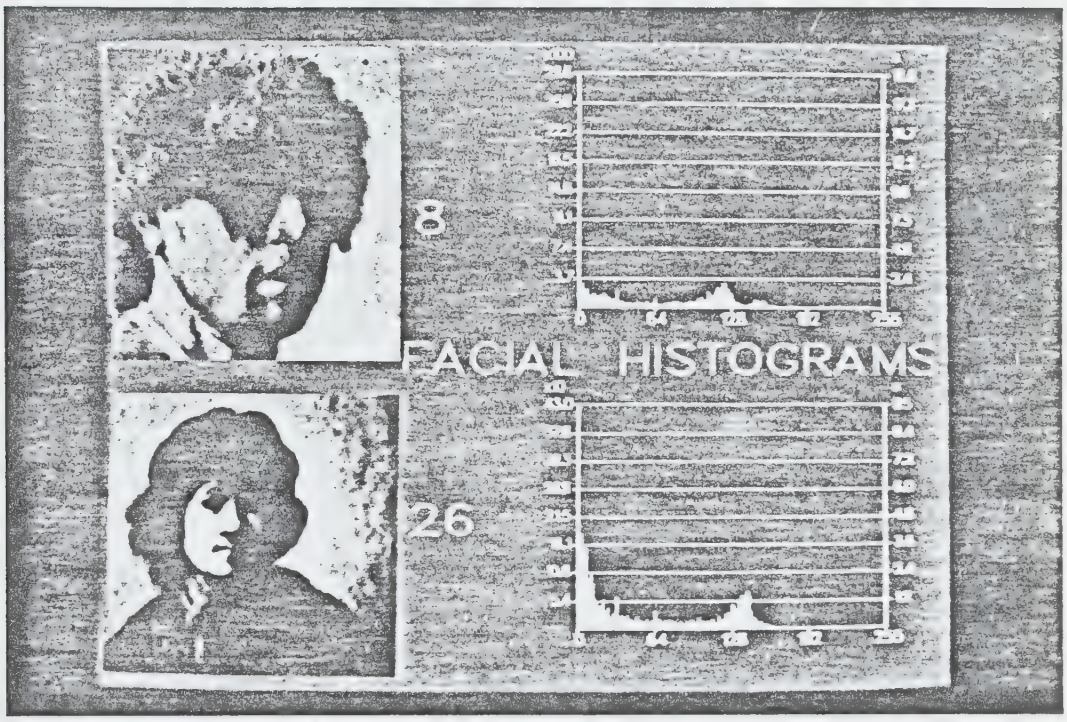
APPENDIX A.

