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FORTRAN PROGRAMMES FOR THE TREATMENT OF PERSONNEL MONITORING DATA

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<u>CONTENTS</u>

1. INTRODUCTION

The personnel monitoring at CERN is based on the information recorded on personal film-badges[1]. The first problem is to calculate the external radiation exposure dose for X and gamma radiation, charged particles, and slow neutrons by analysing the densities found behind different filters in the case of gamma films; the fast neutron dose and the dose due to strong interacting particles is deduced from the scanning by microscope of the nuclear emulsion of the neutron films[2].

The second problem consists of the interpretation of the observed data and the computation of the integrated doses for a given period, for hundreds of people (approximately 1500 in December 1966) in a conveniently short time.

The distribution of the gamma films is made at two different intervals: 10% of the films are exchanged weekly and the rest monthly. The neutron films are always distributed and collected on a monthly basis. Therefore, for the purpose of computation of the results, two almost identical programmes have been elaborated, differing only in periodicity. They have been written in FORTRAN and used extensively on the CDC 6600 computer at CERN.

2. GENERAL REQUIREMENTS

2.1 Identification

The programme for the personnel monitoring data should be able to identify the wearer of the film by means of a code number, which should correspond uniquely to one individual.

The code is restricted to the use of four figures, which is sufficient for grouping the staff in up to 99 different groups by using the first two figures for the group designation and the two last figures for the designation of the individual. Each group may include 99 people. The handling of new arrivals at CERN, of people leaving, as well as the transfer from one group to another of people already working within the Organization, should also be possible, including an eventual introduction of previous data. The period during which the film is used is defined by the two next figures, and this is of importance for the identification of the period during which the doses were recorded. With such a great number of film users, a non-negligible quantity of films is not returned in time but might be delayed by one period or more. In addition, films are sometimes lost. Consequently, in order to cope with the recommended rules, the programme must indicate an artificial dose (which is fixed by these rules) when a distributed film is not returned in time, and correct this dose later when the film is returned.

2.2 Dose computation

For the neutron films, the input data will express the dose directly in mrem.

For the gamma films, the components of the dose due to ionizing radiation and to slow neutrons are calculated from the film blackening read under the various filter areas (seven densities) of the film-holder. Doses are finally divided into three categories: the gamma and hard X-ray dose, the slow neutron dose, and the beta and soft X-ray dose. In the calculation it is important to take into account the fog (natural blackening of the film)

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corresponding to the emulsion particular to the batch of films treated. The various densities are first transformed into radium-equivalent doses using calibration data that may eventually change from one batch of emulsion to the next one, or else alter according to the developing process used. There exist, in fact, two calibration curves for each process corresponding to the two different emulsions on the film[3].

The programme must be flexible enough to accept films with only one density (corresponding to the lead filter and the gamma dose); this is, for example, the case for those films which are used as self-service films, or those intended for the occasional visitor. In normal routine the densities are read by means of a semi-automatic densitometer specially designed for this purpose[4].

2.3 Accumulated data

The programme must provide, for each individual, the doses caused by the different types of radiation for the relevant period, together with the total all-body radiation dose (gamma dose + slow neutron dose + fast neutron dose). The sum of the total doses received during the previous 13 weeks and the sum of the doses for the previous 12 months must also be available. The latter will include an artificial dose in case of non-returned films.

It is desirable to be able to extract at any given moment all information on any person for a period up to one year, with special mention of the doses for the non-returned films. For a person leaving CERN this information is also required, in addition to the total of the effective doses (artificial doses excluded) received since 1 January of the current year. A separate programme is provided for statistics which can be used for printing the above-mentioned information for all groups or for some of them.

2.4 Special information

The requirements of Health Physics include important information that has to be recorded, together with the results. All artificial doses corresponding to non-returned films have to be mentioned; any exposure exceeding the maximum average permissible doses (MPD) for a given period or any other special prescription must be noted[5].

Other information, such as that relevant to newcomers or people leaving CERN, is also required, and finally the results must come out in a workable form with a minimum of four copies. All data stored on the memory tape must be in such a form that they can be used easily at any time in order to establish statistical information or detailed precise information. These general requirements are summarized in Fig. 1.

3. DESCRIPTION OF THE PROGRAMMES

3.1 Main Programmes: WEEKLY AND MONTHLY

The programme WEEKLY which handles the films exchanged once a week is not essentially different from the programme MONTHLY provided for the films exchanged once a month; therefore the general conception of both programmes is fundamentally the same. The subroutines are identical for WEEKLY and MONTHLY.

The programme starts by reading the identification and the names of the different groups, the number of the period under consideration, and the background of this period.

The reference period corresponding to the first week of the year is included in the programme as the first executable statement; this has to be changed yearly. Other information, such as the date of the current period and the month corresponding to the fast neutron doses (normally given for the preceding month), is read in as data. Any data-card issued to indicate changes of the group population is read in next. Certain tests are made to assess whether or not these changes are formally correct (see also Table 1). Formally incorrect cards are ignored. The programme continues to read the cards containing information from the late films, if any, and then the cards of the actual period. In the case of the neutron film (identified by N, see INPUT), the fast neutron dose is calculated directly by rounding off the dose read, using the function IDORND. For the gamma films the appropriate doses are calculated by using the subroutine DOSES. Here again, when reading the cards checks are carried out to control their formal correctness; cards found to be incorrect are ignored. For a given period it is possible to have more than one film; in such a case the information from all these films is added together.

The tape containing the accumulated information of the last 12 months is subsequently scanned in connection with the changes of the group population. Checks are made to eliminate unreasonable changes. The accumulated information on personnel transfers within the groups is stored in a separate section. Messages are printed for unreasonable changes.

