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MUG FILE PROJECT REPORT NUMBER UHMUG-4

The Minolta Montage Synthesizer as a Facial Image Generating Device

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MUG FILE PROJECT REPORTS

UHMUG-1 Summary report for a Research Project *"A Man-Computer System for Solution of the Mug File Problem"*.
B. T. Rhodes, K. R. Laughery, G. M. Batten, and J. D. Bargainer.

UHMUG-2 *An Analysis of Procedures for Generating Facial Images*
K. R. Laughery, G. C. Duval, and R. H. Fowler.

UHMUG-3 *Factors Affecting Facial Recognition*
K. R. Laughery and R. H. Fowler

UHMUG-4 *The Minolta Montage Synthesizer as a Facial Image Generating Device*
F. H. Duncan and K. R. Laughery

UHMUG-5 *An Analysis of Strategies in Remembering and Generating Faces*
G. C. Duval

UHMUG-6 Data Base No. 1 - *Sketches and Identi-Kit Composites*

UHMUG-7 Data Base No. 2 - *Transcripts of Artist/Technician and Witness Interaction*

UHMUG-8 Data Base No. 3 - *Adjective Descriptors Used in Generating Sketches and Identi-Kit Composites*

UHMUG-9 Data Base No. 4 - *Miscellaneous Data from Sketch and Identi-Kit Generation*

UHMUG-10 *Support Hardware for Image Analysis Techniques Applied to the Mug File Program*
J. D. Bargainer

UHMUG-11 *Forgery Application of a Pattern Recognition Algorithm for Facial Images*
B. T. Rhodes and K. Prasertchuang

UHMUG-12 *An Evaluation of the UHMFS Facial Image Pattern Recognition Algorithms*
B. T. Rhodes and C. R. Walters

UHMUG-13 *FORTRAN Subroutines for the Pattern Recognition Algorithm Designed to Find "Look-Alikes" in a Mug File*
K. Sumney

UHMUG-14 *A Computer Simulation of the Minolta Montage Synthesizer*
G. W. Batten and T. Wiederhold

UHMUG-15 *The UHMFS Computer Software*
G. W. Batten, A. Karachievala and H. H. Nguyen

UHMUG-16 *Miscellaneous Computer Software for the Mug File Project*
G. W. Batten

Foreword

Our research team learned about the existence of the Minolta Montage Synthesizer during the early stages of this project. We became excited about its potential to generate facial images which look like photographs of real faces, and we decided to include an analysis of the Montage as part of the overall study. There were numerous problems; obtaining the device, getting pictures to use with it, and making it work. Frank Duncan spent long hours overcoming many of the problems, and we are now closer to realizing a useful, working system. The basis of our enthusiasm for the future utility of the Montage is that humans can make much better identifications of targets, or of photographs of targets, if they have a facial image which looks like a photograph of that person.

Unfortunately our time and money ran out just when development of the Montage was reaching a point of success. The authors of this report have documented the current state of development so that future workers can continue from this point. I would like to thank them for their considerable efforts, and I hope we will see the fruits of their work in the near future.

Ben T. Rhodes, Jr.
Project Director

SUMMARY

The work described in this report was part of an effort to develop a computer-based criminal identification system. An important part of such a system is the generation of facial images from a witness' description. Several techniques have been used in the past including sketch artists and the Identi-kit. A relatively new arrival on the image generation scene is the Minolta Montage Synthesizer. This device produces picture-like images by blending features from different photographs. To date, the Montage has had limited utility because of several shortcomings in the system. The work reported here consisted of several developmental efforts to modify and improve the system.

Current System

The synthesizer technique can best be understood by breaking the description into the hardware or equipment, the software or photographs, and the construction procedures.

Hardware. The hardware of the Minolta Montage Synthesizer consists of three component parts: an optical blender, a closed circuit television camera, and a television monitor. The optical blender enables partial images from separate sources to be combined producing a composite image. The operation consists of inserting a "base" facial photograph in an input port at the bottom of the device. The image in this photograph is picked up by the television camera. Between the input port ant the camera are three

locations where filters can be inserted. The filters are glass slides with mirrored deposits in appropriate locations. These filters block out parts of the basic facial image while simultaneously reflecting corresponding parts of secondary facial images onto the television camera lens. The secondary images are located at three separate input ports. Thus, the design enables the image form the basic photograph to be edited three times before being picked up by the camera. Controls are available to adjust the size and brightness of the images at each input port.

A few other minor design features of the hardware should also be noted. The glass filters are mounted in metal holders which are in turn inserted into the blender. These holders fit with a tight tolerance. The flexibility in locating the parts of the images so that the substitutions can be "finely tuned" comes about through the manipulation of the location of the photographs. Each photograph is mounted in a holder which is magnetically held at the ports. The holder can readily be moved around until the substitute feature is properly located.

Software. No software, or facial photographs, are provided with the basic synthesizer. For obvious reasons, the photographs used in Japan are not useful for constructing American faces.

Construction Procedures. Given the early developmental stage of the Montage, standardized construction procedures had not yet been determined. Basically, the procedures parallel the Identi-kit and Photo-fit techniques. A technician has available a library of facial features -- photographs. Through a series of verbal interactions with the witness, the technician attempts to select various features which look like the target person when put together as a composite.

New Developments

The primary purpose of the Montage development work carried out in this project was to extend and refine the hardware, to begin to develop a software system, and to define a set of procedures for constructing composites.

Hardware. The hardware modifications were intended to extend the number of possible feature substitutions from three to six, to increase the number of filters and to improve their "fit" to facial features, and to improve the filter and photograph holders. The increase in possible feature substitutions was accomplished by redesigning the filters and photographs so that two substitutions could be made at each of the three ports. The redesign enabled the filters and photographs to be superimposed.

The fit of the filters to the facial features is a problem in this type of system, since human features seem to come in a large variety of sizes and shapes. In order to determine more precisely the required dimensions of the various features, a measurement study was carried out to obtain data on feature dimensions for a large number of faces. This data base then permitted the design of filters so that the appropriate feature was blocked out without simultaneously interfering with surrounding facial areas. In the case of some feature filters, such as the mouth, it was necessary to develop more than one alternative filter in order to obtain proper fits.

Software. Clearly the success of the Montage in constructing an accurate representation is a direct function of the feature types contained in the software. Development of a software package in this project essentially started from zero. In order to determine which feature examples should be included in an appropriate software package, it was necessary to obtain actual data on

the range of values and types for the various features. This type of data was collected by measuring a sample of faces. The data then served as a basis for a feature classification scheme.

In addition to the identification of appropriate feature examples, the software development effort also included standardization of the actual photographs in terms of size. This standard was based upon the hardware characteristics of the Montage and upon the results of the facial measurements analysis.

Procedure. Based upon the hardware and software developments, a standard procedure has been defined for a technician working with a witness to construct an image. The procedure involves the interaction with the witness as well as the sequencing and selection of filters and photographs.

A Preliminary Test of the System

In order to achieve some feel for the capability of the redesigned system, a set of 14 white male faces were generated from view that is, the Montage composite was produced while the technician viewed a photograph of the target person. These images were compared to sketches and Identi-kit images generated under similar viewing conditions. Ratings of similarity indicated the Montage composites were better representations than Identi-kit images, but not so good as the sketches. Given the relatively early development stage of the Montage, these results are highly encouraging.

ACKNOWLEDGMENTS

Several people have contributed to the work reported in this document. Mr. Nelson Marquina helped in the analysis of the data collected during the facial measurement study. Mr. Klahan Prasertchaung provided both critical reviews and moral encouragement. Dr. Ben T. Rhodes was indispensable for his continual belief in the significance of the research and in his efforts to provide the personal contacts necessary for the vital exchange of research ideas.

Jim Bargainer, George Batten, Jim Townes, Mike Mauldin, Richard Fowler, Glen Duval and Sharon Neyland also helped in a variety of ways.

To these and others, we express our thanks.

Franklin H. Duncan

Kenneth R. Laughery

TABLE OF CONTENTS

Exhibit 6: Target 56
Exhibit 7: Target 62
Exhibit 8: Target 67
Exhibit 9: Target 69
Exhibit 10: Target 72
Exhibit 11: Target 77
Exhibit 12: Target 81
Exhibit 13: Target 89
Exhibit 14: Target 95

Appendix M: Feature Classifications and Software Features Used in Constructing Composites.

Exhibit 1: Target 21
Exhibit 2: Target 48
Exhibit 3: Target 51
Exhibit 4: Target 53
Exhibit 5: Target 54
Exhibit 6: Target 56
Exhibit 7: Target 62
Exhibit 8: Target 67
Exhibit 9: Target 69
Exhibit 10: Target 72
Exhibit 11: Target 77
Exhibit 12: Target 81
Exhibit 13: Target 89
Exhibit 14: Target 95

CHAPTER 1

INTRODUCTION

An important factor in the general field of law enforcement is the identification of criminals by witnesses. It is not uncommon, particularly for many categories of crimes, to have available a witness who has seen the criminal. In many such instances, the witness may have a good memory for what the criminal looked like. This memory, or internal image, may indeed be good enough to enable the witness to identify the criminal or a photograph of the criminal. Such potential identification is, of course, the reason we use line-up and mug-file search procedures.

Without information about the crime or criminal other than the witness' memory, line-ups and mug files are not particularly useful procedures. The problems are straightforward: a line-up can only be created given some idea about who should be in it; and, mug files tend to be too large for a witness to simply conduct a linear search. On the other hand, line-ups and mug files might be used if it were possible to obtain from the witness advance information about the appearance of the criminal. By knowing in advance what the person looks like (or doesn't look like), suspects and alternates could be selected for a line-up and the inappropriate alternatives eliminated from the mug file. But how do we go about looking inside the head of the witness to find out about the criminal's appearance?

Over the years law enforcement people have wrestled with this problem and developed a variety of techniques for obtaining such images. Two widely known and used procedures are the sketch artist and Identi-kit. A less

common technique is the Photo-fit. Two relatively new developments are known as the Identiface and the Minolta Montage Synthesizer. The work reported in this document was an effort to further develop the Minolta Montage Synthesizer (hereafter referred to simply as the Montage) as a technique for image generation. Before getting into that effort, however, the other four techniques mentioned above will be briefly reviewed.

Sketch Artist

The sketch artist is a familiar technique for obtaining facial images. An artist works with the witness to produce a likeness of someone the witness has seen. The artist is a person skilled in drawing faces and experienced in working with witnesses to produce the images.

The pros and cons of the sketch artist technique are similarly straighforward. One important factor that may be either a pro or con is the skill of the artist. Little need be said regarding this factor since its implications are obvious. Other characteristics of the technique, however, particularly its limitations, are noteworthy. First on the minus side is the fact that the image produced is a drawing; it does not appear to be a real face. Secondly, the sketch artist technique involves a special skill that few people have. Consequently, not everyone (in fact, relatively few) are able or can be trained to produce such images. Thirdly, witnesses usually must be brought to the artists location with resulting time delays. Fourth, small law enforcement agencies may not be able to afford an artist, with the consequence that the procedure is not available to them.

But these limitations do not render the sketch artist technique use-

less; indeed, it is a valuable tool to law enforcement. Perhaps, the most positive dimension of the procedure is its flexibility in image alternatives. Unlike most other techniques with a limited feature vocabulary, the sketch artist can produce an unlimited number of alternative faces. The only limits along these lines are the artistic ability of the artist and the descriptive ability of the witness.

Identi-kit

The Identi-kit is one of several image generation procedures that include some sort of device or set of materials for producing faces. The kit was developed in the early 1960's by a police officer in California. It consists of a file of separate facial features printed on clear plastic sheets. The facial features included are eyes, eyebrows, noses, mouths, chinlines, hair styles and accessories such as eyeglasses, beards, moustaches, sideburns, age lines and headgear. There are numerous examples of each feature. Images are constructed by stacking the appropriate features together, one on top of the other, on a standard positioning board. Features can be made to appear lighter or darker by moving the plastic sheet towards the bottom or top of the stack. The head can be shortened or elongated by altering the distance between the hair line and chin line. Similarly, the location of features can be manipulated by moving them away from (upwards) or towards (downwards) the chin line.

There are several aspects of the Identi-kit that make it a useful law enforcement procedure. First, it is small, easilty transportable and can readily be used "on the scene." This characteristic can minimize time delays between a witness seeing the criminal and attempting to generate an image. A second positive aspect of the kit is that most

people can readily be trained to use it. A standard two-day training course and a reasonable amount of practice can enable a user to produce a potentially useful image. A third, and very important, dimension of the Identi-kit is the fact that the examples of the various features are standardized and coded. Also, the relative position of the various features in the stack and on the board are coded. As a result, the image can be transmitted from one law enforcement agency to another simply by communicating the codes and generating the image at the new site. Finally, the kit is relatively inexpensive and thus available to most agencies.

Not all aspects of the Identi-kit, however, are positive. One shortcoming is the limited feature vocabulary. Often, a good match for the feature is simply not included in the kit. This is particularly a problem on accessories like hair, where new styles are constantly adding new requirements. A second shortcoming, like the sketch, is the fact that the image is a line drawing, not a real face. Indeed, studies carried out as part of this same project have shown that the composites produced by the kit are less realistic than sketches (see Report Number UH MUG -2). Another limitation, and a serious one, is the lack of a good classification system for the features; it simply is difficult to select appropriate features.

Identiface

The Identiface is a recent development in the field of image production. It consists of a special feature book where pages consist of four horizontal strips (hair, eyes, nose, and mouth-chin). These strips can be flipped independently thus permitting combinations of the four facial areas. To

date, three books have been completed; one for Caucasians, one for Negroids, and one for Latin Americans - all males. Additional books are being compiled for females in these three populations.

The Identiface shares several advantages and disadvantages with the Identi-kit. Positive aspects are its portability, standard codes and low costs. Its use requires less training than the Identi-kit, and indeed it may actually be used by the witness. Its disadvantages are a limited feature vocabulary and the fact that the images are drawings. Also, the face is broken down into four areas thus precluding finer detail in the manipulations and permitting less manipulation of the relative positions of the features.

Photo-Fit

The Photo-Fit is a kit consisting of photographs of real facial features that are fitted together to make an image. It represents an effort to develop an image production technique that produces a photograph-like image.

Advantages of this technique also include portability, standard codes, low cost and minimum required training. Also, it produces a more life-like image, although it is still clearly "pasted together."

CHAPTER 2

THE MINOLTA MONTAGE SYNTHESIZER: A NEW APPROACH TO IMAGE GENERATION

The synthesizer is a relatively recent arrival on the image generation scene. The technique was developed in Japan and recently introduced in the United States on a trial basis in Rockland County, New York.

The basic approach incorporated in the synthesizer is to blend facial features from various photographs into a composite face. The result is an image that gives the appearance of an actual face. Indeed, the reality of the image is the major advance offered by this technique. As with other image production techniques, a technician trained in the procedures works with a witness to produce the image.

The synthesizer technique can best be understood by breaking the analysis into three parts; the hardware or equipment, the software or photographs, and the construction procedures. The remainder of this section will present such an analysis.

Hardware

The hardware of the Minolta Montage Synthesizer consists of three component parts: an optical blender, a closed circuit television camera, and a television monitor. The optical blender enables partial images from four separate sources to be combined producing a composite image. This visual information is then gathered by a closed circuit television camera and displayed on a television monitor. Figure 1 shows a schematic of the synthesizer, and a photograph of all three system components is presented in Appendix A.

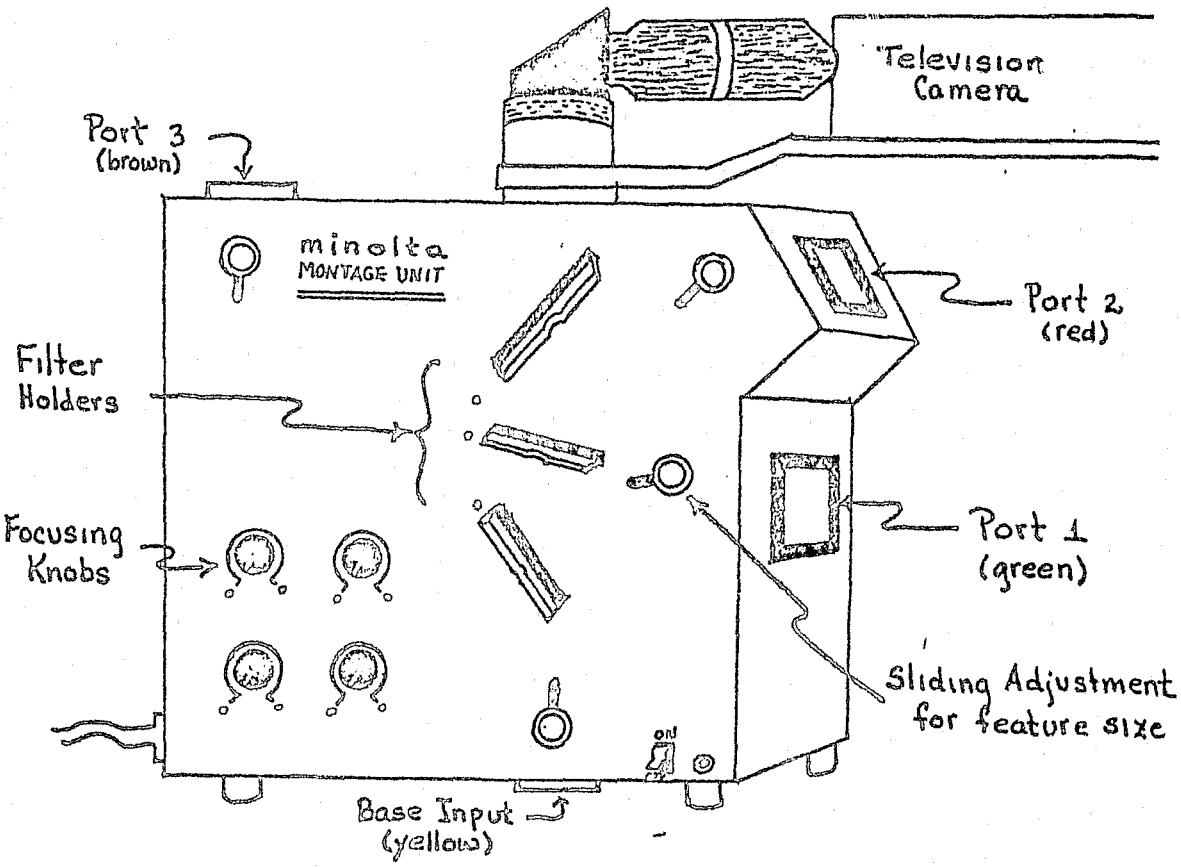


Figure 1.

The Minolta Montage Synthesizer

The optical blender integrates separate facial images by substituting features from secondary photographs for the corresponding features in a base photograph. The system as originally designed permits up to three feature substitutions. The manner in which the blending is carried out can be understood by referring to the schematic in Figure 1. First, a basic photograph is inserted in the basic input port at the bottom of the device. The facial image in this photograph is picked up by the television camera. The lens of the camera is located on top directly above the basic input port. Between the input port and the camera are three locations where filters can be inserted. The filters are glass slides with mirrored deposits in appropriate locations. These mirrored deposits filter or block out parts of the basic facial image while simultaneously reflecting corresponding parts of secondary facial images on to the television camera lens. The secondary images are located at three separate imput ports - ports 1, 2 and 3 in Figure 1. Thus, the design enables the image from the basic photograph to be edited three times before being picked up by the camera.

Two types of controls are available to assist in obtaining a proper blend; focusing is simply a manipulation of the light source. Each photographic input is illuminated by small reflectors located along the inner edges of the port. The light source is variable and operates in a manner similar to a dimmer switch. The operator can compensate for the differences in contrast between photographs by increasing or decreasing the intensity of illumination. The focusing knobs are located on the lower left of the device, one for each port. The size of the photograph is adjusted by

changing the distance between the photograph and a convex lens which is mounted on a moveable track at each of the four port locations. This adjustment, of course, permits the size of the feature in the secondary image to be manipulated so as to "fit" with the basic photograph.

A few other minor design features of the hardware should also be noted. The glass filters are mounted in metal holders which are in turn inserted into the blender. These holders fit with a tight tolerance. The flexibility in locating the parts of the images so that the substitutions can be "finely tuned" comes about through the manipulation of the location of the photographs. Each photograph is mounted in a holder which is magnetically held at the ports. The holder can readily be moved around until the substitute feature is properly located.

Each of the ports and filter slots are also color coded; the three codes are brown, red and green. On the actual machine the dots at the left of the filter slots indicate the color code. The filters for the brown and green slots are interchangeable since they are the same size. The red slot is smaller.

Several filters were provided with the basic synthesizer. These filters enabled substitutions of eyes, nose, and mouth, including different sizes.

Software

No software, or facial photographs, are provided with the basic synthesizer. For obvious reasons, the photographs used in Japan are not useful for constructing American faces.

In Rockland County, New York where the synthesizer was first used in the United STates, their basic mug file served as the software. These photographs were organized on the basis of the standard IDMO classification

system. There are several serious shortcomings with this type of software package. The conditions under which the photographs were originally taken were not standardized, with the result that the pictures varied in size, brightness and contrast. Perhaps more serious, however, was the fact that the types of features represented in the photographs was strictly hit and miss. What is needed, of course, is a software package specifically designed for the synthesizer.

Construction Procedures

Given the early developmental stage of the Montage, standardized construction procedures have not yet been determined. Basically, the procedures will parallel the Identi-kit and Photo-Fit techniques. A technician has available a library of facial features - photographs in the case of the Montage. Through a series of verbal interactions with the witness, the technician attempts to select various features which look like the target person when put together as a composite. As already noted, no set of photographs has been developed which attempts to characterize and represent a variety of features, nor have procedures been worked out for selecting and using particular features.

CHAPTER 3

FURTHER DEVELOPMENT OF THE MINOLTA MONTAGE SYNTEHSIZER

As stated in the introductory section, the primary purpose of the work described in this report was to extend and refine the montage hardware, to begin to develop a software system for the device, and to define a set of procedures for constructing composites.

Hardware Design

The montage procedure involves modifying a basic full-face photograph by substituting features from other photographs. To date a total of three substitutions can be made in producing a composite, although which features are substituted is flexible in the sense that different filters can be used in the three locations.

The potential accuracy of composites produced by the montage is constrained by the limit of three feature substitutions and the specific filters available. There are, of course, more than three features that one might want to modify in constructing any given composite. In addition to eyes, nose and mouth, which the basic device is readily able to modify, other features such as hair, eyebrows and chin line might be appropriate. Furthermore, the ability to modify accessories such as moustaches, sideburns and glasses would be useful. A major emphasis in this project has been to extend the capability of the device by increasing the number of possible simultaneous substitutions to six and by enlarging the filter set to cover different features.

In order to achieve this increased capability, it was necessary to

make four kinds of hardware changes. These changes included redesigning the filter holders, developing a new and extended set of filters, redesigning the photograph holders, and designing appropriate photographs. The latter change is considered a hardware development in the sense that it is concerned with the structure, not the content, of the photographs.

Filter Holders

The fundamental concept for extending the number of possible substitutions to six was to be able to employ two filters at each location. The thickness of the filter glass was reduced from 1.3 mm. to 1.0 mm. so that two filters could be superimposed in the metal holders. New holders were designed so that both glass plates could readily slide into the holder from one end. This design differed from the original holders which essentially framed the glass and had latches at the top and bottom to hold the glass in place. Exhibit 1 in Appendix B presents photographs of the original and modified filter holders. Exhibits 2 and 3 in Appendix B present construction diagrams for the two sizes of the new holders.

The new holders enabled one filter to be stacked on top of the other. The lower filter was designed to slip into the holder completely, and it contained mirrored patterns which masked upper regions of the face such as hair style, eyes, eyebrows and glasses. The upper filter was used to mask lower regions of the face such as the mouth, chinline and moustaches. Patterns on the upper filter were located near the forward edge so that this glass plate only needed to be slid halfway into the holder before masking the proper area of the face. This procedure prevented the upper

glass slide from rubbing agianst the filter deposit on the lower one, which in turn decreased frictional wear and increased the life of the filters.

Filters

Work on the filter set had two purposes; to increase the number and kinds of feature modifications that can be made, and to improve the "fit" between the filters and the areas of the face to be modified. It should be remembered that each filter location may contain two filters. The base (yellow) photograph port has not been altered because of difficulties experienced in obtaining a well integrated light beam when changes were made in the photographic inputs at this port. Also, a standard procedure was adopted of using the base photograph to provide the nasal feature and surrounding area. This procedure eliminated a problem of shadowing in the nasal region which occurred when a filter was used.

Specific input locations, including top or bottom positions, were selected for the various feature filters. This standardization was necessary in order to deal with an "overlay" effect. The overlay effect refers to situations where the substitution of one feature may effect changes in other features. For example, a change in hair style might appropriately affect (cover) part of the chin line as well. It is important to locate two interacting features so that the one being affected by another is further from the camera - or closer to the direct light source (base photograph). The following feature-location assignments were made (refer to Figure 1 for color code locations):

nose - yellow

chinline - green

eyebrows - green

eyes - red

glasses - red

mouth - red

hairstyle - brown

moustache - brown

eyes - brown

The reason eyes appear twice in the above list is that when glasses are to be included, eyes must be filtered after the glasses (at a different port). When glasses are not needed, however, eyes can be filtered at the red port, thus enabling moustaches to be filtered at the brown port. It should be noted that because only two features can be filtered at each port, it is not possible to filter simoultaneously all features noted for the red and brown ports.

Accessory changes have been limited to either the addition of glasses or the addition of a moustache. In order for glasses to be added they had to be substituted before the eye manipulation. This option is the specific reason why the eye filter is sometimes used in the brown input location.

A problem experienced in attempting to use the original filter set was that the filter frequently did not adequately match or fit the anatomy of the facial feature to be manipulated. For example, a long thin rectangle was used to replace the eyes and eyebrows. On many faces, the filter not only masked the original feature, but also erased parts of the hair style on either side. Also, it affected the ridge of the nose. Similarly, the nose filter presented difficulties in that it often masked the upper lip

and inner corners of the eyes. The seven photographs in Exhibit 1 of Appendix C provide examples of the fit problems encountered using the various original filters.

The dimensions of the new filters were determined by the range of feature sizes found within a sample of photographs provided by the Federal Bureau of Investigation. The filter area for each feature type was established on the basis of the largest measures for each of the feature dimensions. In order to achieve some standardization of filter locations on the glass, the vertical location was based upon the average distance between the top of the feature and the interpupillary line. This referent was an imaginary horizontal line which intersected the pupils of the two eyes. The left-right locations of the filters on the glass was not varied from feature to feature. This location was standardized and was positioned so that the vertical midline of each filter could readily be manipulated to correspond with the vertical midline of the base photograph. The actual measures of the various features sizes were obtained simply by projecting the photographs, measuring the feature dimensions, and applying an appropriate reduction ratio. The following subsections describe the specific filter designs.

1. Eyebrow Filter. The eyebrow filter design kept the bar pattern in the original filter but reduced its width. The ends of the bar were doubled in thickness to accomodate the curve of the ends (tails) of the eyebrows which typically extend downwards. Details of the design are shown in Exhibit 2 of Appendix C.
2. Chin Line Filter. The chin line filter was designed with a rectangular indentation in the upper border of the chin line.

The depth of the indentation was equal to the average distance between the cheekbones and the bottom of the lower lip, and the width was equal to the longest distance between the corners of the mouth. This design permitted the filter to be moved upwards or downwards within the filter holder with minimal effect on the nasal and cheekbone regions of the face. Details of the design are shown in Exhibit 2 of Appendix C.

3. Eye Filter. The eye filter did not use the bar pattern because it affected the cheekbones, the superciliary crests, and the ridge of the nose. Instead, a complex pattern was used for each eye as shown in Exhibit 3 of Appendix C. This geometric shape was least likely to cause a change in the other regions. These patterns were positioned so that the inter-pupillary line bisected their vertical dimension, and both patterns were equidistant from the center line of the face. This latter dimension was based on the smallest distance between the inner canthus (corner) of the right and left eyes. The length of the horizontal dimension of the filter was determined by the greatest distance between the inner canthus and the outer canthus, while the vertical dimension was based on the widest palpebral cleft (eye height) measurement.

4. Eyeglass Filter. The eyeglass filter used a modified bar design as shown in Exhibit 3 of Appendix C. The lenses completely covered the area between the eyebrows and the cheekbones with the exception of an indented area below the nasal bridge. This design permitted easy substitution of a variety of eyeglass frame styles without

obscuring the nasal feature.

5. Mouth Filters. A new mouth filter was similar in shape to the original filter. The length and width, however, were increased to accomodate longer, wider mouths. The original filter was reproduced on one of the new glass slides so that both sizes are now available for use. The two mouth filters are shown in Exhibit 3 of Appendix C.

6. Hair Filters. Nine hair style filters were designed to permit modification of the hair given different hair lengths (short, medium and long) and different facial widths (narrow, average and wide). The shortlength filters left the ear regions unaffected. The medium filters were used for hairstyles just covering the earlobes. The long filters were designed to cover collar-length styles. The filter designs are shown in Exhibits 4 and 5 of Appendix C. The "inverted V" shape was used instead of a straight horizontal line because it interfered less with the eyebrow region.

7. Moustache Filters. Two filters were designed for moustaches. One filter resembled a "bow tie" and the other resembled an inverted V. The former was used for large bushy moustaches while the latter was for small thin moustaches. The designs are shown in Exhibit 5 of Appendix C.

Exhibit 6 of Appendix C presents examples of the fits obtained using the newly designed filters. Clearly these filters provide for more appropriate feature substitutions than the originals as shown in Exhibit 1 of Appendix C.

Photograph Holders

Appendix D shows photographs of the original and modified photograph holders, and Appendix E shows construction diagrams of the new designs. The original holders contained clamping devices which were used to press the photograph against the front opening. These clamps, however, added to the difficulty of getting the pictures properly and rapidly aligned within the holders. The new design used a metal sleeve with windows cut in the front and back panels. Metal backings were designed and used to cover the rear openings to prevent dust from entering the machine when not in use.

The important contribution of the new photograph holders is in connection with the alignment. As noted in the next section on the design of the photographs, this problem is particularly acute when superimposing photographs. The sleeve concept with its tighter tolerance alleviates this problem considerably.

Photographs

As with the filters, the basic concept for extending the number of possible substitutions to six was to employ two photographs at each of the input ports. Full photographs were used for features such as moustaches, eyes, eyebrows and eyeglasses. Partial photographs were designed with cut-out areas or "windows" that permitted certain areas of the underlying photograph to be exposed. Photographs of mouths and chin lines had windows located in the upper portion of the photograph, while the hair style photographs had windows in the lower portion. Vertical distances between these features could be manipulated by moving the photographs upward or downward within the holders. Appendix F shows examples of two different window patterns.

Software Design

As noted earlier, the term software refers to the library of photographs from which features are extracted to produce a composite face. Clearly the success of the Montage in constructing an accurate representation is a direct function of the feature types contained in the software. Development of a software package in this project essentially started from zero. The photographs used by the Japanese obviously are inappropriate for a system to be used in the United States. The photographs used by the agency in Rockland County, New York were simply drawn from their mug file. While these photographs have proven useful in constructing faces, they do not represent an adequate standardized software package. The structure of the photographs (sizes) is variable, and the classification of the various features is inadequate.

In order to determine which feature examples should be included in an appropriate software package, it was first necessary to obtain actual data on the range of values and types for the various features. This type of data was collected by measuring a sample of faces in what will be referred to as a Facial Feature Dimensions Analysis.

Facial Feature Dimensions Analysis.

Facial measurements were made on photographs of 112 different white males. The subject faces were in the 17-25 year old range. The pictures were actually color slides that had been photographed with standardized camera setting, lighting, pose and distance conditions. These slides were projected onto a screen so that the faces were life size. Accurate size projections were possible because the slides contained subject identification

numbers that had used block digits. By simply calibrating the projected digit sizes a life-size image was obtained. All facial images were front, bust views. The actual measurements were made using a divider scaled in centimeters.

The measurements obtained consisted of 21 linear distances and a chin angle. The definitions of the various measures are given below. Figures 2 and 3 show the measures pictorially.

1. Interpupillary distance (IPD) - horizontal measurement of the distance between the pupils of the left and the right eye.
2. External biocular breadth (EBB) - horizontal measurement of the distance between the outer canthus of the right eye and the outer canthus of the left eye.
3. Internal biocular breadth (IBB) - horizontal measurement of the distance between the inner canthus of the right eye and the inner canthus of the left eye.
4. Nasal height (NH) - vertical measurement of the distance between the root and the tip of the nose.
5. Nasal breadth (NB) - horizontal measurement of the distance between the alar wings of the nose.
6. Bigonial width (BW) - horizontal measurement of the distance between the right gnathion and the left gnathion of the mandible. This represents the width of the face at the centerline of the mouth.
7. Bizygomatic breadth (BB) - horizontal measurement of the distance between the left and right zygomatic (cheek) bones. This represents the width of the face at the base of the nose.

8. Philtrum distance (PD) - vertical measurement of the distance between the sub-nasal point and the nasolabial furrow.

9. Labial height (LH) - vertical measurement of the distance between the wings of the upper lip and the rim of the lower lip.

10. Mentolabial distance - vertical measurement of the distance between the mentolabial furrow and the mental protuberance (chin).

11. Temporal distance (TD) - horizontal measurement of the distance between the right and the left temporal fossa.

12. Labial breadth (LB) - horizontal measurement of the distance between the corners of the mouth.

13. Upper facial height (UFH) - vertical measurement of the distance between the stamion (center of the mouth) and the nasal root.

14. Glabellar distance (GD)- vertical measurement of the distance between the interpupillary line and the glabellar line (a horizontal line which runs through the glabellar point). The glabellar point is the most anterior point in the mid-sagittal place of the smooth area between the superciliary arches (eyebrows). This represents the height of the eyebrows (mid-point) from the nasal root.

15. Minimal frontal breadth (MFB) - horizontal measurement of the distance between the left and right temporal lines. This represents the distance between the superciliary crests.

16. Eye breadth (EB)- horizontal measurement of the distance between the inner and outer canthus of the eye. When both eyes differ in size, the average distance is used.

17. Inter-glabellar sub-nasal distance (IGSND) - vertical measurement of the distance between the top of the eyebrows and the sub-nasal point.

18. Morphological face height (MFH) - vertical measurement of the distance between the interpupillary line and the gnathion (the lowest point of the lower jaw on the mid-sagittal plane).

19. Trichional distance (TriD) - vertical measurement of the distance between the hair line and the gnathion.

20. Chin angle (CA) - angle formed by the intersection of lines drawn from the gonian through the gnathion.

21. Naso-spinal distance (NSD) - vertical measurement of the distance between the sub-nasal point (nasal spine) and the stamion (centerline of the mouth).

One issue to be addressed in analyzing this type of data concerns feature values at the extremes of the distributions. Clearly this is an important concern since it has direct implications for filter design and for the selection of alternative feature values to be represented in the software. Analysis of the data led to a preliminary decision to adopt as a cut-off point dimension values that occur in 1.8% or less of the faces. Thirteen faces had three or more dimensions that were beyond this cut-off in the distribution, including one face that had a total of eleven low-frequency measures. These faces represent approximatley 10% of the sample. Exhibits 1-21 of Appendix G present the frequency distributions for each of the 21 dimensions. The data for the thirteen faces with three or more low-frequency measures are not included in the distributions.

