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Identification of Skulls by Video Superimposition

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ABSTRACT: A method of matching skulls with photographic portraits or impressions of the face in clay by video superimposition is described. Two different practical cases are presented. The first one deals with the identification of a skull of a six-year-old girl, the second with the identification of the skull of the famous Swiss Pedagogue Johann Heinrich Pestalozzi, who died about 160 years ago. The advantages and versatility of this method are shown; also the setup of the equipment and the working technique.

KEYWORDS: physical anthropology, human identification, musculoskeletal system, superimposition, skulls, video, impression of the face in clay, Johann Heinrich Pestalozzi

Equipment and Working Technique

The most widely known use of the video superimposition method to date is connected with the identification of skulls [*1,2*]. Over a period of about eight years we have found the following equipment and working technique to be the best.

The apparatus should consist of two video tubes, 1 and 2 (advantageously CCD cameras), electronic and mixer units, and three monitors (Fig. 1). The couple of video tubes (including optical lenses) must be adjusted by video test pictures. The skull in question is first taken with Tube 1 and reproduced on Monitor 1. For comparison purposes, a photograph of the missing person is then reproduced with Tube 2 on Monitor 2. The picture-mixing unit not only allows an infinitely variable mixing of the two pictures, but also the creation of horizontal and vertical sections at any desired point. These sections and the mixed pictures are then apprised on Monitor 3. For registration purposes, essential investigation results can be recorded on tape or photographed directly from the monitor with a camera.

The first step in the investigation is to determine the correct height and location for Camera 1 to stand. Thanks to its versatility, the video superimposition method presents enormous advantages over the former photographic superimposition processes [*3–5*]. The correct location has, of necessity, to coincide with that for the taking of comparison photographs and is defined by a number of variable parameters such as distance between camera and object, camera height, and height and orientation of the skull.

The answer to this problem lies in the two-dimensional comparison picture since, as already known, according to optical and perspective laws, *three-dimensional* objects, for instance a skull, appear differently on *two-dimensional* photographs, depending on the direction and distance involved when pictures are being taken.

To achieve an as exact as possible determination of the parameters, we developed various techniques which would facilitate the practical work involved. For instance, one can obtain

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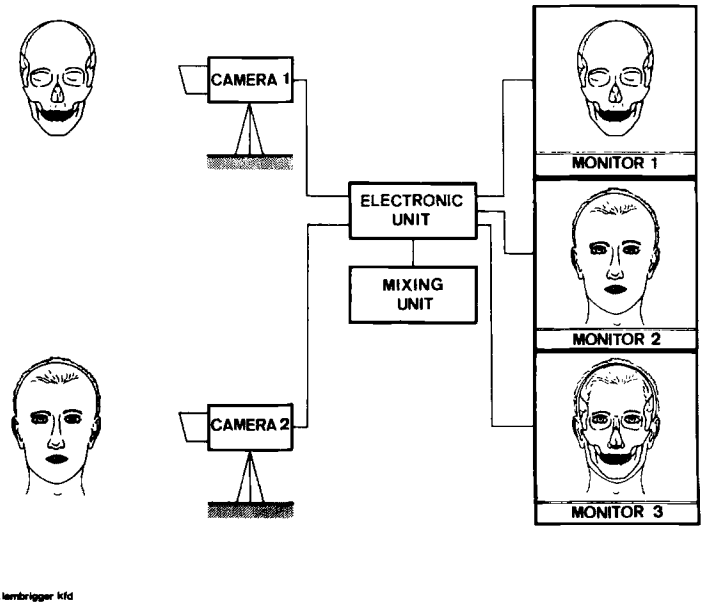

FIG. 1—*Schematic of the setup of the video comparison apparatus consisting of two video tubes, 1 and 2; electronic and mixing units; and three monitors.*

the correct *inclination of the skull* by means of the distance *d* between the eye and auditory canal axes. As one can see on Fig. 2, the auditory canal Axis G will lie nearer or farther away from the eye Axis A, depending on the inclination of the head or skull.

The *orientation or turn of the skull* is defined by the ratio of the distance between the eyes *b* to the peripheral distances *a* and *c*, and can be adjusted in this way, taking into account the thickness of the soft tissues (Fig. 3).