The programme then follows essentially two loops: one over all the groups; and the other (inside the first one) over all the people within a group. This is the part of the programme which constructs an up-dated new tape, taking into account the accumulated information from the input tape and the information supplied on the cards for the period under consideration. In detail, the programme makes tests on people transferred, newcomers, name corrections, and people leaving CERN, and handles them in an appropriate way. The information gathered from the delayed films is duly taken into account, either by replacing the artificial dose by the true one, or by adding the dose from the delayed film to the dose value already stored.

For each person, the accumulated information about the various doses (taken originally from the input tape and since corrected in accordance with the delayed films) is then adjusted to the actual period using the information from the readings of the actual films. If no film is found for the actual period, an artificial dose (MPD) is stored together with an appropriate label which defines this dose as being artificial. The new 13-week and 12-month accumulated doses are then calculated. Several tests are made according to certain rules for every type of overexposure[6]. The results of all these computations are brought into a suitable form for printing-out listings and constructing the new up-dated tape.

The cases of overexposures due to the late films in a group are indicated by messages on the listings. At the end of the loop over all the persons of the group, detailed information regarding those of the group leaving CERN is printed.

3.2 Subroutines

3.2.1 Subroutine DOSES

This subroutine has six arguments and is used to calculate the different components of the dose from the densities read behind the seven filters of the film-badge holder. The six arguments are: an array for the seven densities; the background density; a selection letter (see below); the gamma dose; the beta dose; the slow neutron dose. If only one density is read, the routine computes the radium-equivalent dose corresponding to this density, and this dose then represents the gamma dose; the beta and slow neutron doses are set to zero. When the seven density data are used, the routine starts by calculating the seven radium-equivalent doses. The slow neutron dose is first determined from the difference between the densities behind Cd and Sn filters; the presence of beta or low-energy X-ray doses is verified by a test between the difference in densities behind "thick plastic" and "open window", and "thin plastic" and "thick plastic"; the ratio of these differences is used to choose a multiplying factor in order to derive the beta dose. Finally, the gamma dose is computed from the density corresponding to the Pb filter, corrected for radiation of lower energy (if necessary), using as test the difference in densities behind open window, thick plastic, and lead[7].

The radium-equivalent doses are computed from the densities and the background; the formula used is derived from calibration curves repeated every month. The curve is actually split into four parts: for the lowest densities the relation is linear; for the three other ranges the best fitting formula has the following form:

$$\text{Dose} = \left(\frac{\text{density - background}}{A}\right)^{B}$$

A and B being the parameters which vary for each range.

One of the arguments is a selection letter corresponding to another calibration curve for the less sensitive emulsions (pealed films). In this case, the conversion in radium-equivalent dose is exactly the same as above, but with different coefficients; the background, which is different from the normal one, is assumed to have a fixed value.

The results of the sub-routine are three doses for each film; namely, the gamma dose, the beta dose, and the slow neutron dose. These three doses are rounded off using the function IDORND.

3.2.2 Function IDORND

This function sub-routine has one argument: the dose. It takes care of an appropriate rounding-off of this dose. The following is done:

Dose	Rounded off to the nearest value of a scale in steps of
> 3000 mrem	100 mrem
> 1500 mrem to 3000 mrem	60 "
> 500 " to 1500 "	40 "
> 100 " to 500 "	20 "
> 10 " to 100 "	10 "

Any dose not larger than 10 mrem is set to 0 mrem by this routine.

3.2.3 Subroutine PERIOD

This routine has four arguments and is used to calculate a certain vector containing a sequence of period numbers. For the weekly films, the period number goes from 1 to 99 once it has started at a certain week. After 99, the numbers start again with 1, and so on. For the monthly films, the period number is chosen according to the distribution of weeks and months in a year. Therefore, the period numbers of two consecutive months differ, in general, either by 4 or by 5.

In detail, the subroutine does the following:

i) The third argument is equal to 0.

A vector (which is the second argument) of 52 elements (in the case of WEEKLY, where the fourth argument is 52), or a vector of 12 elements (in the case of MONTHLY, where the fourth argument is 12), is chosen such that the period number which lies just above the period number given by the first argument of the subroutine, is the last element of the vector. In the weekly case, the appropriate set of 52 numbers is simply taken from the sequence 1,2,...,99, 1,2,...,99. The sequence for the monthly case is taken from the data vector of 36 elements which is given as a DATA statement in the subroutine. The vector should be altered every year.

ii) The third argument is equal to 1.

The same is done as under (i), with the exception that the last element of the chosen vector is the period number given by the first argument.

In the monthly case, a test is done to decide whether or not the period number given by the first argument is reasonable. If the test fails the programme will stop.

3.2.4 Subroutine MESAGE

This routine has three arguments: a label, the name of the month to which the fast neutron films belong, and the tape number for the off-line listing. The label decides on the appropriate messages to be printed out in the listings (see OUTPUT).

3.2.5 Subroutine DATEZB

This is a library routine which stores the actual date (i.e. the date when the job is run) into its argument in a Hollerith format.

3.3 Description of input data for weekly and monthly programmes

The input consists of a binary tape and a pack of data-cards.

3.3.1 The binary input tape

This tape contains the accumulated data of the previous year for all the groups in one file, in the following order for each person:

- the group number, the person number, the personal name vector, the period vector, the vectors of gamma doses, beta doses, slow neutron doses, and fast neutron doses.

The personal name vector has three elements, the name starting left-adjusted in the first element, and the christian name starting left-adjusted in the third element. The other vectors have 52 or 12 elements according to the 52 weeks (WEEKLY) or 12 months (MONTHLY). The period vector contains the 52 or 12 previous period numbers. The dose vectors contain the respective doses from these previous periods; some of the gamma doses may have labels defining them as artificial. The tape contains 10 groups in the weekly case and 99 groups in the monthly case; each of these groups contains 99 possible people. The information concerning an individual is found at the place defined by his group number n and person number m. The sequence order is:

- group 01, person 01 to 99, group 02, person 01 to 99,..., group 10 (or 99), person 01 to 99.