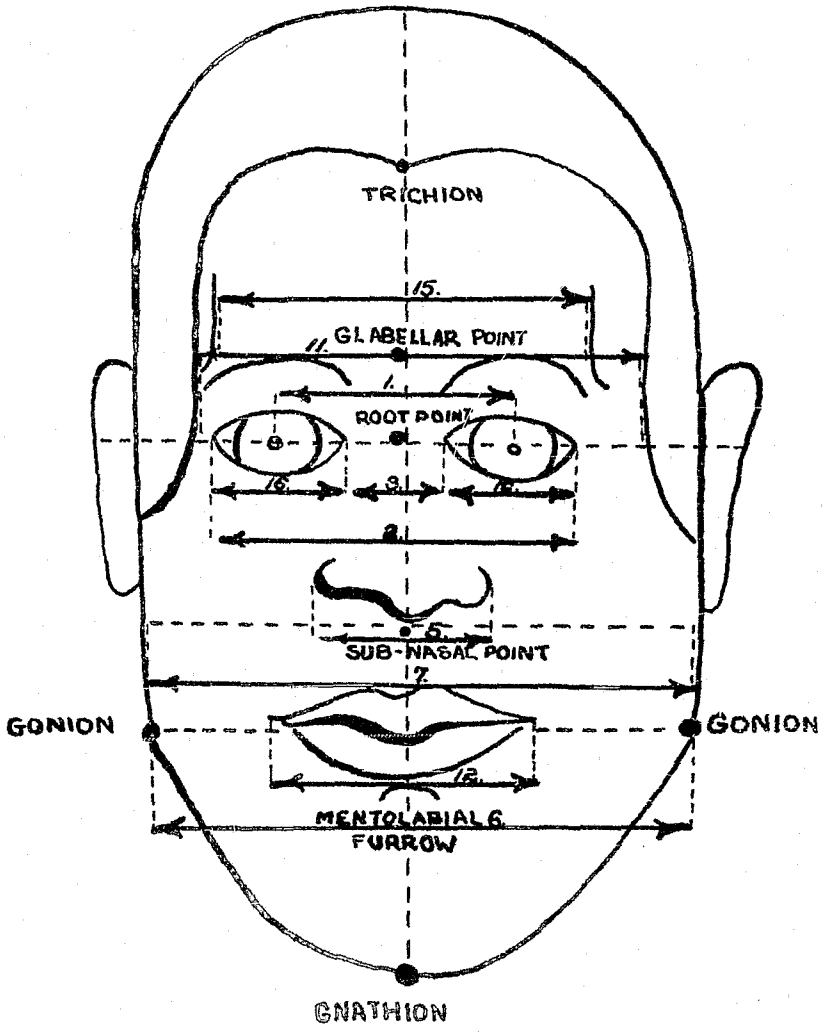


Figure 2. Horizontal Facial Measurements

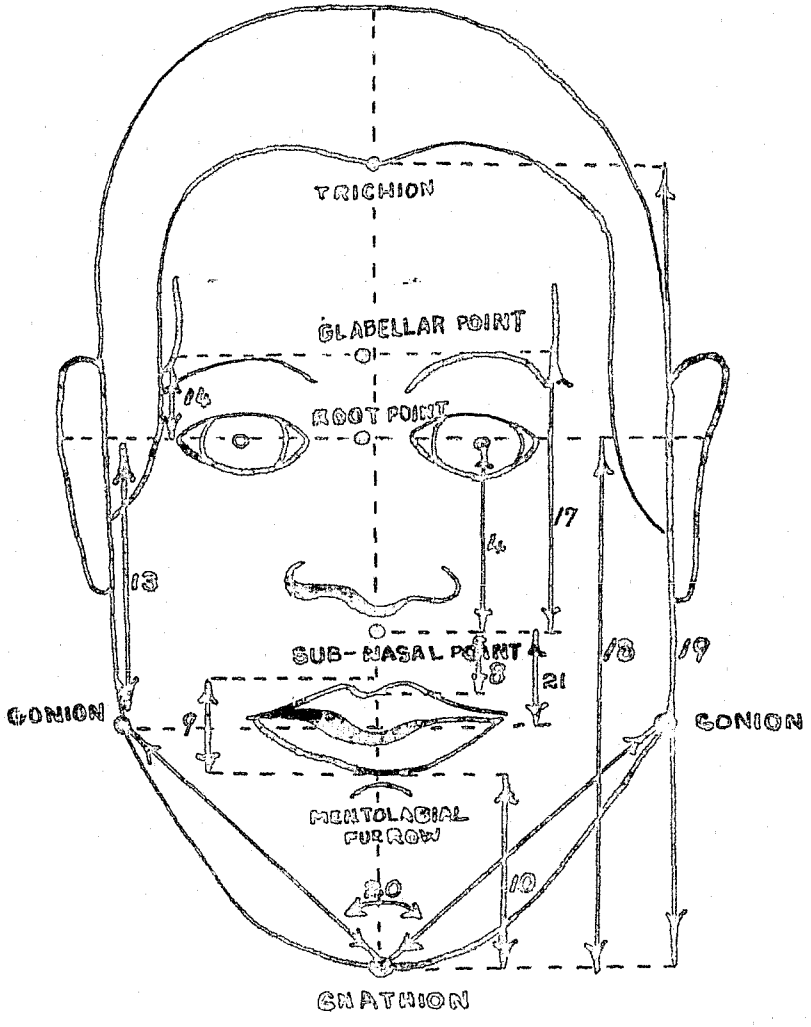


Figure 3. Vertical Facial Measurements

Means and standard deviations were calculated for each dimension. These results as well as the variances and z-scores are presented in Table 1. From the table it can be seen that the internal biocular breadth had the smallest variance among the horizontal measures. This dimension with the least variance had implications for the design of the software as described in the following section.

Photograph Standardization Procedure.

The results of the facial feature dimensions analysis were used to standardize the sizes of photographs used in the software. The procedure was as follows. A large number of slides of faces were available that had been photographed under standard conditions. One face was selected that had a life-size internal biocular breadth measure of 3.3 cm., which was the mean value within the sample population. The focal length of the printing apparatus was then set so that the printed image had an internal biocular breadth measure of 0.6 cm. This value was selected because this distance was classified as the average of this dimension in the F.B.I. classification system. Thus, by holding the focal length constant in printing, photographs were obtained that were compatible with the F.B.I. photographs.

The ability to adopt and supplement the F.B.I. pictures was a considerable advantage in developing a software package. These pictures are a standard set of prints used as examples of feature types when working with witnesses to construct sketches. A good cross section of geature examples is represented in the F.B.I. set; hence the photographs serve as a basic core of the software package.

TABLE 1

Mean, Standard Deviation and Standardized

Score for Each of the 21 Facial Measurements

Facial Measurement	Mean (Cm)	Standard Deviation	S.D./Mean X 100
1. IPD	6.18	.46	7.37
2. EBB	8.96	.63	7.05
3. IBB	3.25	.30	9.25
4. NH	4.81	.41	8.61
5. NB	3.63	.39	10.77
6. BW	11.78	1.37	11.53
7. BB	13.11	.71	6.94
8. PD	1.48	.24	16.14
9. LH	1.68	.45	26.50
10. MD	3.95	.60	15.27
11. TD	11.77	.66	5.57
12. LB	4.73	.45	9.56
13. UFH	7.75	8.30	107.25
14. GD	1.70	1.56	91.93
15. MFB	10.10	1.04	10.37
16. EB	3.24	3.08	95.05
17. IGSND	8.42	7.02	94.60
18. MFH	11.8	1.92	16.27
19. TRID	18.7	1.97	10.53
20. CA	102.33	5.0	4.89
21. NSD	2.12	.48	22.51

Classification Scheme for Facial Features

The basic approach to developing a feature classification scheme was to identify dimensions of each feature that could be characterized and then select appropriate values along these dimensions. The dimensions of features were determined in part by referring to the Bertillon System of Identification. This system defines physical dimensions along which features can vary. A set of descriptive adjectives from the F.B.I. classification system was adopted and defined in terms of linear measurements. Finally, the features were classified according to apparent geometric shape. Together, these systems for defining shape, variable dimensions and labels served as a basis for a useful objective classification scheme.

The strategy in developing the scheme was to be exhaustive; that is, to encompass just about every example of a feature that might exist except perhaps for the most extreme or unusual types. It is important at this point to distinguish between the exhaustive classification scheme and the selection of features for the software package. It is not proposed that a sample from every cell in the classification scheme (virtually thousands) should be incorporated into the software. Clearly this would not be necessary, and it might not even be possible. Some cells might represent combinations of feature dimension values that do not exist in reality. Rather, the approach is to use the scheme to select examples for the software that represent an appropriate range of feature types.

The complexity of the scheme varies from feature to feature because of the variable number of dimensions along which the various features are classified. Eyes, for example, are the most complex feature: the first

dimension was geometric shape; next size was taken into account including the degree of opening, eye notrusion, and size of the palpebral cleft (apparent length of eye slit); finally the eye was classified by upper eyelid configuration and eye positioning which included the inter-biocular breadth, the orbital distance and the obliquinty of the palpebral cleft. The nose, in comparison, was relatively simple as a later description of its classification will show.

On the basis of the feature classification schemes that were developed, a series of charts were derived for each feature. The purpose of the charts, of course, was to provide a visual reference for locating feature examples in the software package. For each feature a particular chart represented a major grouping of types. Within these charts the features were sub-classified according to other dimensions. The intersecting columns and rows provided "boxes" into which specific examples could be placed. The charts were numbered and color coded to indicate the position of small (blue), average (green) and large (red) features.

In using the charts the grid design enables a Montage technician to keep one dimension constant while exploring the effects of another dimension. In this manner the technician can determine the dimension most important to the witness. Also, a glance at an updated classification grid would be sufficient to determine whether an appropriate example was contained within the software or not. If an example were not available, the technician could select a feature type that was closest to the desired type. The numerical color-code was devised to aid in the rapid retrieval of representative features.

Classification charts were prepared for the eyes, the eyebrows, the nose, the mouth, the hair style and the chin line. The charts were constructed using the various dimensions along which a feature could vary. Thus, some features had a large number of charts while other features had relatively few.

Eye. The eye classification scheme was the most complex because of the large number of dimensions involved. Exhibit 1 of Appendix H presents a detailed explanation of the eye classification scheme. An analysis of the charts assists in understanding the scheme.

Exhibit 1 of Appendix I presents an example showing the format of the eye classification charts. Each chart contained eight vertical columns and nine horizontal columns. The vertical columns described the different types of eyelid configurations. These were arranged so that the upper eyelid structures became increasingly larger as one moved from one column to the next. The first and last three columns contained examples which had been contrarily assigned. These included a re-entering eyelid condition and three different overhanging eyelids which were classified according to the region of the eyes that was affected (i.e. outer canthus, central depression and inner canthus). The remaining columns included eyelids with slight, medium, and thick folds as well as an eyelid type that was without any folds (i.e. eyelid absent). The top three horizontal columns contained deep-set eye types with narrow, average, and wide widths. The middle horizontal columns contained the three widths of the average protruding eye types while the bottom colums contained their bulging counterparts. The intersecting columns produced a total of seventy-two eye type combinations that were consecutively numbered. A color-code was used to distinguish the deep-set eyes (blue) from either the average (green) or the protruding eyes (red).

These charts were then arranged to cover all possible combinations of eyeball length and inner occular widths. Each of these dimensions had three possible categories into which a feature could be placed. This resulted in the nine sub-categories listed below:

a. small (short length)/narrow inner occular width

b. small (short length)/average inner occular width

c. small (short length)/wide inner occular width

d. average (average length)/narrow inner occular width

e. average (average length)/average inner occular width

f. average (average length)/wide inner occular width

g. large (long length)/narrow inner occular width

h. large (long length)/average inner occular width

i. large (long length)/wide inner occular width

These nine sub-categories were then added to each of the four basic geometric shapes (i.e. cigar, tear, football, and dome shapes) bringing the total number of classification charts to thirty-six. This classification covered all of the possible combinations of each dimension (excluding the Oriental eye) which resulted in roughly 2,500 eye types.

Mouth. The mouth classification scheme is described in Exhibit 2 of Appendix H. The format of the classification chart is shown in Exhibit 2 of Appendix I. The charts contained nine vertical columns and three horizontal columns. The vertical columns described the various combinations of thick and thin lips. The first three columns contained thin upper lips while the second and third groupings contained average and thick upper lips. Each lip grouping was then matched with three lower lip thicknesses. These were arranged so that the upper lip became gradually thicker as one moved from one column to the next. The three horizontal columns contained mouths

of narrow, average, and wide widths. The intersecting columns produced a total of twenty-seven mouth types. These were consecutively numbered from 1 to 162 until all six charts of each mouth configuration had been numbered. A color-code was also used to distinguish mouths with narrow widths (blue) from mouths with either average (green) or wide (red) widths.

Six charts were used in five of the seven geometric configurations (i.e. wing, straight bow, curved bow, heart, and football). Only the first three charts were used for mouths in the "peanut" and "crescent" categories because these geometric shapes did not contain a flat lower lip. The charts were arranged to cover all possible combinations of lower lip shape and mouth corner configuration. This resulted in the six sub-categories listed below:

a. round lower lip/depressed corners

b. round lower lip/straight corners

c. round lower lip/elevated corners

d. flat lower lip/depressed corners

e. flat lower lip/straight corners

f. flat lower lip/elevated corners.

Nose. Exhibit 3 of Appendix H presents the classification scheme for ses. The classification chart is shown in Exhibit 3 of Appendix I. The nose feature had the smallest number of classification charts. Each of the twelve charts contained twelve vertical columns and three horizontal columns. The vertical columns were divided equally into three groups which contained noses with elevated (red color-code), horizontal (green color-code), and depressed (blue color-code) nasal tips. The vertical columns within each of these groups included narrow, average, wide, and flared nasal widths.

The horizontal columns contained noses with short, medium and long lengths. Thus the intersecting columns produced a total of 36 nose styles. Three charts were used with each of the five geometric categories (i.e. spear, bulbous, rectilinear, wedge, and valve shaped noses) which were consecutively numbered from 1 to 108. Each chart contained examples of noses of either "little," "medium," or "great" projection. All of the charts within each of the geometric categories contained the same numbering system. Corresponding examples could therefore easily be found within each of the geometric categories.

Eyebrows. The eyebrow classification scheme is described in Exhibit 4 of Appendix H. The classification chart is shown in Exhibit 4 of Appendix I. The eyebrow features were divided into seven main categories according to the shape, length, and angle of the position of the eyebrow tails. Each category in turn contained three charts that allowed for variation in the slope of the eyebrow body (i.e. oblique internal; straight or horizontal; oblique external). Each chart was divided into twelve vertical columns and five horizontal columns. The vertical columns were divided equally into three groups which contained eyebrows with long (red color-code), average (green color-code) and short (blue color-code) lengths. The vertical columns within each of these groups included eyebrows with wide, average, narrow, and meeting inter-head distance. This represented the distance between the innermost edges (the heads) of the eyebrows. The horizontal columns contained eyebrows with thin, medium, and thick widths. Variations of the thin and thick categories were included as sparse and bushy eyebrow types. The intersecting columns produced a total of 60 eyebrow types.

The charts within each of the basic categories were consecutively numbered from 1 to 180. All of the charts within each of the geometric categories contained the same numbering system.

Hair Style. The classification scheme for hair style is described in Exhibit 5 of Appendix H, and the classification chart is in Exhibit 5 of Appendix I. The hair styles were divided into three main categories according to the texture of the hair. The "wavy" classification represented the intermediate stage between the "straight" and the "kinky" hair styles. Each of these categories contained six charts which corresponded to the six different facial shapes (i.e. round; square; diamond; oval; egg; oblong). Each hair style was classified according to the shape of the head on which it was found. This classification made it easier for the technician to duplicate head shapes. All of the charts were divided into nine vertical columns and four horizontal columns. The vertical columns were divided into three equal groups according to facial widths. These were color-coded with "blue" representing the narrow widths and "red" representing the wide widths. Green was once again used to label hair styles of average width. These measurements were made so that the hair styles could be matched with chin lines of the same width. This allowed the operator to leave all of the inputs on the same focal length which helped to prevent the distortion of feature sizes. (These measurements would have been unnecessary if each of the feature changes could have been made separately.) These different groups were sub-divided according to hair color. The categories "dark," "medium," and "light" were used because the photographs consisted of black-and-white prints. The horizontal columns represented hair styles of varying lengths. These included "long" (hair below the color), "medium" (hair below the ear

lobe) "short" (hair above the ear lobe), and "bald." Categories were consecutively numbered from 1 to 216 until six of the charts had been filled. This procedure was separated until three sets of charts had been produced.

Chin Line. Exhibit 6 of Appendix H describes the chin line classification scheme. The classification chart is shown in Exhibit 6 of Appendix I. The chin lines and beards were divided into three main categories according to geometric shape. Each group had a different number of charts. The "round" chin line had only one chart since any chin shape other than "round" would have placed it into another category. The "square" chin line had four chin shapes that included "round," "flat," "pointed," and "bilobed" categories. The "parabolic arch" chin line group had the greatest number of chin shapes. These included the four categories found with the "square" chin lines as well as an "angular, flat" chin shape.

All of the charts were divided into nine vertical columns and three horizontal columns. The vertical columns were divided into three equal groups according to facial width. These were color-coded in the same manner as the hair style widths. Each group was, in turn, divided into "receding," "average," and "jutting" chins. The horizontal columns described chins that varied according to the visibility of the jaw line. These were classified as "distinct," "double," or "indistinct." The charts were consecutively numbered from 1 to 108 until four charts had been completed. This numbering process was repeated until the remaining categories each had a set of charts. The "round" chin line group had one chart while the "parabolic arch" chin line group contained an extra chart that was consecutively numbered from 109

to 135. Beards were only classified according to facial width and geometric shape because the chin shape and chin protrusion was masked by the beard.

Summary. The above scheme provides a procedure for classifying facial features. The scheme is designed to permit new features to be readily assimilated in an organized fashion. Its major purpose, of course, is to enable the rapid retrieval of appropriate feature types for use in the Montage.

Selection of Software Photographs.

Due to time limitations, the selection of photographs for the software system was essentially a pilot effort; that is, only a limited number of features were selected and classified as part of the current project. A total of 44 target and witness slides were selected for the system image generation study carried out as part of this project. Photographs were printed from these slides according to the photograph standards described earlier. Actually, eight prints were made from each slide so that the photographs could be used as examples of the various features and accessories.

The features in these photographs along with a number of F.B.I. photographs were then classified on the basis of the scheme described in the previous section. The classification of the features is shown in Appendix J. Exhibits 1 - 6 present the feature examples for eyes, mouths, eyebrows, noses, chin lines and hair styles.

Construction Procedures

The general approach to constructing facial images with the Montage parallels most other standard techniques. Like the sketch artist and Identi-

kit procedures, a person trained in the technique works with a witness to construct the image.

The procedure has been designed to allow the Montage technician to take a witness step by step through the entire image generation sequence. The schedule of feature changes gives a sense of order to the entire process and consequently eliminates much of the confusion associated with a less rigorous approach. The witness is made to feel that he/she maintains control during the task, since the technician plays the role of a guide during the session. The most important changes (i.e. facial shape, hair style and accessories) are made first, giving the witness additional confidence because the facial composite begins to conform closely to the target image even at the very beginning. Finer changes are made as the interview progresses until the desired result is achieved.

The Initial Phase

At the outset basic information must be obtained regarding the appearance of the target person. The following series of questions are answered prior to beginning the photographic manipulations.

1. What is the target's race.

    A. White

    B. Black

    C. American Indian

    D. Mexican American

    E. Oriental

    F. Other

A brief explanation of the racial type should be made if the "other" response is selected.

2. Was the target male or female?

3. How old was the target person?

   A. 17 or younger.

   B. 18-24 (early 20's)

   C. 25-29 (late 20's)

   D. 30-34 (early 30's)

   E. 35-39 ((late 30's)

   F. 40-44 (early 40's)

   G. 45-49 (late 40's)

   H. 50-54 (early 50's)

   I. 55-59 (late 50's)

   J. 60-64 (early 60's)

   K. 65-69 (late 60's)

   L. 70 or older

4. How tall was the target person?

   A. Short

   B. Medium

   C. Tall

5. What was the target's build?

   A. Light

   B. Medium

   C. Stocky

6. What was the target's weight?

   A. Underweight

   B. Average

   C. Overweight

7. What accessories were present?

   A. Head apparel

   B. Eyeglasswear

   C. Sideburns

   D. Moustache

   E. Beard

8. What color was the target's hair?

   A. Blonde

   B. Brown

   C. Black

   D. Red

   E. Gray

9. How long was the target's hair?

   A. Long (collar length or longer)

   B. Medium (cover ears)

   C. Short (above ears)

   D. Balding

   E. Bald

10. What color was the target's facial hair?
    (i.e. beards, sideburns, moustaches and eyebrows)

   A. Blonde

   B. Brown

   C. Black

   D. Red

   E. Gray

11. What color eyes did the target have?

    A. Blue

    B. Green

    C. Brown

    D. Black

    E. Hazel

The image generation sequence now begins with the technician concentrating on the geometric shape of the target's face. This manipulation includes selction of the chin line, hair style, facial hair, and accessories. Subsequent manipulations deal with different regions of the face such as the eyes and the eyebrows, the nose, and the mouth. Separate instructions are outlined for each of these facial feature manipulations.

Geometric Facial Shape

Accurate representations of facial shape depend on two facial characteristics -- the chin line and the hair style. Witnesses, however, are able to remember hair style better than chin line. The technician should therefore first attempt the hair style manipulation. A search is then made for the appropriate chin line following the selection of this feature.

Hair Style Selection Procedure

The following steps should be followed in selecting hair style.

1. Establish the size of the head involved - The technician must know the apparent size of the head since this relates directly to the types of features that are found within it. This information also helps in selecting the appropriate size of the chin line structure.

(Question to be asked of the witness.) What was the apparent size of the target's head that you witnessed?

(Answers to be obtained from the witness.) Smaller than average; average; larger than average.

The technician may use the color code to find the appropriate feature sizes. These include: red (wide width), green (average width), and blue (narrow width). These color codes should be the same for the hair style and chin line to assure accurate blending of these photographs.

2. Establish the head shape involved - The witness is asked to select a head shape that most closely resembles the head shape of the target. These choices consist of "round," "square," "diamond," "oval," "egg," and "oblong" shaped faces.

3. Establish the characteristics of the hair style - The questions at the beginning of the image generation sequence have already provided the technician with information concerning the color and length of the hair. The witness is now shown photographic examples of "straight," "wavy," and "kinky" hair style types. The appropriate hair style is then projected onto the screen that contains the correct hair structure and geometric shape.

Chin Line Selection Procedure

The following steps are followed in selecting chin line.

1. Establish the visibility of the chin - This refers to the "distinctness" of the chin line. Obviously it is difficult to make comparisons between chin line shapes when these characteristics are obscured by

a deposition of fat. The witness is to be shown examples of "distinct," "indistinct," and "double" chins in order to determine the clarity of the conditions under which the feature was viewed.

2. Establish the chin line shape to be used - The selection of the head size and facial shape have begun to set limitations on the chin line types that may be used. For example, "round" and "square" chin lines appear to occur most commonly among "round" and "square" shaped faces. Other geometric shapes, however, are not as restricted and may use either "parabolic arch" or "angular" chin line types. The technician can further specify the shape of the chin line by projecting examples of the major sub-categories of each chin line type. These vary according to the slope and angles of the chin structure (i.e., round, flat, pointed, bilobed and angular, flat shapes). All photographic examples should be the appropriate facial width.

3. Establish the degree of chin protrusion - Finer discriminations can still be made by showing the witness examples of "receding," "average," and "jutting" chins. These photographs of course contain all of the characteristics that have previously been selected.

Accessory Selection Procedure

Accessories are selected according to the following procedures.

1. Establish the moustache style - The apparent thickness of the moustache is determined using examples which vary according to the amount of facial hair present (i.e. "sparse," "medium," and "thick"). The color has already been determined using information obtained

from the witness' descriptive statement. Positioning of the feature is now important (i.e. the distance of the moustache from the upper lip, the angle of the slope of the moustache). The size and slope of this feature is obviously determined by the type of lip structure. Thus it is wise to select the mouth feature prior to the addition of this accessory. The final selection concerns itself with the geometric shape and the separation distance between the sides of the moustache body. (This category within the software system is incomplete and consequently cannot be used at the present time).

2. Establish the eyeglass style - The selection of appropriate eyeglasses depends on the style of the frame (geometric shape), of the lenses, and the material from which it is constructed. (This category within the software system is incomplete and consequently cannot be used at the present time). This accessory information must be added to the composite prior to the addition of the eye and eyebrow structure because of its masking effects on these features.

3. Selection of the beard style - Selection of a chin line is unnecessary if the target has a beard that obscures the entire feature. A beard style is determined according to the amount and color of the facial hair. The beard is selected according to geometric shape and involves the same procedure used in chin line selection. Full beards, however, are now used instead of chin lines. The lower portion of the beard is first added to the composite. This is then

followed by the selection of the mouth structure and the addition of the moustache region of the beard. Other facial hair configurations (i.e. partial beards, sideburns) may also be determined using this procedure. (This category is limited at the present time because of a lack of sufficient photographic examples and filters.)

Remaining Features

Once the geometric facial shape has been determined, construction proceeds on the remaining facial features.

Mouth Selection Procedure

This feature is selected after the selection of the nasal structure unless the target is wearing a beard or a moustache. The immediate selection of the mouth feature under these circumstances allows for the rapid completion of the facial shape and the accessory sequence. These changes enable high similarity between the composite and the target to be reached as quickly as possible during the interview. The following steps outline the procedure.

1. Establish the mouth size and location - The witness is shown examples of "wide," "average," and "narrow" width mouths. The position from the nasal base is mechanically manipulated.
2. Establish the thickness of the lips - The witness is shown examples of "thin," "average," and "thick" lipped mouths. Both the upper and lower lips should be the same thickness. Finer discriminations are made regarding the lip combinations once the geometric shapes have been selected.
3. Establish curvature of the mouth line - The witness is shown examples

of "downward sloping," "upward sloping," and "horizontal" mouth lines.

4. Establish the geometric shape of the lips - Only use those geometric configurations that contain the appropriate mouth width and lip thickness. Three lip combinations may be found for each of the thicknesses. These should also conform to the curvature of the mouth.

Nose Selection Procedure

This feature should be selected after the completion of the geometric facial shape sequence and prior to the selection of the mouth structure.

1. Establish the elevation of the nasal tip - The witness is shown examples of "downward," "horizontal," and "upward" pointing nasal tips.
2. Establish the length and projection of the nasal feature - The witness is shown photographs of noses with "small," "average," and "great projections." In addition, the witness is shown noses of varying lengths and widths which include the "long," "average," "short," "wide," and "narrow" nasal types.
3. Establish the shape and the position of the nasal feature - Examples are now shown of nasal features that represent each of the basic geometric shapes. These photographs also contain the characteristics of the feature that were selected by the witness. The appropriate feature is then positioned correctly.

Eye Region - Eyes and Eyebrows

The accurate representation of the eye region depends on the selection of the eyes and the eyebrows. Combined together each of these features accentuates the other. Witnesses are usually better able to remember the

eyes so work should begin with this feature. A search is then made for the appropriate eyebrow structure following the selection of the eye type. It should be remembered that the placement of the eyebrows can also affect the apparent protrusion of the eyeballs. Thus "deep-set" eyes might be accentuated even more by placing the brow region closer to the eye sockets. Protruding eyeballs, on the other hand, would not have the eyebrow region so close to the eye sockets.

The following steps outline the eye feature selection procedure.

1. Establish the geometric shape of the eye - The witness is shown examples of each of the four geometric shapes. These examples should contain "average" measurements for each of the eye dimensions.
2. Establish the upper eyelid configuration - Show the witness examples of different upper eyelid configurations (321-328) that contain the appropriate geometric shape.
3. Establish the protrusion of the eyeball - Show the witness examples of eye types that differ along this dimension: 297-304 (deep-set), 321-328 (average), and 345-352 (protruding). The example that is most similar to the original image should be used. If examples cannot be found in the "average width" category (width of the palpebral cleft), then the "narrow" or "wide" examples should be used.
4. Establish the length of the palpebral cleft - Examples of "large," "average," and "small" eyes should be shown to the witness. All of these examples should correspond to the eye types that were previously selected.
5. Establish the distance of the inner biocular breadth - Examples

may be found in the following groupings: 217-288 (narrow), 289-360 (average), and 361-432 (wide). These examples should contain all of the characteristics previously selected by the witness.

Following the selection of the eye feature type, the eyebrows are selected according to the following steps.

1. Establish the thickness of the eyebrow structure - The witness is shown examples of "sparse," "thin," and "medium" eyebrow thicknesses. If the eyebrows are thicker than these examples, then either the "thick" or the "bushy" category may be used.
2. Establish the elevation of the eyebrows - The witness is shown "oblique internal," "straight," and "oblique external" examples from the "rectilinear" eyebrow group.
3. Establish eyebrow size (i.e. length and inter-head distance) - Examples are now shown which represent the different lengths and inter-head distances found in the classification system.
4. Establish the geometric shape of the eyebrows - The witness is shown examples of each of the eight geometric categories with the appropriate elevation and thickness.
5. Establish the eyebrow distance from the eyeball socket - The selected features are moved along a vertical axis until they closely approximate the proper distance from the eye sockets.

The eyebrow manipulation represents the final phase of the image generation procedure. Appendix K presents a series of photographs showing an example of a construction sequence. Of course, once the total image is formed it is possible and appropriate to reconsider the various features

and make additional substitutions and adjustments. Indeed, adjustments will frequently be required in order to properly position the features with respect to each other.

Hard copy of the final image is obtained by photographing the TV monitor, usually with a polaroid-type camera. Identification numbers of the selected features are also recorded to permit later reconstruction of the image if necessary.

CHAPTER 4

A PRELIMINARY ANALYSIS OF THE REDESIGNED MONTAGE SYSTEM

Within the time frame of the current project, it was not possible to carry out an actual test of the Montage for generating images from witnesses' descriptions. It is important, however, to get at least some sense of the capability of the system, and it was with this objective in mind that a preliminary study was carried out.

The study consisted of generating 14 Montage composites of white male faces. The specific faces were randomly selected from a larger set of White males who had participated as target subjects in an earlier study on the use of sketch artists and the Identi-kit. The earlier study was part of the same overall research effort, and it is described in detail in Report Number UH MUG-2 of this project. The reason for selecting these targets was that sketches and Identi-kit composites were available on them for comparisons.

All 14 Montage composites were generated directly from view; that is, the technician constructed the image while viewing the target face projected on a screen. The projected face was approximately life size. The technician was Franklin Duncan who had carried out the work in redesigning the system.

The target numbers from the earlier imgage generation experiment, the Montage composites, and photographs of the targets are presented in Exhibits 1-14 of Appendix L. The feature classifications for each target and the software features used in constructing the composite for each face are described in Exhibits 1-14 of Appendix M.

The matter of determining the goodness - of - fit between an image and photograph of a face is not a simple matter. What does one measure? The approach in this study was to use a rating procedure where a group of subjects rated each image-photograph pair on a six-point similarity scale. The rating procedure consisted of carrying out an experiment in which 30 subjects separately rated each image with its respective photograph. Actually, each subject rated 42 pairs; the 14 Montage composites and the 14 sketches and 14 Identi-kit composites of the same targets that were generated in the earlier image generation experiment. The sketches and Identi-kit composites had been generated from view; that is, they were produced while the artist and technician directly viewed the target person. Thus, in all three sets the images represent what might be regarded as the maximum potential performance of the technique, since they were generated while looking at the target or his photograph. Obviously this assumption must be tempered since factors such as artist/technician skill and experience were not considered. Nevertheless, these results represent a reasonable first approximation to testing the capability of the Montage.

The rating study consisted of running three groups of ten subjects each. The subjects were students enrolled in an introductory psychology course at the University of Houston who received extra credit for their participation. The subjects were seated in a normal classroom. Two standard Kodak carousel slide projectors were used to project the image and photograph side-by-side on a screen in front of the room. The photograph was always on the left. Each pair was shown for ten seconds. The subject looked at the images, made a decision regarding the goodness - of - fit of the image to the photograph, and then indicated his/her rating on a response sheet. The ratings were made on the basis of a six-point similarity scale, where the

ends of the scale were defined as "most similar" and "least similar."

The sequence of 42 pairs was arranged into three blocks of 14 each. Each target appeared once in each block. Each block consisted of approximately an equal number of occurrences of each type of image; that is 1/3 sketches, 1/3 Identi-kit composites, and 1/3 Montage composites. (The "approximately" was necessary simply because 14 does not divide evenly by three). The three groups of subjects each received a different sequencing of the three blocks of pairs, so that each block appeared first one time, second once and third once.

The means and standard deviations of the ratings for each technique are presented in Table 2.

TABLE 2

Means and Standard Deviations for Similarity Ratings for Each Technique

	Sketch	Identi-kit	Montage
Mean	2.94	4.22	3.95
Std. Dev.	.54	.53	.65

The rating scale was constructed so that the small numbers represented better fits. An analysis of variance indicated that the effect of technique was statistically significant, $F(2,58)=76.58$, $p < .001$.

These results are encouraging. Even at this early stage of software development, it appears that the Montage is capable of producing images as good as or better than the Identi-kit. Of course, such conclusions are very prelimary, since many dimensions of the Montage have not yet been addressed.

For example, how easy/difficult will it be to learn to use it? How much time will it be to learn to use it? How much time will be required to produce an image? How effectively will witnesses be in selecting features? These are only a few of the legitimate questions remaining; but as noted, these results are encouraging.

CHAPTER 5

GENERAL DISCUSSION

The results from the similarity rating study demonstrate that the Montage, even in this early stage of development, is capable of producing composites that are rated as better representations than the Identi-kit images.

With one possible exception, the effort to extend the number of feature substitutions in the Montage from three to six has been successful. This exception relates to the problem of brightness contrasts that are evident in the composites in Appendix L. Work on this problem is continuing, and it appears the problem can be dealt with in two ways. First, the use of lower contrast masks on the photograph will reduce the lines. Secondly, more careful control of the homogeneity of photograph brightness will permit better blending.

The basic outline of the software system provides a general scheme for classifying and retrieving features. Most likely, the scheme is far more detailed than necessary. This fine-grained approach was intentional, however, since it is always possible to collapse across categories. The photographs that were placed in the software system for purposes of constructing faces in the preliminary study described in the last chapter were not selected to represent a range or variety of features. Rather, they were simply pictures that were available from our ongoing work. This fact makes the outcome of the preliminary analysis (Montage composites better than

Identi-kit composites) even more encouraging. It seems most reasonable to assume that a carefully selected set of representative features will lead to even better composites.

One concern with the overall system as now designed is that it is complex. Considerable training may be required for technicians to use it, and the time for generating an image may be excessive. Whether or not these problems are serious is not yet clear. In any case, the training and time requirements would have to be balanced against the quality of images produced.

Clearly the Montage is a potential answer to one of the shortcomings of the sketch artist and Identi-kit techniques; namely, the reality of the images. Sketches and Identi-kit composites are drawings. A Montage composite, properly constructed, is a "real face." It seems quite likely that this reality dimension of images will lead to higher rates of success in the identification of criminals.