Albedo Statistics for 28 Rembrandt Self-Portraits

The histograms for the self-portraits presented in the text are supplemented here by a much larger collection to demonstrate that the smaller group is characteristic of the full range of of Rembrandt's output.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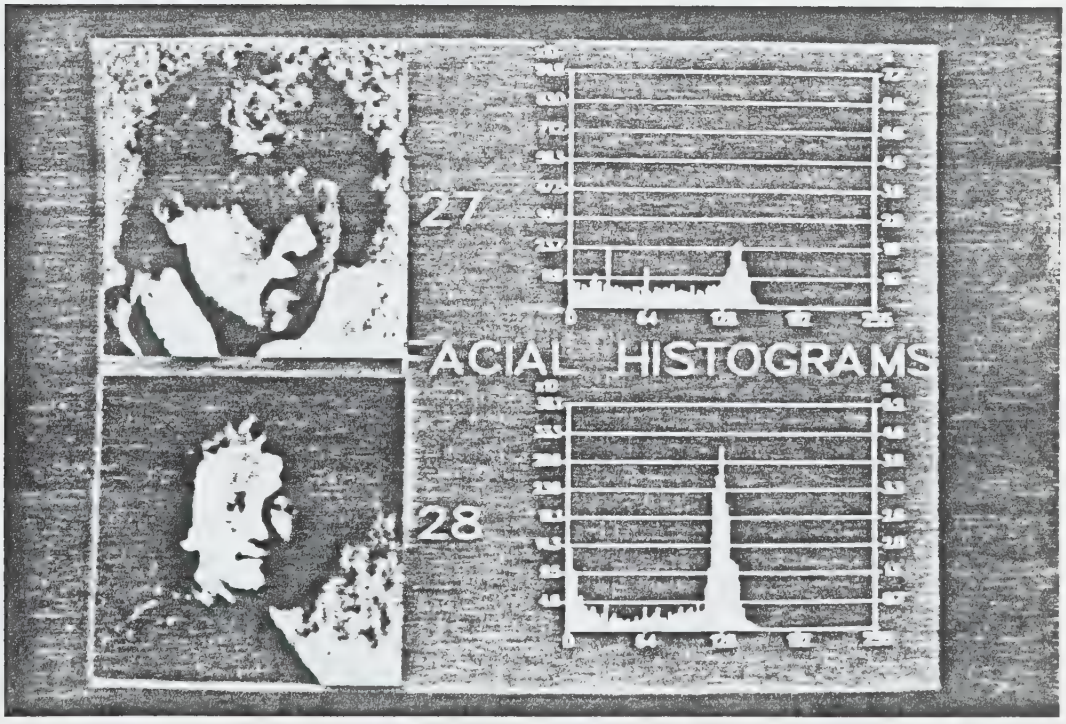
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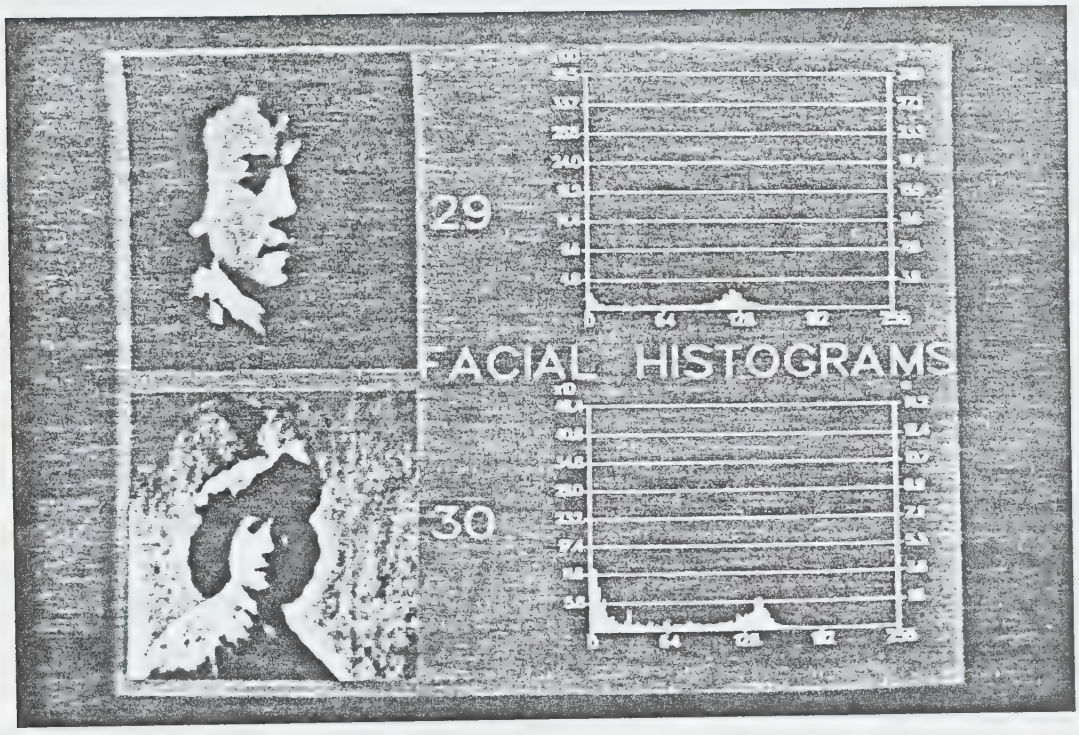
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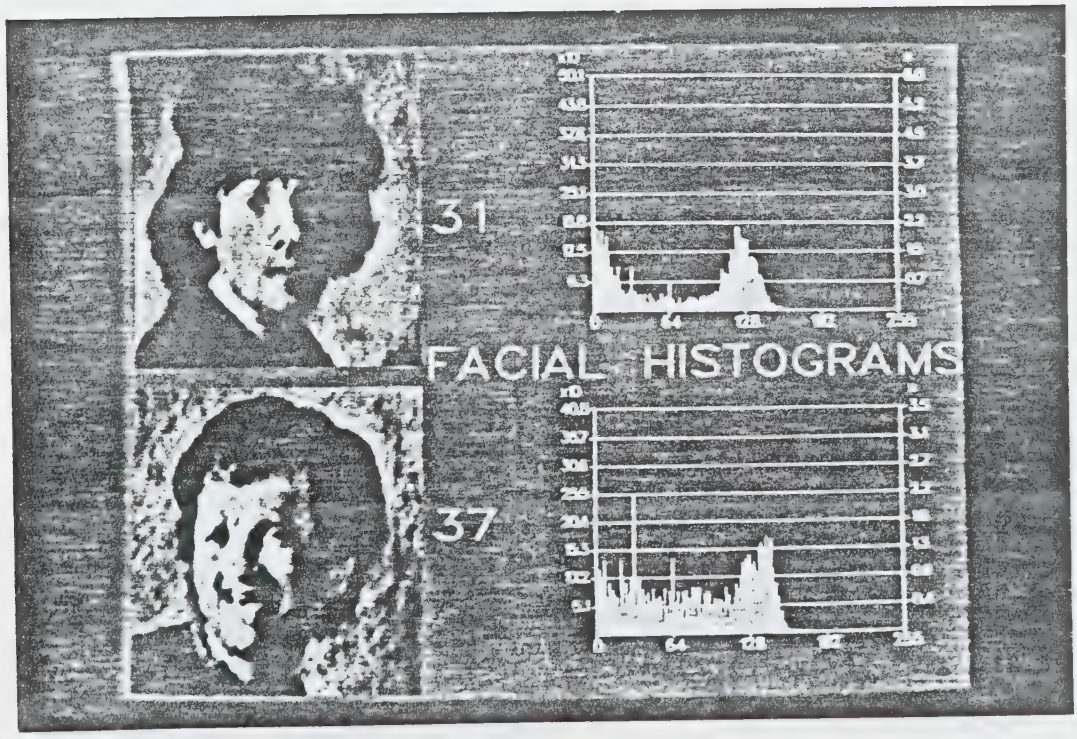