An array on the tape defined by a group number and by a person number is considered as populated if the first element of the personal name vector is not blank.

3.3.2 Input cards (see Figs. 2 and 14)

a) FORMAT (I2,3X2A10,5XA3)

10 (WEEKLY) or 99 (MONTHLY) cards containing the group number, the group name, and the division name of this group. These cards must be in the right order, i.e. the group with number j must be on the j^{th} card. Groups which are not populated should be present by their numbers on the card.

b) FORMAT (I2,I8,4A10,2A10)

1 card containing the period number under consideration, the background, a Hollerith message up to 40 characters defining the calender date of the actual period, and a Hollerith message up to 20 characters defining the period for the fast neutron dose. These messages will appear in the listings.

c) FORMAT (2I1,1X2I1,2XA2,1X3A10)

Up to 200 (WEEKLY) or 500 (MONTHLY) cards defining changes in the group population; the order of the cards is not important. These cards contain:

- the group number n in two figures (i.e. 2 as 02);
- the person number m in two figures (i.e. 2 as 02);
- a code consisting of not more than two Hollerith characters left-adjusted;
- the personal name vector of not more than 20 Hollerith characters for the name starting in col. 11 and not more than 10 Hollerith characters for the christian name starting in col. 31.

Table 1 shows the permissible codes for the changes of the populations, their effect and the imposed restrictions. It is not possible to have either N, NØ, or TN cards and an L card for the same (n m) in the same run. A person leaving CERN will still appear on the actual listings. A person transferred within CERN will be listed only on its new place. Not more than 100 (WEEKLY) and 250 (MONTHLY) transfers are allowed in the same run.

d) A separation card containing an asterisk (*) in col. 11.

e) FORMAT (4I1,I2,4XA1,9X9(I4,1X),14XA1)

Up to 200 (WEEKLY) or 500 (MONTHLY) cards in any order containing information about delayed films. The cards contain, from left to right, according to the above format:

- the group number n in two figures)
- the person number m in two figures } (i.e., 2 as 02)
- the period number k in two figures)
- either a blank (gamma films) or an N (fast neutron films, directly the dose);
- seven densities corresponding to the seven filters of the film-holder; in the case of one density only, this must appear as the fifth one, all the others being zero; the fast neutron dose, however, has to be placed in the first position;
- two densities testing the stability of the densitometer;
- a test character for the choice of the right calibration curve (blank for unpealed film and P for pealed film).

f) A separation card such as (d).

g) Up to 500 (WEEKLY) or 3000 (MONTHLY) cards in any order containing information about the films from the period under consideration. They have the same format as the cards for the delayed films under (e). A check is done on whether k is the period under consideration or not.

h) A separation card such as (d).

In the case where the limits under (c), (e), or (g) are exceeded, the remaining cards are simply ignored.

3.4 Description of the output data for weekly and monthly programmes

The output consists of a binary tape, an on-line print-out of the resulting listings, and a BCD tape containing these listings for off-line printing.

3.4.1 The binary output tape

This tape contains the updated accumulated data of the previous year for all the groups, in the same order as in the input tape (see Section 3.3.1).

3.4.2 The on-line print-out

This print-out contains the following:

i) A record of the card input, which record consists of:

a) a listing of the changes in the group population, (ignored cards are labelled in the listing);

b) a listing of the late films with their code and their measured densities (ignored cards are labelled in the listings);

c) a listing of the films of the actual period with their code and densities (ignored cards are labelled in the listing);

d) a listing of demanded but unreasonable changes of the group population, if any, giving information on expected new and existing old population.

ii) A listing of the results per group (see Fig. 3). Each of them consists of the name and identification number of the group, the division and the period, in which the films were used, successive listing of the members of the group, giving the four components of the dose and the total dose for the relevant period, plus the integrated total dose over the preceding 3 and 12 months. In addition, at the end of each group listing, messages appear if necessary. These messages may be:

- the relevant period for the fast neutron dose;
- the explanations for the artificial dose average (maximum permissible dose for the period) if a film is not returned. Such a dose is indicated by an asterisk (*) following just after the gamma dose;
- indications and explanation messages of the various types of overexposures, when such occur in the group:

a) the word OVEREXPOSURE preceding the code number of a person indicates that the relevant personal dose is higher than the average maximum permissible dose for the period;

b) the sign == preceding the code number of the person means that the last 12 months' dose exceeds the maximum permissible level;

c) the sign = means that the last 3 months' dose exceeds the maximum permissible level;

d) the sign + corresponds to an overexposure of the last 3 months, the lens of the eye being considered as the critical organ;

e) the sign ++ corresponds to a fast neutron dose higher than the maximum permissible level, the lens of the eye being considered as the critical organ.

(The dose limits mentioned above are given in DATA statements in the main programme).

f) the corrections for the dose given by the delayed films will only appear on the up-dated tape, except when there is overexposure or when the total accumulated dose results in an overexposure;

g) the sign $ after the 3-month dose indicates that the corresponding person is present at CERN for less than 13 weeks.

iii) Listings for people leaving CERN, if there are any in the group, with all the information relevant to the person extracted from the binary output tape, plus the total of the dose components for the actual calendar year (example is seen in Fig. 4).

iv) The films which have not been considered during the run are listed finally for check purposes.

3.4.3 The BCD type for off-line print-out

This ½" tape contains exactly the information described under Section 3.4.2. Reproduction of the listings may be made from this tape.

4. STATISTICS

4.1 Requirements

The storage tape contains all information of the last 52 or 12 periods for the radiation workers registered at the period when this tape was produced. A first requirement consists of the necessity of providing access to this information, and to list for selected groups the results of the previous 52 weeks (or 12 months) for all the workers of selected groups, and to know the time distribution of the accumulated doses. This information is very useful when planning, for instance, an important machine shut-down when radiation doses to be received are expected to be high and distributed among several workers.