The *distance between camera and object* is determined on the basis of perspective distortion. One sees in Fig. 4 the differences between pictures of the same skull taken at closeup (35 cm) and those taken at 2 m.

After the skull has been correctly orientated, the *size of the skull* shown on the monitor can be matched with the comparison picture by means of a zoom lens. For example, to obtain an exact result, one uses the eye distances from the comparison photograph and the skull, these being best obtained by direct measurement from the monitor. After the correct parameters have been established, and the comparison picture and skull have been brought into line, one can begin comparing the portrait picture with that of the skull. This procedure is carried out on the monitor. By mixing and producing picture sections at the desired points, one is able to compare all the anatomical and morphological characteristics, taking into account the thickness of the soft tissues, which is known from the literature [*2,6,7*] and depends strongly on the build of the body. Of especial importance are the permanent, exactly defined anatomical features, such as auditory canal, eyesockets, cheekbones, jawbone, root of nose, teeth, chin, skull contour, and so forth.

Identification of the Skull of a Murdered Girl

This particular case deals with the identification of a child whose sparse remains were found in a forest near Zurich (Fig. 5). Since the usual criminal investigatory and forensic

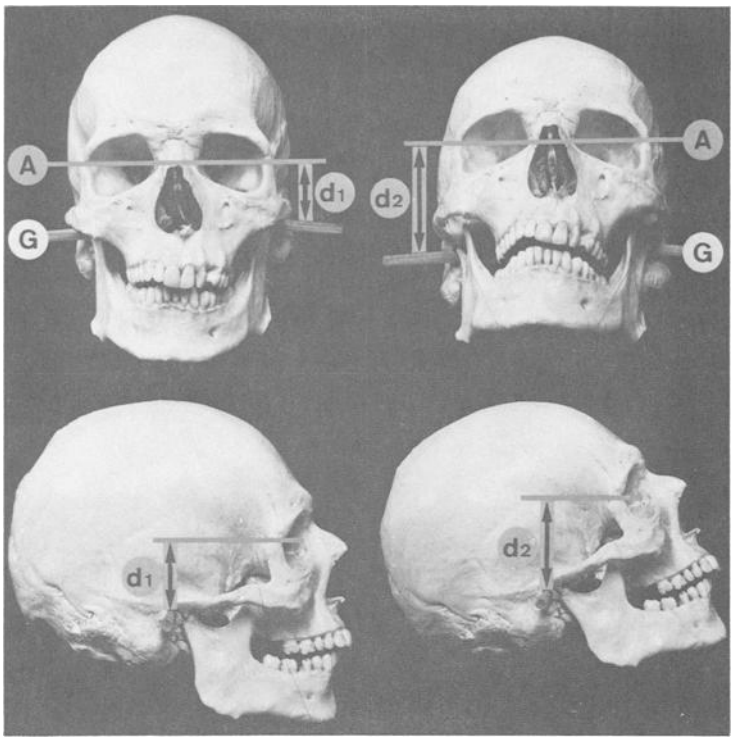

FIG. 2—*Determination of the correct inclination of the skull by means of the distance* d *between the eye and auditory canal Axes* A *and* G. *Compare* d1 *and* d2.

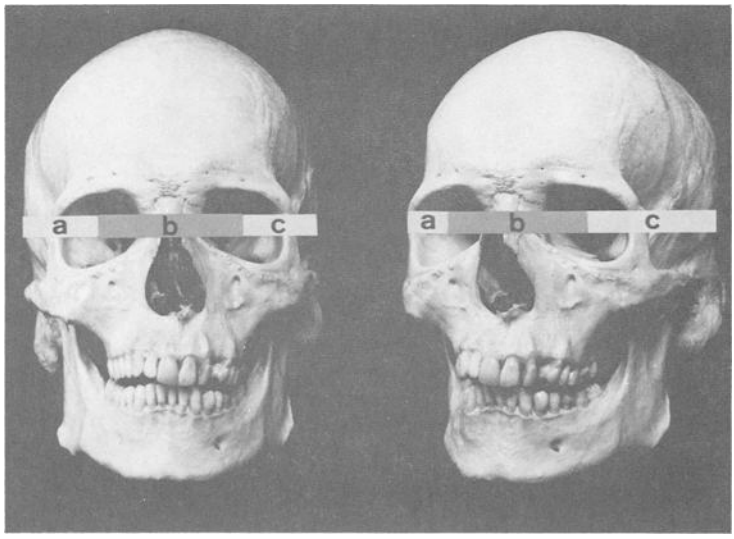

FIG. 3—*Determination of the correct orientation of the skull by means of the distances between the eyes* b *and the peripheral distances* a *and* c.