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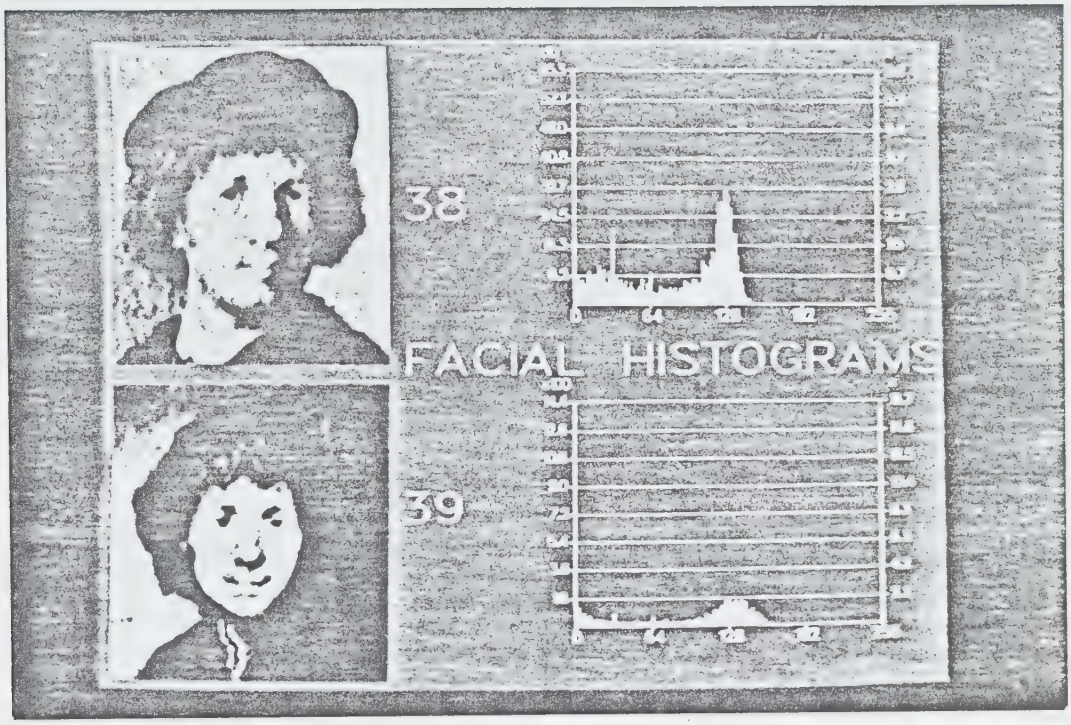
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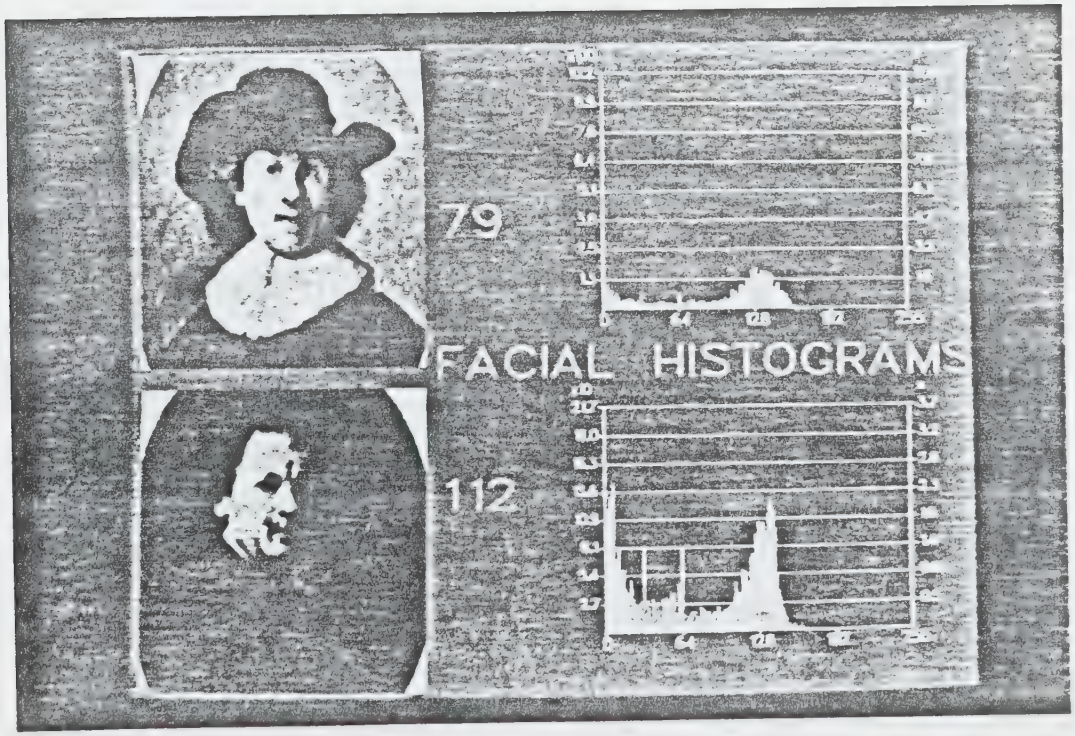
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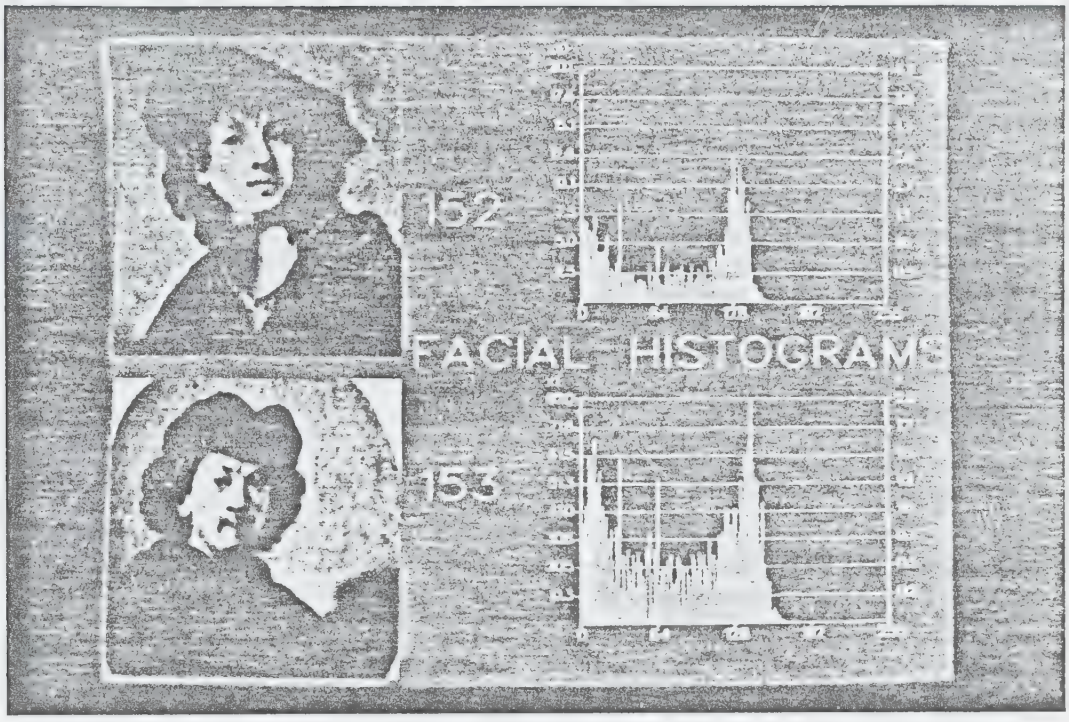
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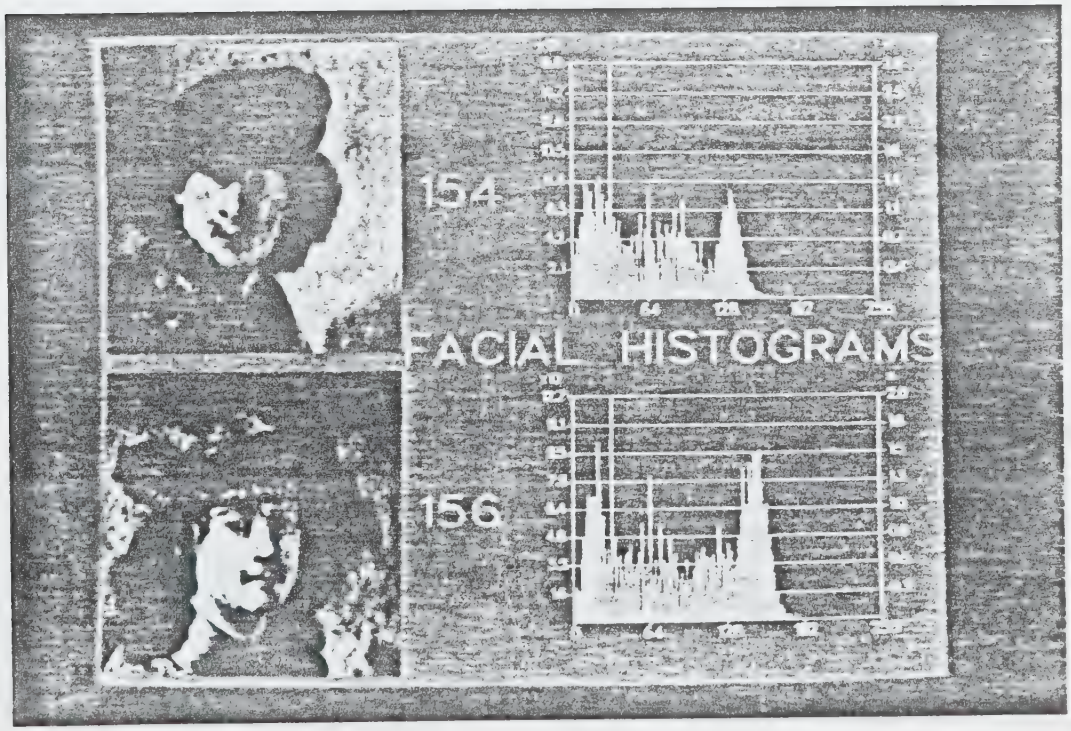
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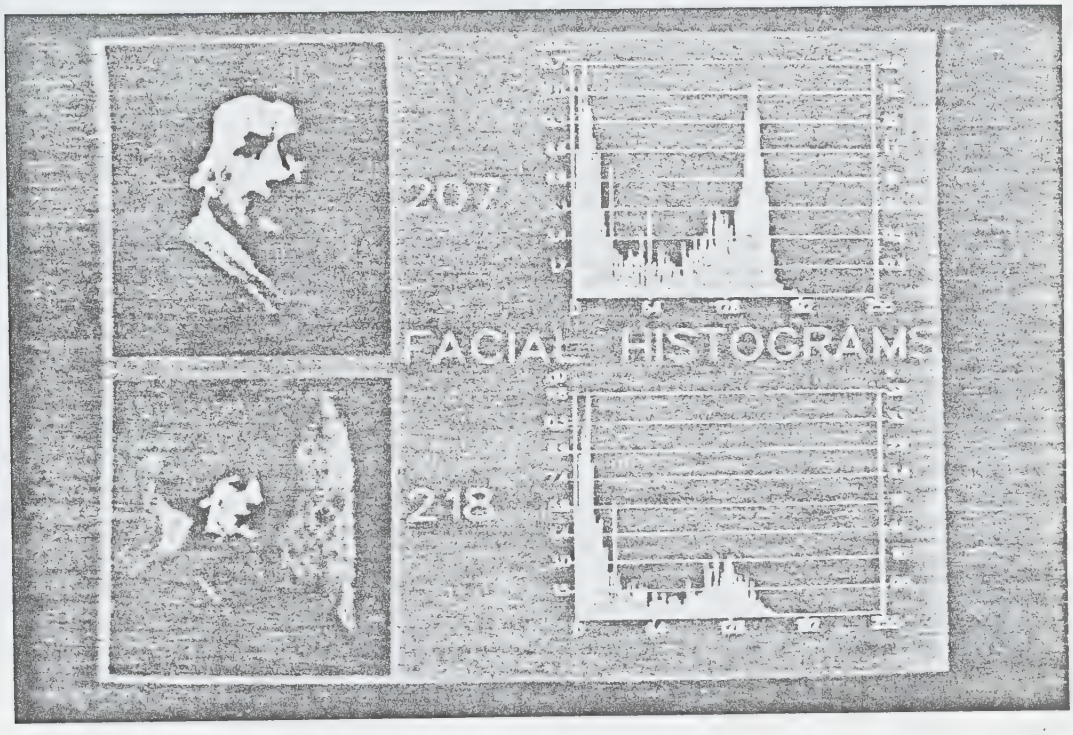