APPENDICES

Appendix A
Components of the Minolta Montage Synthesizer

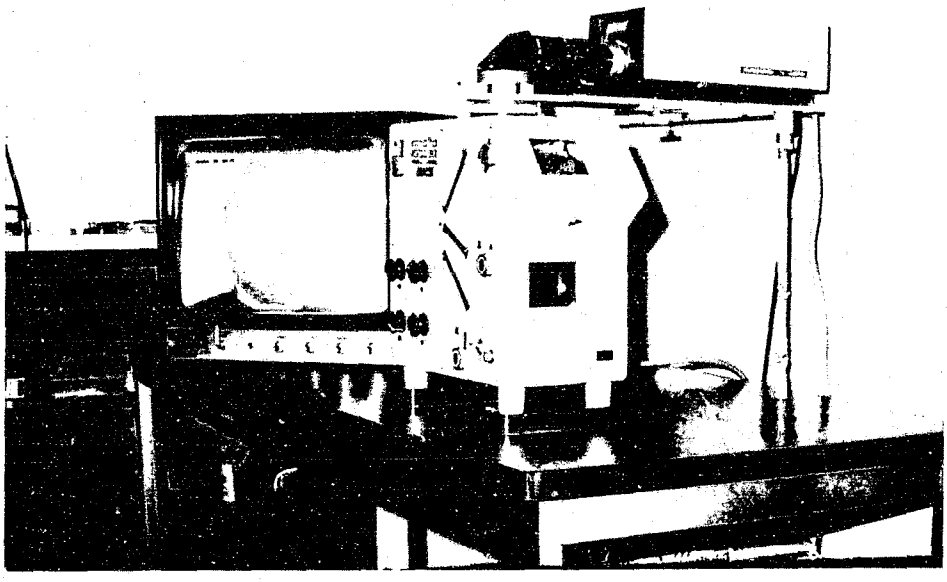
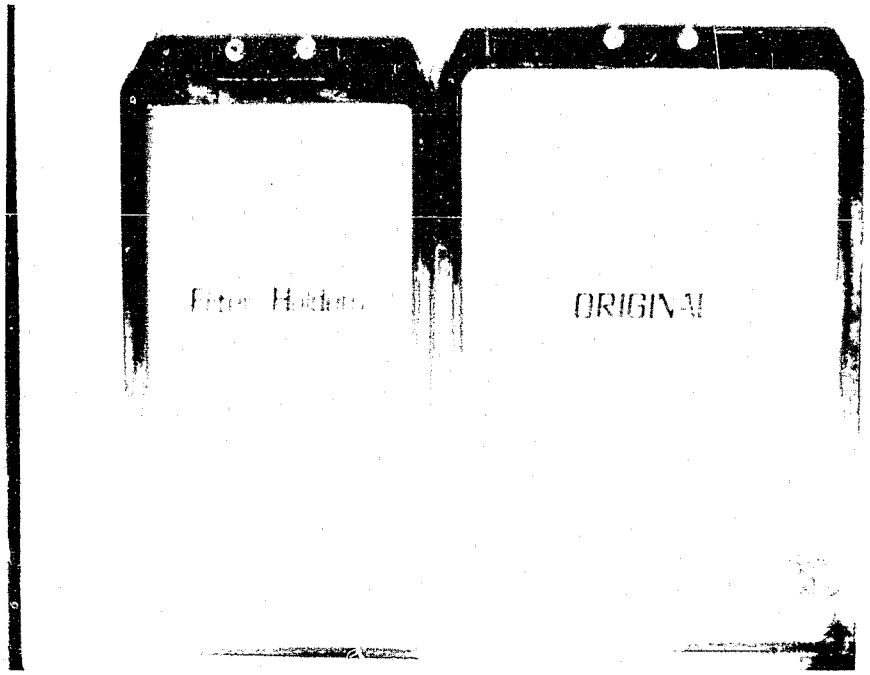
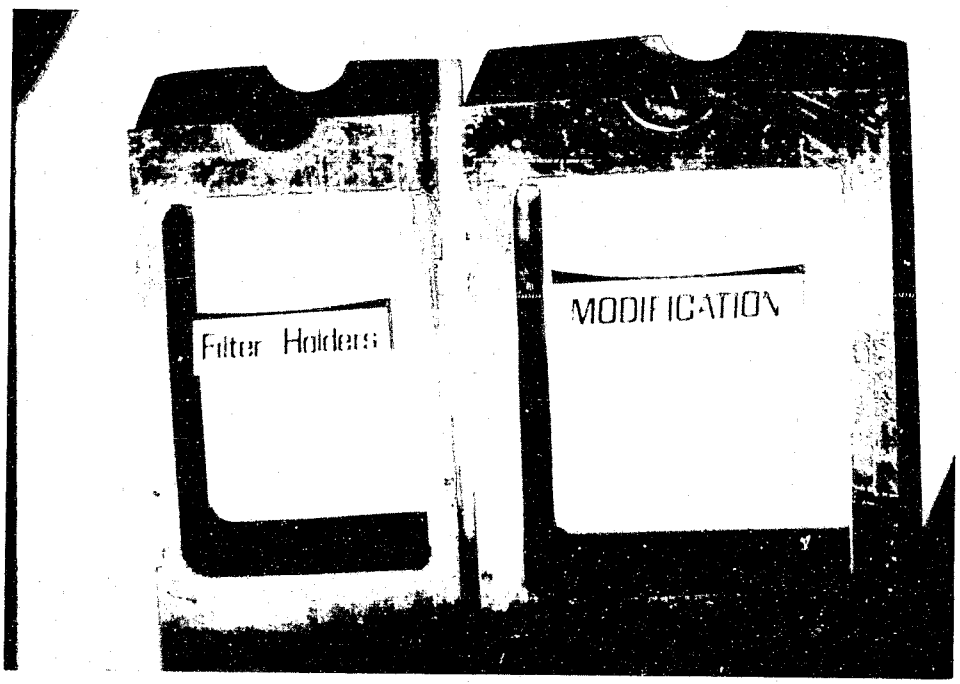


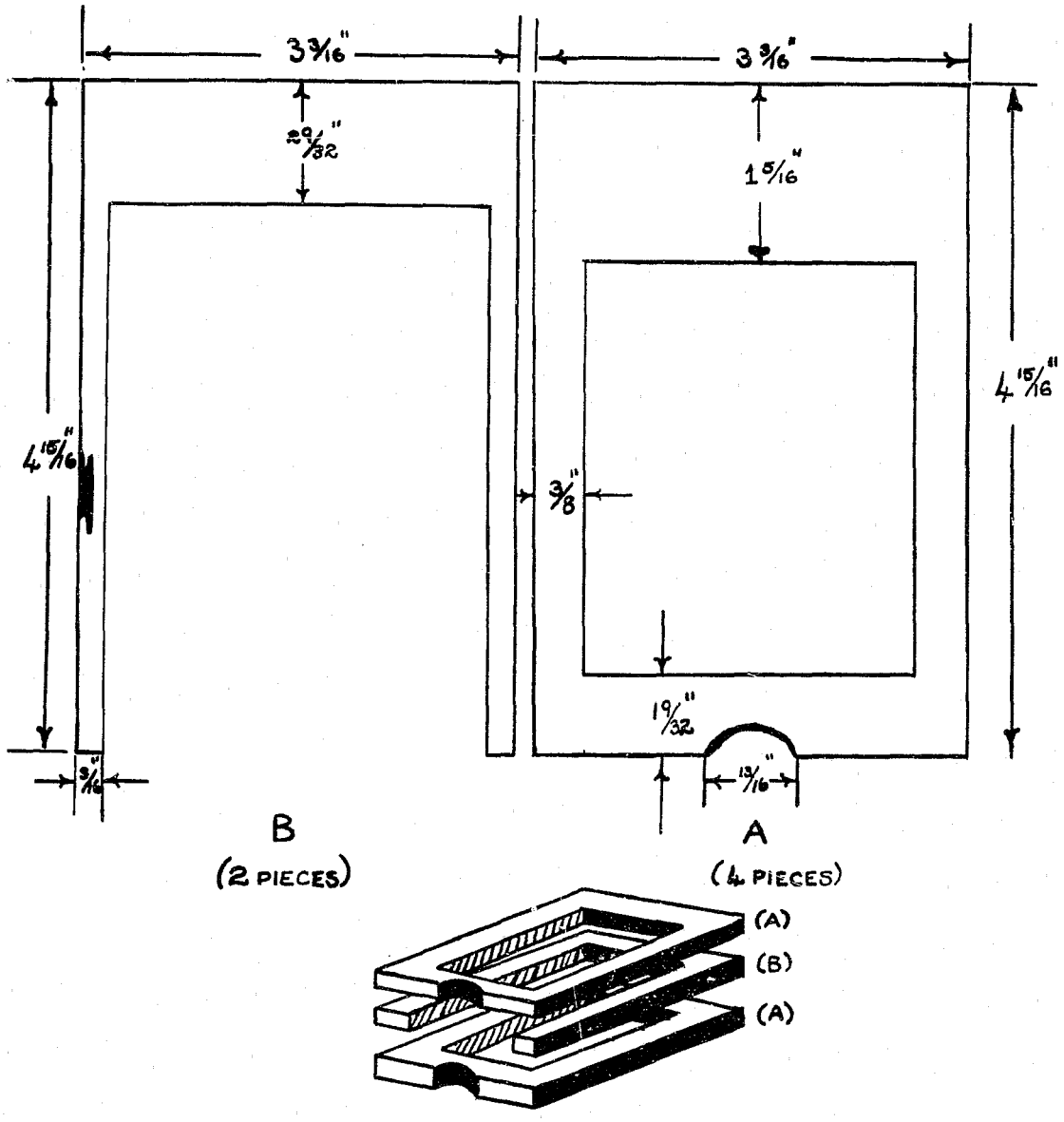
Exhibit 1
Appendix B
Photographs of Original and Modified Filter Holders





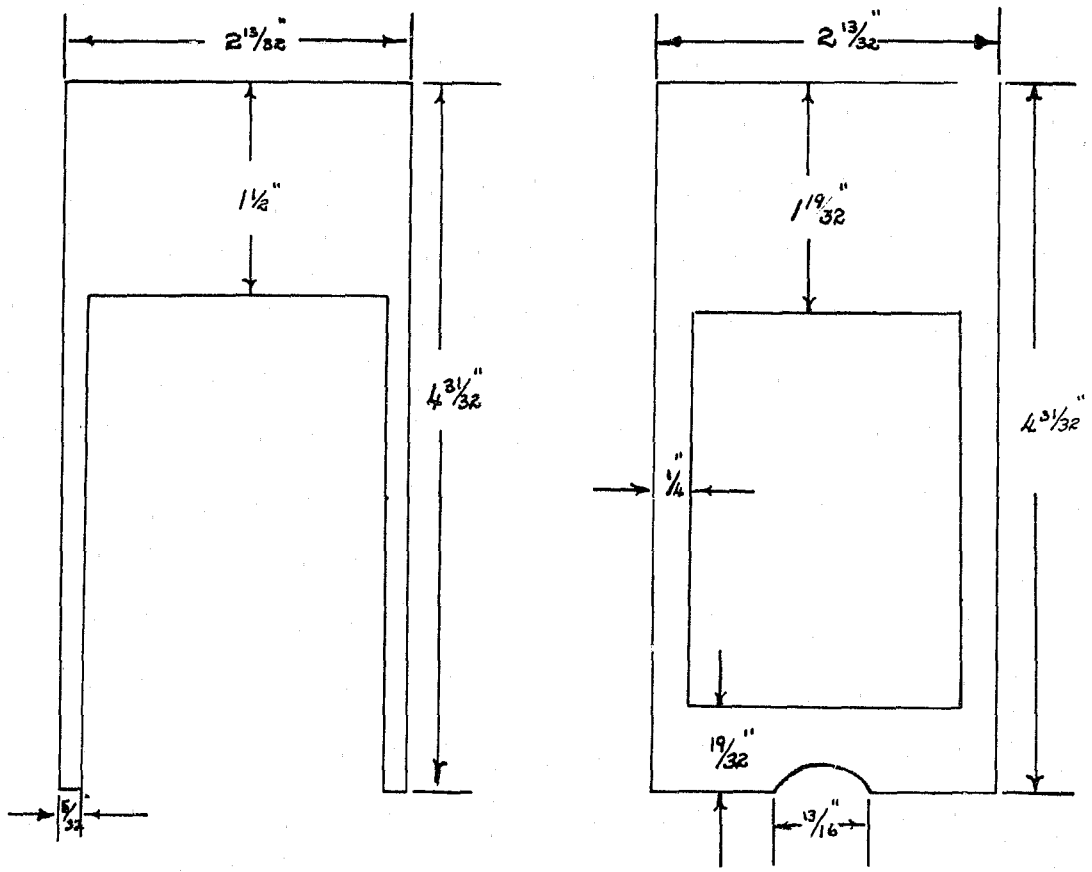
Appendix B
Exhibit 2

Construction Diagram for Brown
and Green Filter Holders



Appendix B
Exhibit 3

Construction Diagram
for red Filter Holder



B
(1 PIECE)

A
(2 PIECES)

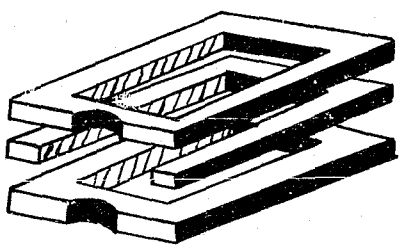


Exhibit 1
Appendix C
Photographs Demonstrating Problems of Fit Using Original Filters

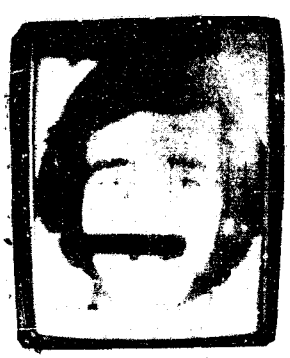
3A
Eyebrow Filter

3B
Eye Filter

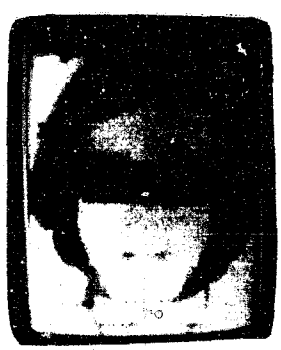
3C
Mouth Filter

3D
Chin Line Filter

3E
Hair Filter



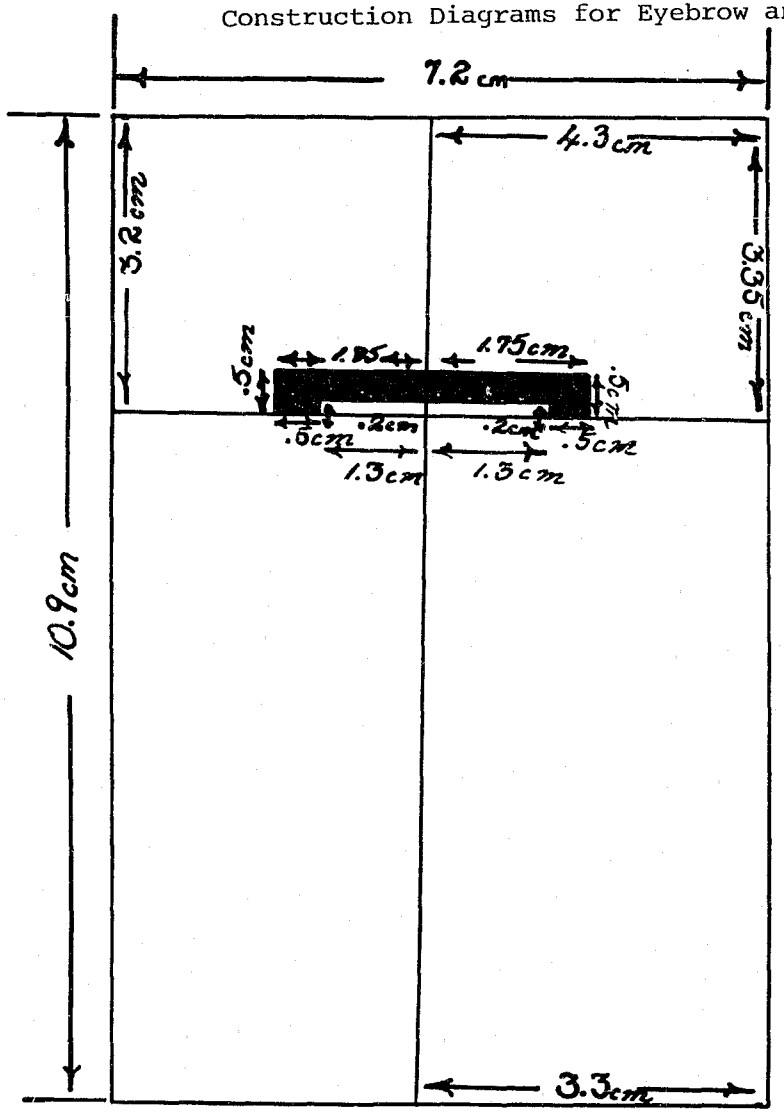
3F
Moustache Filter



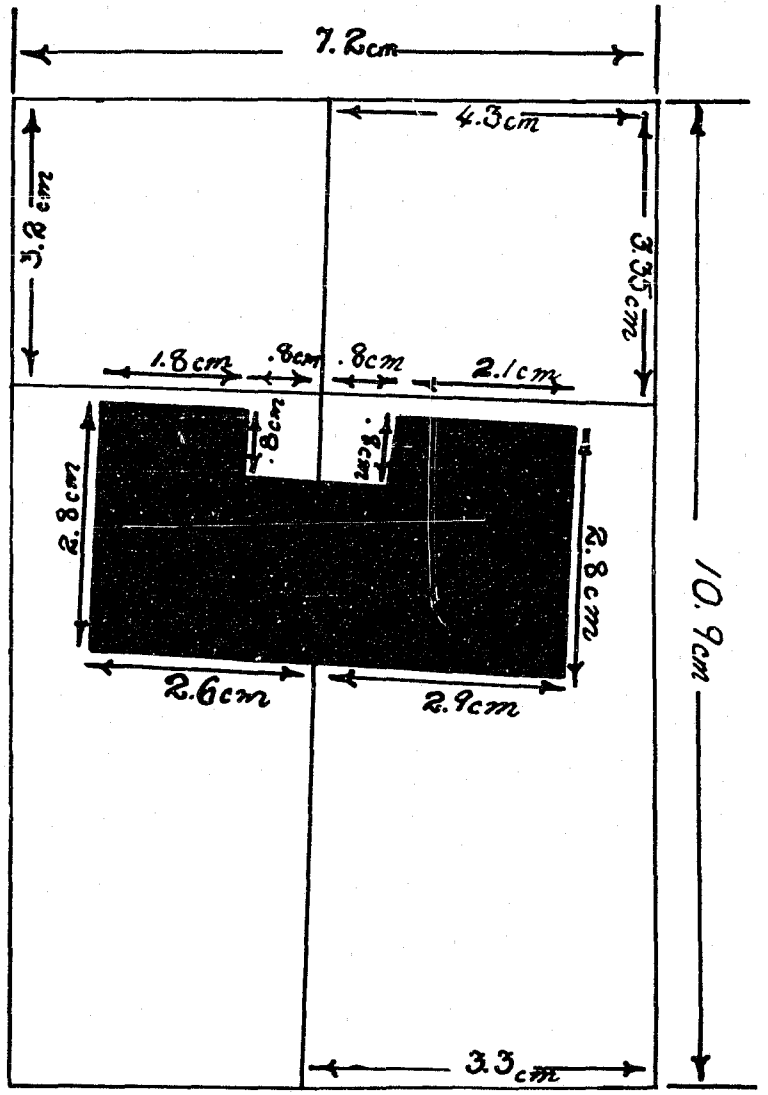
3G
Eyeglasses Filter

Appendix C Exhibit 2

Construction Diagrams for Eyebrow and Chinline Filters (Typically Used in Green Input Port)



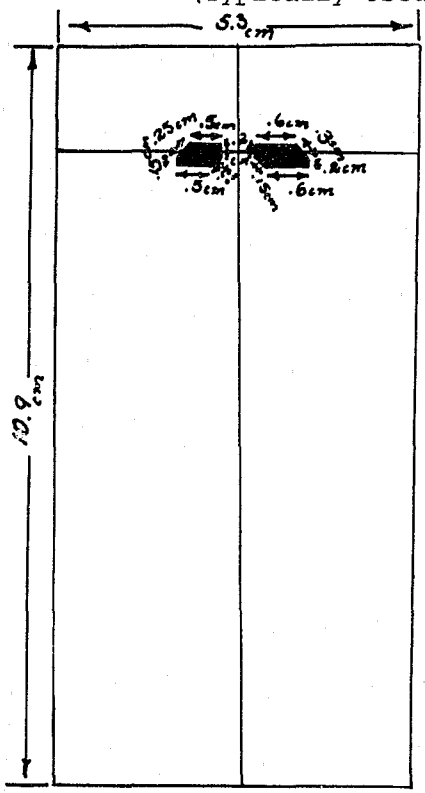
Eyebrow Filter



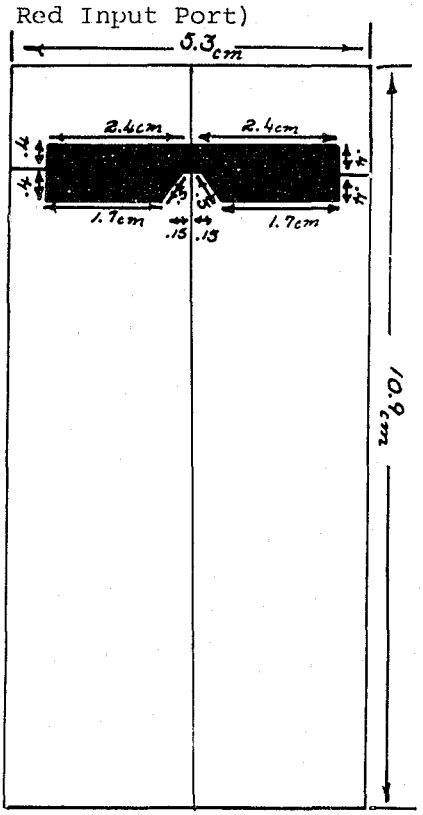
Chin Line Filter

Appendix C Exhibit 3

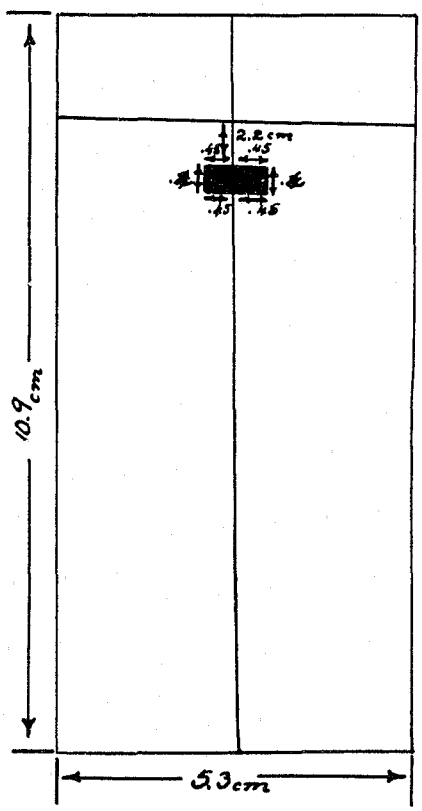
Construction Diagrams for Eye, Eyeglasses, and Mouth Filters
(Typically Used in Red Input Port)



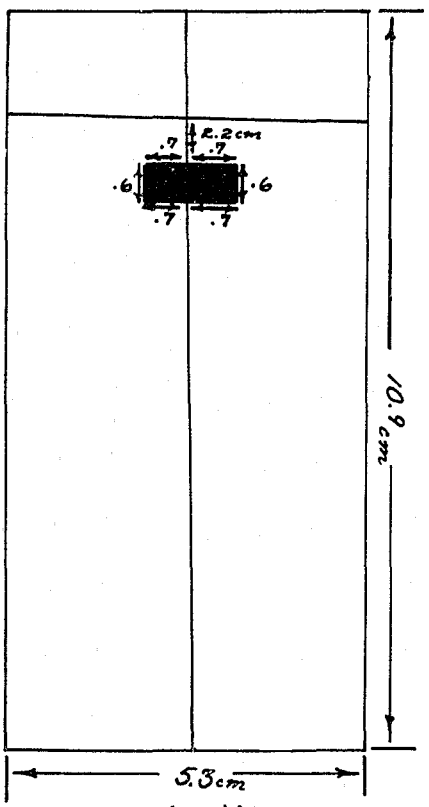
Eye Filter



Eyeglasses Filter



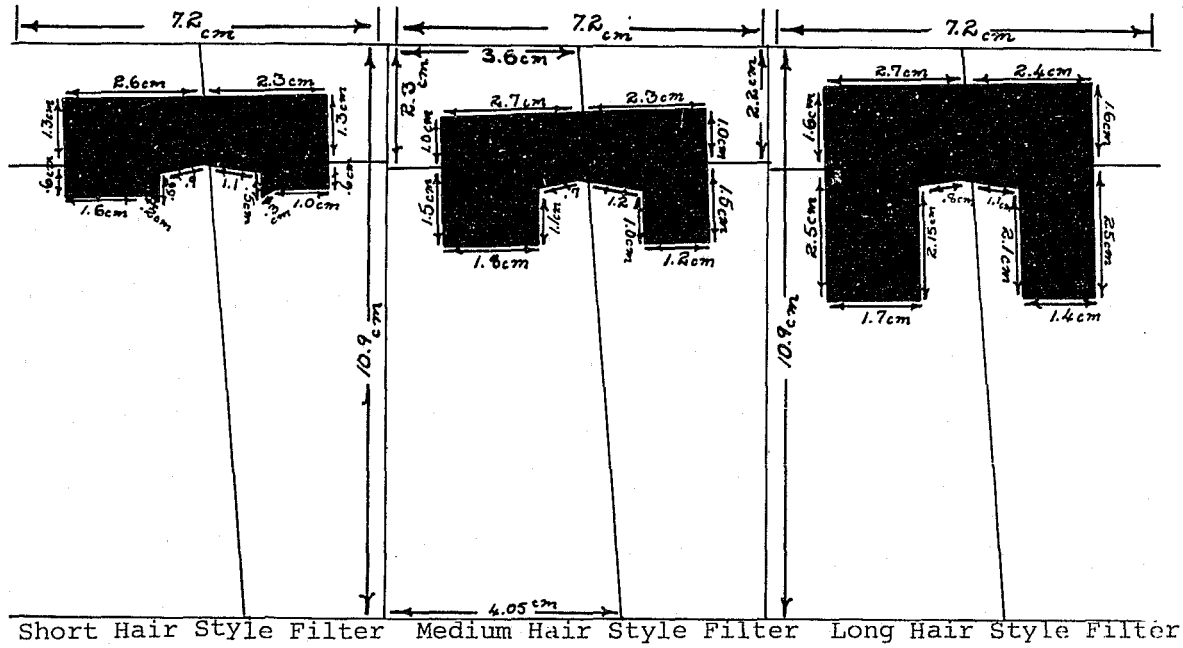
Mouth Filter



Mouth Filter

Appendix C Exhibit 4

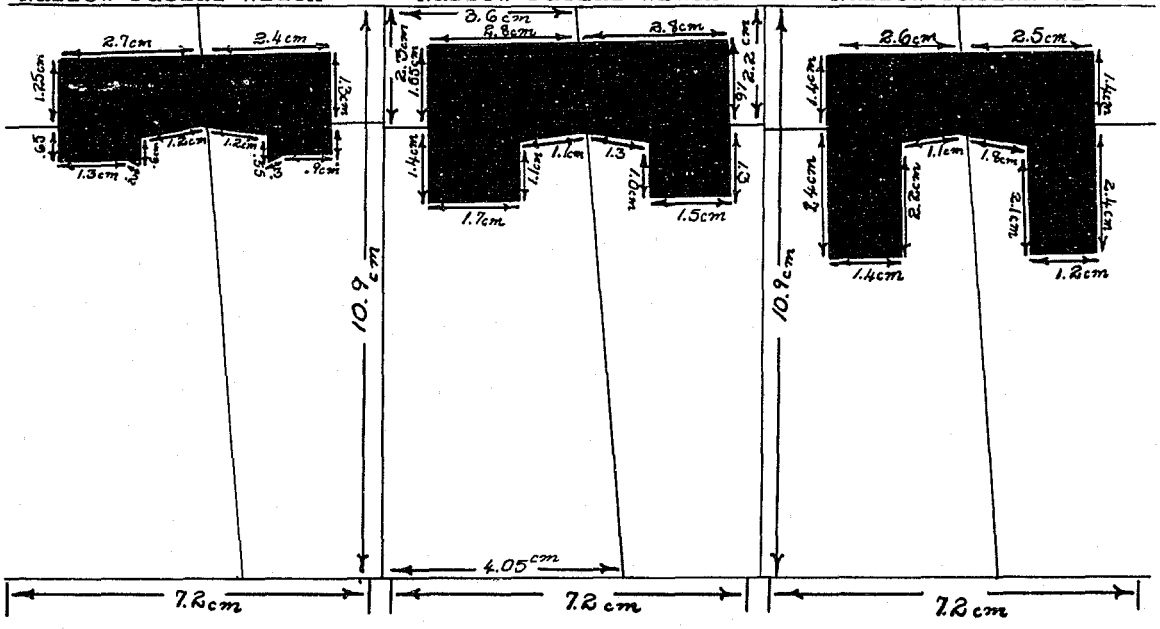
Construction Diagrams for the Narrow and Medium Facial Width Hair Filters
(Typically Used in Brown Input Port)



Short Hair Style Filter Narrow Facial Width

Medium Hair Style Filter Narrow Facial Width

Long Hair Style Filter Narrow Facial Width



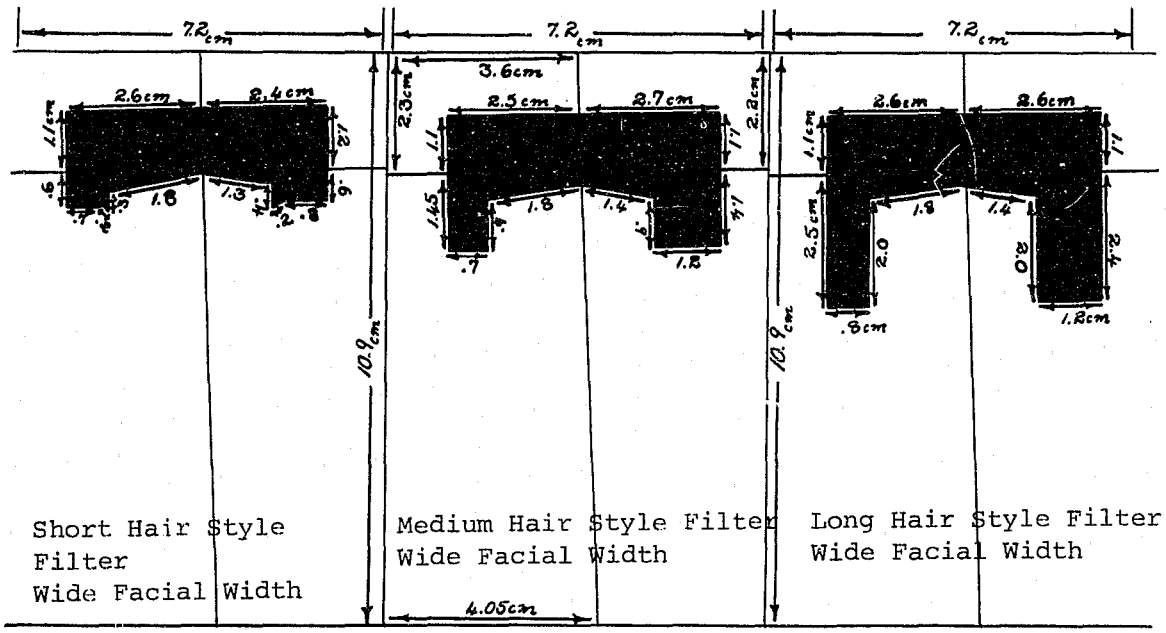
Short Hair Style Filter Average Facial Width

Medium Hair Style Filter Average FAcial Width

Long Hair Style Filter Average FAcial Width

Appendix C
Exhibit 5

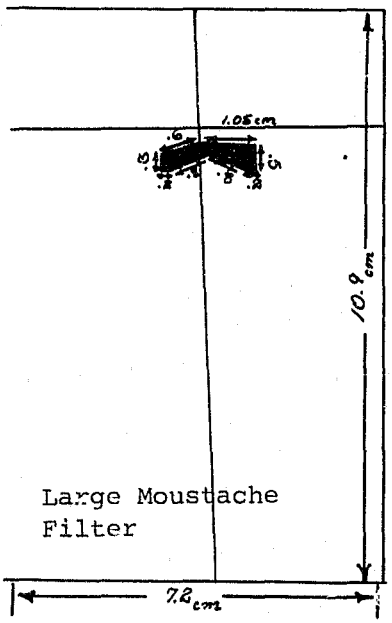
Construction Diagram for the Wide Facial Width Hair Filters and Moustache Filters (Typically Used in Brown Input Port)



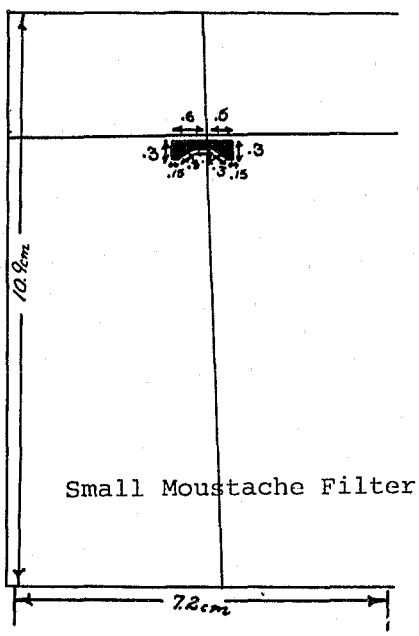
Short Hair Style Filter
Wide Facial Width

Medium Hair Style Filter
Wide Facial Width

Long Hair Style Filter
Wide Facial Width

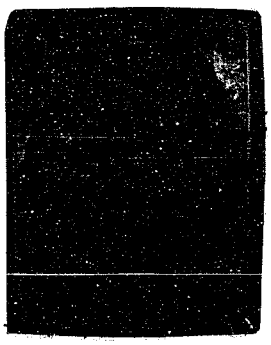


Large Moustache Filter

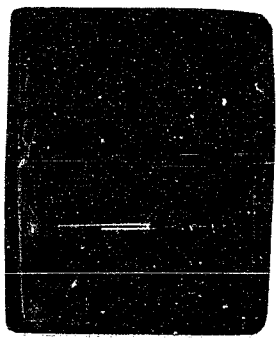


Small Moustache Filter

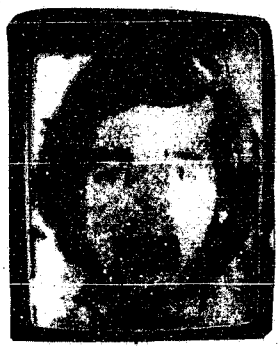
Exhibit 6
Appendix C
Photographs Demonstrating Fit Using New Filters