At the end of the legal year, such a listing for the whole staff is also needed, thus permitting for each individual to have the list of the various doses received at any period of the year and also of the total dose accumulated in a year; these records are subsequently filed following an individual filing system.

From the information stored during the course of a year, statistics have to be computed per group, per division, and for the whole CERN; these data include the quarterly doses, the maximum dose received during a single period, the number of periods during which the recommended average dose had been exceeded, and the number of non-returned films (lost or damaged), for each individual.

Other useful information for groups is the following: the total doses, the average dose per person per year and per period, the maximum dose recorded per period and the number of overexposures (with the signification of doses higher than the recommended maximum dose per period on an equally distributed base), and an overexposure factor in per cent, representative of the inequality in time or people of the distributed total dose. This factor, expressed in per cent, is equal to the number of times the average maximum permissible dose had been exceeded in a given group, divided by the product of the population of the group and the number of periods in a year. A repartition of the doses in per cent between the groups of each division is also given.

Finally, the total dose per division, the average dose per individual, the maximum dose received in a single period by a person, and the total number of films missing in the different divisions are obtained, and the same data are repeated for the whole CERN. At this stage the programme must foresee the possibility of incorporating the global (division) results of the weekly films. The percentage distribution between the divisions is also obtained (of course the population of radiation workers in groups, divisions, and CERN is important and is recorded at all levels).

4.2 Description of the programmes for statistics

4.2.1 Main programmes WSTATI and MSTATI

There are two programmes for statistics, WSTATI for the weekly case and MSTATI for the monthly. Both calculate in a fairly straightforward way the required quantities as outlined above and need no detailed description. MSTATI is more flexible than WSTATI. For instance, one can ask for the listing of the accumulated data (complete or partial) from the storage tape without any statistics. There is also a possibility to introduce accumulated data (for instance, results from WSTATI) from outside on data cards.

4.2.2 Function MAXMUM

This function enquires for the largest number of a one-dimensional array which is given as first argument. Starting at 1, the length of the array is defined by the second argument.

4.2.3 Function MORMAX

This function counts the number of members of a one-dimensional array (first argument) which are larger than a certain quantity (second argument). Starting at 1, the array length is defined by the third argument.

4.2.4 Function ISUM with Entries LSUM, MSUM, NSUM

This function sums up the numbers of an array (first argument) starting from the place given by the second argument to the place given by the third argument. Entry LSUM calculates the ordinary sum; entry MSUM ignores labels; entry NSUM ignores numbers with labels.

4.2.5 Subroutine EXCHZL

This library routine when called for, unloads the existing reel of tape and puts a request to the operators for the next reel to be loaded onto the logical unit defined by the argument.

4.2.6 Input description for MSTATI (see Fig. 5)

The input consists of a binary tape and a pack of cards.

i) The binary input tape is the storage tape from MONTHLY.

ii) Input cards:

a) FORMAT (I4)
1 card containing the year (e.g. 1966).

b) FORMAT (I2,3X2A10,5XA3)
99 cards containing the group number, the group name, and the Division name of the group. These cards must be in the right order (see Section 3.3.2 a).

A division name which is not in the division list (given as a DATA statement in MSTATI) leads to a message to be printed. One or more incorrect division names will stop the run.

c) FORMAT (I2)

Either a blank card, in which case all populated groups will be treated and complete statistics will be carried out; or, cards containing the two figure numbers for the selected group (in any order) ended by a blank card. In this latter case only listings of the contents of the memory tapes are done in an appropriate format for the populated groups given by these cards. No statistics are done.

d) FORMAT (I2,3XI5)

One card containing the logical number of the output unit for the results and the number of people under fast neutron film-badge control. If tape output is requested, the programme will need on this unit N/750+1 tapes for BCD output, plus 1 tape for the results of the statistics. N is the number of people inside the selected groups (i.e. for 1600 people including statistics, four tapes).

e) FORMAT (A3,2XI5,7I10)

Not more than one card per division (in any order) containing statistical data outside the memory tape. These cards contain each from left to right:

- the division name,
- the number of people,
- the total gamma dose } for the division
- the total slow neutron dose } for the division
- the total fast neutron dose } for the division
- the maximum of the gamma dose } recorded in the division
- the maximum of the fast neutron dose } recorded in the division
- the maximum of the total dose } recorded in the division

f) A card having an asterisk (*) in col. 1.

4.2.7 Input description for WSTATI

The input consists of a binary tape and a pack of cards:

i) The binary input tape is the storage tape from WEEKLY.

ii) Input cards

a) FORMAT (I4)

1 card containing the year (e.g. 1966)

b) FORMAT (I2,3XA10,5XA3)

10 cards instead of 99, but otherwise the same as for ii) b) under MSTATI.

c) 1 card containing the logical number of the output unit. In the case of tape output the procedure is similar to that of MSTATI. All populated groups are listed and statistics are always done.

4.3 Output for monthly statistics

The output for statistics (complete) consists of a BCD tape containing all information required:

4.3.1

A listing for each individual consisting of the name and identification of the group and division, the four components of the dose for each period of the year (52 weeks or 12 months), the four components accumulated for the year, the artificial doses not taken into consideration, the total yearly dose (time), the number of missing films, and the corresponding total artificial dose (Fig. 6).

4.3.2

A listing per group giving for each member the four quarterly doses, the yearly dose and the average monthly dose including the four components of the dose for each case (Fig. 7).

4.3.3

A listing per group giving for each member the maximum monthly gamma, fast neutron and total dose, and the times the maximum admissible monthly dose had been exceeded, plus the number of missing films for the year (Fig. 8).

4.3.4

A listing per division (see Fig. 9), giving for each group the number of members, the total yearly dose, the monthly and yearly average doses per individual, the maximum monthly dose in the group, and the number of overexposures, plus the overexposure factor as defined in Section 4.1.