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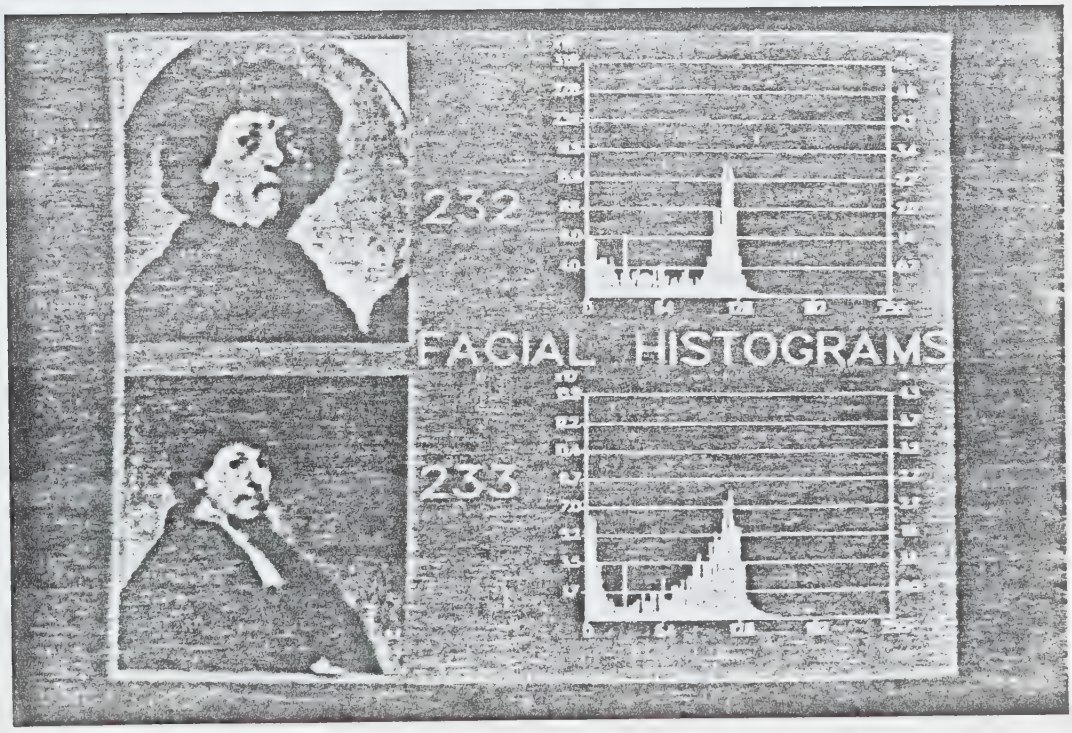
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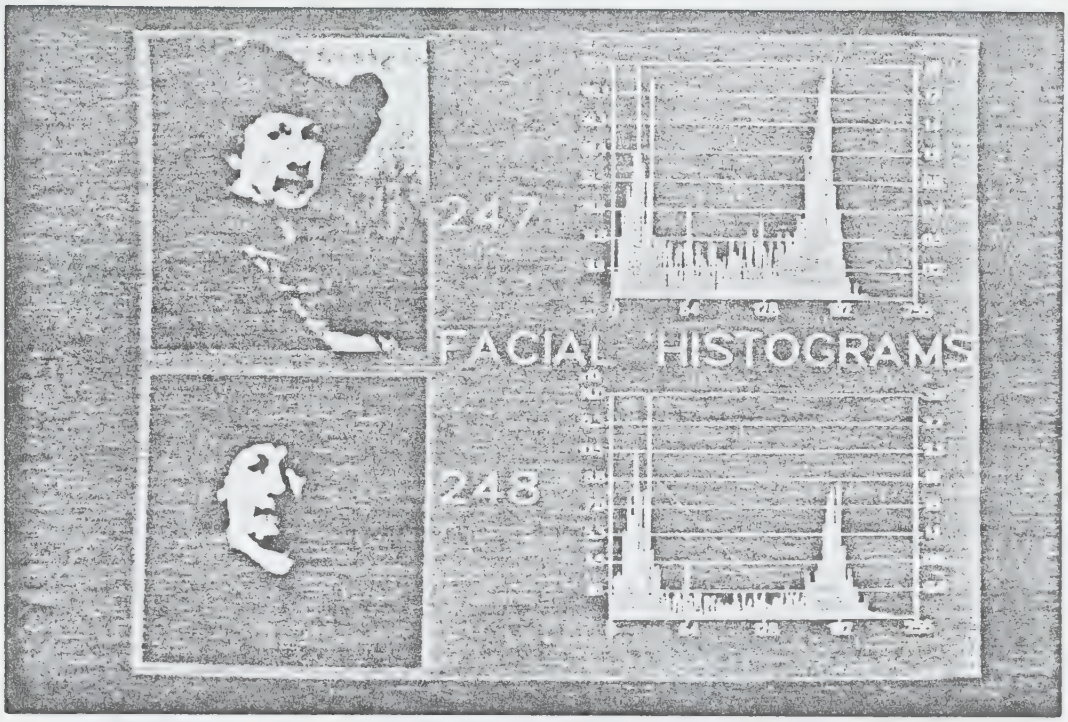
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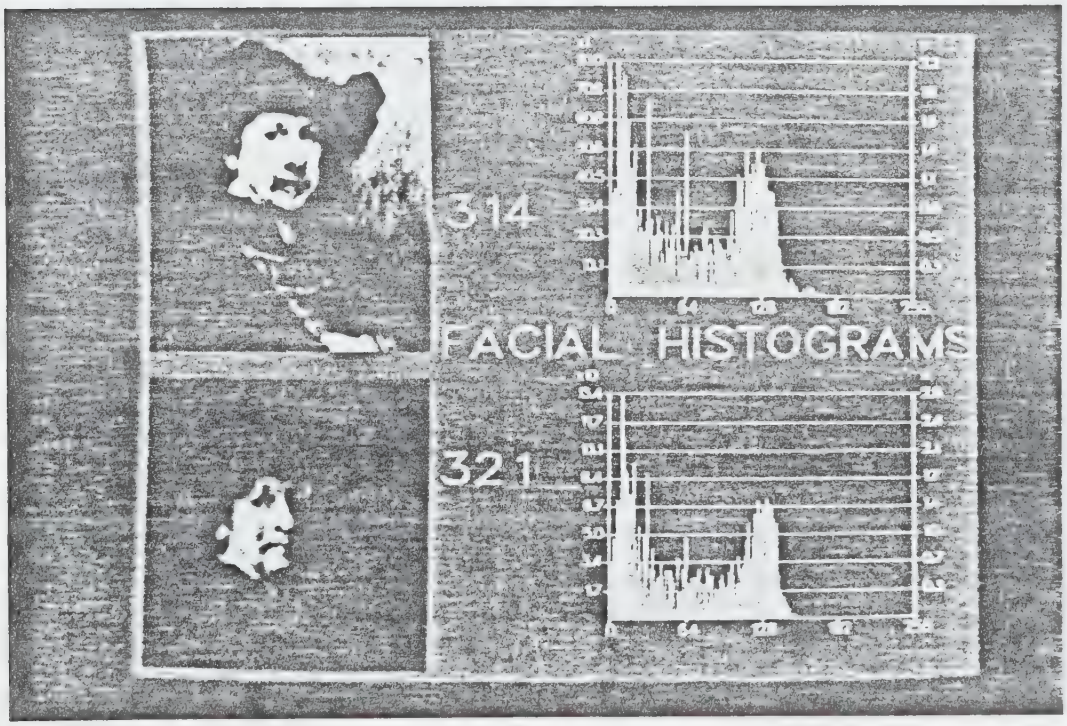
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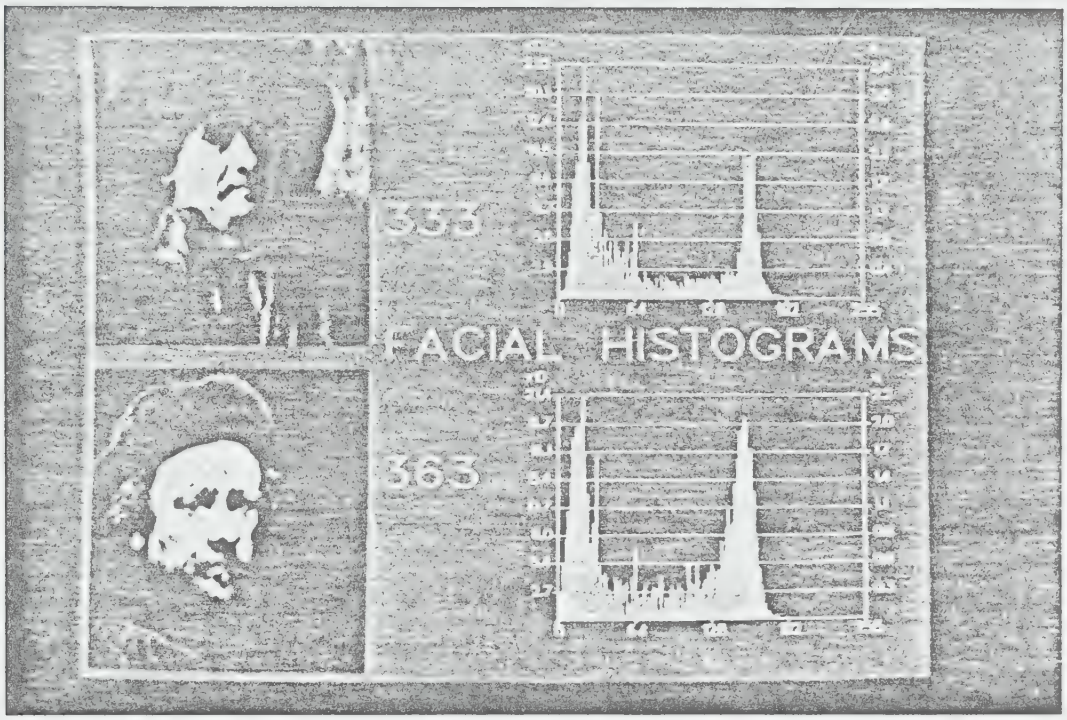
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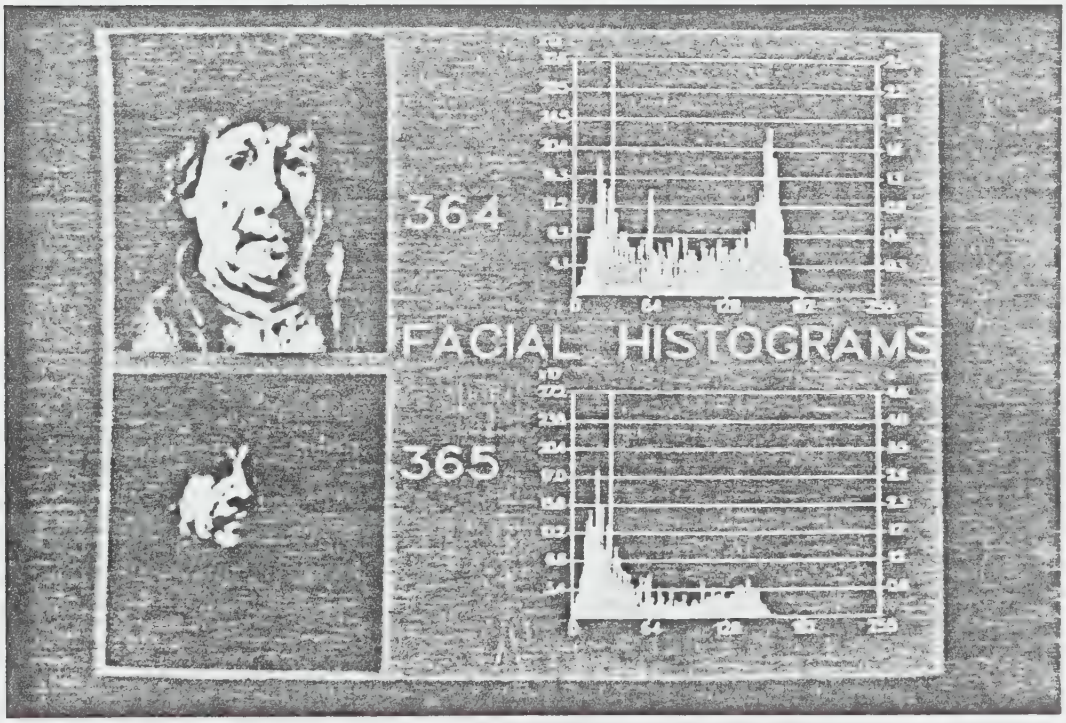
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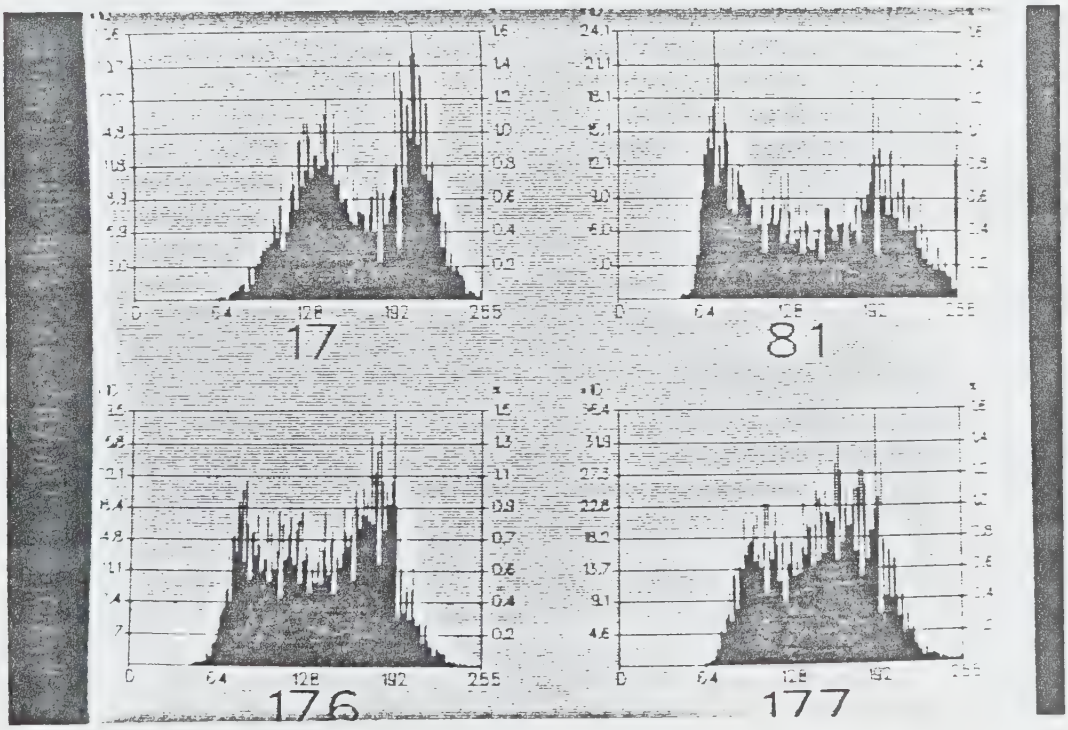
APPENDIX B