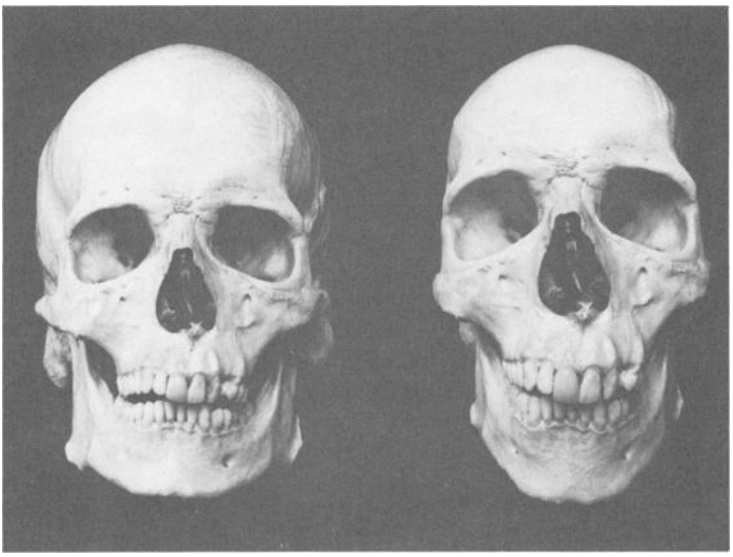

FIG. 4—*Determination of the distance between camera and object on the basis of perspective distortion. Compare the differences between pictures of the same skull taken at close-up (35 cm,* right*) and those taken at 2 m* (left).

FIG. 5—*Case 1: sparse remains of an unknown child found in a forest near Zurich.*

medical methods had failed, it was finally decided to try video superimposition. Some pictures taken from the entire investigation are shown in Figs. 6 through 13.

On the basis of this investigation, into which other comparison photographs were incorporated, the identity of the child could be obtained with an almost 100% probability. The identification could be verified on the basis of additional facts obtained later.

Note that in cases like the present one, examinations on children's skulls are especially specific because proportions constantly change as a result of differences in skull growth (refer to Fig. 14). It is therefore very important to obtain a recent photograph with the date on which it was taken, if possible. To check the sensitivity of the method, we superimposed the skull in question with a photo of another girl of the same age and body build (Fig. 15). After setting the skull, complete with teeth and root of nose, into the comparison picture, it could clearly be seen that there were differences in the remaining anatomical marks (Fig. 16). For instance, one can see the completely different run of the auditory canal (Fig. 17). In contem-