4.3.5

A listing per division (see Fig. 10) of the distribution in per cent of the total dose between the various groups of the divisions, plus the total number of missing films per division.

4.3.6

A listing for CERN (Fig. 11), giving per division the number of members, the total yearly dose, the average monthly and yearly dose per individual, and the maximum monthly dose.

4.3.7

The distribution of the total dose measured at CERN between the divisions and the total dose for the whole CERN, with the average monthly and yearly dose (see Figs. 12 and 13).

For weekly statistics, all information referred to 'monthly' is translated into 'weekly'. For incomplete statistics, only Section 4.3.1 is transferred onto the BCD output tape.

Table 1

Code for change in group population

Code	Order	Restrictions
C	correction; replace for person (n m) the name vector	(n m) must be populated on the input tape
N	newcomer; populate person (n m) set all doses to zero	(n m) must not be populated on the input tape
N$	as N; in addition, a label is stored (together with the beta dose) indicating that this newcomer needs special attention during the first 13 weeks; this label appears on the listings	(n m) must not be populated on the input tape
L	person (n m) leaving CERN; extract the accumulated information of (n m) after being treated and depopulate (n m)	(n m) must be populated on the input tape. At least the first character of the name and the first character of the christian name (the initials), which are at $(nm)_L$ on the input tape must agree with the corresponding characters on the L card.
TL	transfer (old place); the information of $(n\ m)_{TL}$ is transferred to $(n\ m)_{TN}$, depopulating $(n\ m)_{TL}$	$(n\ m)_{TL}$ must be populated } on the input tape. $(n\ m)_{TN}$ must not be populated } on the input tape. At least the first character of the name and the first character of the christian name (the initials) which are at $(n\ m)_{TL}$ on the input tape must agree with the corresponding characters on the TL card. At least the first five characters of the name and the first five characters of the christian name on the TL card must agree with the corresponding characters on the TN card.
TN	transfer (new place); store the information from $(n\ m)_{TL}$ to $(n\ m)_{TN}$.	

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APPENDIX

A listing of the programme MONTHLY is given.

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      PROGRAM MONTHLY
C
      DIMENSION KPER(12),LG(12),LB(12),LS(12),LF(12),LD(7),LX(2)
      DIMENSION P(3),DI(99),GR(99,2),OV(2),PDATE(4),XMO(2)
      DIMENSION NMKN(500),IGN(500),IBN(500),ISN(500),IFN(500)
      DIMENSION NMC(500),CC(500),PC(500,3),LTOTLT(99),NKLT(99),NML(99)
      DIMENSION NM(3000),IG(3000),IB(3000),IS(3000),IF(3000)
      DIMENSION PT(250),LGT(250,12),LBT(250,12),LST(250,12),LFT(250,12)
      DATA (BLANK=10H          ),(STAR=1H*),(DOLLAR=1H$)
      DATA (HN=1HN),(HL=1HL),(HC=1HC),(HTL=2HTL),(HTN=2HTN),(HND=2HN$)
      DATA (OV=12HOVEREXPOSURE),(GNORED=7HIGNORED)
      DATA (NTELEF=2155),(LABEL=100000000),(MAXDOS=400)
      DATA (MAXD2=5000),(MAXD3=3000),(MAXD4=8000),(MAXD5=2500)
      DATA (HPP=2H++),(HP=1H+),(HEE=2H==),(HE=1H=)
      DATA (NOLDTP=12),(NNEWTP=13),(NOUT=4),(NCOMTP=14)
      LOGICAL IOV1,IOV2,IOV3,IOV4,IOV5,IMISS,INEWC,IPAGE,INEUT
C
      NMKF(NNN,MMM,KKK)=10000*NNN+100*MMM+KKK
      NMF(NNN,MMM)=100*NNN+MMM
C
      KPERST=06
C
      REWIND NOLDTP
      REWIND NNEWTP
      REWIND NOUT
      CALL DATEZB (DATE)
      DO 71 IN = 1,500
   71 IFN(IN)=-1
      DO 72 IR = 1,3000
   72 IF(IR)=-1
C
C     IDENTIFICATION OF GROUPS, PERIODS AND BACKGROUND
C
      DO 60 N = 1,99
   60 READ 104, N1,GR(N,1),GR(N,2),DI(N)
      READ (1,100) KP,IBCKGR,PDATE,XMO
C
C     CHANGES IN GROUP POPULATION
C
      WRITE (NOUT,300) KP,DATE
      PRINT 300,       KP,DATE
      IC=0
   24 READ(1,103) N1,N2,M1,M2,C,P
      IF(P(1) .EQ. STAR) GO TO 26
      N=10*N1+N2
      M=10*M1+M2
      COMT=GNORED
      IF(N*M .EQ. 0 .OR. IC .GE. 500) GO TO 61
      IF(C .NE. HC  .AND. C .NE. HN  .AND. C .NE. HND .AND.
     1   C .NE. HL  .AND. C .NE. HTL .AND. C .NE. HTN) GO TO 61
      IC=IC+1
      COMT=BLANK
      NMC(IC)=NMF(N,M)
      CC(IC)=C
      DO 25 J = 1,3
   25 PC(IC,J)=P(J)
   61 WRITE (NOUT,301) N1,N2,M1,M2,C,P,COMT
      PRINT 301,       N1,N2,M1,M2,C,P,COMT
      GO TO 24
C
C     LATE FILMS, CALCULATION OF DOSES
C
   26 WRITE (NOUT,302) KP,DATE
      PRINT 302,       KP,DATE
      IN=0
```