Histograms of Other Rembrandt Portraits

The histograms for the Rembrandt portraits exhibit a great deal more diversity than do the self-portraits.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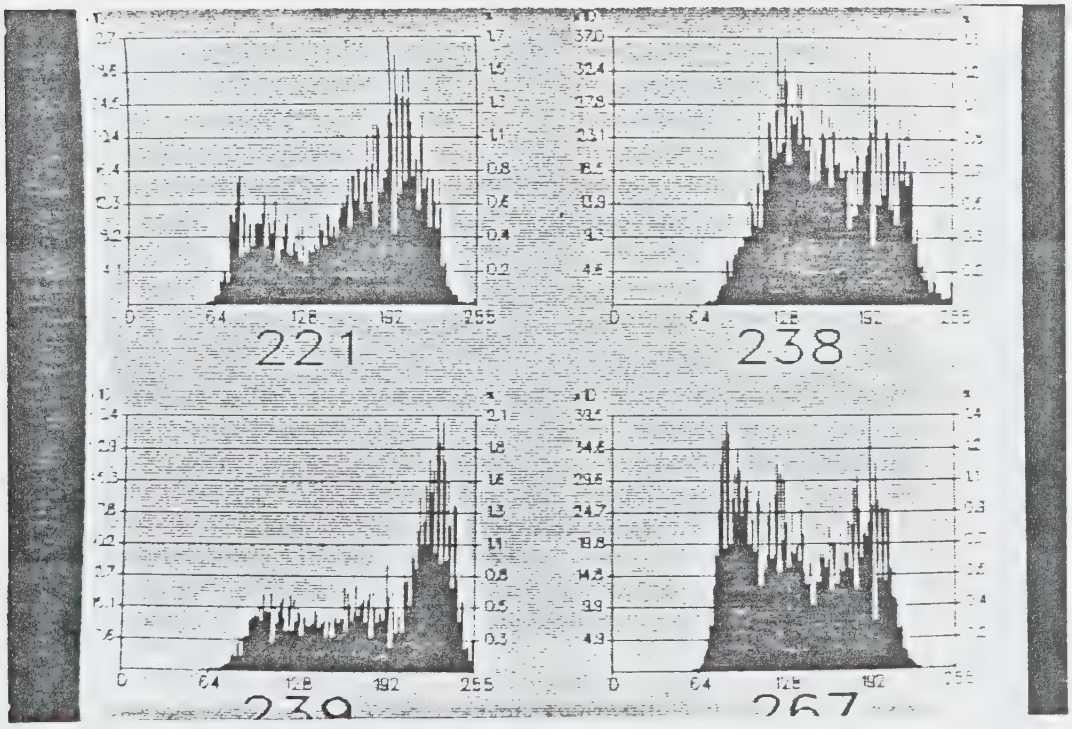
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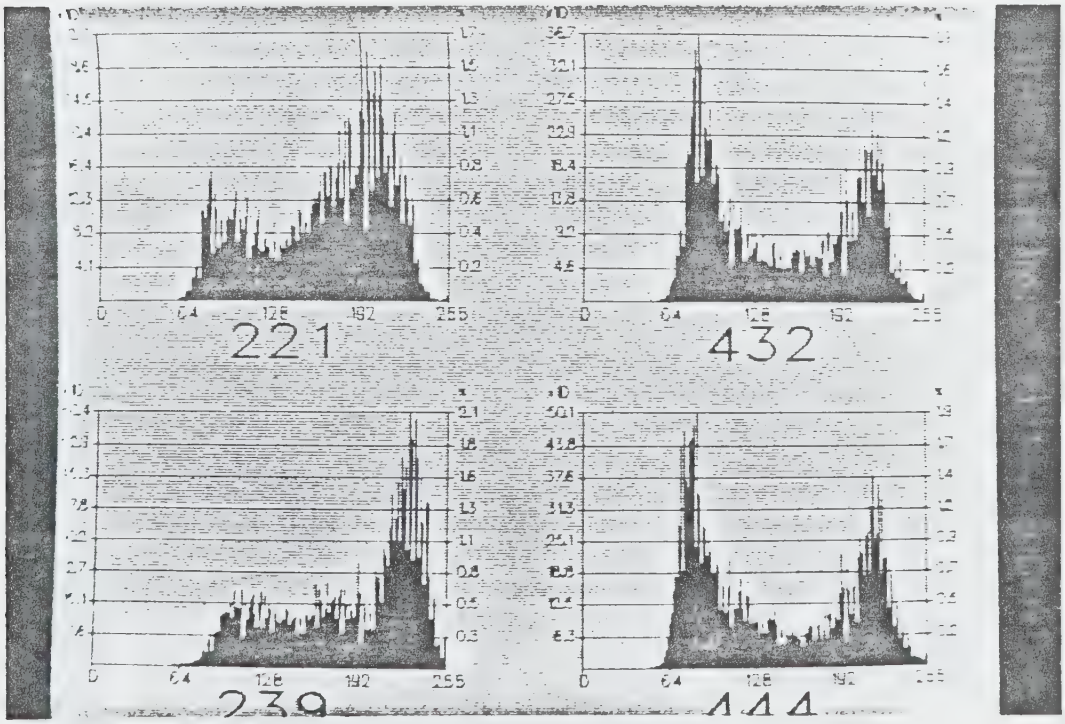
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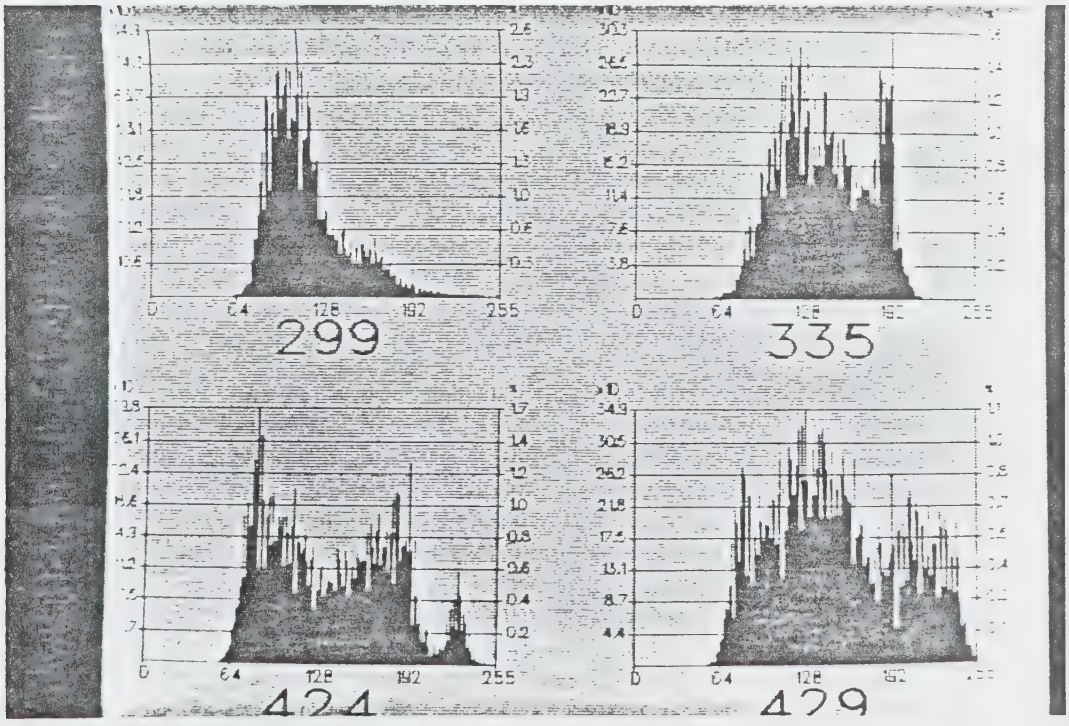
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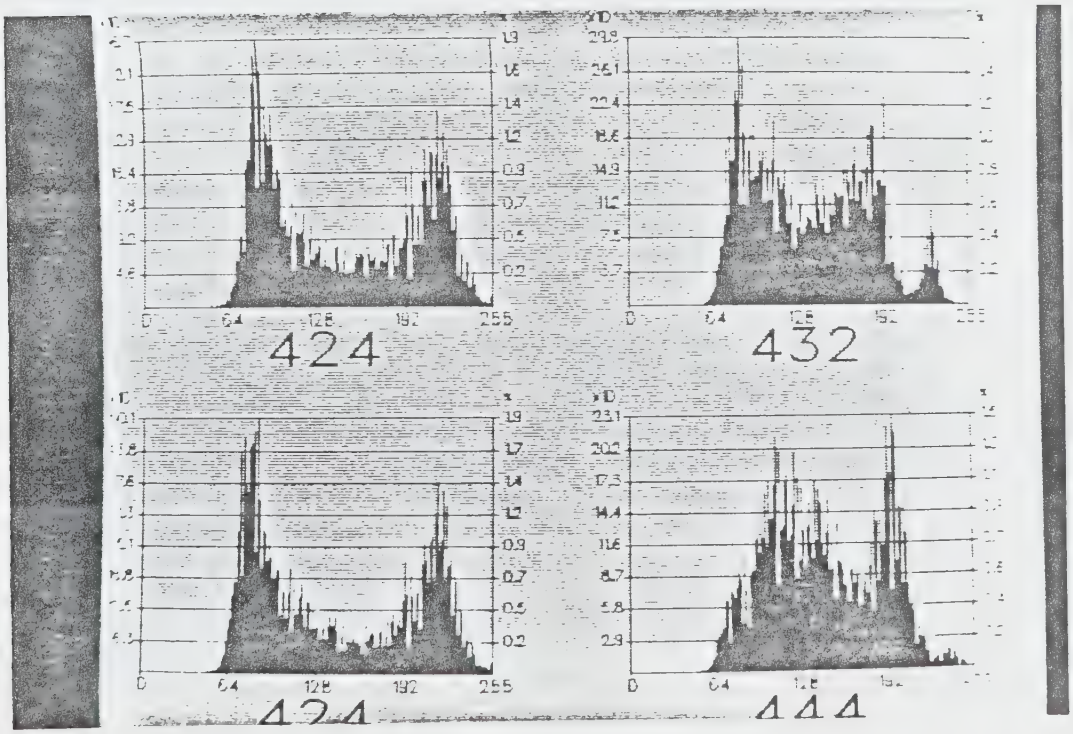
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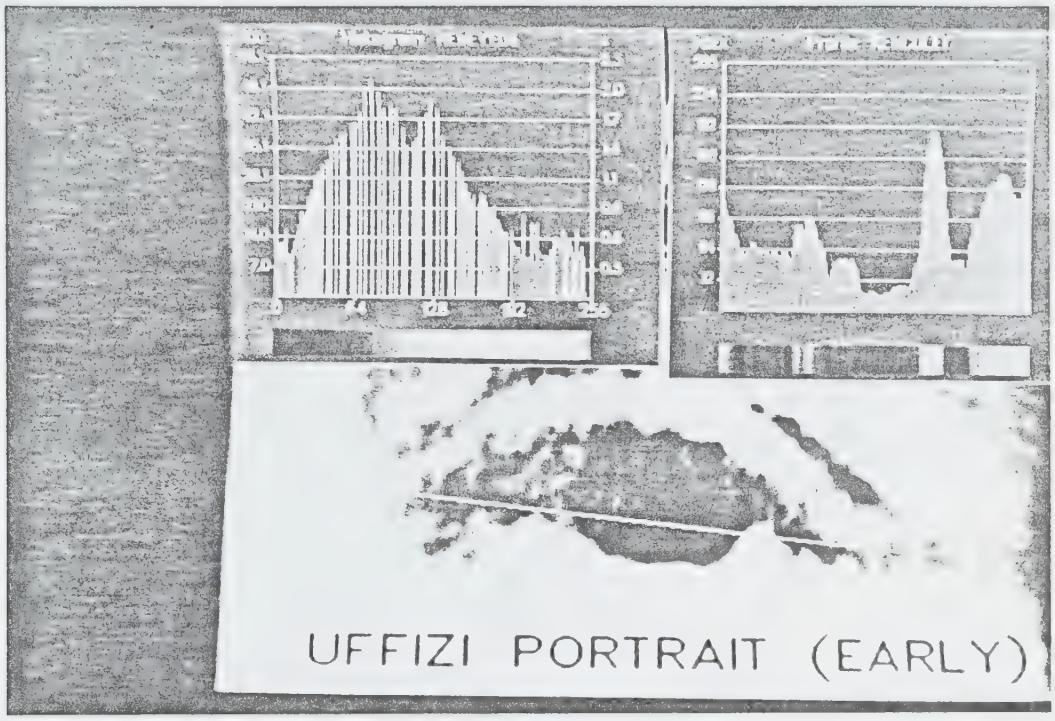
APPENDIX C.