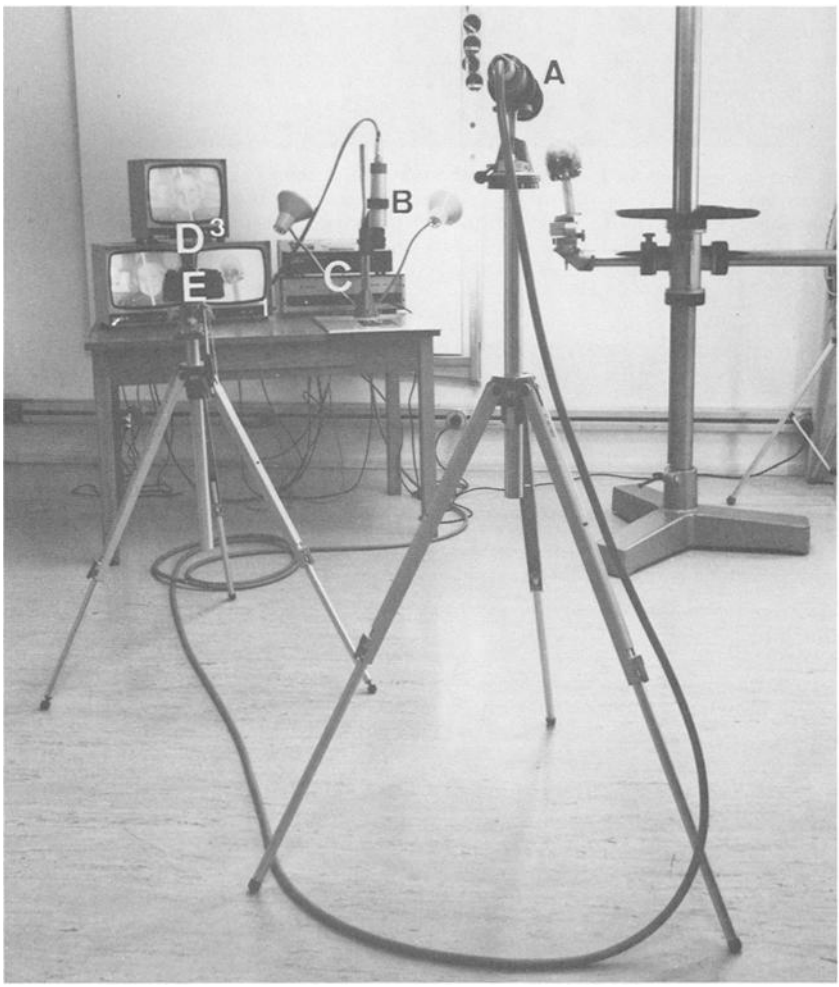

FIG. 6—*Video comparison apparatus in our laboratory consisting of two video tubes* (A and B), *electronic and mixing units* (C), *three monitors* (D), *and camera* (E).

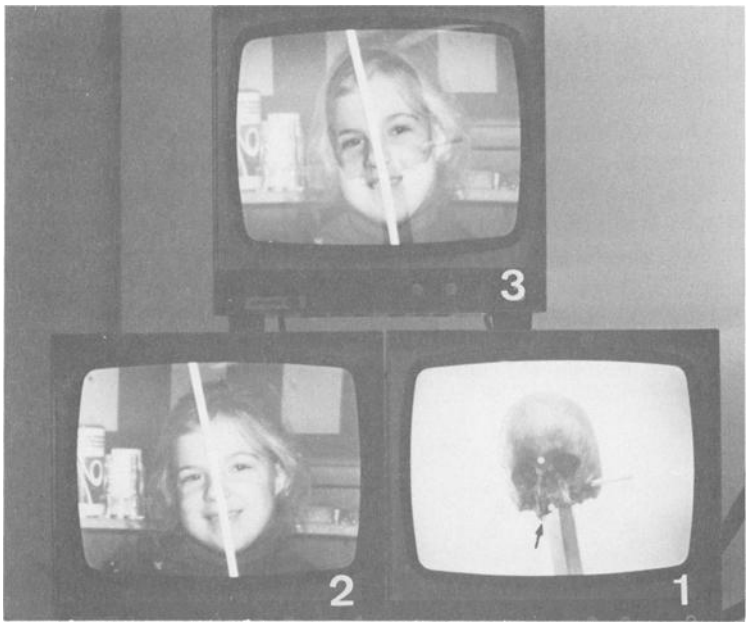

FIG. 7—*Photograph of the three monitors.* Bottom left: *video picture of the latest photograph of a missing six-year-old girl which we used for comparison purposes. The axis of the face is marked by a white line.* Bottom right: *video picture of the skull in question. The axis of the face is marked by white dots at the root of the nose and at the center of the upper jawbone. The small white stick on the right shows the axis of the left acoustic duct and the arrow indicates an inserted right eye tooth.* Top: *mixed picture.*

FIG. 8—*Video picture, mixed.*

FIG. 9—*Another mixed video picture. This allows a clearer view of the concordance in the markings of the face axes; see white line and white dots.*

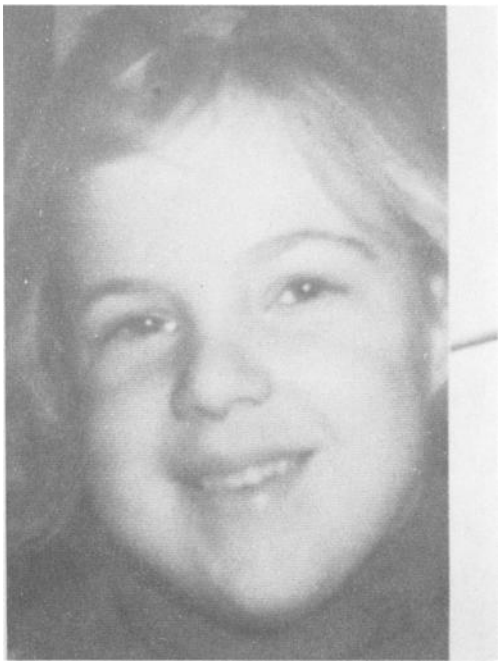

FIG. 10—*Vertical video picture section giving clearer view of the concordance at the left ear duct.*