```
   12 READ(1,102) N1,N2,M1,M2,K,TEST,LD,LX,TEST1
      IF(TEST .EQ. STAR) GO TO 21
      N=10*N1+N2
      M=10*M1+M2
      COMT=GNORED
      IF(N*M*K .EQ. 0 .OR. IN .GE. 500) GO TO 63
      IN=IN+1
      COMT=BLANK
      NMKN(IN)=NMKF(N,M,K)
      IF(TEST .EQ. HN) GO TO 96
      CALL DOSES (LD,IBCKGR,TEST1,IGN(IN),IBN(IN),ISN(IN))
      GO TO 63
   96 IFN(IN)=IDORND(LD(1))
   63 WRITE (NOUT,303) N1,N2,M1,M2,K,TEST,COMT,LD,LX,TEST1
      PRINT 303,        N1,N2,M1,M2,K,TEST,COMT,LD,LX,TEST1
      GO TO 12
C
C     ACTUAL FILMS, CALCULATION OF DOSES
C
   21 WRITE (NOUT,304) KP,DATE,IBCKGR
      PRINT 304,        KP,DATE,IBCKGR
      IR=0
   14 READ(1,102) N1,N2,M1,M2,K,TEST,LD,LX,TEST1
      IF(TEST .EQ. STAR) GO TO 80
      N=10*N1+N2
      M=10*M1+M2
      COMT=GNORED
      IF(N*M*K .EQ. 0 .OR. K .NE. KP .OR. IR .GE. 3000) GO TO 65
      IR=IR+1
      COMT=BLANK
      NM(IR)=NMF(N,M)
      IF(TEST .EQ. HN) GO TO 92
      CALL DOSES (LD,IBCKGR,TEST1,IG(IR),IB(IR),IS(IR))
      GO TO 65
   92 IF(IR)=IDORND(LD(1))
   65 WRITE (NOUT,303) N1,N2,M1,M2,K,TEST,COMT,LD,LX,TEST1
      PRINT 303,        N1,N2,M1,M2,K,TEST,COMT,LD,LX,TEST1
      GO TO 14
C
C     SCANNING OF OLD TAPE FOR CHANGES IN GROUP POPULATION AND
C     STORAGE FOR TRANSFERS
C
   80 IF(IC .EQ. 0) GO TO 3
      WRITE(NOUT,209)
      PRINT 209
      IT=0
      DO 83 N = 1,99
      DO 83 M = 1,99
      READ(NOLDTP) ND,MD,P,KPER,LG,LB,LS,LF
      DO 81 I = 1,IC
      IF(NMC(I) .NE. NMF(N,M)) GO TO 81
      IF(CC(I) .EQ. HC  .AND. P(1) .EQ. BLANK .OR.
     1   CC(I) .EQ. HN  .AND. P(1) .NE. BLANK .OR.
     2   CC(I) .EQ. HND .AND. P(1) .NE. BLANK .OR.
     3   CC(I) .EQ. HL  .AND. P(1) .EQ. BLANK .OR.
     4   CC(I) .EQ. HTL .AND. P(1) .EQ. BLANK .OR.
     5   CC(I) .EQ. HTN .AND. P(1) .NE. BLANK) GO TO 82
      IF(CC(I) .EQ. HC  .OR. CC(I) .EQ. HN  .OR.
     1   CC(I) .EQ. HND .OR. CC(I) .EQ. HTN) GO TO 81
      ENCODE(10,150,P1) P(1),P(3)
      ENCODE(10,150,P2) PC(I,1),PC(I,3)
      IF(P1 .NE. P2) GO TO 82
      IF(CC(I) .EQ. HL) GO TO 81
      IF(IT. GE. 250) GO TO 82
      IT=IT+1
      ENCODE (10,151,P1) PC(I,1),PC(I,3)
```

```
      PT(IT)=P1
      DO 85 K = 1,12
      LGT(IT,K)=LG(K)
      LBT(IT,K)=LB(K)
      LST(IT,K)=LS(K)
   85 LFT(IT,K)=LF(K)
      GO TO 81
   82 WRITE(NOUT,210) N,M,CC(I),P,PC(I,1),PC(I,2),PC(I,3)
      PRINT 210,      N,M,CC(I),P,PC(I,1),PC(I,2),PC(I,3)
      CC(I)=BLANK
   81 CONTINUE
   83 CONTINUE
      REWIND NOLDTP
C
C     LOOP OVER ALL GROUPS
C
    3 DO 1 N = 1,99
      N1=N/10
      N2=MOD(N,10)
      IOV1=.FALSE.
      IOV2=.FALSE.
      IOV3=.FALSE.
      IOV4=.FALSE.
      IOV5=.FALSE.
      IMISS=.FALSE.
      INEWC=.FALSE.
      IPAGE=.FALSE.
      INEUT=.FALSE.
      REWIND NCOMTP
C
C     LOOP INSIDE EACH GROUP
C
      DO 2 M = 1,99
      LTOTLT(M)=0
      NML(M)=0
      READ(NOLDTP) ND,MD,P,KPER,LG,LB,LS,LF
C
C     TEST FOR DECISION FOR EACH INDIVIDUAL
C
      DO 38 I = 1,IC
      IF(NMC(I) .NE. NMF(N,M)) GO TO 38
      IF(CC(I) .EQ. HTL) GO TO 75
      IF(CC(I) .EQ. HN .OR. CC(I) .EQ. HND .OR. CC(I) .EQ. HC) GO TO 76
      IF(CC(I) .EQ. HTN) GO TO 77
      IF(CC(I) .EQ. HL) GO TO 78
   38 CONTINUE
      IF(P(1) .EQ. BLANK) GO TO 29
      GO TO 35
C
C     SUPPRESION OF A TRANSFERRED INDIVIDUAL
C
   75 P(1)=BLANK
      GO TO 29
C
C     INTRODUCTION (WITH PROPER LABEL) OF A NEWCOMER OR
C     A NAME CORRECTION
C
   76 DO 33 J = 1,3
   33 P(J)=PC(I,J)
      IF(CC(I) .EQ. HC) GO TO 35
      CALL PERIOD (KP,KPER,0,12)
      DO 34 K = 1,12
      LG(K)=0
      LB(K)=0
      LS(K)=0
   34 LF(K)=0
```