Statistical Analyses of Various Eyes

Various eyes in painted portraits by Rembrandt, Titian, and Rotari were analyzed by histogram and profile. As no consistent patterns or trends could be discerned, these results were not incorporated into the study of MR.



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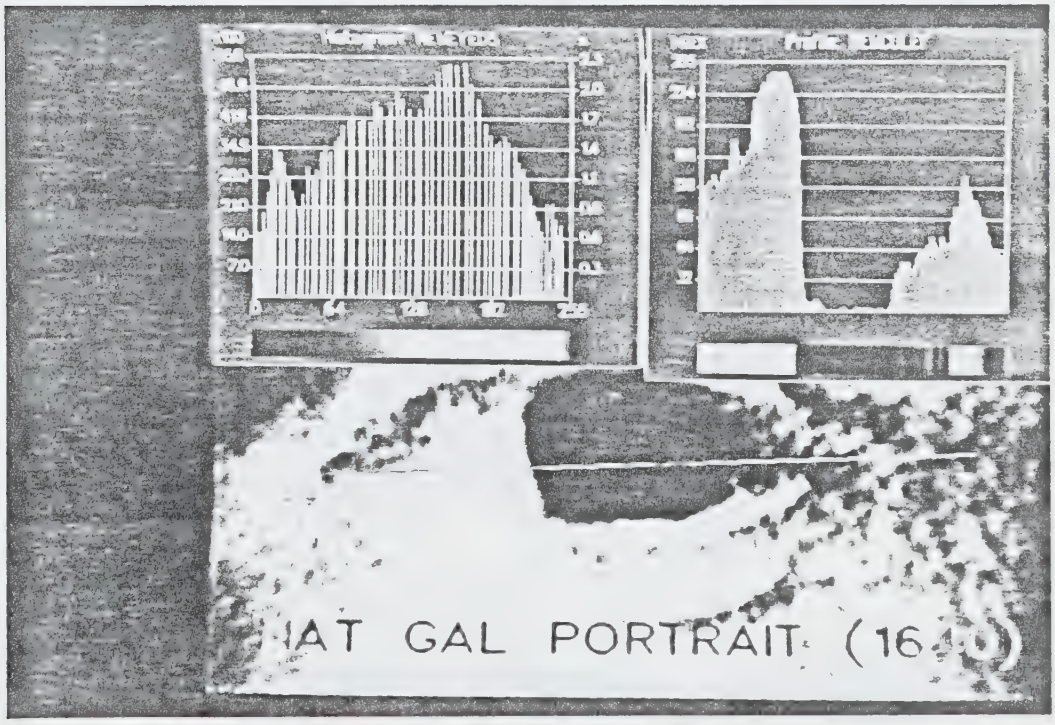