FIG. 11—*Vertical video picture section in region of the left eye.*

FIG. 12.—*Notice the agreement in respect to the right eyetooth.*

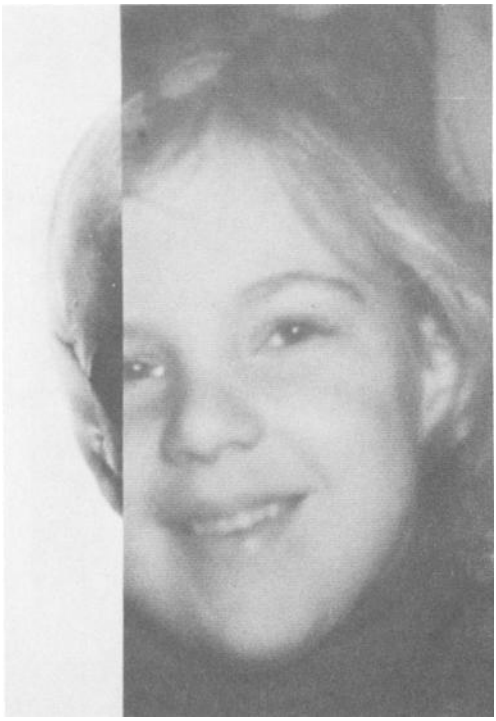

FIG. 13—*Vertical picture section in the region of the right eye.*

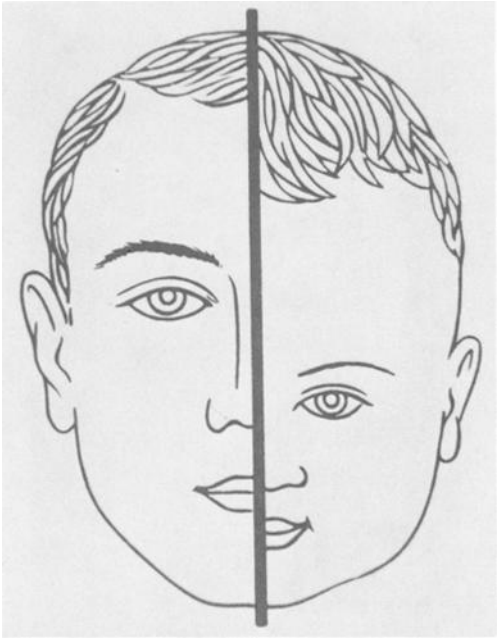

FIG. 14—*Illustration of change of proportions as a result of differences in skull growth.*

FIG. 15— *Video picture of the photograph of another girl of the same age and same body build which we superimposed with the skull in question to check the sensitivity of the method.*

FIG. 16— *Video picture mixed of another girl (compare Fig. 15) and the skull in question.*

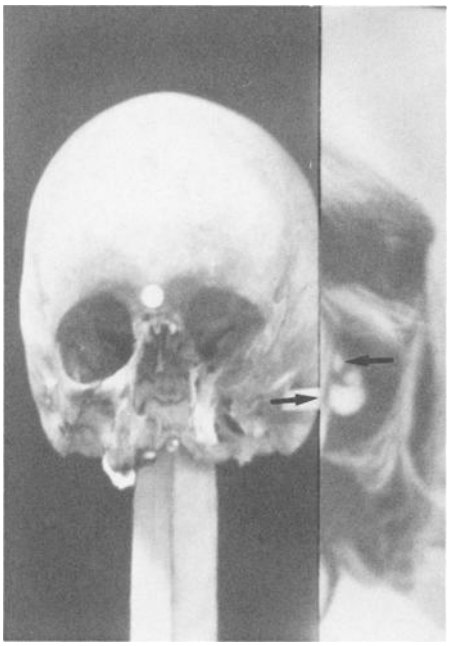

FIG. 17— *Vertical video section picture giving a clearer view of the completely different run of the auditory canal, see arrows.*

plation of the whole, these differences must be regarded as absolutely exemptory factors in cases of identity investigation.