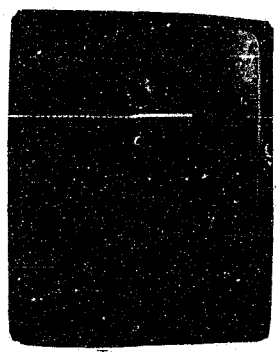
3FA
Eyebrow Filter



3FB
Eye Filter

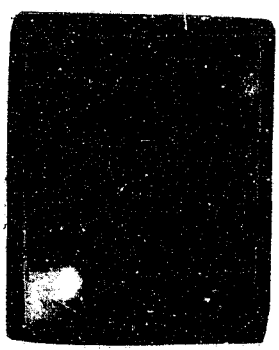


3FC
Mouth Filter



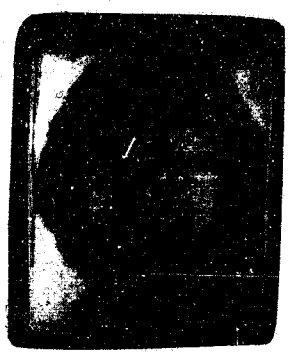
3FD
Chin Line Filter

3FE
Long Hair Filter

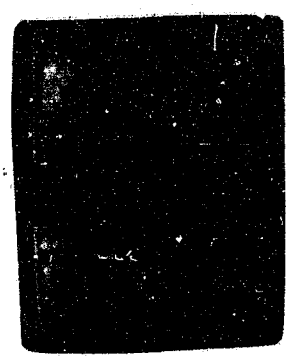


3FF
Medium Hair Filter

3FG
Short Hair Filter

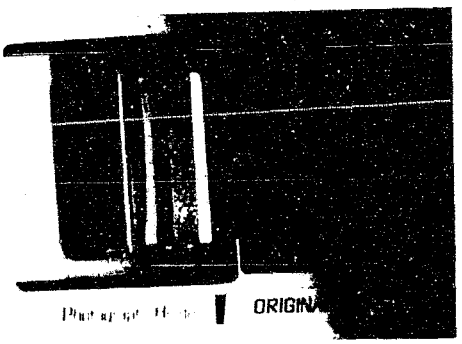


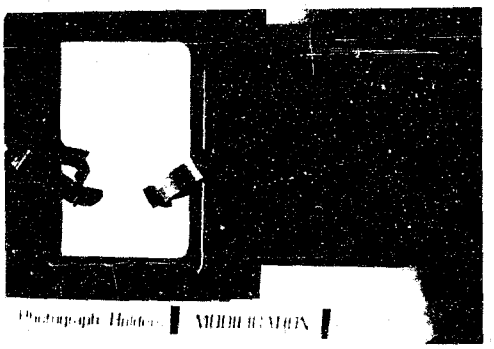
3FH
Moustach Filter



3FF
Eyeglass Filter

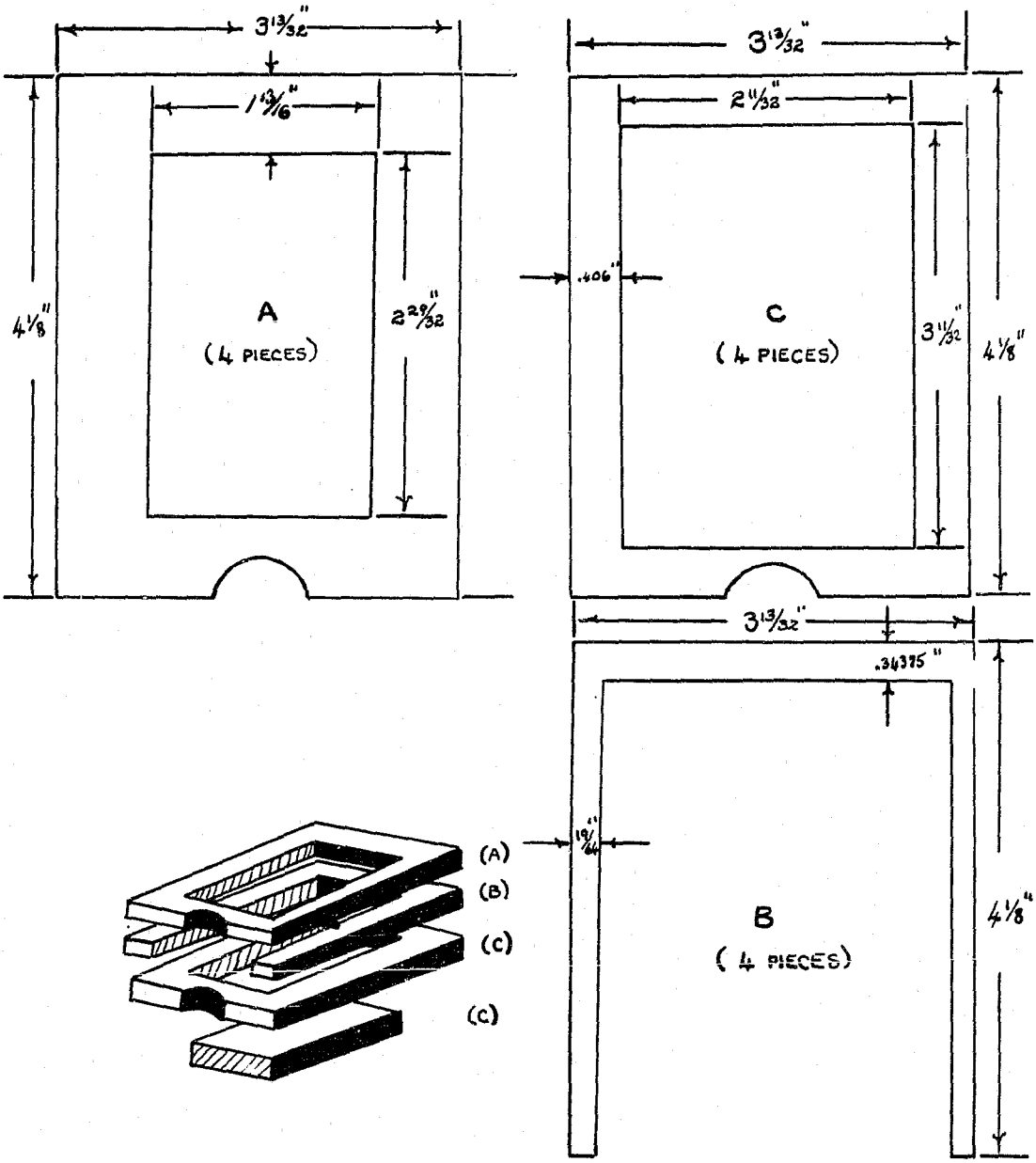
Appendix D
Photographs of Original and Modified Photograph Holder Designs



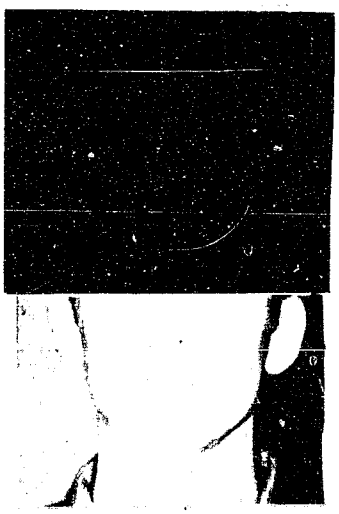


Appendix E

Construction Diagrams for the Modified Photograph Holder Designs



Appendix F
Photographs of Two Window Patterns

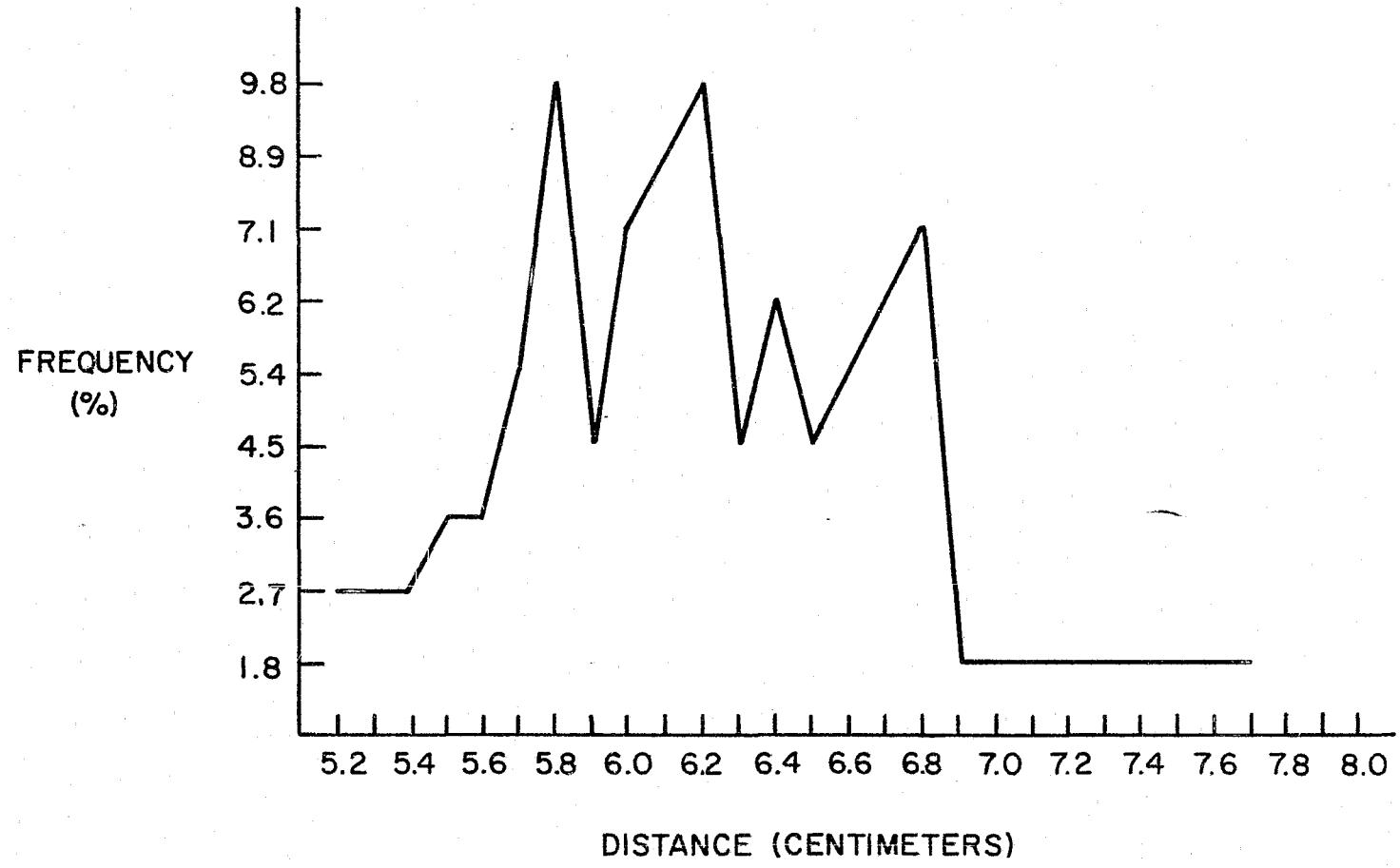


Upper Face Window

Lower Face Window

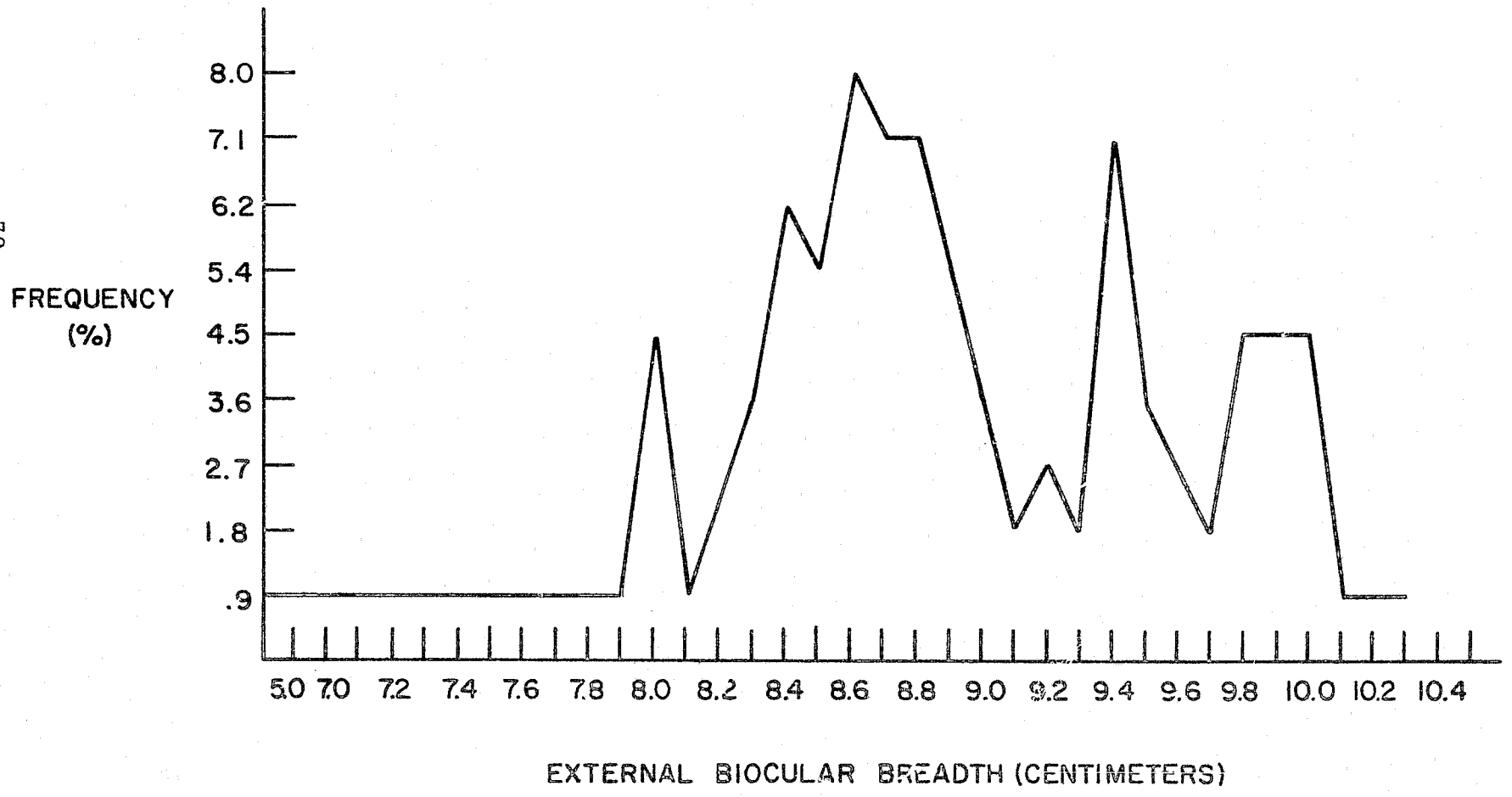
APPENDIX G
EXHIBIT 1

FREQUENCY DISTRIBUTION OF INTERPUPILLARY DISTANCE



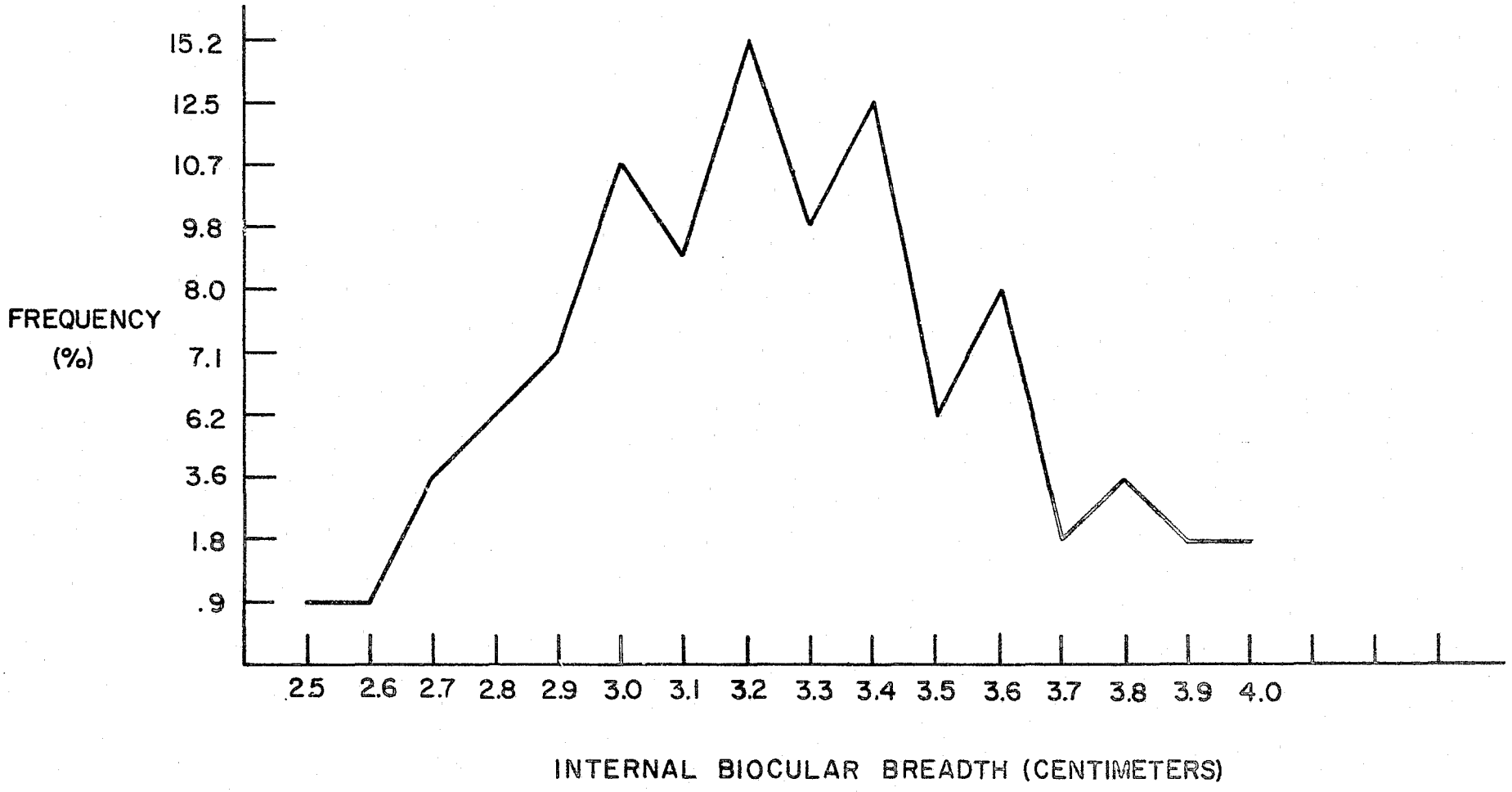
APPENDIX G
EXHIBIT 2

FREQUENCY DISTRIBUTION OF EXTERNAL BIOCULAR BREADTH



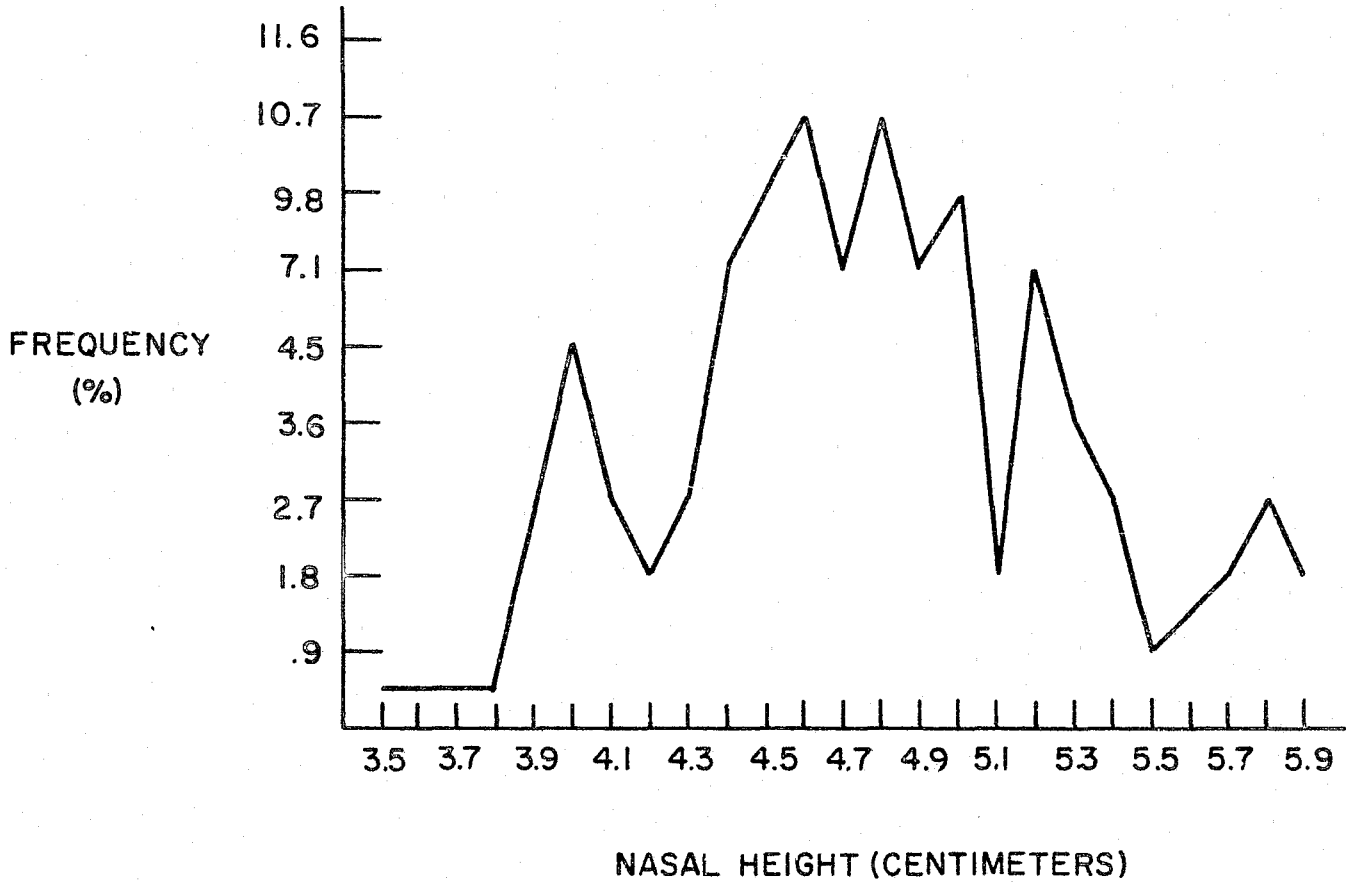
APPENDIX G
EXHIBIT 3

FREQUENCY DISTRIBUTION OF INTERNAL BIOCULAR BREADTH

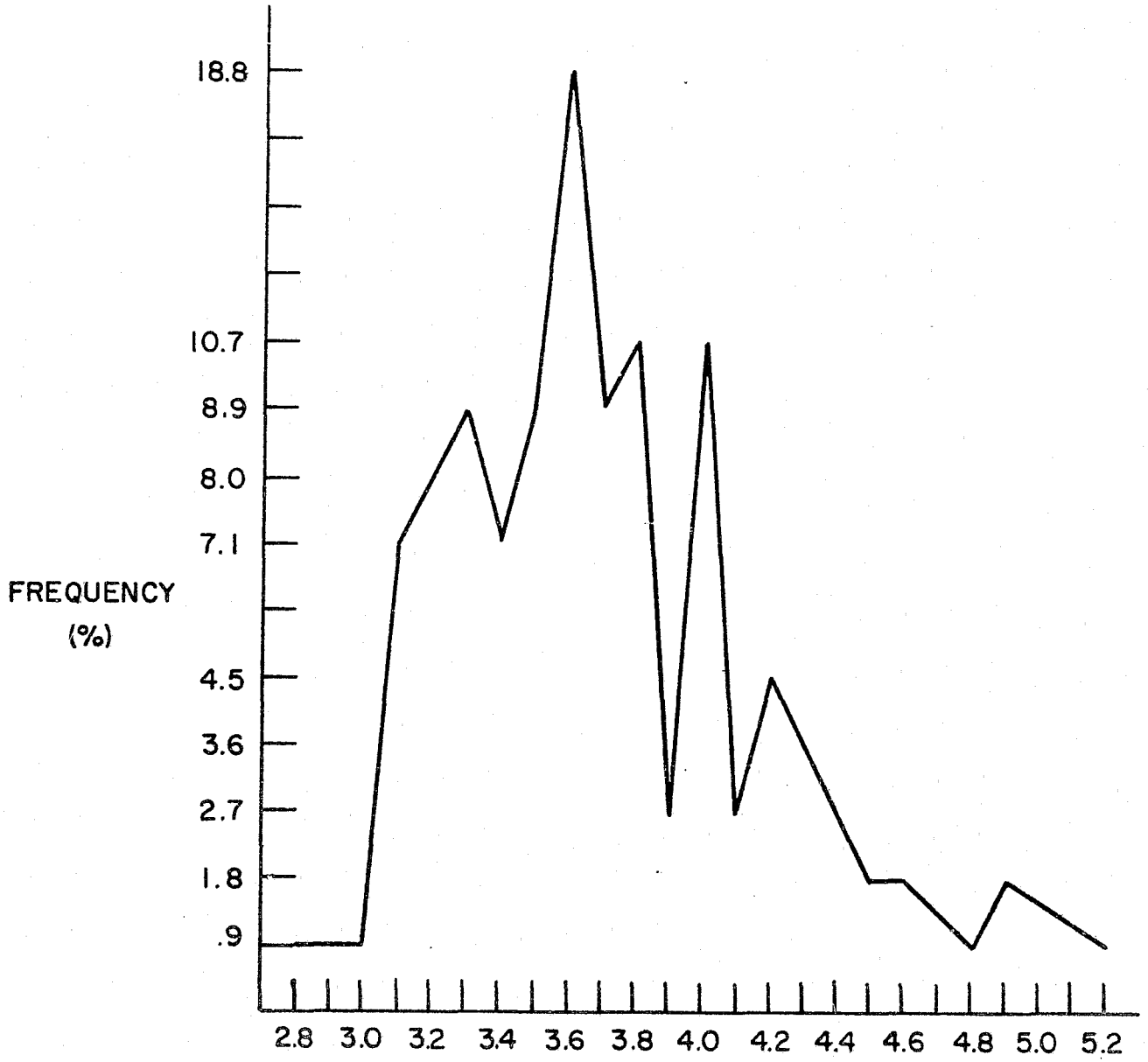


APPENDIX G
EXHIBIT 4

FREQUENCY DISTRIBUTION OF NASAL HEIGHT

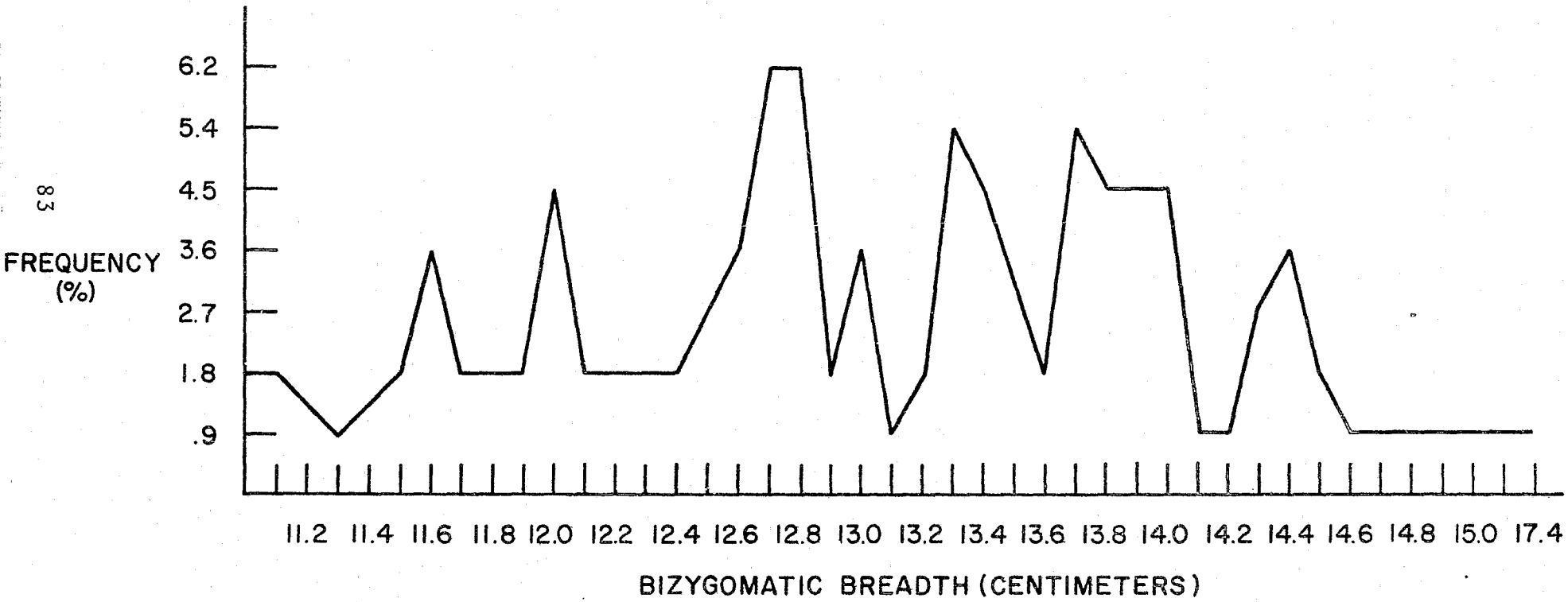


FREQUENCY DISTRIBUTION OF NASAL BREADTH



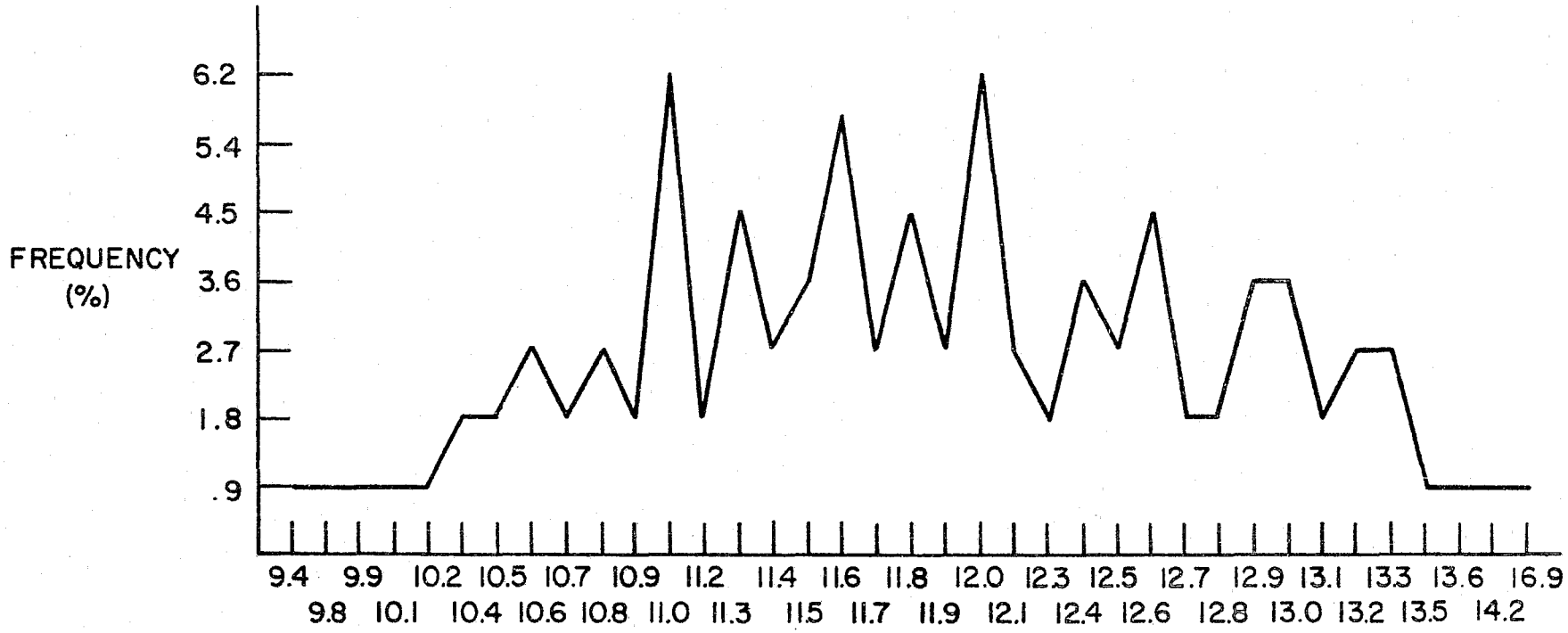
APPENDIX G
EXHIBIT 6

FREQUENCY DISTRIBUTION OF BIZYGOMATIC BREADTH



APPENDIX G
EXHIBIT 7

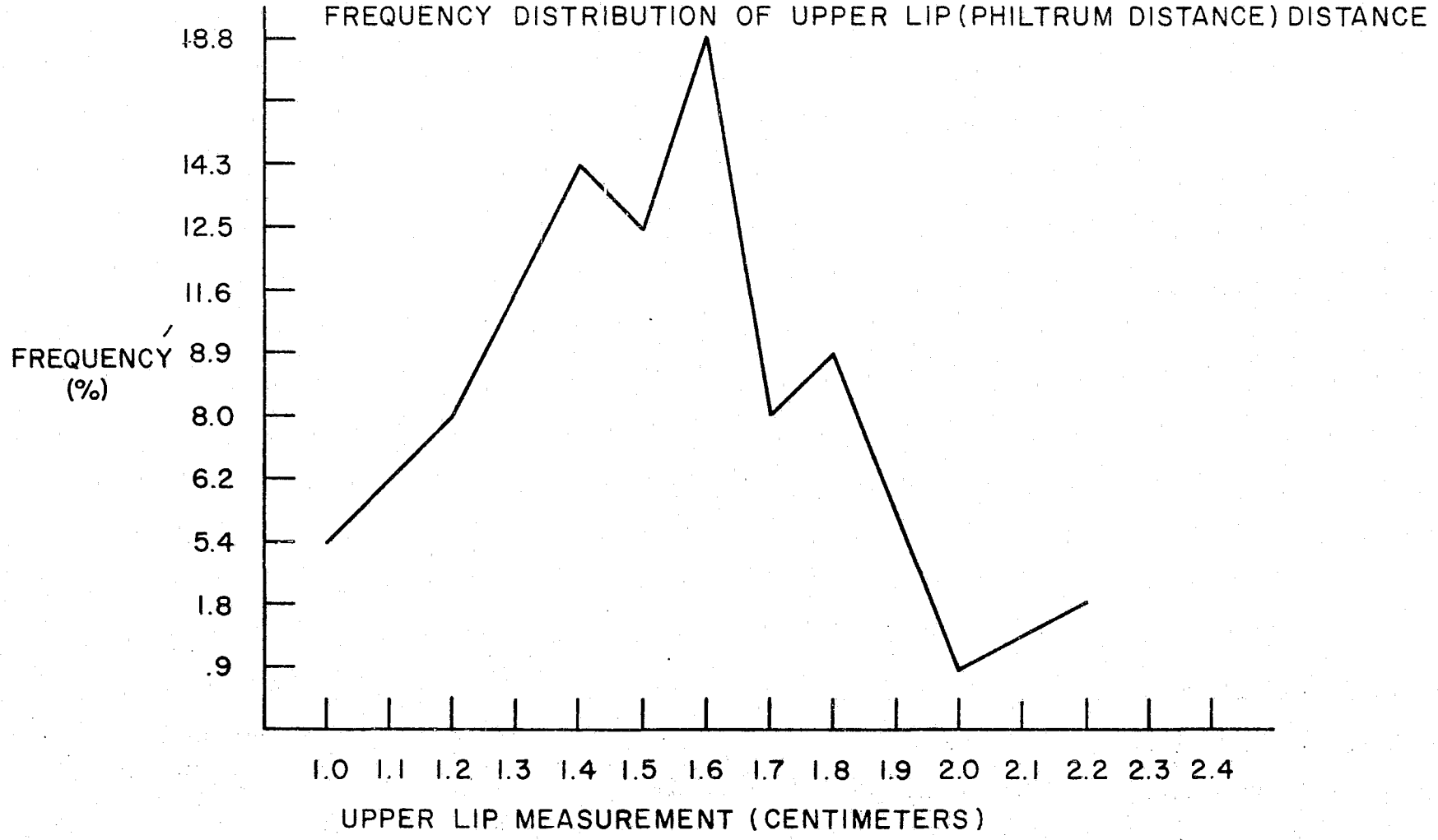
FREQUENCY DISTRIBUTION OF BIGONIAL WIDTH