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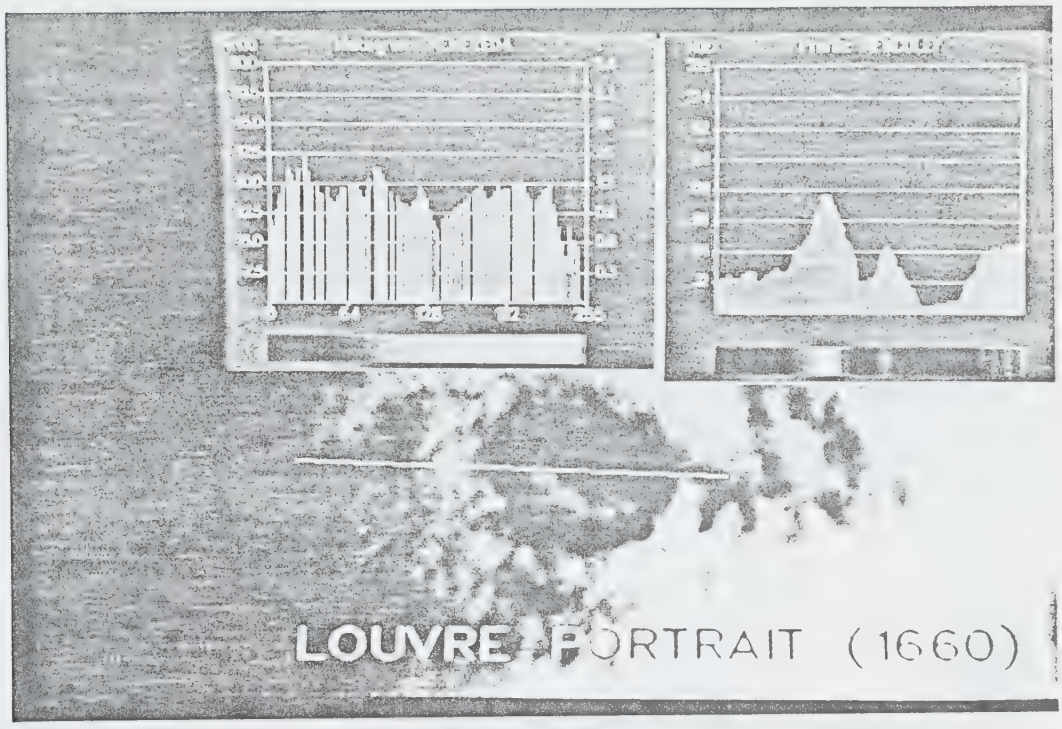
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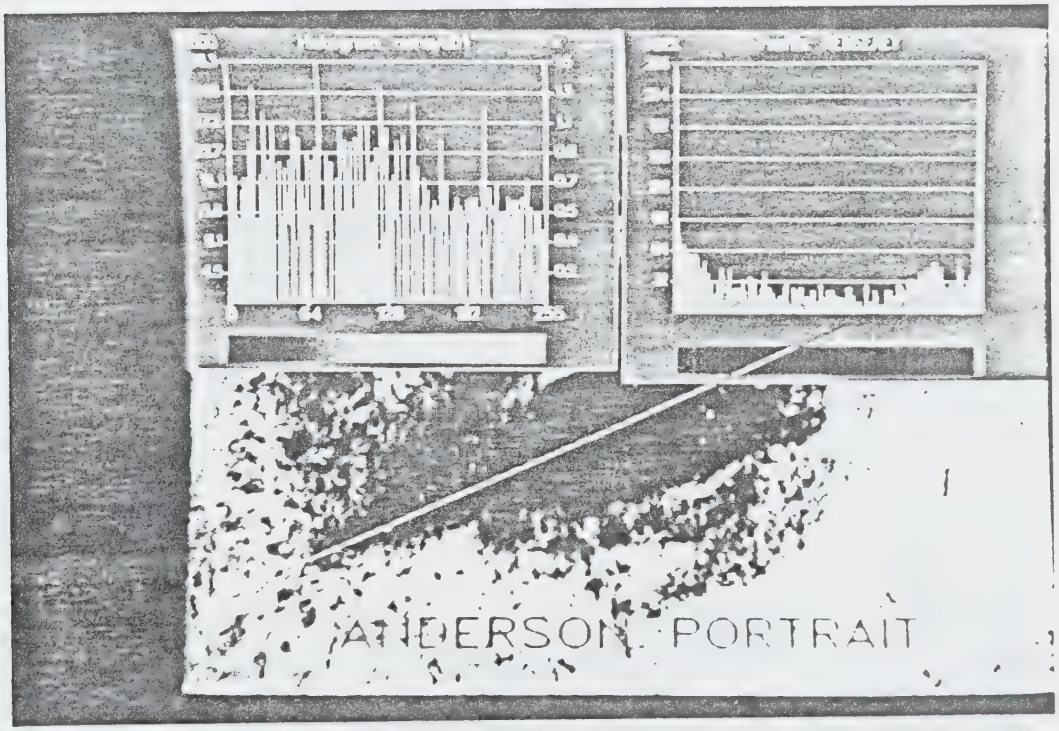
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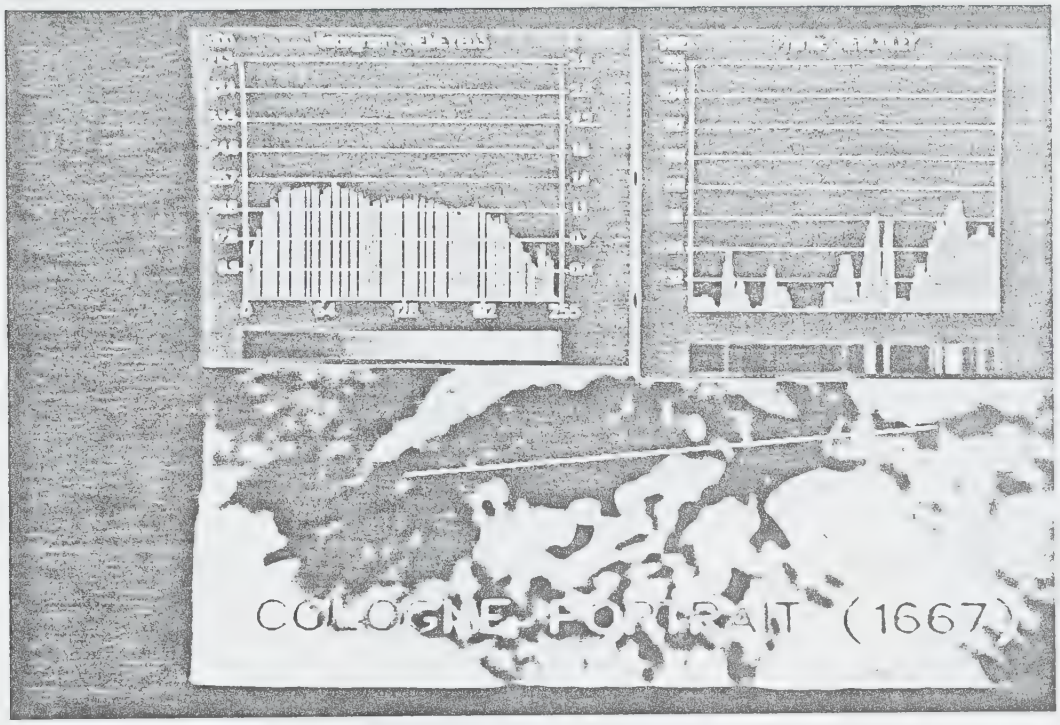
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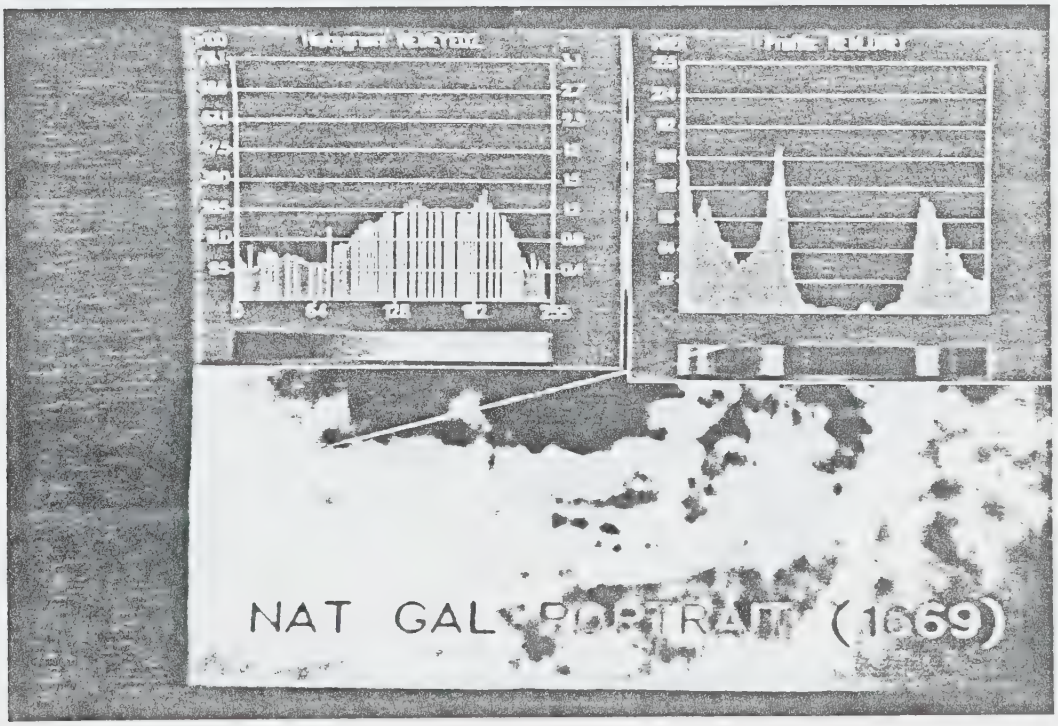
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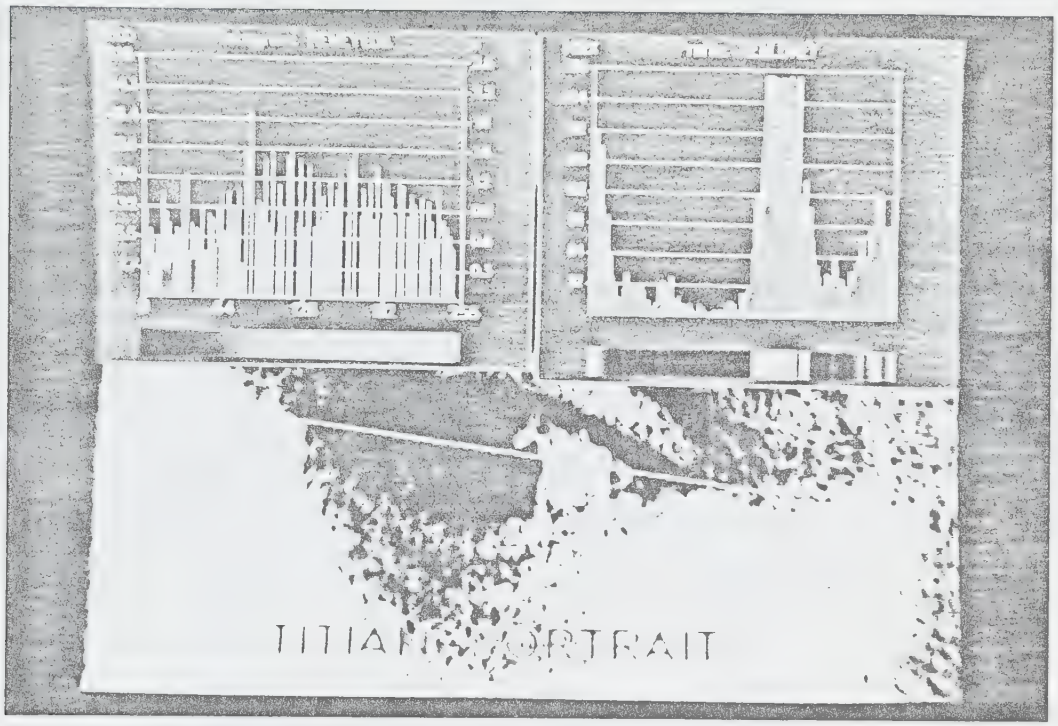
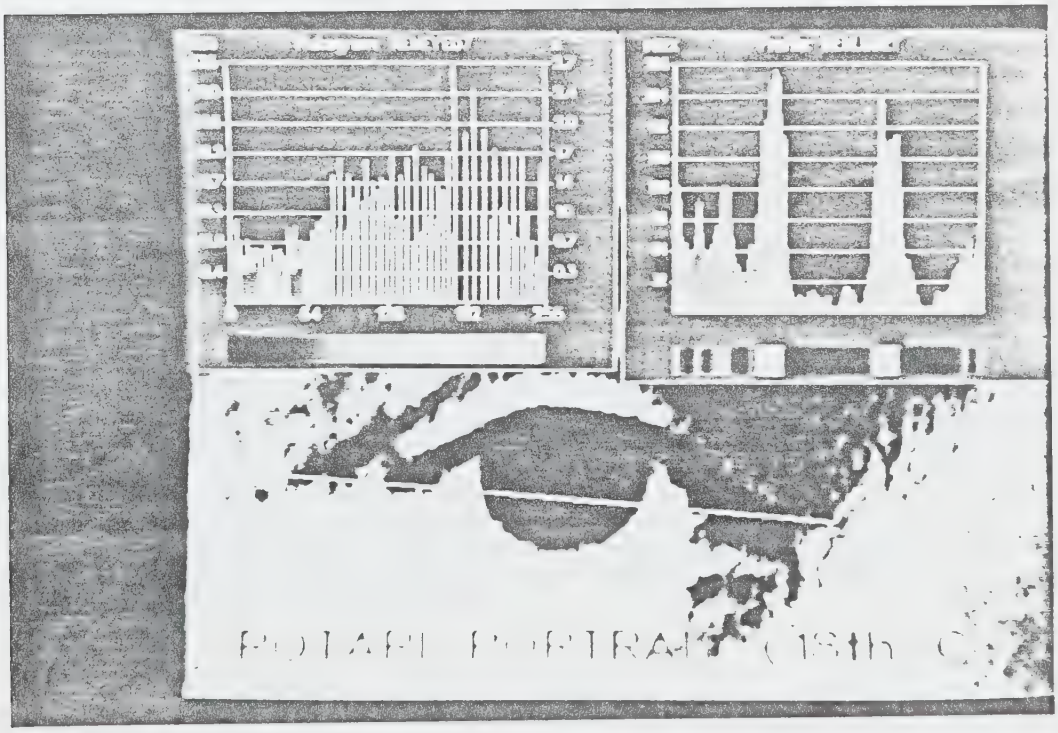