Identification of the Skull of Johann Heinrich Pestalozzi

The next case is, perhaps, a unique one. During the renovation of a building, workers discovered in Birr, Switzerland the remains of a skeleton which was soon thought to be that of the famous Swiss Pedagogue Johann Heinrich Pestalozzi (1746–1827). From this man, who died about 160 years ago, there was left only an impression of his face in clay, from which comparison could be made. Rotating clay impression and skull into a frontal, lateral, and slight angle position we were able to do the identification investigations from different angles. Therefore, we achieved a more reliable result. Photographs taken during the investigation are given in Figs. 18 through 26. Together with anthropological and historical contributions [*8*], it could be proven beyond doubt that these workers had indeed found the bones of J. H. Pestalozzi.

Conclusion

Video superimposition has proven to be very successful in the investigation of identities. Thanks to its versatility, this method presents enormous advantages over the usual photographic superimposition processes. This modern method provides numerous possibilities for application, but up to now many investigators seem either to have disregarded this potential or have not made full use of it. And this despite the fact that the first results were published approximately nine years ago [*1*].

FIG. 18—*Setup of the video comparison apparatus: two video tubes* (A and B), *electronic and mixing units* (C), *three monitors* (D), *skull in question* (E), *and impression of the face of Pestalozzi in clay* (F).