CONTINUED

1 OF 3

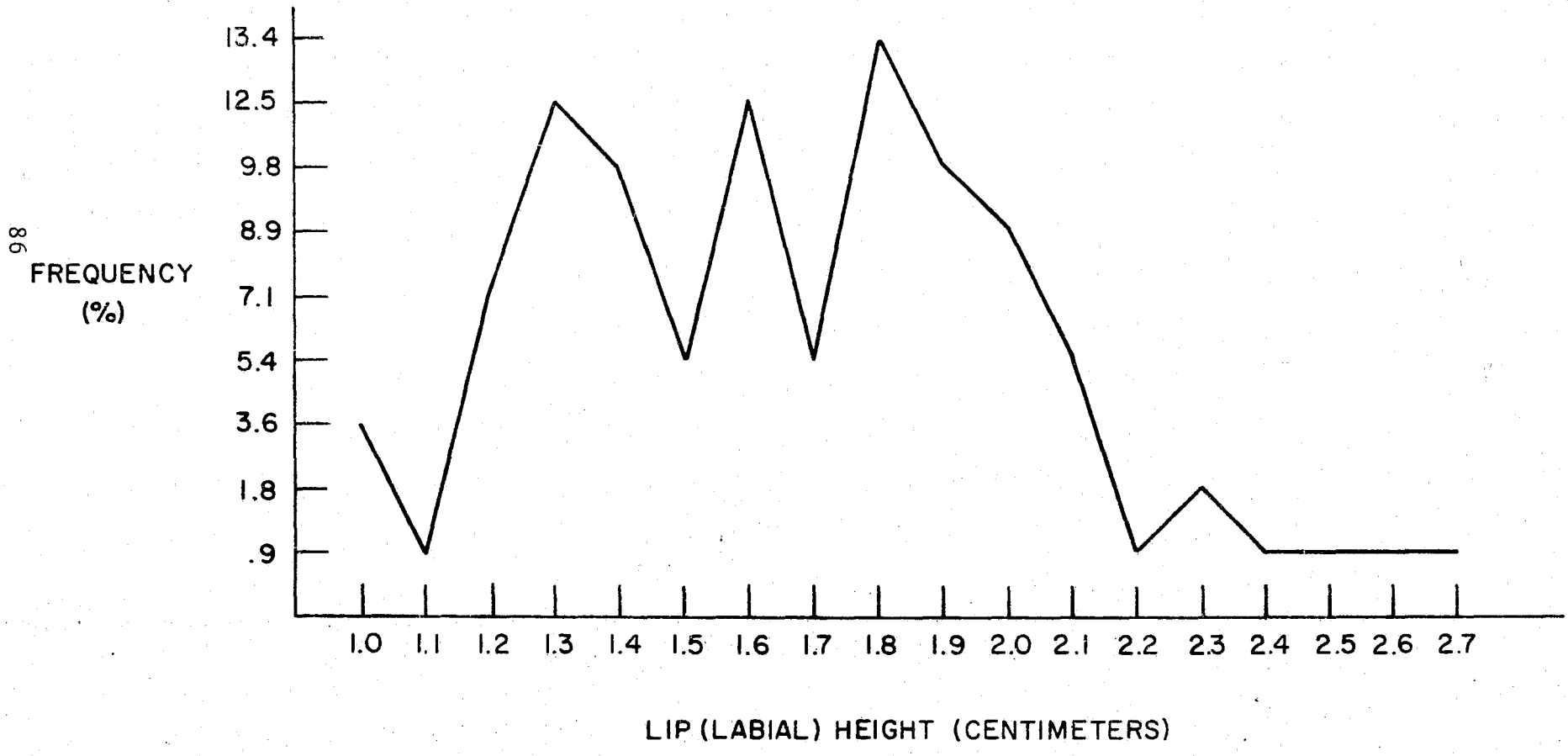
APPENDIX G
EXHIBIT 8



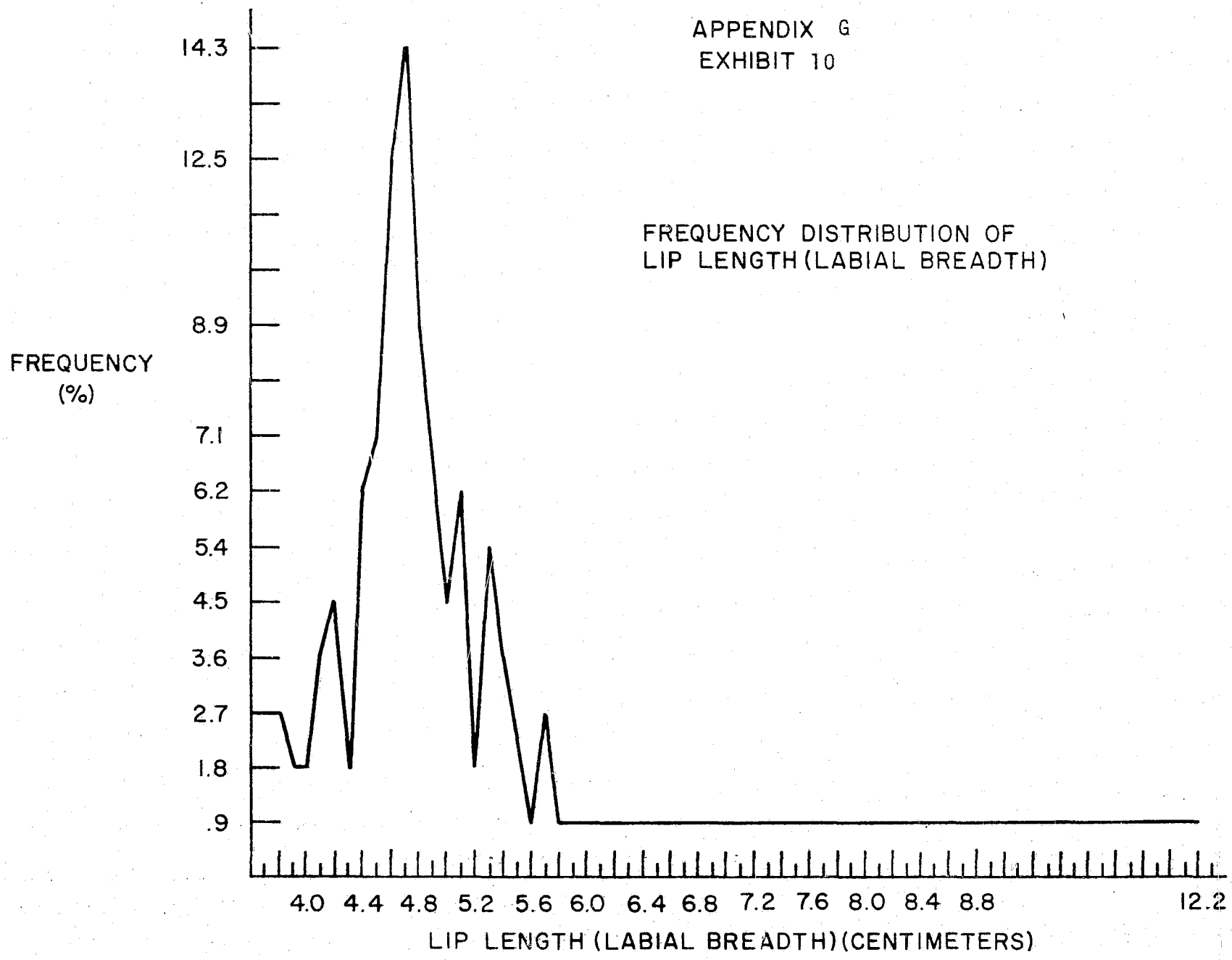
APPENDIX G

EXHIBIT 9

FREQUENCY DISTRIBUTION OF LIP (LABIAL) HEIGHT

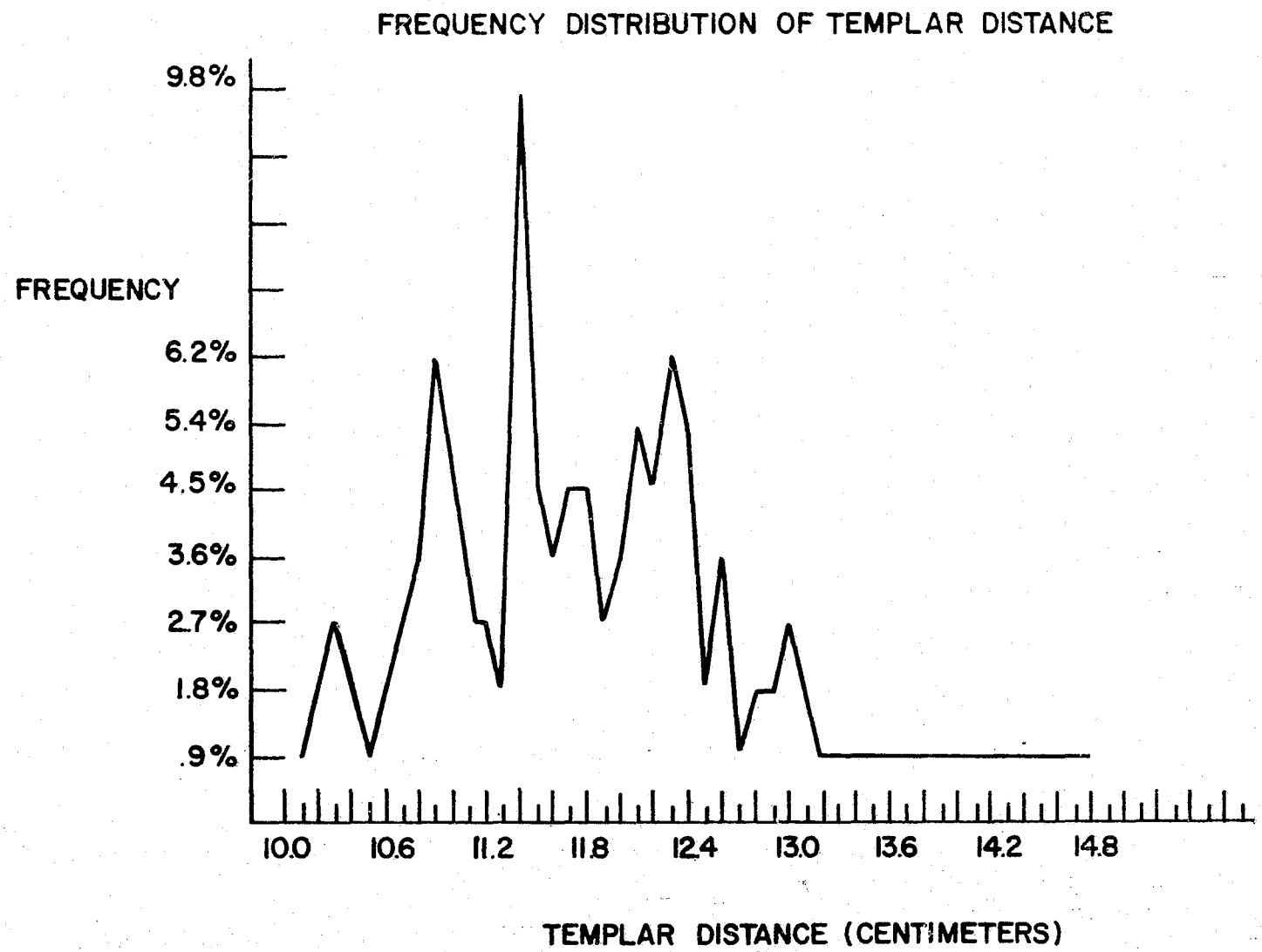


APPENDIX G
EXHIBIT 10



APPENDIX G

EXHIBIT 11



APPENDIX G
EXHIBIT 12

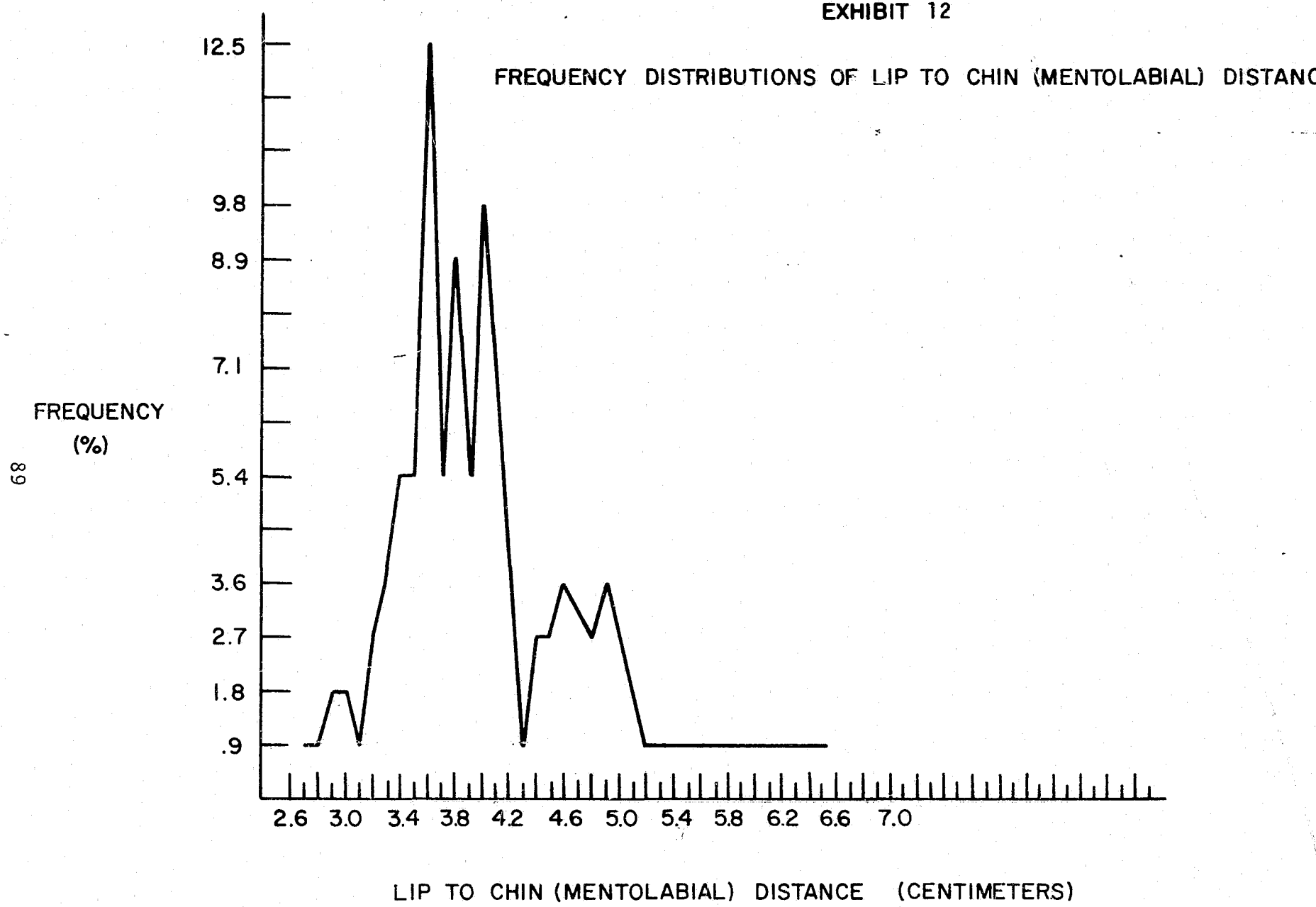


EXHIBIT 13

FREQUENCY DISTRIBUTION OF LIPDISTANCES (UPPER FACE HEIGHT)

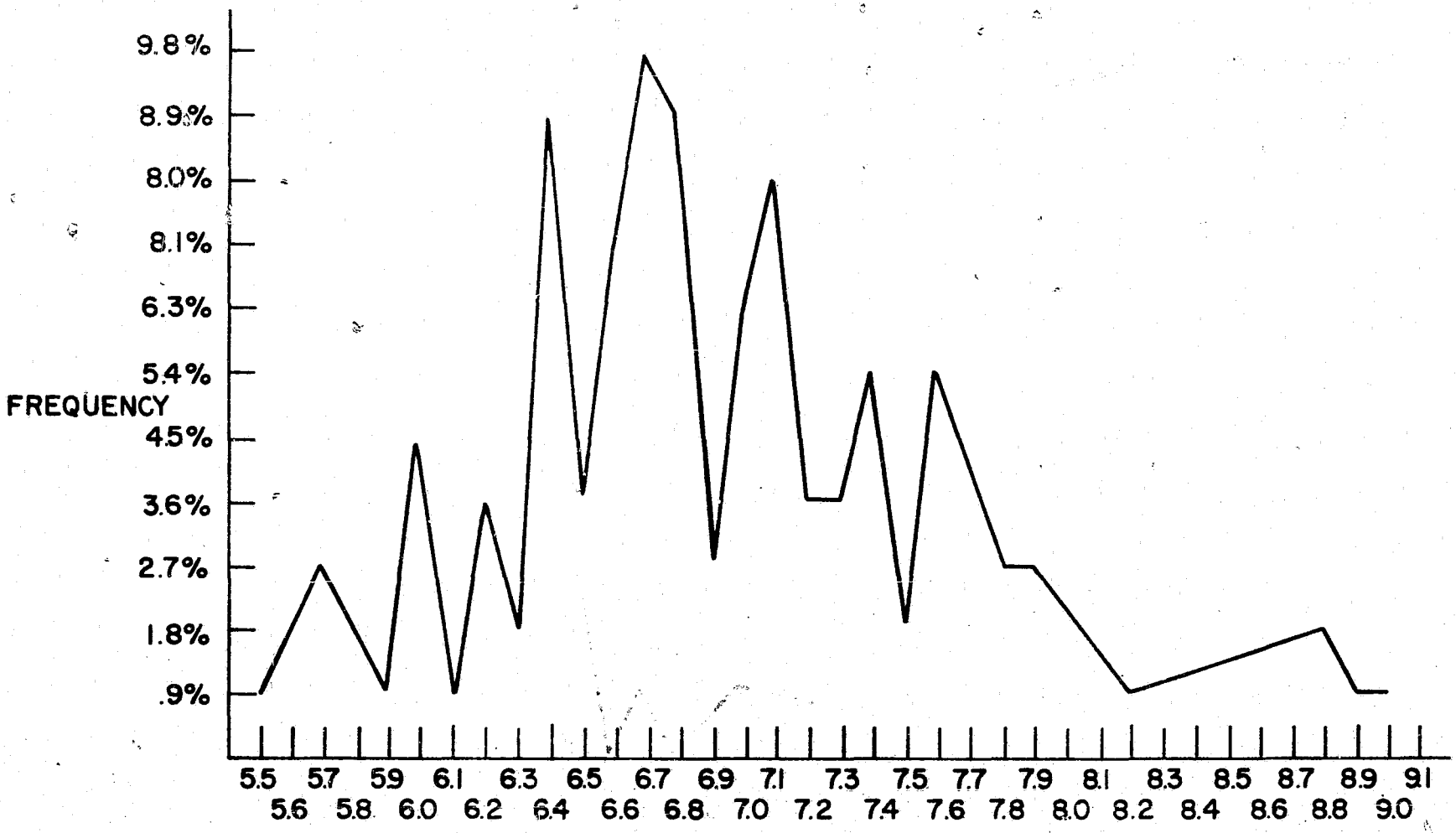


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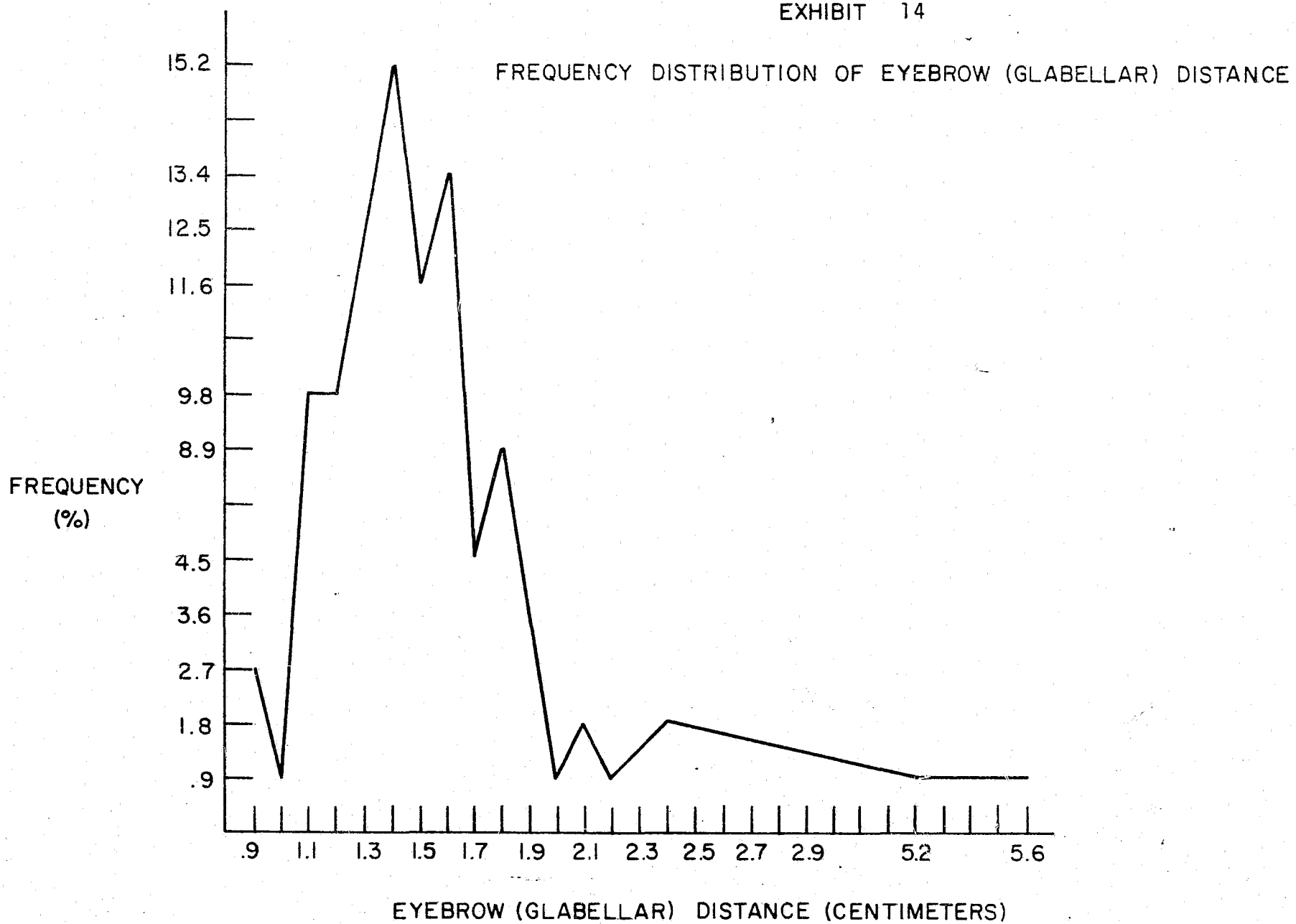
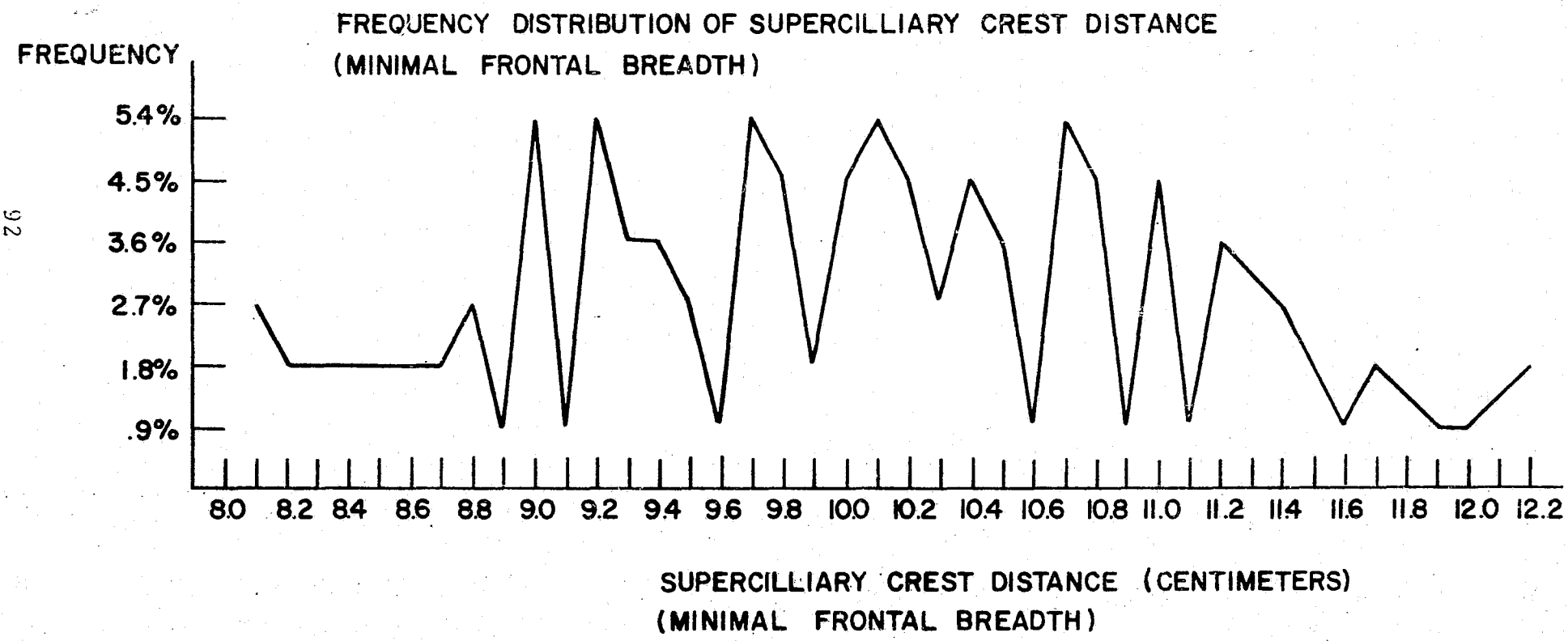
EXHIBIT 14