```
      IF(CC(I) .EQ. HND) LB(12)=LABEL
      GO TO 35
C
C     INTRODUCTION OF A TRANSFERRED INDIVIDUAL
C
   77 IF(IT .EQ. 0) GO TO 97
      DO 44 JT = 1,IT
      ENCODE (10,151,P1) PC(I,1),PC(I,3)
      IF(PT(JT) .NE. P1) GO TO 44
      DO 46 J = 1,3
   46 P(J)=PC(I,J)
      CALL PERIOD (KP,KPER,0,12)
      DO 47 K = 1,12
      LG(K)=LGT(JT,K)
      LB(K)=LBT(JT,K)
      LS(K)=LST(JT,K)
   47 LF(K)=LFT(JT,K)
      GO TO 35
   44 CONTINUE
   97 WRITE(NOUT,210) N,M,CC(I),P,PC(I,1),PC(I,2),PC(I,3)
      PRINT 210,      N,M,CC(I),P,PC(I,1),PC(I,2),PC(I,3)
      GO TO 29
C
C     SET LABEL FOR A LEAVING INDIVIDUAL
C
   78 NML(M)=M
C
C     PRINTING  HEADLINES FOR LISTINGS
C
   35 M1=M/10
      M2=MOD(M,10)
      IF(IPAGE) GO TO 5
      WRITE (NOUT,200) NTELEF,DATE,DI(N),N1,N2,GR(N,1),GR(N,2),KP,PDATE
      PRINT 200,       NTELEF,DATE,DI(N),N1,N2,GR(N,1),GR(N,2),KP,PDATE
      IPAGE=.TRUE.
C
C     INTRODUCTION OF LATE FILM INFORMATIONS, IF ANY
C
    5 IF(IN .EQ. 0) GO TO 42
      DO 15 K = 1,12
      DO 15 I = 1,IN
      IF(NMKN(I) .NE. NMKF(N,M,KPER(K))) GO TO 15
      NMKN(I)=NMKN(I)+LABEL
      LGK=LG(K)
      IF(LGK .GE. LABEL) LGK=0
      IF(IFN(I) .GE. 0) GO TO 98
      LG(K)=LGK+IGN(I)
      LB(K)=MOD(LB(K),LABEL)+IBN(I)
      LS(K)=LS(K)+ISN(I)
      LNEWSM=IGN(I)+ISN(I)
      GO TO 27
   98 LF(K)=LF(K)+IFN(I)
      LNEWSM=IFN(I)
   27 LTOTSM=LGK+LS(K)+LF(K)
      LOLDSM=LTOTSM-LNEWSM
      IF(LTOTSM .LE. MAXDOS .OR. LNEWSM .LE. 0) GO TO 15
      IF(LOLDSM .LE. MAXDOS) LTOTLT(M)=LTOTSM-MAXDOS
      IF(LOLDSM .GT. MAXDOS) LTOTLT(M)=LNEWSM+LABEL
      NKLT(M)=KPER(K)
   15 CONTINUE
C
C     UPDATING OF ACCUMULATED DATA, INTRODUCTION OF ACTUAL FILMS, OR
C     ACCOUNT FOR MISSING FILMS
C
   42 DO 16 K = 1,11
      KPER(K)=KPER(K+1)
```

```
      LG(K)=LG(K+1)
      LB(K)=LB(K+1)
      LS(K)=LS(K+1)
   16 LF(K)=LF(K+1)
      KPER(12)=KP
      LG(12)=MAXDOS+LABEL
      LB(12)=0
      LS(12)=0
      LF(12)=-1
      IF(IR .EQ. 0) GO TO 52
      DO 50 I = 1,IR
      IF(NM(I) .NE. NMF(N,M)) GO TO 50
      NM(I)=NM(I)+LABEL
      IF(IF(I) .GE. 0) GO TO 51
      IF(LG(12) .GE. LABEL) LG(12)=0
      LG(12)=LG(12)+IG(I)
      LB(12)=LB(12)+IB(I)
      LS(12)=LS(12)+IS(I)
      GO TO 50
   51 LF(12)=MAX0(0,LF(12))+IF(I)
   50 CONTINUE
C
C     COMPUTATION OF ACCUMULATED DOSES
C
   52 LGASN=0
      LFNEU=0
      DO 17 K = 10,12
      LFNEU=LFNEU+MAX0(0,LF(K))
   17 LGASN=LGASN+MOD(LG(K),LABEL)+LS(K)
      LSUM3=LGASN+LFNEU
      LSUM12=LSUM3
      DO 18 K = 1,9
   18 LSUM12=LSUM12+MOD(LG(K),LABEL)+LS(K)+LF(K)
C
C     CHECK FOR OVEREXPOSURE CONDITIONS
C
      LG12=MOD(LG(12),LABEL)
      LTOTAL=LG12+LS(12)+MAX0(0,LF(12))
      IF(LG(12) .GE. LABEL) IMISS=.TRUE.
      S1=BLANK
      S2=BLANK
      IF(LFNEU .LE. MAXD5) GO TO 500
      S1=HPP
      IOV5=.TRUE.
      GO TO 501
  500 IF(LGASN+3*LFNEU .LE. MAXD4) GO TO 502
      S1=HP
      IOV4=.TRUE.
      GO TO 501
  502 IF(LSUM3 .LE. MAXD3) GO TO 501
      S1=HE
      IOV3=.TRUE.
  501 IF(LSUM12 .LE. MAXD2) GO TO 503
      S2=HEE
      IOV2=.TRUE.
  503 O1=BLANK
      O2=BLANK
      IF(LG(12) .GE. LABEL .AND. LS(12)+LF(12) .LE. MAXDOS
     1                               .OR. LTOTAL .LE. MAXDOS) GO TO 55
      O1=OV(1)
      O2=OV(2)
      IOV1=.TRUE.
C
C     OUTPUT FOR LISTINGS
C
   55 FLAG=BLANK
```