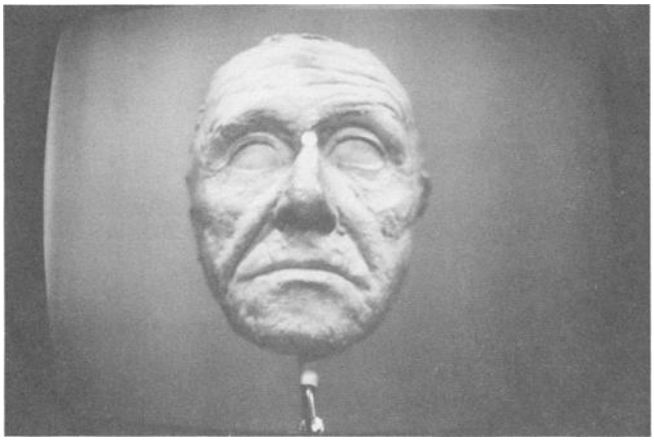

FIG. 19—*Video picture of the impression in clay.*

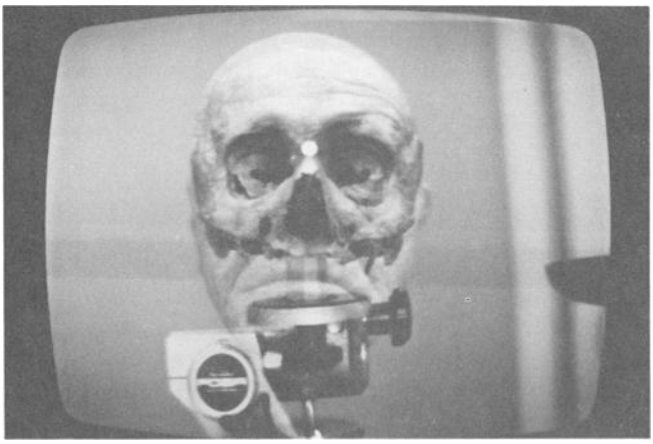

FIG. 20—*Mixed picture of skull and impression in clay.*

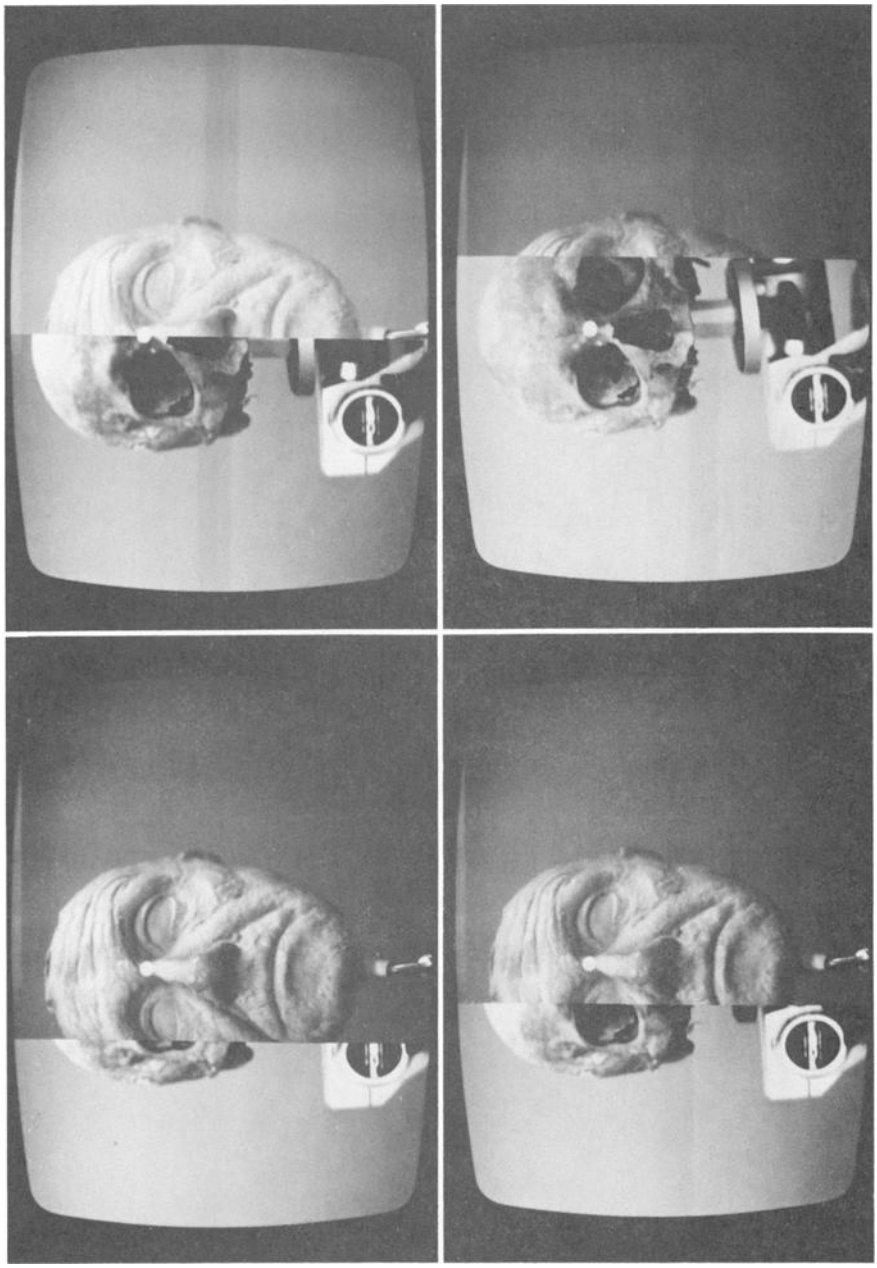

FIG. 21—*A series of vertical picture sections.*

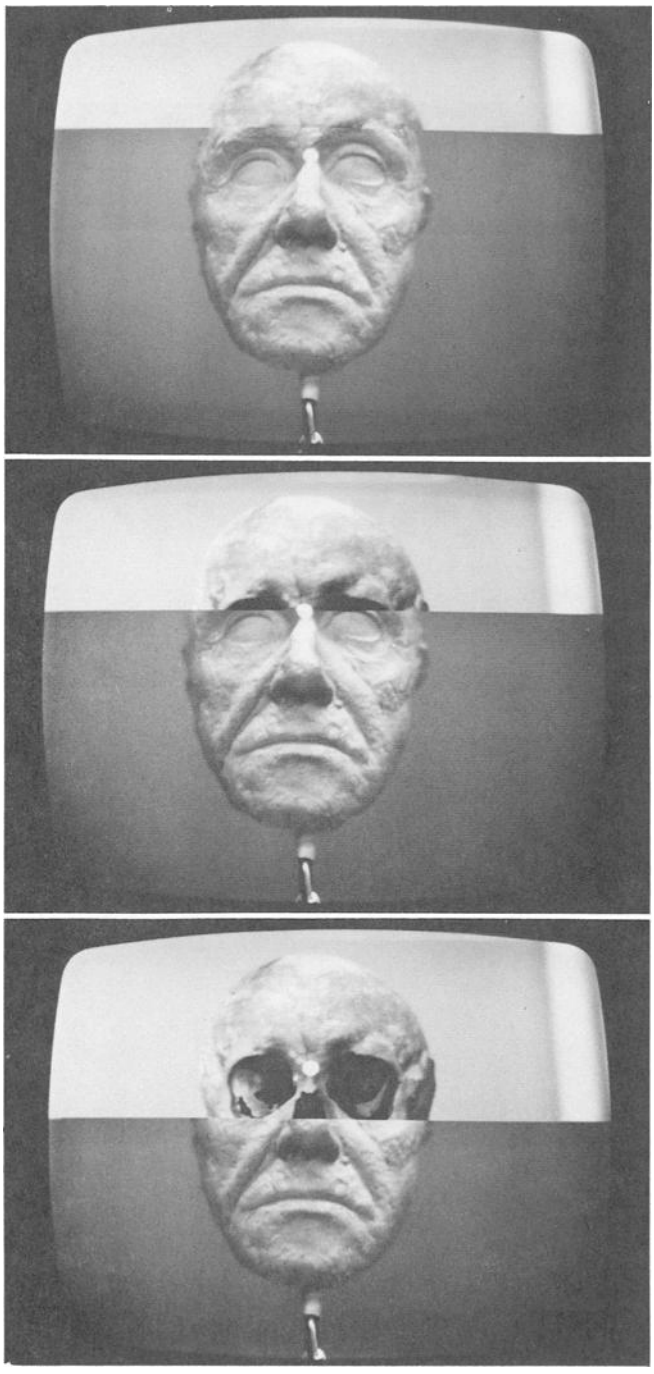

FIG. 22—*A series of horizontal picture sections.*