APPENDIX G

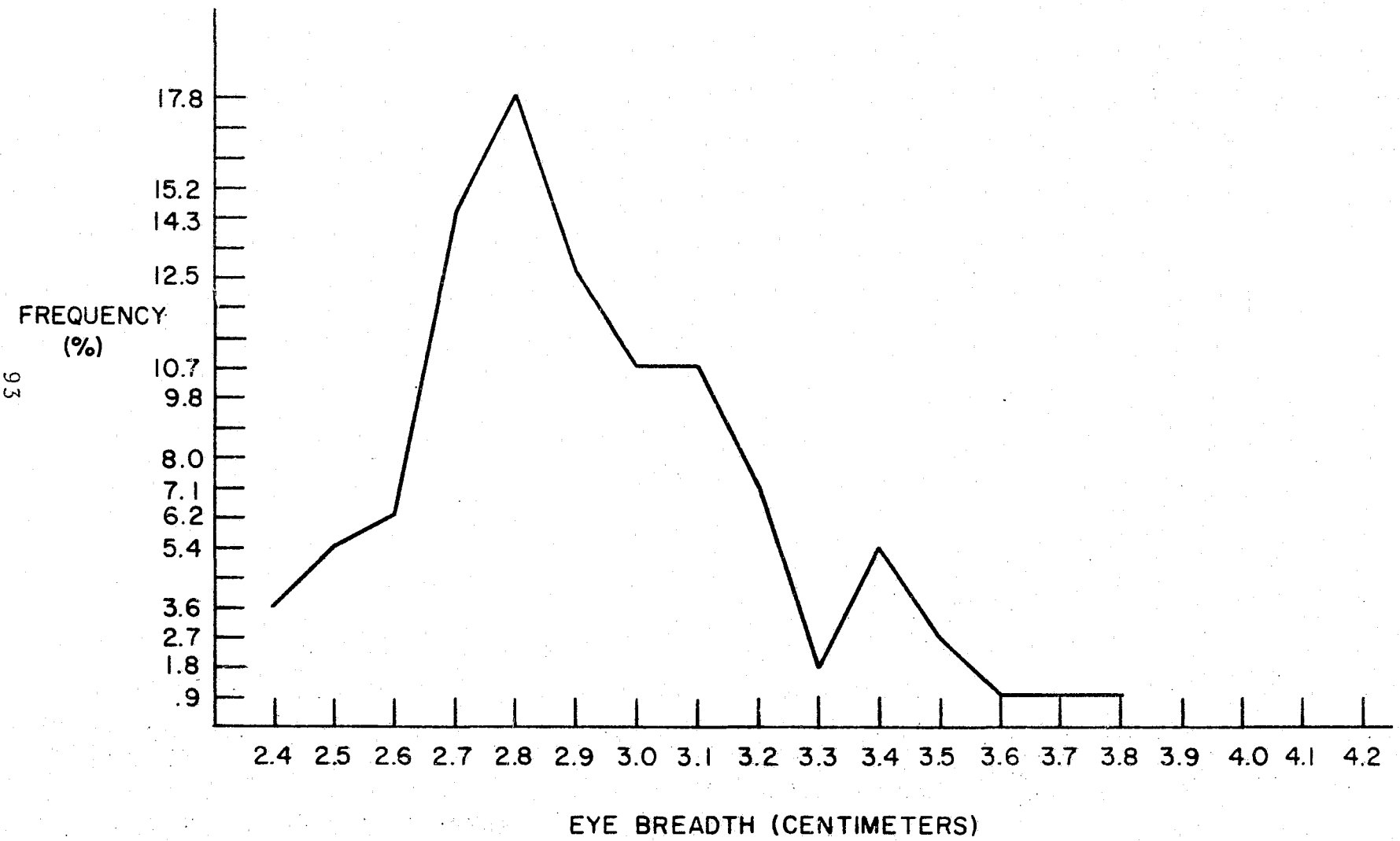
EXHIBIT 15



APPENDIX G

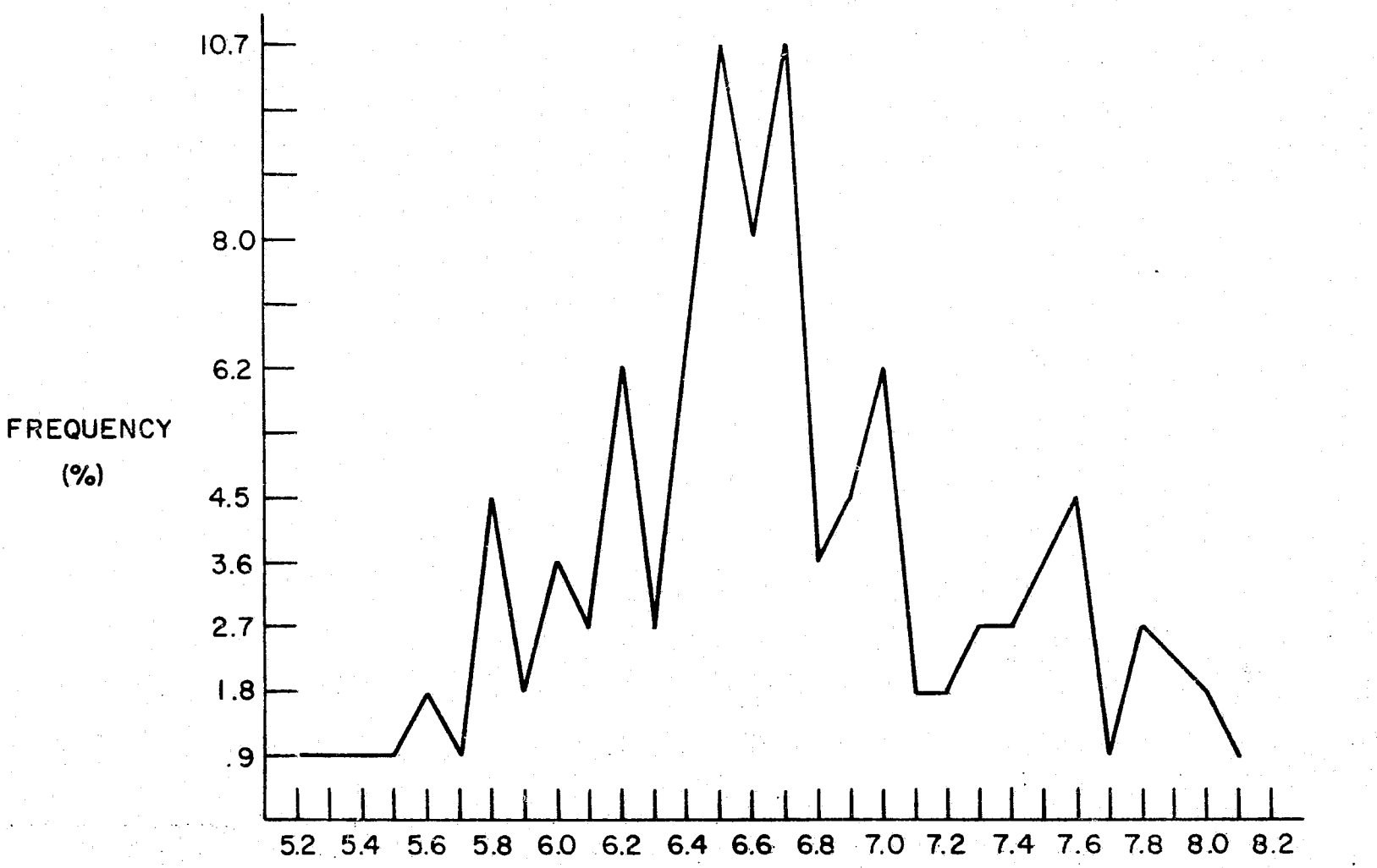
EXHIBIT 16

FREQUENCY DISTRIBUTION OF EYE BREADTH

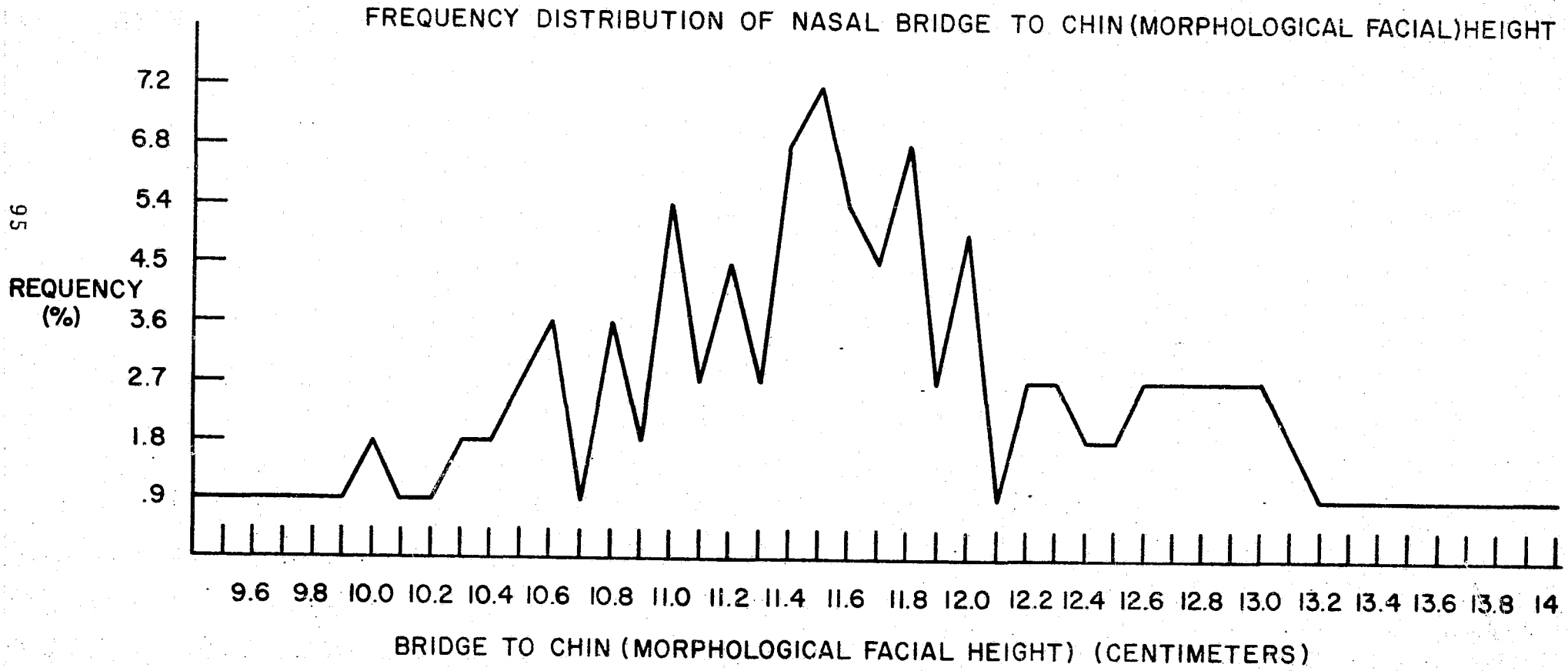


APPENDIX G
EXHIBIT 17

FREQUENCY DISTRIBUTION OF EYEBROW TO NOSE (INTER-GLABELLAR SUB-NASAL) DISTANCE

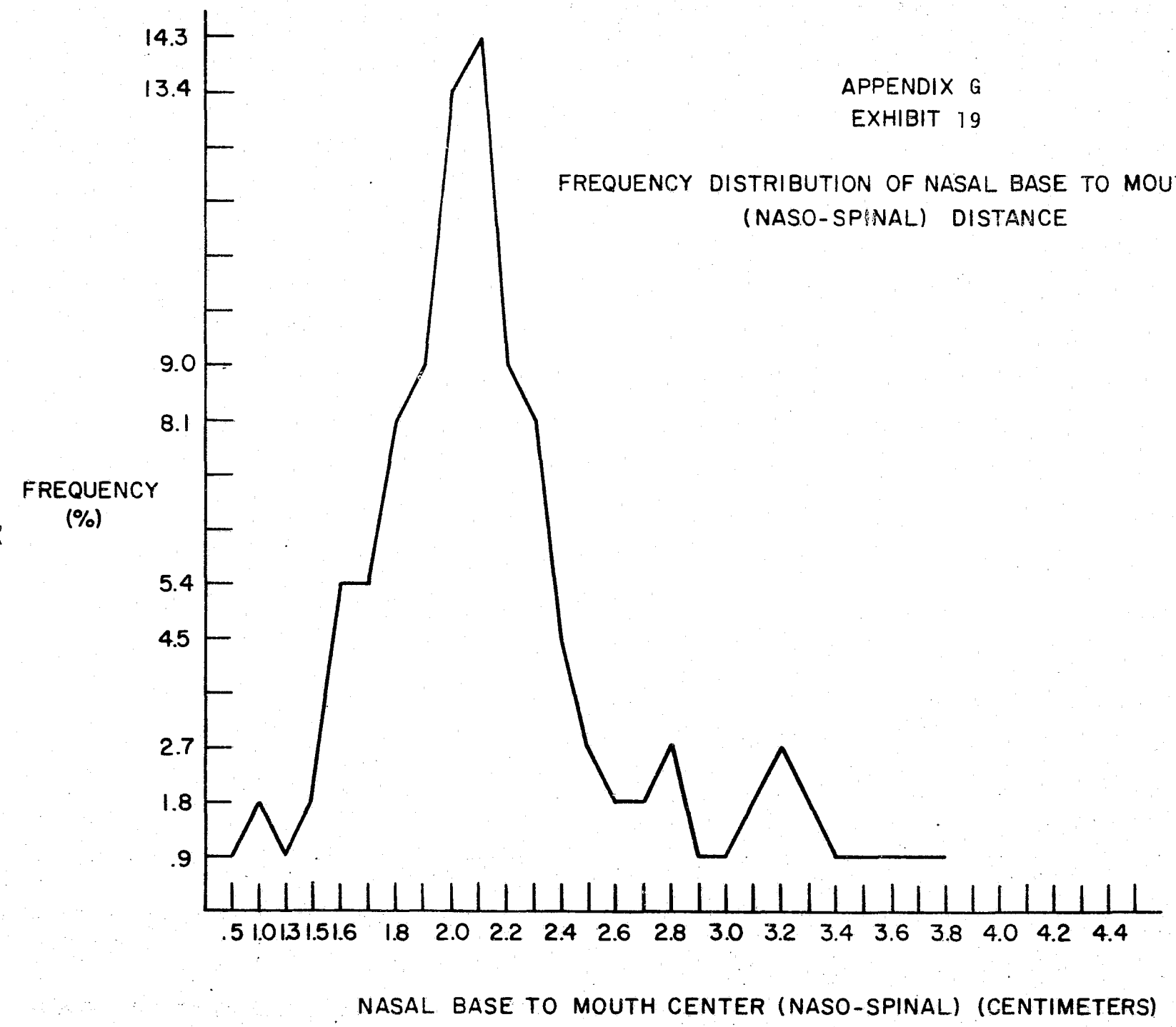


APPENDIX G
EXHIBIT 18



APPENDIX G
EXHIBIT 19

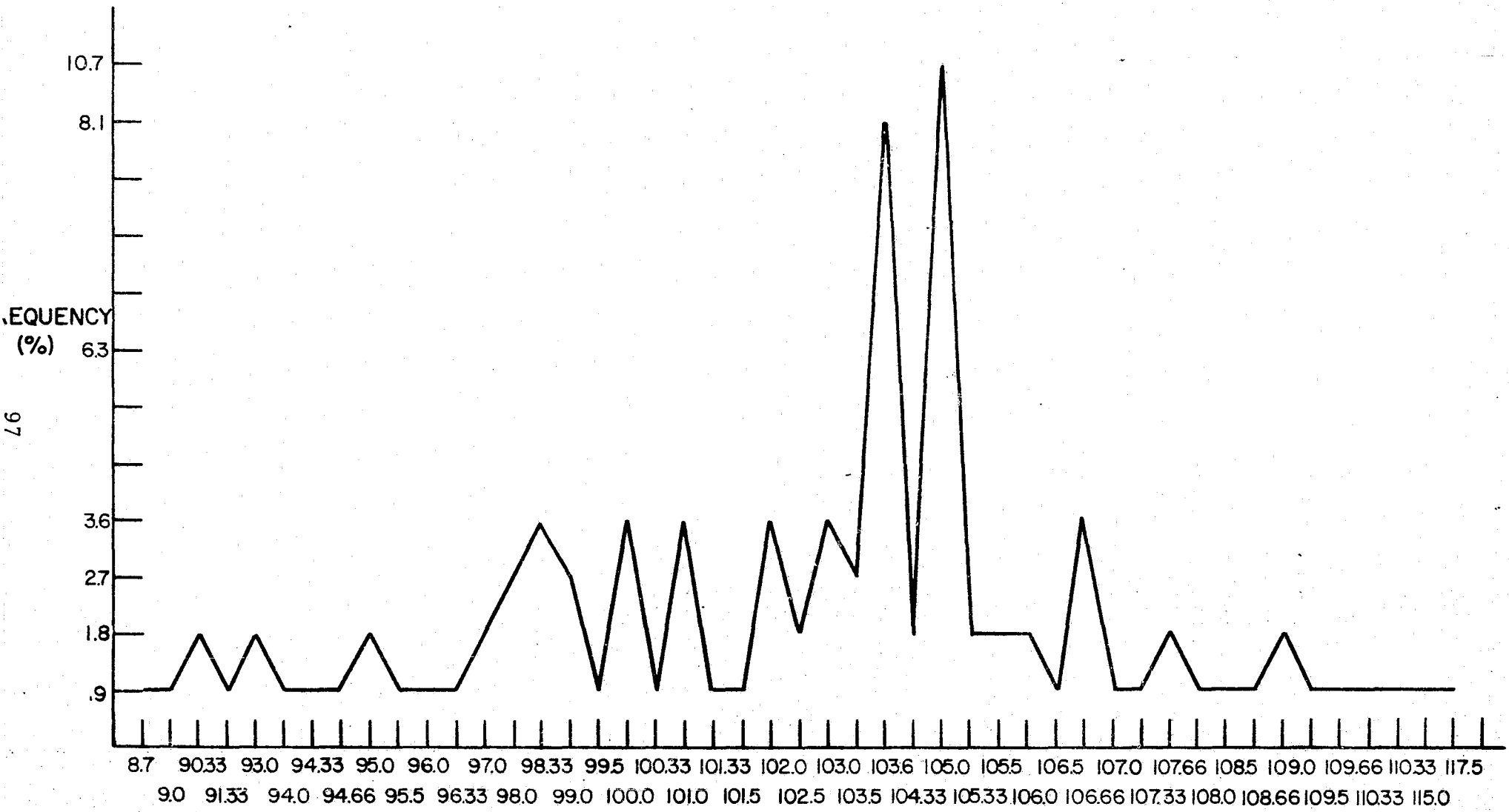
FREQUENCY DISTRIBUTION OF NASAL BASE TO MOUTH CENTER (NASO-SPINAL) DISTANCE



[redacted] PEN[redacted] G [redacted]

EXHIBIT 20

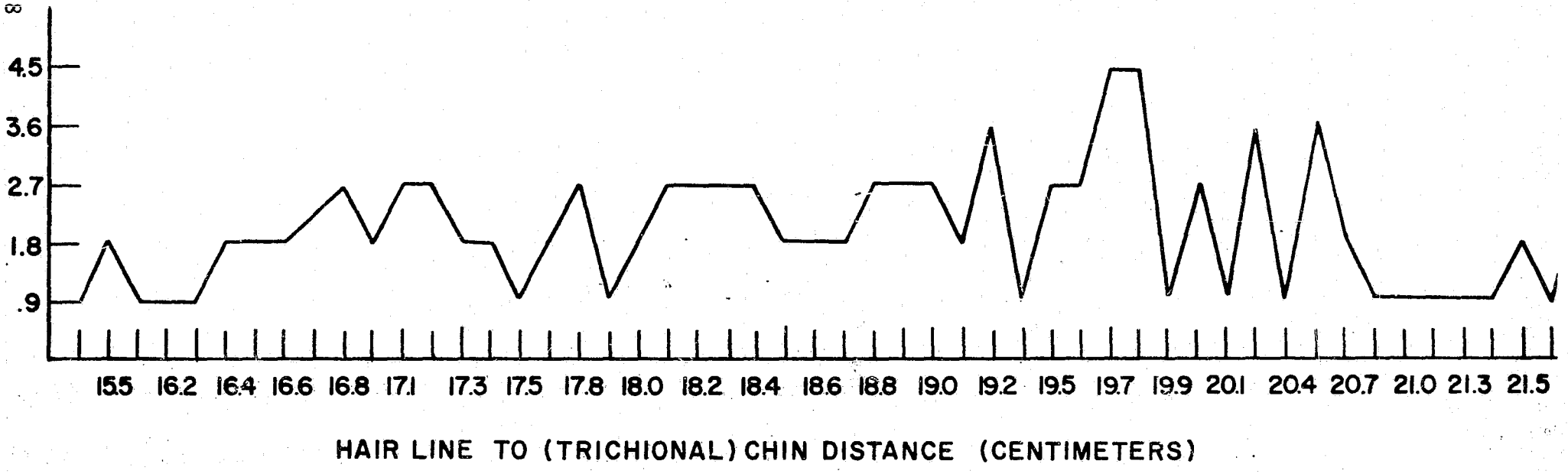
FREQUENCY DISTRIBUTION OF CHIN ANGLES



97

APPENDIX G
EXHIBIT 21

FREQUENCY DISTRIBUTION OF HAIRLINE TO CHIN (TRICHIONAL) DISTANCES



Appendix H

Exhibit 1

Eye Classification Scheme

A. Geometric Shape

1. Cigar. Characteristically this geometric configuration has the narrowest elliptical width of all of these basic shapes.

2. Dome. Similar to the cigar shape except that the lower eyelid forms a straight line which cuts through the cornea of the ocular globe.

3. Tear. Often exhibits a drooping of the lower eyelid that leaves the sclerotic exposed below the cornea. This condition is classified as the "raised iris" configuration within the F.B.I. classification.

4. Football. Widest elliptical width of all the geometric types. The upper and lower eyelids arch steeply to form the football shape. These eyes are often described as "large" or "wide-awake" eyes because such a large area of the sclerotic is exposed.

B. Size

1. Degree of opening. This classification refers to the apparent elliptical width regardless of whether it was artificially or naturally produced. It includes the following categories:

a. Narrow - represent eyes with a narrow opening. The average eye width within this group was c.m. These measurements were taken from the F.B.I. photographs.

b. Average - represents eyes with an average opening (.2 c.m.). This condition is classified as "average" within the F.B.I. classification.

c. Wide - represents eyes with a wide opening. It is difficult to establish which of the F.B.I. categories would include this specific dimension.

2. Degree of Palpebral Protrusion

a. Sunken or Deep-set eyes - both types are housed in

in deep sockets. Overhanging or re-entering eyelids are commonly found within this orbital configuration. This category is also found within the F.B.I. classification.

b. Average eyes or Medium Protrusion - represents eyes which are neither "deep-set" nor "bulging" in appearance. This category is also found within the F.B.I. classification.

c. Bulging eyes - this configuration contains bulging upper and lower eyelids. These are not usually found within deep sockets and commonly appear to be football or tear shaped. This category is also found within the F.B.I. classification.

3. Size of palpebral cleft - is the apparent distance between the inner canthus and the outer canthus of each eye. This dimension includes the following categories:

a. Small - short length (.5 c.m.).

b. Average - average length (.6 c.m.).

c. Large - long length (.7 c.m.).

C. Upper Eyelid Configuration

1. Overhanding lid - represents the extreme of the "covered eyelid" condition in which part of the eyelid structure hangs over in front of the eyeball. The location of this overhand may vary masking either the corners or the central portion of the eye. This category is also found within the F.B.I. classification.

2. Eyelid absent - represents the "covered eyelid" condition. The immovable band above the eyelid completely covers the eyelid when it is in the open position.

3. Slight eyelid - represents the "uncovered eyelid" condition in which the upper eyelid structure can barely be seen.

4. Medium eyelid - represents the "uncovered eyelid" condition for examples not found within either the "slight eyelid" or the "thick eyelid" groups.

5. Thick eyelid - represents the "uncovered eyelid" condition in which the eyelid structure forms a thick band above the eye. These eyes are classified as "heavy lid" within the F.B.I. classification.

6. Re-entering - represents the extreme of the "uncovered eyelid" condition in which the body of the ocular globe is partially isolated by a hollow or crease. These eyes are classified as "sunken" or "deep-set" within the F.B.I. classification.

D. Eye Position

1. Inter-biocular breadth - represents the distance between the inner corners of the eyes. This distance is directly related to the horizontal spread of the nasal root. Thus wide eyed individuals tend to have larger noses than narrow or average eyed individuals. This dimension includes the following categories:

   a. Narrow - refers to an inter-biocular breadth of .5 c.m. for photographs that have been standardized to the size of the V.B.I. photographs.

   b. Average - refers to an inter-biocular breadth of .6 c.m. for photographs that have been standardized to the size of the F.B.I. photographs.

   c. Wide- refers to an inter-biocular breadth of .7 c.m. for photographs that have been standardized to the size of the F.B.I. photographs.

2. Orbital distance - represents the distance between the eyeball and the supercilliary crests or eyebrows. Examples of low, average, and high eyebrow ridges could be fabricated by moving the eyebrow structures towards or away from the eye sockets. The eye types were therefore not classified according to vertical position.

E. Eye color.

Appendix H

Exhibit 1
(Continued)

Eye Color was interpreted in terms of light, medium, and dark gray tones because only black and white images could be produced with the Minolta Montage Photoblender Unit. These categories included the following:

a. Light Gray Tone - pink or blue eye color.

b. Medium Gray Tone - hazel, gray, or green eye color.

c. Dark Gray Tone - brown or black eye color.

Appendix H

Exhibit 2

Mouth Classification Scheme

A. Geometric Shape

1. Wing. Upper lip appears larger than the lower lip because it masks the outer edges of the lower lip. The "wing" appearance results from the projection of the upper lip beyond the plane of the lower lip. This is a variation of the "straight bow" category.

2. Peanut. Upper and lower lips contain an indention in the center of the mouth structure. This indention is caused by a thinning of the labial width near the philtrum.

3. Crescent. This configuration results from a combination of a thin upper lip and an average, or thick, round lower lip. The curvature of the lower lip dominates the effect of the upper lip because of its large size.

4. Straight Bow. This mouth type contains an upper lip configuration that resembles an archer's bow. The edges of the upper lip are straight and do not form the "s-shape" that is commonly found among the mouth types in the "curved bow" classification. The mouth corners usually are either "straight" or "depressed". The "depressed" condition results from the projection of the lower lip.

5. Curved Bow. This is a variation of the "straight bow" category. The edges of the upper lip form a gentle s-curve on either side of the mouth. This often results in the corners of the mouth being affected at all.

6. Football. The upper and lower lips resemble gently sloping arches which combine to form a wide ellipse or "football" shape. These lips are usually of average or thick width.

7. Heart. This "open mouth" condition often results from the projection of the front teeth, a small philtrum distance, or a large dental structure. All of these factors prevent the upper and lower lips from meeting when they are in the relaxed position.

B. Inclination of Mouth Corners. - this characteristic refers to the slope of the outermost edges (corners) of the mouth. It includes the following variations:

1. Downturned Corners. Mouths of this type commonly have downward sloping mouth lines or straight bow configurations.

2. Straight Corners. Corners of the mouth are neither downturned nor upturned.

3. Upturned Corners. Mouths of this type commonly have upward sloping mouth lines or curved bow configurations.

C. Lower Lip Configurations. This refers to the geometric shape of the lower lip. These may be combined with any of the upper lip configurations. They include two basic types:

1. Round lip. The lower lip line forms a gently sloping arch. This characteristic is most commonly observed with lips that form a wide ellipse or "football" shape.

2. Flat Lip. The lower lip line forms a horizontal line that is parallel with the mouth line. This characteristic is most commonly found with mouths that have thin lower lips.

D. Naso-labial Distance. Represents the distance between the philtrum (a vertical depression of the upper lip) and the septum (the partition separating the left and right nostrils). This distance could be adjusted by moving the mouth towards or away from the nose.

E. Size

1. Labial breadth. Refers to the distance between the corners of the mouth. Measurements of the "small," "average," and "large" mouth types within the F.B.I. classification revealed that the length of these features was the sole criterion for this categorization. Thickness of lips was not considered important. These categories were therefore included as sub-categories within the various geometric shape configurations. Thus a "small" mouth became a "mouth of narrow width," and a "large" mouth became a "mouth of wide width." Physical measurements taken from the F.B.I. photographs were used to determine the sizes of the mouths that were to be included within the following sub-categories:

a. Narrow Width. These mouth types had mouth widths of .9 c.m. or less.

b. Average Width. These mouth types had mouth widths of 1.0 c.m.

c. Wide Width. These mouth types had mouth widths of 1.1 c.m. or more.

2. Labial Thickness. Refers to the distance between the mouth line and the upper and lower edges of the lips. The lips were classified using the following F.B.I. definitions of lip size:

a. Thin. These lips had a width of .1 c.m. or less.

b. Average. These lips had a width that was not contained in group "a" or "c".

c. Thick. These lips had a width of .2 c.m. or more.

Appendix H

Exhibit 3

Nose Classification Scheme

A. Geometric Shape

1. Spear. The septum, a partition separating the right and left nostrils, extends well below the nasal tip thereby accentuating the downward slant of the nasal wings. The resulting geometric shape resembles the head of a spear with the septum representing the tip and the nasal wings representing the cutting edges. This category does not correspond with any of the categories contained within the F.B.I. classification.

2. Bulbous. The apex and the nasal wings combine to produce a concave shape. This category corresponds to the "concave" nasal group found within the F.B.I. classification.

3. Wedge. The width of the nasal root is smaller than the width of the nasal base. The lateral cartilage descends from the bridge to the nasal wings in a straight line forming the sides of an equilateral triangle while the distance between the nasal wings provides the base for this "wedge" configuration. This does not represent a category found within the F.B.I. classification.

4. Valve. The lateral surfaces of the nose form two concave arcs which intersect the base of the nasal bridge at their mid-points. These curved sides then flare outward to form the wings of the nose. Together these characteristics resemble the shape of an engine "valve." This does not represent a category found within the F.B.I. classification.

5. Rectilinear. This represents an "average" nose type. The ridge of the nose, or dorsum, descends from the bridge to the apex in a straight line. This type is often described as a nose with a "high Greek root." This category corresponds with the "average" nasal group found within the F.B.I. classification.

B. Inclination of the Nasal Tip. This characteristic refers to the position of the nasal tip. It includes the following variations:

1. Depressed tip. The nasal tip dips below the septum and masks part of the nasolabial furrow. This category is similar to the "downward tip" category contained within the F.B.I. classification.

2. Horizontal tip. The nasal tip neither dips below nor projects above the septum. These types of noses are described as "average" within the F.B.I. classification.

3. Elevated tip. The nasal tip projects upward above the septum leaving the nostrils exposed. This category is similar to the "snub nose" category contained within the F.B.I. classification.

C. Projection. This refers to the apparent distance between the septum and the nasal tip. Noses may be classified according to three categories:

1. Little projection.he distance between the septum and the nasal tip is very small. The nasal tip often appears as if it has been squashed against the face.

2. Medium projection. The distance between the tip and the septum is neither "small" nor "large."

3. Great projection. The distance between the septum and the nasal tip is large. The nasal tip appears as if it has been elongated.

D. Size. The F.B.I. system classified noses according to apparent size (i.e. small; average; large) and nasal width (i.e. narrow; average; wide.) The present system was designed to allow for a more precise classification of nasal size. This classification included the following dimensions:

1. Nasal breadth. Refers to the greatest transverse distance between the two wings. These distances were defined using the following F.B.I. definitions of nasal width:

a. Narrow. These noses had a width of .6 c.m. or less.

b. Average. These noses had a width of .6 c.m.

c. Wide. These noses had a width of .7 c.m. or more

2. Nasal length. Refers to the distance between the nasal root and the septum. These distances were defined using the following

Appendix H

Exhibit 3
(Continued)

F.B.I. definitions of nasal length:

a. Short. These noses had a length of .8 c.m. or less.

b. Medium. These noses had a length of 1.0 c.m.

c. Long. These noses had a length greater than 1.0 c.m.

Appendix H

Exhibit 4

Eyebrow Classification Scheme

A. Geometric Shape

1. Rectilinear. These eyebrow shapes resemble straight lines. The eyebrow body and tail fall on the same plane.

2. Rectilinear depressed. These eyebrow shapes have tails that slant downward at either 45^{o} or 90^{o}. These tails may also differ in shape being either rectilinear (i.e. straight) or curved. This results in the following four categories:

   a. Straight 45^{o}.

   b. Straight 90^{o}.

   c. Curved 45^{o}.

   d. Curved 90^{o}.

3. Sinuous. These eyebrow shapes resemble a wave-like pattern.

4. Arched. These eyebrow shapes form an arch above the supercilliary crests.

B. Size

1. Inter-head distance. This refers to the distance between the left and the right eyebrow heads. These distances were determined using the following F.B.I. definitions of inter-head size:

   a. Narrow. The distance between the heads is less than or equal to .2 c.m.

   b. Average. The distance between the heads is .3 c.m. or .4 c.m.

   c. Wide. The distance between the heads is greater than or equal to .5 c.m.

2. Eyebrow Length. This refers to the distance between the eyebrow head and the eyebrow tail. When the distances for the right and the left eyebrows are dissimilar then the larger measurement is

used. Eyebrow types were classified according to the following F.B.I. definitions of eyebrow length:

a. Short. Eyebrows have a length between .6 c.m. and .7 c.m.

b. Average. Eyebrows have a length between .8 c.m. and .9 c.m.

c. Long. Eyebrows ahve a length greater than or equal to 1.0 c.m.

C. Eyebrow Position. This refers to the angle of theslope of the eyebrow bodies. Lateral movement also could not be manipulated with the machine's hardware so the eyebrows were classified according to the inter-head distance (see eyebrow size). Vertical movement, however, could be manipulated by moving these features within the photograph holders. The following are the three basic eyebrow positions:

1. Oblique Internal. The eyebrows slope upward from the center of the supercilliary crests at an angle of 45^{o}.

2. Straight. The eyebrows form a horizontal line that is parallel with the inter-Pupillary line.

3. Oblique External. The eyebrows slope downward from the center of the supercilliary crests at a 45^{o} angle.

D. Eyebrow thickness. This refers to the width of the eyebrow structure. The following are the basic categories according to the F.B.I. classification system:

1. Thin. Eyebrow width is less than .1 c.m. These eyebrow types usually are linear in appearance.

2. Average. Eyebrow width is between .1 c.m. and .125 c.m.

3. Sparse. A variation of the "average" category. These eyebrow types do not contain a large quantity of eyebrow hairs. The underlying skin is often visible through the hairs.

4. Thick. Eyebrow width is between .15 c.m. and .2 c.m.

5. Bushy. Variation of "thick" eyebrow type. These eyebrow types usually contain an overabundance of hairs which give the eyebrow structure a "ragged" appearance.

Appendix H

Exhibit 5

Hair Style Calssification Scheme

A. Geometric Shape. The hair styles were classified according to the facial settings in which they were found. This included the following five geometrical categories:

1. Square. The forehead width and cheekbone width are the same size as the facial length. These faces usually have large jowls and a square shaped chin.

2. Round. These hair styles share the same characteristics as the "square" hair styles. The round appearance, however, is produced by the curve of the hair style or the hair line and the apparent "roundness" of the chin line.

3. Oval. The cheekbonres represent the widest region of the face which is roughly 2/3 of the facial length. The hair styles and chin lines of this group differ from those found in the "round" category in that they resemble the steep curve of a parabolic arch.

4. Egg. The forehead width is the same size or larger than the cheekbone width. Thus wide hair styles (i.e. "square" or "round") are commonly found with examples of this geometric shape. The chin lines invariably resemble parabolic arches with steeply sloping sides (i.e. "pointed" chins).

5. Oblong. These appear as long, thin faces. The cheekbone width is usually very narrow being equal to less than 1/2 of the facial length.

6. Diamond. The cheekbone width is the same size that is found with "oval" shaped faces. The "diamond" appearance results from the combination of a "narrow" forehead and a "pointed" chin line.

B. Size

1. Width. Represents the distance between the cheekbones (i.e. bizygomatic breadth). These distances were defined using the following F.B.I. definitions of facial width:

a. Narrow. The distance between the cheekbones is 2.0 c.m.

b. Average. The distance between the cheekbones is 2.4 c.m.

c. Wide. The distance between the cheekbones is 3.0 c.m.

2. Length. This measurement was not taken because it was not important in the selection of the sizes of the hair styles and the chin lines. Facial width, however, had to be similar for both the chin line and the hair style in order for the focal lengths of the inputs to remain at the same settings. This control prevented the distortion of the feature characteristics (i.e. size) by standardizing all of the features to normality.

C. Hair Length.

1. Short. The hair style follows the contours of the head closely usually leaving the forehead and the ears exposed.

2. Medium. The hair styles covers the ears to the ear lobes.

3. Long. The hair style length obscures the forehead region and descends below the collar.

4. Bald. Or receding hair line.

D. Hair structure. This refers to the character of the hair which is determined by the hair follicle. It includes the following categories:

1. Straight. The hair grows from a straight follicle and does not have either a "kinky" or "wavy" appearance.

2. Wavy. The hair grows from a curved follicle which leaves the hair with a curly appearance.

3. Kinky. This hair style consists of small, tight curls or tufts of hair which give it a "frizzy" appearance.

E. Hair Color. This was difficult to determine because only black-and-white photographs could be used with the system. Hair style color was therefore defined in terms of the following gray tones:

1. Dark. These hairstyles appeared to be "black" when displayed on the television monitor. These hair styles were often black or dark brown in color.

Appendix H

Exhibit 5
(Continued)

2. Medium. These hair styles appeared to be "dark gray" on the television monitor. These hair styles were either "light brown", "dark blonde," or "red" in color.

3. Light. These "blonde" or "light blonde" hair styles appeared to be "light gray" on the television monitor.

Appendix H

Exhibit 6

Chin Line Classification Scheme

A. Geometric Shape. This refers to the apparent geometric shape of the lower jaw or chin line. The F.B.I. classification of the chin line dealt only with the chin and did not take the variation of the chin line into account. Below is a listing of the four basic chin line shapes:

1. Parabolic arch. This resembles a "U-shaped" curved or parabola.

2. Angular. The sides of the face do not curve outward (i.e. parabolic arch) but are parallel with one another and perpendicular to the mouth line.

3. Square. The sides of the face are "angular" with the cheekbone width equaling the head length.

4. Round. The sides of the face are "round" with the cheekbone width equaling the head length.

B. Chin shape. This refers to the shape of the mental protuberance or the projection at the chin. These are divided into the following five chin shapes:

1. Round. The chin resembles a circular curve. These chins are labeled as "average" within the F.B.I. classification system.

2. Flat. The edge of the chin forms a straght line that is parallel with the mouth line. These chins are classified as "square" within the F.B.I. classification system.

3. Pointed. The edges of the chin form straight lines that converge forming a "V" shape. This category is also found in the F.B.I. classification system.

4. Bilobed. The chin has a centrally located cleft or dimple. These chins are labeled as "cleft" or "dimple" within the F.B.I. classification system.

5. Angular, flat. This chin type is only fond with "parabolic arch" chin lines. This category is a combination of the "pointed" and the "flat" chin types. The sides of the chin converge without

forming a point because they combine with the flat surface that represents the tip of the chin. This chin type is classified as being "square" within the F.B.I. system.

C. Chin Protrusion. This refers to the forward or backward tilt of the chin tip. The chin may be described as being in one of the following categories:

1. Jutting. The chin tip projects forward forming a small bulge at the end of the chin. This category is also found within the F.B.I. classification system.

2. Average. This chin type does not fall into the "jutting" or the "receding" categories. The F.B.I. classification also includes this category within its system.

3. Receding. The chin tip does not project beyond the edge of the upper jaw but instead retreats behind it. This category is also found within the F.B.I. classification system.

D. Chin Distinction. This refers to the sharpness of the chin line contours. The basic categories are listed below:

1. Indistinct. The contour of the chin line is not readily visible because of the deposition of fat around the lower jaw. The affected areas can be the sides of the jaw, the chin tip, or even the entire region. In this extreme condition the lower jaw appears to merge with the neck. This category does not exist within the F.B.I. classification system.

2. Distinct. The contours of the chin line are clearly visible. This category can not be found within the F.B.I. classification system.

3. Double. The contours of the chin line are visible. However, a deposition of fat near the throat on the underside of the lower jaw creates a "second chin" from these skin folds. This category is found within the F.B.I. classification system.

E. Size.

Appendix H

Exhibit 6
(Continued)

1. Width. Represents the distance between the cheekbones. These distances were defined using the following F.B.I. definitions of facial width:

   a. Narrow. The distance between the cheekbones is 2.0 c.m.

   b. Average. The distance between the cheekbones is 2.4 c.m.

   c. Wide. The distance between the cheekbones is 3.0 c.m.

