ing. The overall significance of coded aperture imaging is the added freedom which the technique can bring to the solution of nuclear medicine imaging problems. For instance, the relationship between aperture transmission and the shape of the error kernel illustrated in Fig. 1 provides a flexibility which allows some control over the error distribution in the image. The problem of detector uniformity becomes greatly reduced with coded apertures since the coded image is spread over a large area of the detector. The advantage of coded apertures cited by Dr. Levy and others (*2*) in the case of detector noise permits, for example, consideration of gamma-ray detectors utilizing large diameter, efficient photocathodes, with correspondingly increased thermal noise. Or, film may be used as a detector in spite of its intrinsic fog level and the small number of film grains exposed by an interacting gamma-ray (*3*). One also has the option of designing apertures with spatial frequency response functions tailored to specific needs.

These are some of the reasons we feel that coded aperture imaging stands an excellent chance of bringing significant advances in nuclear medicine and will provide a fruitful area of research for some time to come in spite of the fact that the gain in imaging efficiency does not simply equal the gain in solid angle.

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A CODING SYSTEM FOR NUCLEAR MEDICINE USING UNIT RECORD EQUIPMENT

In 1969 we designed a coding system to fit our special needs. We feel it has worked so well for us that it may be of interest to others. It uses code cards, computer punch cards, a two-digit filing system, an alphabetic card file, and unit record equipment, i.e., an IBM 407 accounting lister, an 082 card sorter and an 026 card punch, for processing the files. The 5 × 8 in. code card serves as an alphabetic cross-file card. It is imprinted with groups of rectangular blocks representing the 80 columns on a punch card as shown in Fig. 1, purposely arranged in four rows.

The receptionist fills in the top row with the patient's personal information: social security number, last name, initials, and last two digits in the year of birth. If the name is longer than 10 letters, the tenth letter is replaced by an asterisk. The card with this information is attached to the study request and given to the technologist.

The second row is completed by the technologist and contains study or test information. Space is provided for entering the date of the test, the amount of radioactivity and its unit (mCi or μCi), the route of administration, the procedure, and the instrument. The isotope is identified by its mass number. Mnemonic code characters are used in this row so they can be remembered easily but a listing of the code is kept readily available. Below are examples of the study code.

SB—scan, brain
SBF—scan, brain and cerebral blood flow
STU—scan, thyroid, uptake
RG—renogram

When the procedure is completed, the request with the attached card and the actual technical data such as scans, recording, and calculations are given to the physician.

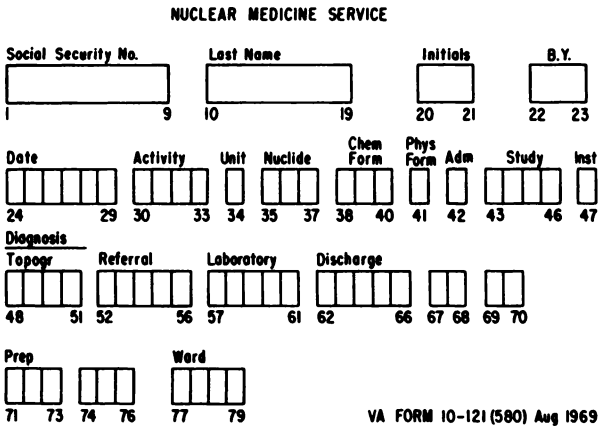

FIG. 1. Code Card. Note grouping of information in four rows: First row, patient's personal data (clerk), second row, description of work done (technician), third row, diagnostic information (physician), fourth row, additional data.

The third row of the code card is allocated to the physician for interpretation and medical diagnosis using the Systematized Nomenclature of Pathology code (SNOP). Four groups, each containing 4 or 5 digits, are available for the topography of the patient's illness, the referral diagnosis, the study diagnosis, and the discharge diagnosis. The number of blocks provided in the third row offer the physician many possibilities for designing a system to meet his own particular needs or interests.

The fourth row of the code card is reserved for additional data such as location of the patient, medication that might influence test finds, teaching file information, etc.

The study and a copy of the physician's report are filed in an x-ray folder using the 6th and 7th digits of the social security number marked in color code on the folder's edge. A summary of the diagnostic and therapeutic procedures performed on the individual is listed on the face of the x-ray folder in chronological order.

The information is next transferred from the code card onto an 80-column computer card that is punched according to column numbering on the code card. The cards are sorted, monthly and yearly, with a card sorter, first by patient names in alphabetical order, then by chemical form of the tracer, next by study, and finally by nuclide. The readout then provides a monthly or yearly listing of patients examined, procedures performed, nuclides and compounds used along with referral diagnosis and test results as well as referring service.

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THE ARGUMENT FOR MINIFICATION

Barber (*1*) has correctly drawn attention to the fact that the benefits many workers appear to have derived from the "minification" of photoscans (*2–5*) cannot be attributed to an increase in count density which could offset an increase in scan speed as has sometimes been suggested. One can go further and say that if a display is modulated solely by the ratemeter output, then it is dependent only upon the counting rate and ratemeter time constant and is independent of changes in count density resulting from scan speed variations.

The statistical quality of a photoscan display depends upon the total of the integration which takes place in the ratemeter in the film, due to overlapping light spots, and in the eye of the observer. Since the latter is increased by reducing the size of the scan image, minification can, in fact, produce a real improvement in the observed display statistics. However, if the combination of ratemeter time constant and light-spot size and frequency is already such as to provide maximum integration for the desired resolution, then increasing this further by reducing the image size will result in some loss of resolution of the smaller features. This loss will not always be immediately apparent, as an observer will tend to be influenced by the improved definition of the larger features. The same result could, in any case, be achieved by other means such as a coarser resolution collimator or a longer viewing distance.

There are other physiological reasons why minification may improve a photoscan display. Tuddenham (*6*) has considered that there is a minimum density gradient on the retina of the eye below which no demarcation between adjacent areas is discernible. That this is true of the photoscan type of display may be demonstrated by scanning a phantom which provides a slow change in counting rate with the moving detector position. Since minification increases all the density gradients on the retina, it is to be expected that by its use some features which were not seen on the larger display may become discernible.

DePalma and Lowry (*7*) have measured the modulation transfer function for the human eye and found that there is a maximum response when the spatial frequency on the retina is about 10 cycles per millimeter and that there is a fairly rapid decline in visual acuity either side of this frequency. Using DePalma and Lowry's experimental results, Morgan (*8*) produced a plot of the relationship between the object diameter required for optimum perception and the viewing distance.

At a typical viewing distance of 1 meter, this diameter is about 3 mm. Since all the features that one can expect to observe in a scan are larger than this, it follows that minification should improve the perceptibility of all relevant features. Furthermore, this argument applies to colorscan as well as photoscan displays.

The foregoing discussion does not provide grounds for the general use of minified displays since similar results are achieved by viewing full-size displays from a greater distance. However, for areas much in excess of the normal large film size 17 in. $\times$ 14 in., such as total skeletal scans, it becomes impracticable