FIG. 23—*Mixed video picture in side view.*

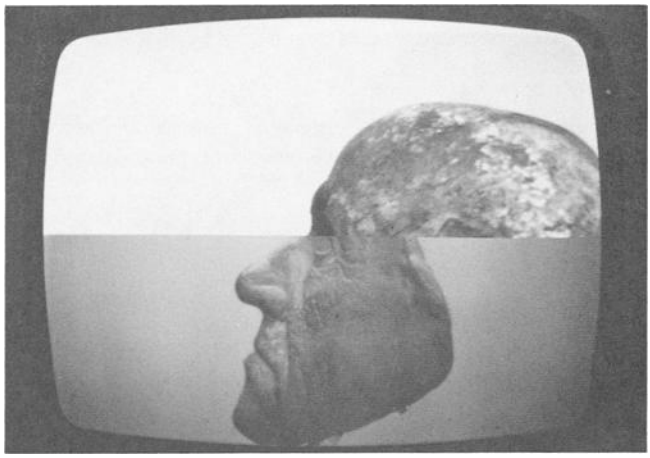

FIG. 24—*Horizontal picture section in the region of the eye.*

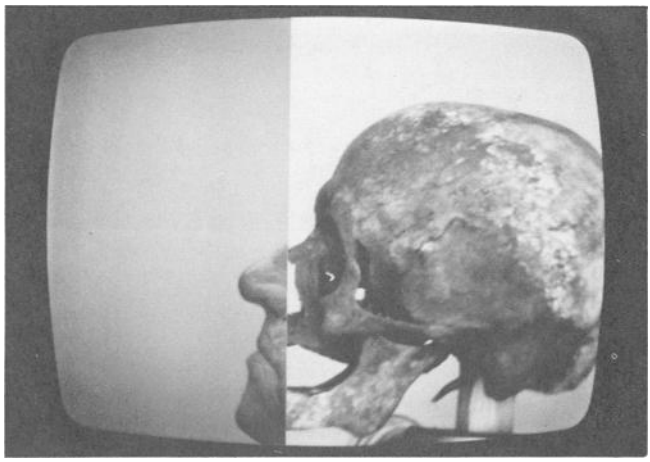

FIG. 25—*Vertical picture with inserted lower jawbone.*

FIG. 26—*Mixed video picture at a slight angle.*

Acknowledgment

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