2. Length. This measurement was not needed since each chin line type was classified according to its geometric shape.

Appendix I
Exhibit 1
Eye Classification Chart

	OVERHANGING LID								
	OUTER CANTHUS	CENTRAL DEPRESSION	INNER CANTHUS	EYELID ABSENT	SLIGHT EYELID	MEDIUM EYELID	THICK EYELID	RE-ENTERING EYELID	
NARROW									
AVERAGE									DEEP-SET
WIDE									
NARROW									
AVERAGE									AVERAGE
WIDE									
NARROW									
AVERAGE									PROTRUDING
WIDE									

Appendix I
Exhibit 2
Mouth Classification Chart

THIN UPPER	THIN UPPER	THIN UPPER	AVERAGE UPPER	AVERAGE UPPER	AVERAGE UPPER	THICK UPPER	THICK UPPER	THICK UPPER
THIN LOWER	AVERAGE LOWER	THICK LOWER	THIN LOWER	AVERAGE LOWER	THICK LOWER	THIN LOWER	AVERAGE LOWER	THICK LOWER
								NARROW
								AVERAGE
								WIDE

Appendix I
Exhibit 3
Nose Classification Chart

NASAL WIDTH				NASALWIDTH				NASAL WIDTH				
FLARED	WIDE	AVERAGE	NARROW	FLARED	WIDE	AVERAGE	NARROW	FLARED	WIDE	AVERAGE	NARROW	
												SHORT LENGTH
												MEDIUM LENGTH
												LONG LENGTH

Appendix I
Exhibit 4
Eyebrow Classification Chart

INTER-HEAD DISTANCE				INTER-HEAD DISTANCE				INTER-HEAD DISTANCE				
WIDE	AVERAGE	NARROW	MEETING	WIDE	AVERAGE	NARROW	MEETING	WIDE	AVERAGE	NARROW	MEETING	
												SPARSE
												THIN
												MEDIUM
												THICK
												BUSHY

Appendix I
Exhibit 5
Hair Style Classification Chart

HAIR COLOR			HAIR COLOR			HAIR COLOR			
DARK	MEDIUM	LIGHT	DARK	MEDIUM	LIGHT	DARK	MEDIUM	LIGHT	
									LONG
									MEDIUM
									SHORT
									BALD

Appendix I
Exhibit 6
Chin Line Classification Chart

PROTRUSION OF CHIN			PROTRUSION OF CHIN			PROTRUSION OF CHIN			
RECEDING	AVERAGE	JUTTING	RECEDING	AVERAGE	JUTTING	RECEDING	AVERAGE	JUTTING	
									DOUBLE
									INDISTINCT
									DISTINCT

Appendix J
Exhibit 1

Eye Types Used in Software System

(See Key at End of Appendix for Picture Code)

Physical Dimensions Along Which the Feature Varies

Shape	Length	Internal Biocular Breadth	Upper Eyelid	Protrusion	Width	Picture Code
Cigar	Small	Narrow	Re-entering	Deep set	Narrow	KB4-9
Cigar	Small	Narrow	Slight	Average	Narrow	T33
Cigar	Small	Narrow	Re-entering	Average	Narrow	KB6-R
Cigar	Small	Narrow	Slight	Average	Average	KB6-9
Cigar	Small	Narrow	Slight	Average	Average	T 79
Cigar	Small	Narrow	Slight	Average	Wide	W 100
Cigar	Small	Average	Absent	Average	Narrow	T 43
Cigar	Small	Average	Outer canthus	Average	Average	KB9-4
Cigar	Small	Average	Outer canthus	Average	Average	KB1-3
Cigar	Small	Average	Absent	Average	Average	T 87
Cigar	Small	Average	Absent	Average	Average	T 52
Cigar	Small	Average	Slight	Average	Average	T 03
Cigar	Small	Average	Slight	Average	Wide	KB1-8
Cigar	Small	Average	Slight	Average	Wide	T 60
Cigar	Small	Wide	Slight	Average	Average	KB 7-9
Cigar	Small	Wide	Medium	Average	Wide	KB 5-1
Cigar	Average	Narrow	Slight	Average	Wide	T 70
Cigar	Average	Average	Outer Canthus	Average	Average	KB 9-8
Cigar	Average	Average	Absent	Average	Average	T 55
Cigar	Average	Average	Slight	Average	Average	T 71
Cigar	Average	Average	Absent	Average	Wide	T 20
Cigar	Average	Average	Slight	Average	Wide	T 07
Cigar	Average	Average	Medium	Bulging	Average	KB 8-6
Cigar	Average	Wide	Outer Canthus	Average	Average	KB 7-8
Cigar	Average	Wide	Medium	Average	Average	KB 8-4
Cigar	Average	Wide	Thick	Bulging	Narrow	KB 8-9
Cigar	Average	Wide	Medium	Bulging	Average	KB 8-8
Cigar	Large	Average	Medium	Average	Average	KB 7-4
Cigar	Large	Wide	Slight	Average	Average	KB 7-2
Cigar	Large	Wide	Medium	Bulging	Average	KB 8-2
Cigar	Large	Wide	Slight	Bulging	Wide	KB 1-4

Appendix J
Exhibit 1

Eye Types Used in Software System

(See Key at End of Appendix for Picture Code)

Physical Dimensions Along Which the Feature Varies

Shape	Length	Internal Biocular Breadth	Upper Eyelid	Protrusion	Width	Picture Code
Tear	Small	Narrow	Outer Canthus	Deep-set	Average	KB 6-1
Tear	Small	Narrow	Slight	Average	Average	T 47
Tear	Small	Average	Average	Deep-set	Average	KB 4-1
Tear	Small	Average	Slight	Average	Narrow	T 32
Tear	Small	Average	Slight	Average	Average	W 97
Tear	Small	Average	Medium	Average	Average	T 14
Tear	Small	Average	Slight	Average	Wide	T 12
Tear	Small	Average	Absent	Bulging	Wide	T 58
Tear	Small	Average	Slight	Bulging	Wide	T 45
Tear	Average	Average	Re-entering	Deep-set	Wide	KB 4-7
Tear	Average	Average	Slight	Average	Average	KB 1-1
Tear	Average	Average	Slight	Average	Wide	T 08
Tear	Average	Average	Medium	Average	Wide	KB 5-12
Tear	Average	Average	Central Depression	Bulging	Average	KB 2-7
Tear	Average	Average	Slight	Bulging	Wide	T 46
Tear	Average	Average	Thick	Bulging	Wide	KB 2-8
Tear	Average	Average	Re-entering	Bulging	Wide	T 24
Tear	Average	Wide	Re-entering	Average	Wide	KB 5-5
Tear	Average	Wide	Absent	Bulging	Wide	KB 8-6
Tear	Average	Wide	Medium	Bulging	Wide	KB 2-12
Tear	Large	Average	Slight	Bulging	Average	KB 2-3
Football	Small	Narrow	Absent	Deep-set	Average	KB 4-4
Football	Small	Narrow	Central Depression	Average	Average	KB 1-2
Football	Small	Narrow	Slight	Average	Average	T 27
Football	Small	Narrow	Re-entering	Bulging	Average	KB 5-6
Football	Small	Average	Absent	Deep-set	Average	KB 4-6
Football	Small	Average	Absent	Deep-set	Average	KB 5-11
Football	Small	Average	Outer Canthus	Average	Average	KB 9-1
Football	Small	Average	Slight	Average	Average	KB 1-10
Football	Small	Average	Slight	Average	Average	T 61
Football	Small	Average	Slight	Average	Average	T 11
Football	Small	Average	Medium	Average	Average	T 94

Appendix J
Exhibit 1

Eye Types Used in Software System

(See Key at End of Appendix for Picture Code)

Physical Dimensions Along Which the Feature Varies

Shape	Length	Internal Biocular Breadth	Upper Eyelid	Protrusion	Width	Picture Code
Football	Small	Average	Slight	Average	Wide	KB 5-9
Football	Small	Average	Slight	Average	Wide	T 16
Football	Small	Average	Slight	Bulging	Wide	W 170
Football	Small	Wide	Outer Canthus	Average	Average	KB 7-7
Football	Small	Wide	Absent	Average	Average	T 40
Football	Small	Wide	Absent	Average	Average	T 34
Football	Small	Wide	Medium	Average	Wide	KB 5-10
Football	Small	Wide	Re-entering	Bulging	Average	KB 4-8
Football	Small	Wide	Re-entering	Bulging	Average	KB 7-1
Football	Small	Wide	Medium	Bulging	Wide	KB 2-5
Football	Average	Average	Slight	Deep-set	Average	T 68
Football	Average	Average	Absent	Average	Average	KB 1-11
Football	Average	Average	Slight	Average	Average	KB 1-5
Football	Average	Average	Medium	Average	Wide	KB 5-4
Football	Average	Average	Medium	Bulging	Average	KB 1-7
Football	Average	Average	Absent	Bulging	Wide	KB 2-11
Football	Average	Average	Re-entering	Bulging	Wide	KB 2-1
Football	Average	Wide	Re-entering	Bulging	Average	KB 8-7
Football	Average	Wide	Absent	Bulging	Widw	KB 2-9
Football	Large	Wide	Slight	Average	Wide	W 58
Dome	Small	Narrow	Outer Canthus	Average	Narrow	KB 3-6
Dome	Small	Narrow	Slight	Average	Average	T 50
Dome	Small	Average	Medium	Deep-set	Wide	KB 3-5
Dome	Small	Average	Slight	Average	Narrow	KB 3-8
Dome	Small	Average	Absent	Average	Average	T 22
Dome	Small	Average	Slight	Average	Average	T 78
Dome	Small	Average	Slight	Average	Average	T 80
Dome	Small	Average	Slight	Bulging	Average	KB 1-90
Dome	Small	Wide	Outer Canthus	Average	Narrow	KB 3-1
Dome	Small	Wide	Outer Canthus	Average	Narrow	KB 3-9
Dome	Small	Wide	Absent	Average	Narrow	KB 3-7
Dome	Small	Wide	Outer Canthus	Average	Average	KB 7-6
Dome	Small	Wide	Absent	Average	Average	T 49
Dome	Average	Narrow	Outer Canthus	Average	Average	KB 9-11
Dome	Average	Narrow	Slight	Average	Average	KB 1-12
Dome	Average	Narrow	Outer Canthus	Deep-set	Narrow	KB 3-11
Dome	Average	Average	Outer Canthus	Deep-set	Average	KB 9-6

Appendix J
Exhibit 1

Eye Types Used in Software System

(See Key at End of Appendix for Picture Code)

Physical Dimensions Along Which the Feature Varies

Shape	Length	Internal Biocular Breadth	Upper Eyelid	Protrusion	Width	Picture Code
Dome	Average	Average	Outer Canthus	Average	Narrow	KB 9-10
Dome	Average	Average	Slight	Average	Narrow	KB 1-6
Dome	Average	Average	Outer Canthus	Average	Average	KB 9-2
Dome	Average	Average	Central Depression	Average	Average	KB 9-9
Dome	Average	Average	Medium	Average	Average	T 23
Dome	Average	Wide	Outer Canthus	Average	Narrow	KB 3-6
Dome	Average	Wide	Outer Canthus	Average	Narrow	KB 9-12
Dome	Average	Wide	Outer Canthus	Average	Average	KB 9-3
Dome	Large	Average	Absent	Average	Wide	T 42

Appendix J
Exhibit 2

Mouth Types Used in Software System

Physical Dimensions Along Which the Feature Varies

Shape	Corners	Lower Lip Shape	Mouth Width	Upper Lip Thickness	Lower Lip Thickness	Picture Code
Peanut	Depressed	Round	Wide	Average	Average	T 68
Peanut	Straight	Round	Narrow	Thin	Thin	T 87
Peanut	Elevated	Round	Narrow	Thin	Thin	T 71
Wing	Straight	Round	Narrow	Thin	Thin	T 80
Wing	Straight	Round	Narrow	Thin	Thin	W 100
Wing	Straight	Round	Narrow	Average	Average	T 41
Wing	Straight	Round	Narrow	Average	Average	T 52
Wing	Straight	Round	Narrow	Average	Thick	T 08
Wing	Straight	Round	Average	Thin	Thick	T 07
Crescent	Elevated	Round	Narrow	Thin	Average	T 60
Straight Bow	Straight	Round	Narrow	Thin	Thick	T 47
Straight Bow	Straight	Round	Narrow	Average	Average	T 79
Straight Bow	Straight	Round	Narrow	Thick	Thick	T 03
Straight Bow	Straight	Round	Average	Average	Average	T 49
Straight Bow	Elevated	Round	Narrow	Thin	Average	W 170
Straight Bow	Elevated	Round	Narrow	Average	Average	T 94
Straight Bow	Straight	Flat	Narrow	Thin	Thin	T 14
Curved Bow	Depressed	Round	Narrow	Thin	Average	T 43
Curved Bow	Elevated	Round	Narrow	Thin	Thin	T 78
Curved Bow	Elevated	Round	Narrow	Thin	Average	T 27
Curved Bow	Elevated	Round	Narrow	Average	Thick	T 24
Curved Bow	Elevated	Round	Average	Thin	Average	T 16
Curved Bow	Elevated	Flat	Narrow	Thin	Thin	T 32
Curved Bow	Elevated	Flat	Narrow	Thin	Thick	T 35
Heart	Straight	Round	Narrow	Thin	Average	T 55
Heart	Straight	Round	Narrow	Thick	Thick	T 50
Heart	Straight	Round	Average	Thin	Average	T 42
Football	Straight	Round	Narrow	Thin	Thick	T 58
Football	Straight	Round	Narrow	Average	Average	T 33
Football	Straight	Round	Narrow	Average	Average	T 46
Football	Straight	Round	Narrow	Average	Thick	T 70
Football	Straight	Round	Average	Average	Average	T 61
Football	Straight	Round	Wide	Thick	Thick	W 58
Football	Elevated	Round	Average	Average	Thick	T 23

Appendix J
Exhibit 3

Eyebrow Types Used in Software System

Physical Dimensions Along White the Feature Varies

Shape	Body Angle	Body Length	Thick-ness	Tail Shape	Tail Angle	Inter-head Distance	Picture Code
Rectilinear	Oblique Internal	Average	Medium	Curved	45°	Average	T 46
Rectilinear	Oblique Internal	Average	Medium	Curved	45°	Average	T 61
Rectilinear	Oblique Internal	Short	Medium	Curved	45°	Wide	T 79
Rectilinear	Ob.Int.	Short	Medium	Curved	45°	Average	T 47
Rectilinear	Straight	Short	Thin	Curved	45°	Wide	T 34
Rectilinear	Straight	Average	Medium	Curved	45°	Wide	T 08
Rectilinear	Straight	Average	Medium	Curved	45°	Average	T 70
Rectilinear	Straight	Short	Medium	Curved	45°	Average	T 87
Rectilinear	Straight	Average	Sparse	Curved	90°	Wide	T 52
Rectilinear	Ob.Int.	Average	Thick	Recti-linear	45°	Average	T 32
Rectilinear	Ob. Int.	Average	Thick	Recti-linear	45°	Average	T 68
Rectilinear	Ob.Int.	Average	Medium	None	None	Average	T 20
Rectilinear	Straight	Long	Sparse	None	None	Wide	T 16
Rectilinear	Straight	Average	Sparse	None	None	Wide	T 55
Rectilinear	Straight	Short	Sparse	None	None	Wide	T 40
Rectilinear	Straight	Short	Thin	None	None	Wide	T 94
Rectilinear	Straight	Short	Medium	None	None	Average	T 27
Rectilinear	Ob. Int.	Average	Sparse	None	None	Wide	T 49
Rectilinear	Ob.Int.	Short	Medium	None	None	Wide	T 23
Rectilinear	Ob. Int.	Average	Bushy	None	None	Wide	T 12
Arched	Straight	High Arch	Sparse	None	None	Average	T 45
Arched	Straight	Med. Arch	Medium	None	None	Wide	W 100
Arched	Straight	Med. Arch	Medium	None	None	Average	T 80
Arched	Straight	Low Arch	Medium	None	None	Wide	T 22
Arched	Straight	Med. Arch	Bushy	None	None	Wide	T 07
Arched	Ob.Ext.	Med. Arch	Sparse	None	None	Wide	T 39
Arched	Ob.Ext.	Med. Arch	Sparse	None	None	Wide	T 71
Arched	Ob.Ext.	Low Arch	Sparse	None	None	Wide	T 43
Arched	Ob.Ext.	Low Arch	Sparse	None	None	Wide	T 58
Arched	Ob. Ext.	Med. Arch	Thin	None	None	Wide	T 14
Arched	Ob.Ext.	Med.Arch	Medium	None	None	Wide	T 24
Arched	Ob.Ext.	Med.Arch	Medium	None	None	Average	T 33
Arched	Ob.Ext.	Med. Arch	Thick	None	None	Wide	T 03

Appendix J
Exhibit 4

Nose Types Used in Software System

Physical Dimensions Along Which the Feature Varies

Shape	Projection	Width	Length	Nasal Elevation	Picture Code
Spear	Great	Average	Short	Straight	T 87
Spear	Great	Average	Short	Depressed	T 27
Spear	Great	Wide	Long	Straight	T 71
Bulbous	Medium	Flared	Short	Straight	T 52
Bulbous	Medium	Flared	Short	Depressed	T 40
Bulbous	Medium	Average	Medium	Depressed	T 45
Bulbous	Great	Wide	Short	Upturned	T 68
Bulbous	Great	Flared	Medium	Straight	T 61
Bulbous	Great	Average	Medium	Straight	T 16
Rectilinear	Medium	Flared	Short	Upturned	T 33
Rectilinear	Medium	Average	Short	Upturned	T 43
Rectilinear	Medium	Average	Short	Straight	T 55
Rectilinear	Medium	Average	Short	Straight	T 12
Rectilinear	Medium	Average	Short	Straight	T 49
Rectilinear	Medium	Average	Short	Straight	W 100
Rectilinear	Medium	Average	Medium	Straight	T 58
Rectilinear	Great	Flared	Short	Upturned	T 08
Rectilinear	Great	Average	Short	Upturned	T 03
Rectilinear	Great	Flared	Short	Straight	T 20
Rectilinear	Great	Wide	Short	Straight	T 23
Rectilinear	Great	Average	Short	Straight	W 97
Rectilinear	Great	Average	Medium	Depressed	T 47
Rectilinear	Great	Wide	Long	Straight	T 24
Wedge	Medium	Wide	Short	Upturned	T 50
Wedge	Medium	Wide	Short	Straight	T 32
Wedge	Medium	Wide	Short	Straight	T 79
Wedge	Medium	Average	Short	Straight	T 78
Wedge	Medium	Narrow	Short	Straight	T 94
Wedge	Medium	Flared	Medium	Upturned	T 70
Wedge	Medium	Wide	Medium	Straight	T 41
Wedge	Medium	Wide	Long	Upturned	T 42
Wedge	Great	Flared	Short	Straight	T 07
Wedge	Great	Wide	Short	Straight	T 34
Wedge	Great	Average	Short	Straight	T 14
Valve	Little	Wide	Short	Straight	T 22

Appendix J
Exhibit 5

Chin Line Types Used in Software System

Physical Dimensions Along Which the Feature Varies

Chin Line Shape	Bizygomatic Breadth	Chin Shape	Chin Protrusion	Facial Contour	Picture Code
Parabolic Arch	Average	Round	Jutting	Double	T 22
Parabolic Arch	Average	Round	Average	Indistinct	T 50
Parabolic Arch	Wide	Round	Average	Distinct	T 71
Parabolic Arch	Wide	Round	Average	Distinct	T 42
Parabolic Arch	Wide	Round	Jutting	Distinct	W 58
Parabolic Arch	Average	Round	Average	Distinct	T 45
Parabolic Arch	Average	Round	Average	Distinct	T 60
Parabolic Arch	Average	Round	Average	Distinct	T 61
Parabolic Arch	Average	Round	Average	Distinct	W 100
Parabolic Arch	Average	Round	Average	Distinct	T 52
Parabolic Arch	Average	Round	Jutting	Distinct	T 12
Parabolic Arch	Average	Round	Jutting	Distinct	T 14
Parabolic Arch	Average	Round	Jutting	Distinct	T 23
Parabolic Arch	Average	Round	Jutting	Distinct	T 87
Parabolic Arch	Average	Flat	Jutting	Distinct	T 49
Parabolic Arch	Average	Pointed	Receding	Distinct	T 03
Parabolic Arch	Average	Pointed	Average	Distinct	T 27
Parabolic Arch	Average	Pointed	Average	Distinct	T 55
Parabolic Arch	Average	Bilobed	Average	Double	T 16
Parabolic Arch	Average	Bilobed	Average	Double	W 170
Parabolic Arch	Narrow	Bilobed	Jutting	Distinct	T 34
Parabolic Arch	Average	Angular,Flat	Average	Distinct	T 08
Parabolic Arch	Average	Ang. Flat	Average	Distinct	T 32
Parabolic Arch	Average	Ang. Flat	Average	Distinct	T 79
Angular	Average	Round	Average	Distinct	T 24
Angular	Average	Round	Average	Distinct	T 70
Angular	Average	Flat	Average	Distinct	T 47
Angular	Average	Pointed	Average	Distinct	T 33
Square	Average	Round	Average	Distinct	T 78
Square	Wide	Flat	Jutting	Indistinct	T 68
Square	Average	Pointed	Average	Distinct	T 58
Square	Average	Pointed	Jutting	Distinct	T 43
Round	Average	Round	Average	Double	T 80
Round	Average	Round	Average	Indistinct	T 07
Round	Average	Round	Average	Distinct	T 34
Round	Average	Round	Average	Distinct	W 97

Appendix J
Exhibit 6

Hair Style Types Used in Software System

Physical Dimensions Along Which the Feature Varies

Structure	Shape	Bizygomatic Breadth	Length	Color	Picture Code
Straight	Round	Wide	Long	Dark	T 40
Straight	Diamond	Average	Long	Dark	T 20
Straight	Diamond	Wide	Medium	Dark	W 58
Straight	Oval	Average	Long	Dark	T 08
Straight	Oval	Average	Long	Dark	T 43
Straight	Oval	Average	Long	Dark	T 49
Straight	Oval	Average	Long	Light	T 14
Straight	Oval	Average	Medium	Dark	T 12
Straight	Oval	Average	Medium	Dark	T 61
Straight	Oval	Average	Medium	Dark	T 79
Straight	Oval	Average	Medium	Medium	T 34
Straight	Egg	Wide	Long	Dark	T 42
Straight	Egg	Average	Medium	Dark	T 45
Straight	Egg	Average	Medium	Dark	T 60
Straight	Egg	Average	Short	Dark	T 16
Straight	Oblong	Average	Medium	Medium	T 24
Straight	Oblong	Average	Medium	Medium	T 78
Straight	Oblong	Average	Medium	Light	T 47
Straight	Oblong	Average	Short	Dark	T 70
Straight	Oblong	Average	Short	Dark	W 100
Straight	Oblong	Narrow	Short	Dark	T 94
Curly	Round	Average	Medium	Dark	T 35
Curly	Round	Average	Short	Dark	T 07
Curly	Square	Wide	Medium	Dark	T 68
Curly	Square	Average	Medium	Dark	T 58
Curly	Oval	Average	Long	Dark	T 27
Curly	Oval	Average	Medium	Dark	T 23
Curly	Oval	Average	Medium	Dark	T 39
Curly	Oval	Average	Medium	Dark	T 32
Curly	Oval	Average	Medium	Medium	W 97
Curly	Oval	Average	Short	Dark	T 03
Curly	Oval	Average	Short	Dark	T 80
Curly	Egg	Average	Long	Dark	T 11
Curly	Egg	Average	Medium	Dark	W 170
Kinky	Diamond	Average	Long	Dark	T 50
Kinky	Diamond	Average	Long	Medium	T 55
Kinky	Oval	Average	Long	Dark	T 33
Kinky	Oval	Average	Long	Medium	T 41
Kinky	Oval	Average	Medium	Dark	T 87
Kinky	Diamond	Wide	Short	Dark	T 71

Key to Appendix J

1. Codes that start with letter T are pictures of targets in earlier image generation study.
2. Codes that start with letter W are pictures of witnesses in earlier image generation study.
3. Codes that start with letters KB are FBI photographs.

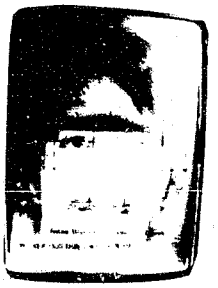
Appendix K

Photographs Showing Example of Image Generation Sequence

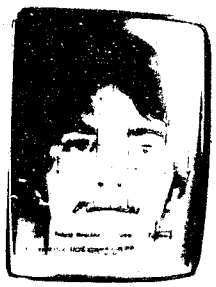
Base Photograph. (1)

Base Photograph and chin line filter area. (2)

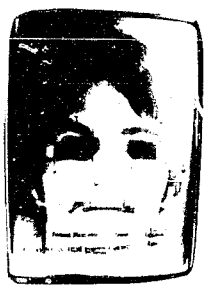
Base Photograph with chin line manipulation and hair style filter area. (3)



Base Photograph with chin line and hair style manipulations and eyebrow filter area. (4)

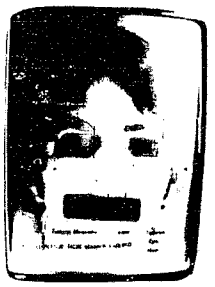


Base Photograph with chin line, hair style, and eyebrow Manipulations. (5)



Base Photograph with chin line, hair style, and eyebrow manipulations and eye filter area. (6)

Base Photograph with chin line, hair style, eyebrow and eye manipulations. (7)



Base Photograph with chin line, hair style, and eyebrow manipulations and eye and mouth filter areas. (8)

Base Photograph with chin line hair style, eyebrow, eye and mouth manipulations. (9)

Base Photograph with five filter areas. Only the original nose remains. (10)

Exhibit 1
Appendix L
Montage Composite and Photograph of T 21

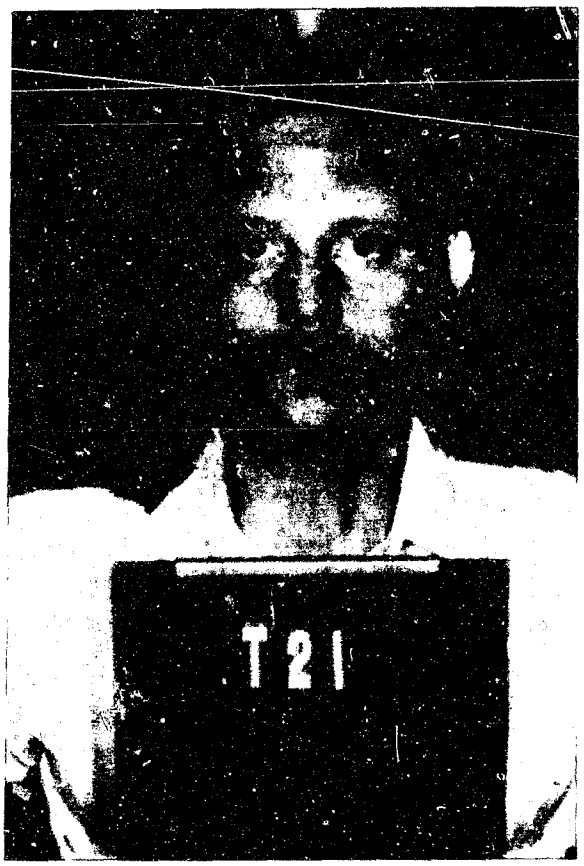


Exhibit 2
Appendix L
Montage Composite and Photograph of T 48

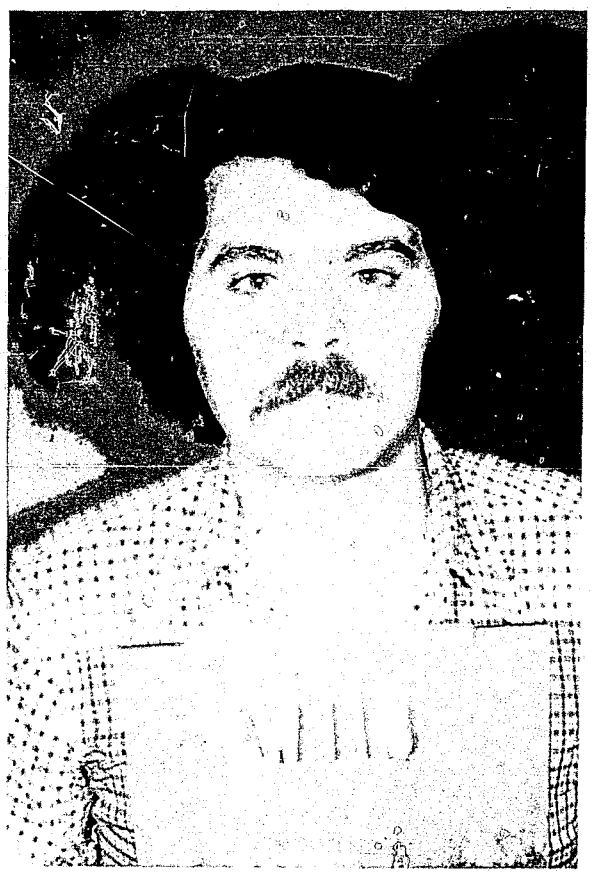


Exhibit 3
Appendix L
Montage Composite and Photograph of T 51

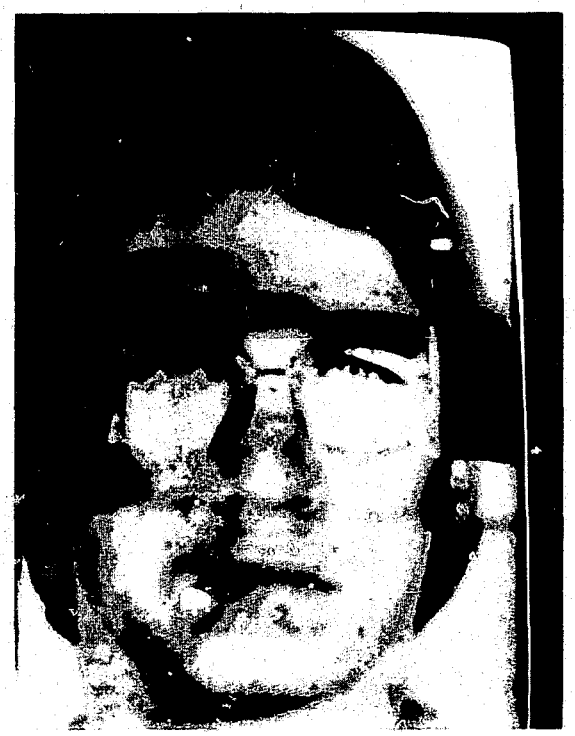


Exhibit 4
Appendix L
Montage Composite and Photograph of T 53

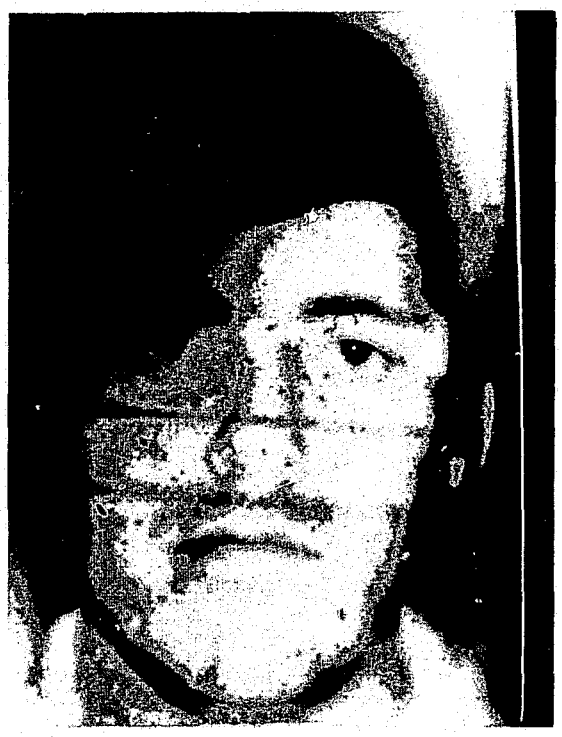
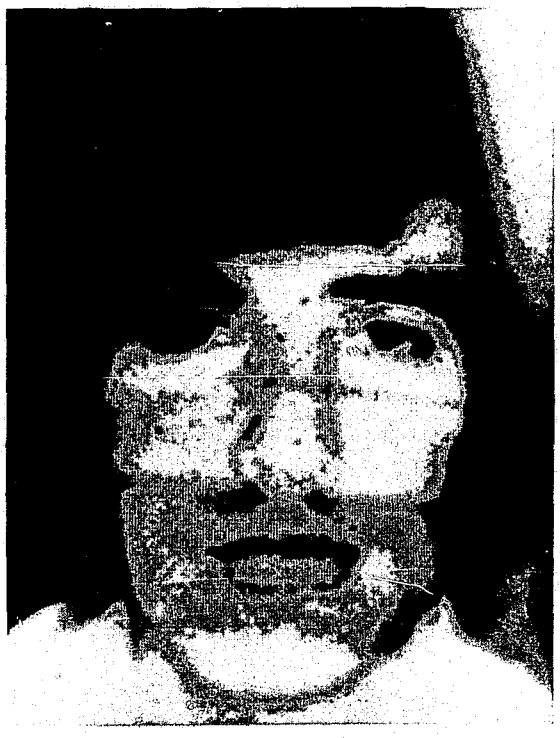


Exhibit 5
Appendix L
Montage Composite and Photograph of T 54



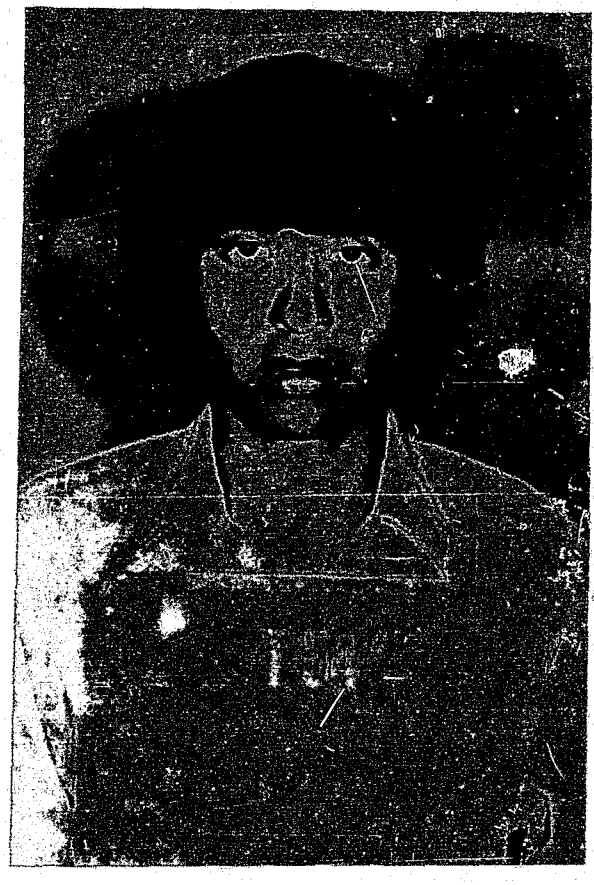
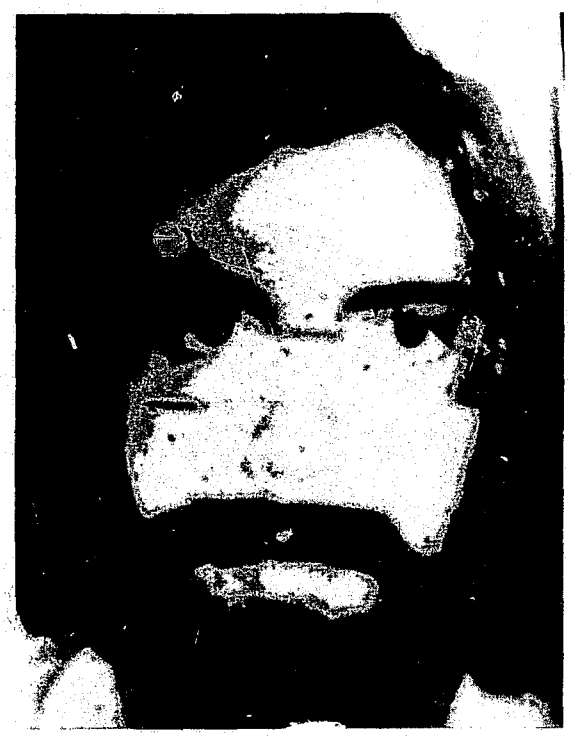