TITIAN PORTRAIT



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FROM 1/74 TO 6/74	University of California, Davis	Lecturer
FROM 10/73 TO 6/74	(12/73-12/74) UCSD Foundation (10/73-12/74) UCSD AMES	Consultant Res. Associat
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1/53-6/54	Chaffee Union HS	Ontario, CA		Diploma	6/54
9/54-6/58	California Institute of Technology	Pasadena, CA	E.E.	B.S.	6/58
9/58-6/59	California Institute of Technology	Pasadena, CA	E.E.	M.S.	6/59
9/59-9/64	California Institute of Technology	Pasadena, CA	E.E./ Physics	Ph.D.	6/65

Please indicate areas of sub-specialization, if any. Also include special licenses or permits.

Art restoration, plasma physics, lasers and applications, image enhancement of art works.

Memberships: Please list membership in scholarly societies, accreditation boards, civic organizations, etc. You may exclude any organization the name or character of which may indicate the race, religion, or national origin of its members

International Institute for the Conservation of Historic and Artistic Works

Institute of Electronic and Electrical Engineers

American Institute for Conservation

Common Cause

National Trust for Historic Preservation

(see Attachment for further listing)

Honors, Awards: Please list honors or awards such as Fulbright grants, Woodrow Wilson scholarships, special lectureships, medals, etc., and dates received.

Graduation with Honors (CIT, 1958)
Tau Beta Pi
Sigma Xi
American Legion Speech Award (1954)
Drake Scholar
Schlumberger Fellowship
Tektronix Fellowship
Listed in American Men of Science
Who's Who in America

Supplemental Information for Biography for Academic Personnel

John F. Asmus, Research Physicist, IPAPS

Employment

6/60 9/64	*Aero Geo Astro Corp. Alexandria, VA	Head, Optical Systems Staff Consultant	12,000 yr
7/54 6/60	*U.S. Naval Ordnance Corona, CA	Physical Science Aid Senior Engineer	2,750 10,800 yr

*Concurrent part-time employment while attending college.

Memberships

Venice Society

Advisory Group on Electron Devices (DDR&E, Special Group on Optical Masers)

Smithsonian Associates

Bay Area Art Conservation Guild

Patent

November 1971 - U.S. Patent - Metallic Vapor Laser

Additional biographical data

Has been engaged primarily in laser research and the development of laser applications since 1960. Recent activities have centered on studies of the interaction of laser radiation with matter as applied to art, archeology and laser catalyzed chemistry. A current project utilizes ultrasonic imaging to locate defects in frescos and map the interior of a Renaissance wall thought to contain a mural by Leonardo da Vinci. Present focus on excimer laser research as well as new surface preparation techniques employing pulsed light.

Name _____

Department IPAPS

Information on this page
☐ MAY MAY NOT ☐
be released to the public.

Initial here: _____

PUBLISHED WRITINGS and/or CREATIVE ACTIVITIES

Published writings and/or creative activities may be listed here or appended separately.

☒ Please check box if you are attaching information.

Signature _____ **Date** _____

NOTE: Be sure you have checked the appropriate box and placed your initials in the spaces provided on pages 3 and 4

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4. Asmus, John F. 23 May 1972, Sandia Laboratories (Albuquerque, N.M.)

5. Asmus, John F. 4 October 1972, University of New Mexico, Physics Department (Albuquerque, N.M.)

6. Asmus, John F. 10 June 1985, Matrix Midland Festival (Midland, Michigan)

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