Exhibit 6
Appendix L
Montage Composite and Photograph of T 56



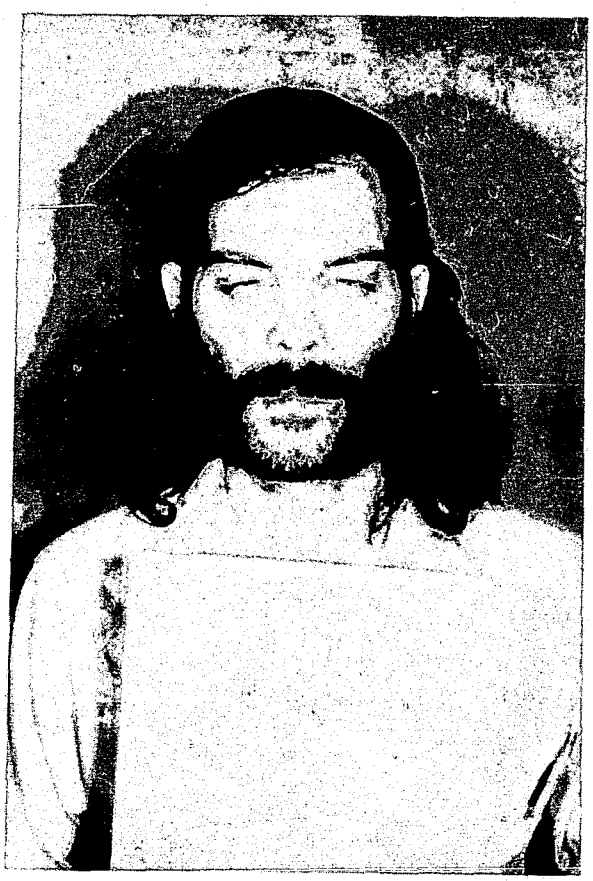
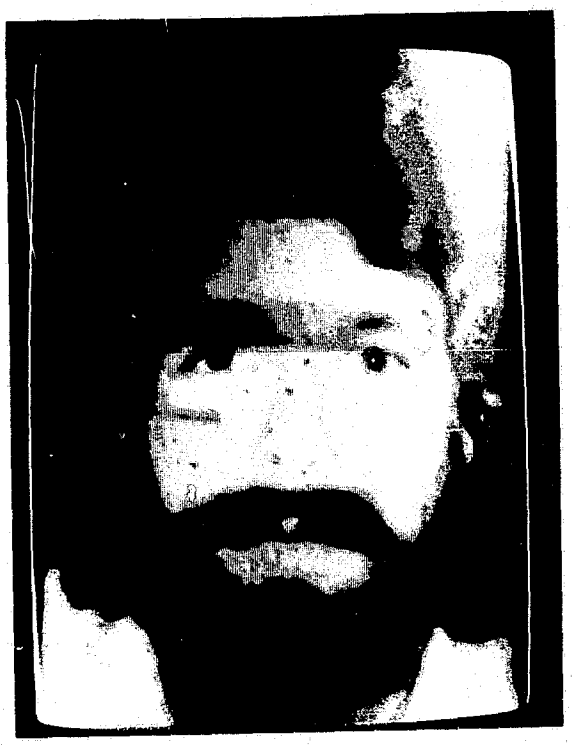


Exhibit 7
Appendix L
Montage Composite and Photograph of T 62



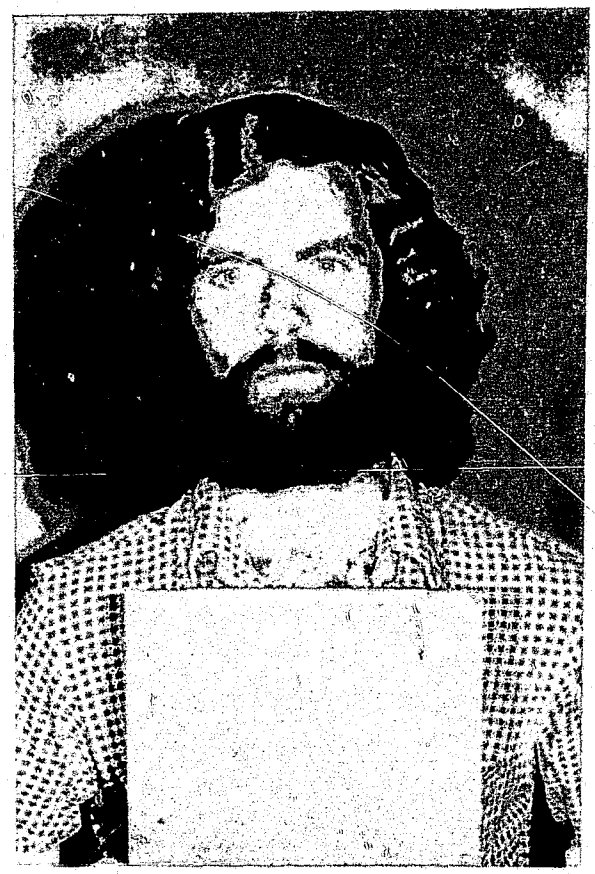
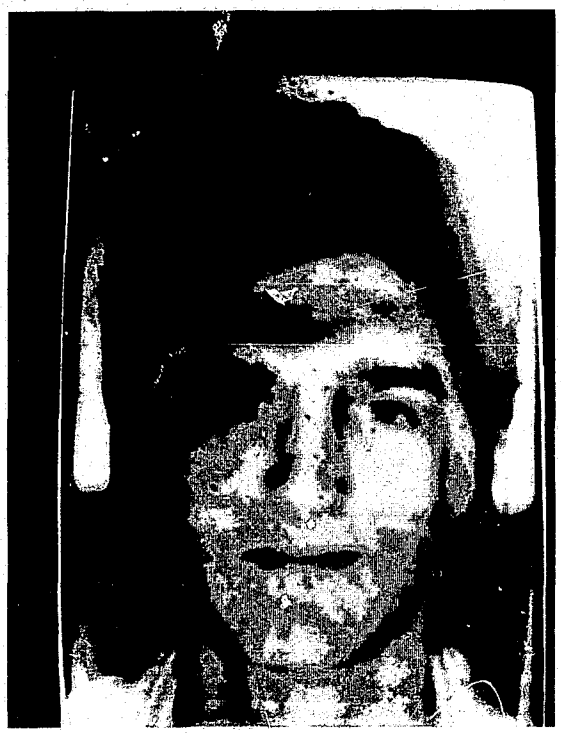


Exhibit 8
Appendix L
Montage Composite and Photograph of T 67



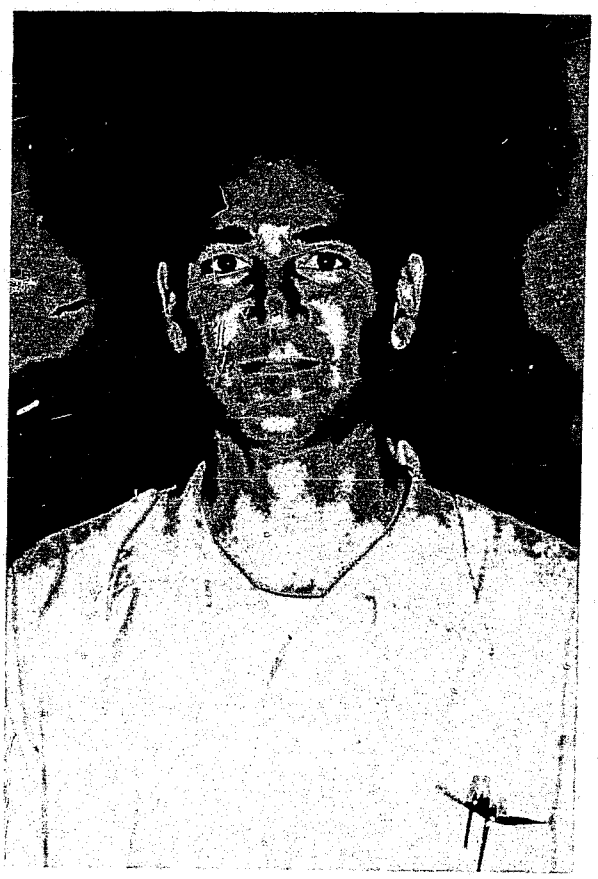


Exhibit 9
Appendix L
Montage Composite and Photograph of T 69

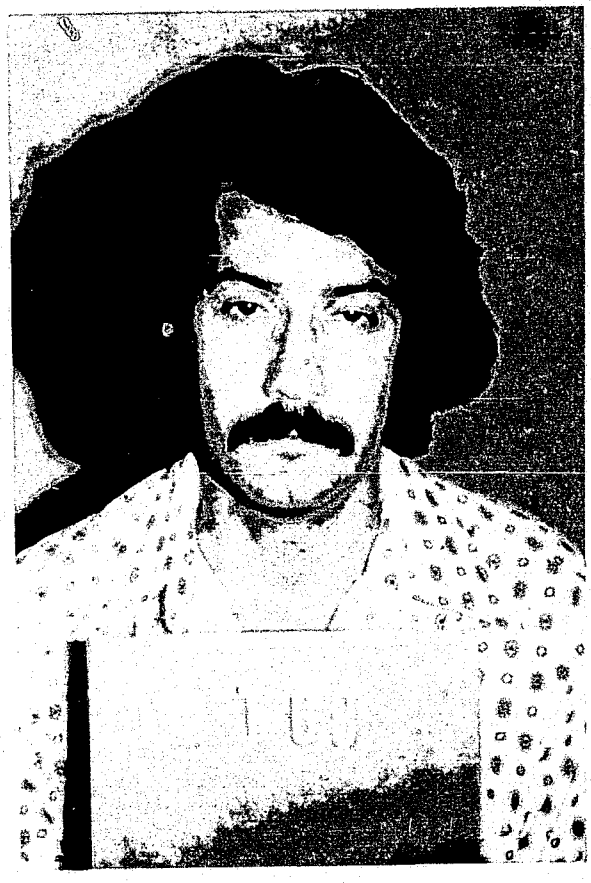
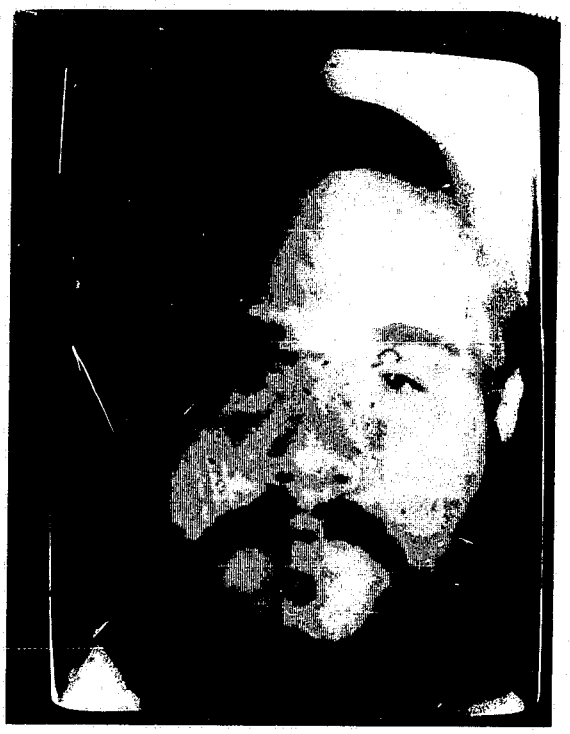


Exhibit 10
Appendix L
Montage Composite and Photograph of T 72

Exhibit 11
Appendix L
Montage Composite and Photograph of T 77

Exhibit 12
Appendix L
Montage Composite and Photograph of T 81



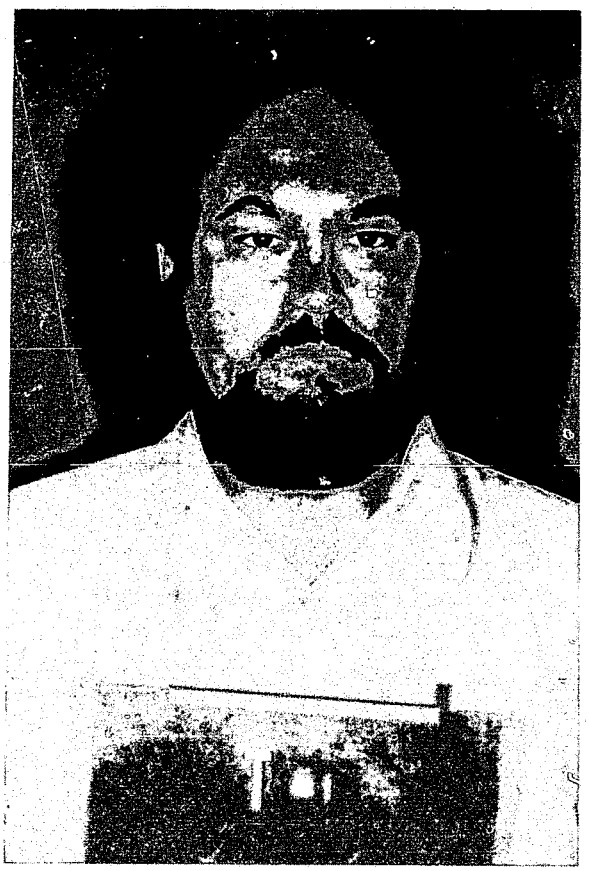


Exhibit 13
Appendix L
Montage Composite and Photograph of T 89

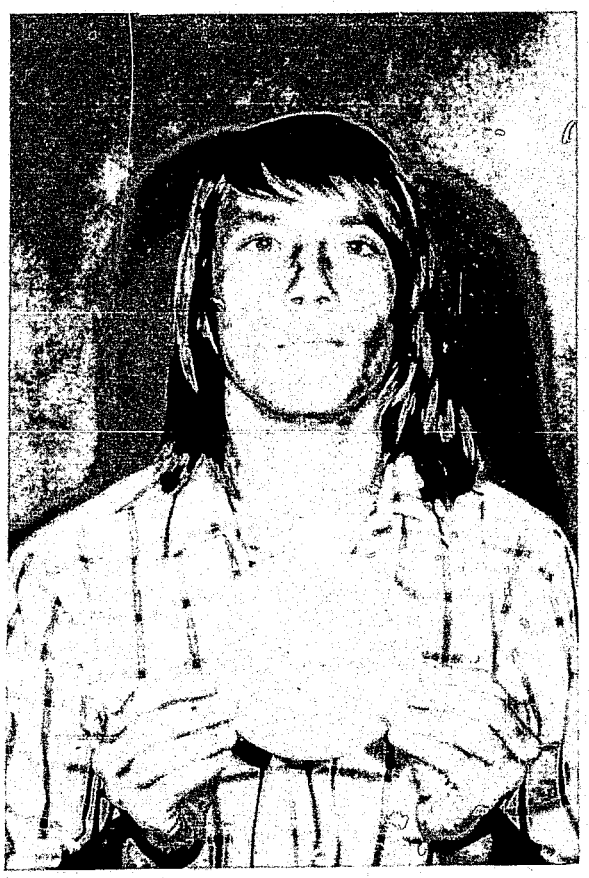
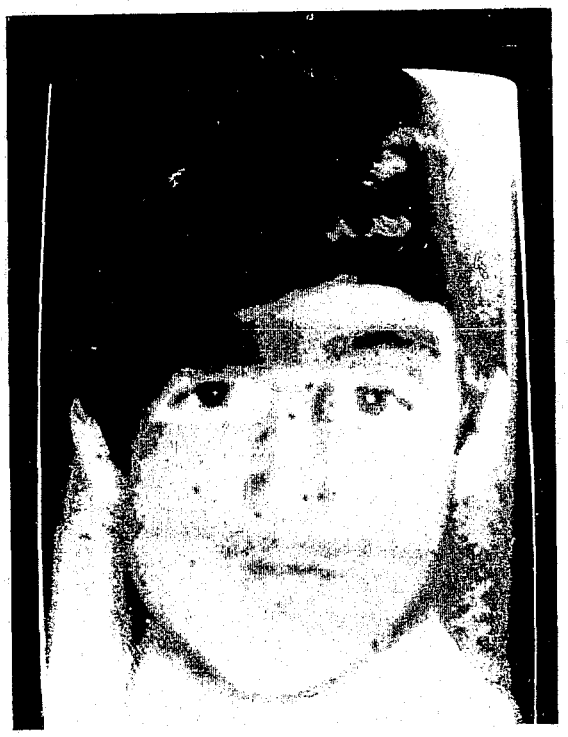
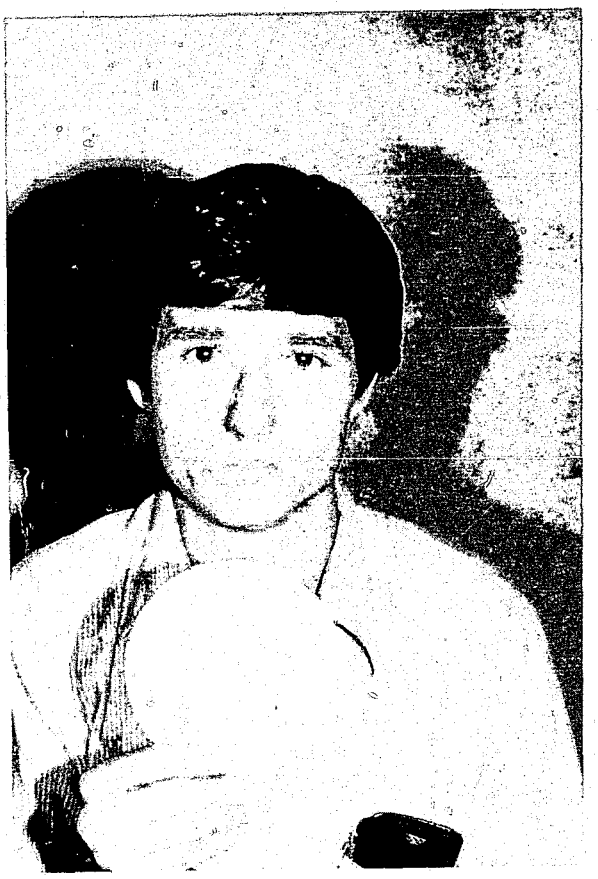


Exhibit 14
Appendix L
Montage Composite and Photograph of T 95





Appendix M
Exhibit 1

Feature Classifications and Software Features

Used in Constructing Composite of Target 21

Feature Classification			
Head shape	-	oval	
Hair style	-	long, straight, blonde	
Chin line	-	parabolic arch (bilobed) double, jutting chin	
Nose	-	bulbous (width & length ?)	
Eyebrows	-	Arched (straight) sparse (length & inter-head distance?)	
Eyes	-	tear, protruding, (sixe & I.B.B.?)	
Mouth	-	round lower lip (thin) - shape?	
Moustache	-	blonde, fu man chu	
Software Features Used			**I.D. code**
Hair style	-	straight (oblong) avrg width	(green 195)
Chin line	-	parabolic arch avrg width (round)	(green 6)
Nose	-	bulbous (medium projection)	(green A1)
Eyebrows	-	arched (straight)	(blue 70)
Eyes	-	tear sml/avrg	(red 141)
Mouth	-	curved bow (elevated) round lip	(green 65)
Moustache	-	T 71	

Note: unable to find accessories that could closely approximate the characteristics of this target (ie; hair style & moustache). Difficulty experienced in masking upper lip without affecting the mouth structure itself.

Appendix M
Exhibit 2

Feature Classifications and Software Features

Used in Constructing Composite of Target 48

Feature Classification

Head shape	-	round or diamond
Hair style	-	Kinky/long/dark or medium
Chin Line	-	wide width/round (distinct) average chin
Eyes	-	Cigar or tear length =Sml I.B.B. = Avrg
Eyebrows	-	oblique internal rectinliner depressed (curved 45°) bushy
Nose	-	bulbous
Mouth and moustache		

Software Features Used

Hair style	-	kinky avrg/wd (diamond)	(Green 77)
Chin line	-	round nar/average width	(Green 23)
Eyes	-	tear size =sml I.B.B. = nar	(Green 37)
Eyebrows	-	rectilinear depressed (Curved 45°) oblique internal	(Green 30)
Nose	-	bulbous (great projection)	(Green 89)

Mouth & Moustache: taken from chin line that was used; inadequate accessories in software.

Appendix M
Exhibit 3

Feature Classifications and Software Features

Used in Constructing Composite of Target 51

Feature Classification

Head shape	-	oval
Hair Style	-	Wavy; dark; med or short
Chin line	-	parabolic arch (Bilobed) jutting chin
Eyes	-	Dome (eyelid fold absent) size =avrg
		I.B.B = wide overhanging lid (outer canthus
Eyebrows	-	arched (straight) medium
Mouth	-	straight bow (round) avrg upper/thick lower
		avrg width depressed corners
Nose	-	wedge

N.B. Problems experienced with the addition of eyeblasses

Software Features Used

Hair style	-	wavy (oval) avrg/wd width	(Green 1210
Chin line	-	parabolic arch (round) wide width	(Red 21)
Eyes	-	dome avrg size/wide I.B.B	(Green 393)
Eyebrows	-	arched (straight)	(Green 89)
Mouth	-	straight bow (straight) round lower	
		narrow width thick upper thick lower	(Blue 36)
Nose	-	wedge (great projection)	(Green 77)
Eyeglasses	-	T11	

Appendix M
Exhibit 4

Feature Classifications and Software Features

Used in Constructing Composite of Target 53

Feature Classification

Head shape	-	oval
Hairstyle	-	short, wavy, black
Chin line	-	parabolic arch (round) indistinct chinline
Nose	-	spear (width & length?) or rectilinear
Eyebrows	-	arched (straight) avrg. thickness (length & inter-head distance?)
Eyes	-	cigar (med. eyelid) (size?)
Mouth	-	curved bow (round) avrg. thickness
Moustache	-	none

Software Features Used

Hair style	-	wavy (oval) avrg width	(Green 121)
Chin line	-	round (round) avrg wisth	(Green 5)
Nose	-	rectilinear (medium)	(Green 43)
Eyebrows	-	arched (straight)	(Green 90)
Mouth	-	curved bow (round lip) elevated corners	(Green 65)
Eyes	-	cigar (avrg/avrg)	(Green 324)
Moustache	-	none	

Appendix M
Exhibit 5

Feature Classifications and Software Features

Used in Constructing Composite of Target 54

Feature Classification

Head shape	-	egg
Hair style	-	wavy, medium length, black
Chin line	-	angular, (flat)
Nose	-	bulbous or wedge
Eyebrows	-	rectilinear depressed. (straight) curved 45° med.
Eyes	-	tear (raised iris) med/thick eyelid
Mouth	-	curved bow (round) avrg upper/thick lower
Moustache	-	none

Software Features Used

Hair style	-	wavy (oval) nar/avrg width	(Green 121)
Chin line	-	parabolic arch (angular, flat) nar/avrg width	(Green 131)
Nose	-	rectilinear (medium)	(Green 43)
Eyebrows	-	rectilinear depressed (curved 45°) straight	(Blue 94)
Eyes	-	tear sml/avrg	(Green 101)
Mouth	-	curved bow (flat) elevated corners	(Blue 138)

Appendix M
Exhibit 6

Feature Classifications and Software Features

Used in Constructing Composite of Target 56

Feature Classification

Head shape	-	diamond
Hair style	-	long, black, wavy
Chin line	-	beard (angular flat)
Nose	-	bulbous or rectilinear
Eyebrows	-	arched (oblique internal)
Eyes	-	tear, bulging
Mouth	-	lower lip thick, flat
Moustache	-	black, thick

Software Features Used

Hiar style	-	wavy (oval) averg/wd.	(Green 121)
Chin line	-	beard parabolic arch. avrg.	(Green 103-105)
Nose	-	rectilinear (medium)	(Green 43)
Eyebrows	-	rectilinear (oblique internal)	(Green 30)
Eyes	-	tear avrg/avrg	(Red 357)
Mouth	-	same as chin line	(Green 103-105)
Moustache	-	used chin line	

Note: Difficulty experienced in masking upper lip of appropriate mouth structure. No manipulation was therefore made.

Appendix M
Exhibit 7

Feature Classifications and Software Features

Used in Constructing Composite of Target 62

Feature Classification

Shape	-	oblong
Hair Style	-	long kinky med (color)
Chin line	-	beard parabolic arch chin?
Eyes	-	size = SML I.B.B = avrg dome
Eyebrows	-	Rectilinear straight avrg - inter-head distance sparse
Nose	-	bulbous length = short width = flared

Software Features Used

Hair style	-	kinky (oval) avrg	(Green 113)
Chin line	-	beard parabolic arch avrg.	(Green 103-105)
Eyes	-	dome sml = size I.B.B. = avrg	(Green 109)
Eyebrows	-	rectilinear (straight)	(Green 65)
Nose	-	bulbous (Medium projection) length-short width-flared	
Mouth	-	No change (mouth that was used was the same mouth that was with the beard).	

Appendix M
Exhibit 8

Feature Classifications and Software Features

Used in Constructing Composite of Target 67

Feature Classification

Head shape	-	oval
Hair Style	-	short/dark/straight
Chin line	-	parabolic arch (round) jutting chin
Eyes	-	cigar size =sml I.B.B. = nar
Eyebrows	-	rectilinear (straight) bushy narrow inter-head distance
Nose	-	rectilinear (broken)
Mouth	-	straight bow (round) thin upper/average or thick lower

Software Features Used

Hair style	-	wavy (round) avrg/wd	(Green 22)
Chin line	-	parabolic arch (round) avrg	(Green 24)
Eyes	-	cigar sml size/nar I.B.B.	(Green 29)
Eyebrows	-	arched (straight)	(Green 113)
Nose	-	spear (great projection)	(Green 79)
Mouth	-	peanut (straight) round lip	(Blue 28)

Appendix M
Exhibit 9

Feature Classifications and Software Features

Used in Constructing Composite of Target 69

Feature Classification

Head shape	-	oblong
Hair style	-	wavy; (dark) black; long
Chin line	-	parabolic arch (round) bilobed chin
Eyes	-	cigar size-sml I.B.B.=avrg
Eyebrows	-	rectilinear depressed (curved 45°) or arched oblique internal inter-head distance = avrg.
Mouth	-	& moustache
Nose	-	rectilinear length - short width- Nar

Software Features Used

Hair style	-	wavy (oval) nar/avrg width	(Green 121)
Chin line	-	parabolic arch (bilobed) avrg width	(Green 86)
Eyes	-	cigar sml size/avrg I.B.B.	(Green 100)
Eyebrows	-	Rectilinear depressed (curved 45°) (oblique internal)	(Blue 33)
Mouth & Moustache	-	T45	
Nose	-	rectilinear (medium projection)	(Green 44)

Note: all F.L.'s on large distance except "Brown" input which was using a "small" focal length.

Appendix M
Exhibit 10

Feature Classifications and Software Features

Used in Constructing Composite of Target 72

Feature Classification

Head shape	-	round	
Hair Style	-	short/dark/straight	(Green 22)
Chin line	-	round/indistinct chinline	(Green 14)
Eyes	-	size - avrg I.B.B. = Avrg. Football	
Eyebrows		(oblique internal) rectilinear depressed (curved 45°) thick narrow inter-head distance	(Green 43)
Nose	-	wedge length-short width-wide	(Green 42)
Mouth	-	Wing thin upper/thin lower (Flat lower lip) depressed corners	
Moustache			

Software Features Used

Hair style	-	straight (oblong) avrg	(Green 206)
Chin Line	-	Round (round) avrg/wd	(Green 14)
Eyes	-	football avrg size/avrg I.B.B.	(Blue 301)
Eyebrows	-	rectilinear depressed curved 45° oblique internal)	(Green 30)
Nose	-	wedge (medium projection)	(Green 42)
Mouth & Moustache		- peanut (straight) round lip	(Blue 55)

Appendix M
Exhibit 11

Feature Classifications and Software Features

Used in Constructing Composite of Target 77

Feature Classification

Head shape	-	egg
Hair Style	-	Short (balding) /straight/medium color
Chin Line	-	angular round or pointed narrow or average width
Eyebrows	-	rectilinear straight
Eyes	-	football med or thick upper lid size -SML IBB - NAR or cigar
Mouth	-	curved bow (round) avrg upper & lower
Nose	-	bulbous or wedge avrg or short length/narrow width

Software Features Used

Hairstyle placed on smallest focal length while all other inputs were adjusted to use the largest focal lengths.

Hair style	-	straight (egg) width = 2.7 cm avrg/wd	(Green 166)
Chin line	-	angular (round) avrg/wd	(Green 23)
Eyebrows	-	rectilinear straight	(Green 65)
Eyes	-	cigar small = size I.B.B. = Narrow	(Green 45)
Mouth	-	Mouth type on chinline was accurate therefore it was used	
Nose	-	Wedge (medium protrusion)	(Green 44)

Appendix M
Exhibit 12

Feature Classifications and Software Features

Used in Constructing Composite of Target 81

Feature Classification

Hair style - Balding/black, straight (ovel shape)

Chin line - wide width/parabolic arch (angular, flat)

protrusion of chin? (beard)

Eyes - size = SML(Small) I.B.B. = AVRG (average) cigar

eyelid absent (oblique internal) narrow opening

Eyebrows - rectilinear depressed (oblique internal) rectilinear

45° inter-head distance - AVRG sparse

Mouth - do not change

Nose - wedge great projection short length flared nostrils

Software Features Used

Hair style - (width - 2.8 cm) round wide straight (Red 1)

Chin line - beard round wide (Red 19-20)

Eyes - size = sml I.B.B. = avrg cigar/eyelid

absent/narrow opening

Eyebrows - arched (straight) (Green 113)

Mouth same mouth used that was with the beard

Nose - wedge great projection short length/flared nostrils.

Appendix M
Exhibit 13

Feature Classifications and Software Features

Used in Constructing Composite of Target 89

Feature Classification

Head shape	-	oval
Hair style	-	straight/long/med color
Chin line	-	Parabolic arch (round) jutting chin (jowls)
Eyes	-	dome
Eyebrows	-	arched (straight) bushy
Mouth	-	straight bow (round) avrg. upper/thick lower avrg width depressed corners
Nose	-	Upturned wedge length - width =

Software Features Used

Hair Style	-	straight (oval) avrg width	(Green 114)
Chin line	-	parabolic arch (round) avrg/wd width	(Green 14)
Eyes	-	dome sml size/avrg I.B.B	(Green 109)
Eyebrows	-	arched (straight)	(Green 113)
Mouth	-	curved bow (round) elevated corners avrg width	(Green 65)
Nose	-	wedge (medium projection) wide width/ short length	(Red 38)

Note: All focal lengths at same "small" setting

CONTINUED

2 OF 3

Appendix M
Exhibit 14

Feature Classifications and Software Features

Used in Constructing Composite of Target 95

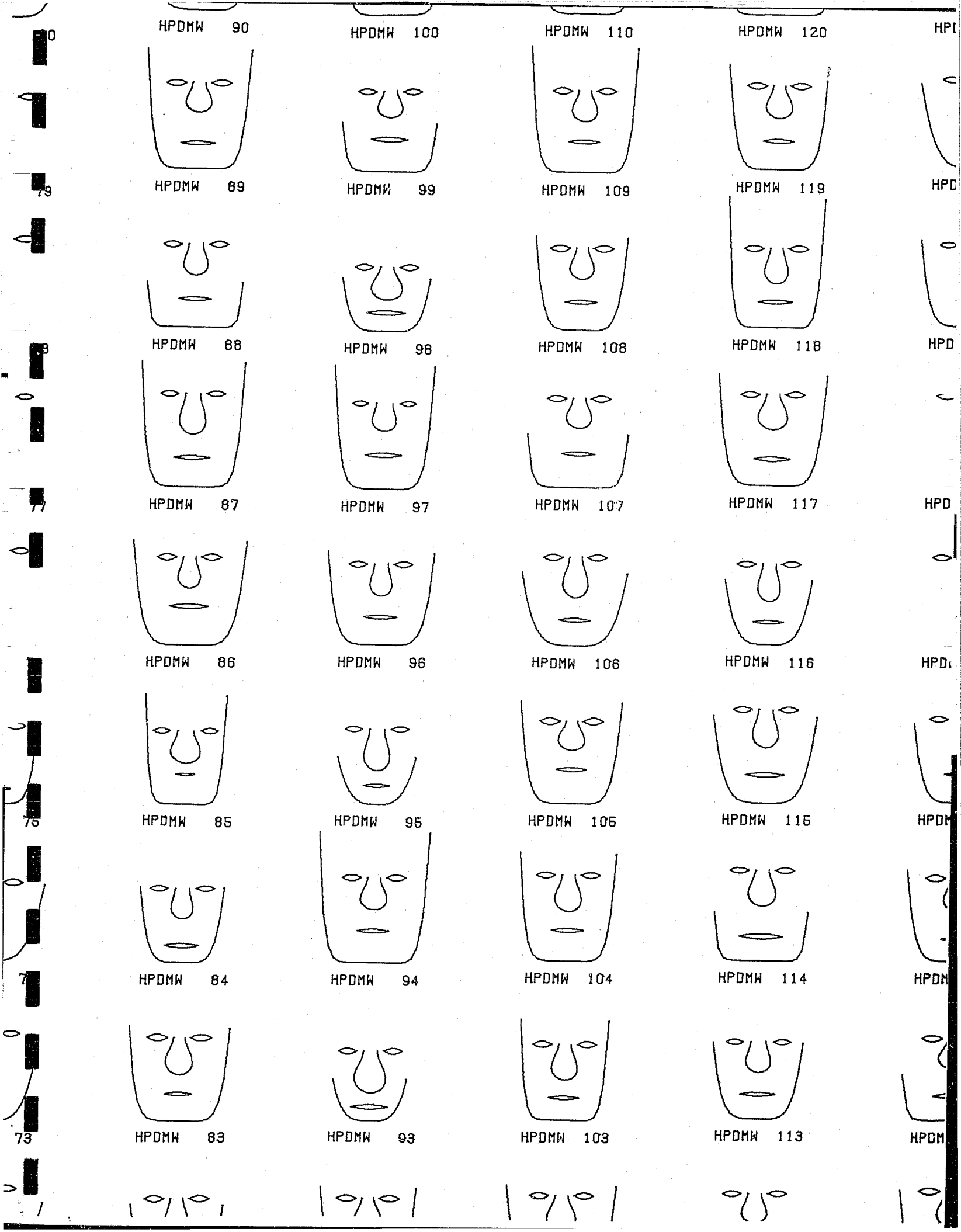
Feature Classification

Head shape	-	oblong	
Hair style	-	medium/dark/straight	
Chin line	-	angular (round or pointed)	
Eyes	-	cigar size = avrg I.B.B = avrg eyelip absent	
Eyebrows	-	rectilinear sparse (straight) wide inter-head distance	
Nose	-	spear average width/short length	Green 79)
Mouth	-	curved bow (round) thick lower/avrg upper narrow width	(Blue 60)

Software Features Used

Hair style	-	straight (Oblong) average width	(green 202)
Chin line	-	angular (pointed) width: nar/avrg	(Green 77)
Eyes	-	Cigar avrg size/avrg I.B.B	(Green 325)
Eyebrows	-	rectilinear (straight)	(Green 65)
Nose	-	spear (great projection)	(Green 79)
Mouth	-	curved bow (round lip) (elevated corners)	(Blue 60)

Note: Small F. L. used for all ports except (Green) which had a large F.L.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HPDMW 93
HPDMW 103
HPDMW 113


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