```
      IF(LG(12) .GE. LABEL) FLAG=STAR
      FLAG1=BLANK
      DO 19 K = 9,11
   19 IF(LB(K) .GE. LABEL) FLAG1=DOLLAR
      IF(FLAG1 .EQ. DOLLAR) INEWC=.TRUE.
      IF(LF(12) .GE. 0) GO TO 70
      LF(12)=0
      WRITE(NOUT,201) O1,O2,S1,S2,N1,N2,M1,M2,P,LG12,FLAG,LB(12),LS(12),
     1 LTOTAL,LSUM3,FLAG1,LSUM12
      PRINT 201,      O1,O2,S1,S2,N1,N2,M1,M2,P,LG12,FLAG,LB(12),LS(12),
     1 LTOTAL,LSUM3,FLAG1,LSUM12
      GO TO 20
   70 WRITE(NOUT,202) O1,O2,S1,S2,N1,N2,M1,M2,P,LG12,FLAG,LB(12),LS(12),
     1 LF(12),LTOTAL,LSUM3,FLAG1,LSUM12
      PRINT 202,      O1,O2,S1,S2,N1,N2,M1,M2,P,LG12,FLAG,LB(12),LS(12),
     1 LF(12),LTOTAL,LSUM3,FLAG1,LSUM12
      INEUT=.TRUE.
C
C     SAVING INFORMATION FOR LEAVING INDIVIDUAL
C
   20 IF(NML(M) .EQ. 0) GO TO 29
      WRITE(NCOMTP) P,LG,LB,LS,LF
      P(1)=BLANK
C
C     BUILDING UP NEW TAPE
C
   29 WRITE(NNEWTP) N,M,P,KPER,LG,LB,LS,LF
C
C     END OF LOOP INSIDE GROUP
C
    2 CONTINUE
C
C     MESSAGES RELEVANT TO PARTICULARITIES IN THE GROUP
C
      IF(IPAGE.AND.INEUT) CALL MESAGE(10,XMO,NOUT)
      DO 89 M = 1,99
      IF(LTOTLT(M) .LE. 0) GO TO 89
      WRITE(NOUT,215)
      PRINT 215
      M1=M/10
      M2=MOD(M,10)
      LOVER=MOD(LTOTLT(M),LABEL)
      IF(LTOTLT(M) .GE. LABEL) GO TO 90
      WRITE(NOUT,211) N1,N2,M1,M2,LOVER,NKLT(M)
      PRINT 211,      N1,N2,M1,M2,LOVER,NKLT(M)
      GO TO 89
   90 WRITE(NOUT,212) N1,N2,M1,M2,LOVER,NKLT(M)
      PRINT 212,      N1,N2,M1,M2,LOVER,NKLT(M)
   89 CONTINUE
      IF(IOV1 ) CALL MESAGE(8,XMO,NOUT)
      IF(IMISS) CALL MESAGE(9,XMO,NOUT)
      IF(IOV5 ) CALL MESAGE(5,XMO,NOUT)
      IF(IOV4 ) CALL MESAGE(4,XMO,NOUT)
      IF(IOV2 ) CALL MESAGE(2,XMO,NOUT)
      IF(IOV3 ) CALL MESAGE(3,XMO,NOUT)
      IF(INEWC) CALL MESAGE(7,XMO,NOUT)
      WRITE(NOUT,203)
      PRINT 203
C
C     LISTING OF INFORMATION FOR ALL LEAVING INDIVIDUALS IN THE GROUP
C
      REWIND NCOMTP
      CALL PERIOD (KP,KPER,1,12)
      DO 4 M = 1,99
      IF(NML(M) .EQ. 0) GO TO 4
      M1=M/10
```

```
      M2=MOD(M,10)
      READ(NCOMTP) P,LG,LB,LS,LF
      WRITE(NOUT,204) N1,N2,M1,M2,P,N1,N2,KP,DATE
      PRINT 204,      N1,N2,M1,M2,P,N1,N2,KP,DATE
      DO 66 K = 1,12
      IF(KPER(K) .EQ. KPERST) GO TO 67
   66 CONTINUE
   67 KPST=K
      DO 49 K = 1,12
      IF(K .NE. KPST) GO TO 95
      WRITE (NOUT,224)
      PRINT 224
   95 FLAG=BLANK
      IF(LG(K) .GE. LABEL) FLAG=STAR
      LGK=MOD(LG(K),LABEL)
      LBK=MOD(LB(K),LABEL)
      WRITE(NOUT,222) K,KPER(K),LGK,FLAG,LBK,LS(K),LF(K)
   49 PRINT 222,      K,KPER(K),LGK,FLAG,LBK,LS(K),LF(K)
      LGS=0
      LBS=0
      LSS=0
      LFS=0
      DO 57 K = KPST,12
      LGS=LGS+MOD(LG(K),LABEL)
      LBS=LBS+MOD(LB(K),LABEL)
      LSS=LSS+LS(K)
   57 LFS=LFS+LF(K)
      LYEAR=LGS+LSS+LFS
      WRITE (NOUT,223) LGS,LBS,LSS,LFS,LYEAR
      PRINT 223,       LGS,LBS,LSS,LFS,LYEAR
    4 CONTINUE
C
C     END OF LOOP OVER ALL GROUPS
C
    1 CONTINUE
C
C     LISTING OF NONTREATED FILMS
C
      IF(IN .EQ. 0) GO TO 58
      WRITE(NOUT,205) KP
      PRINT 205,      KP
      DO 59 I = 1,IN
      IF(NMKN(I) .GE. LABEL) GO TO 59
      WRITE(NOUT,207) NMKN(I),GNORED
      PRINT 207,      NMKN(I),GNORED
   59 CONTINUE
   58 IF(IR .EQ. 0) GO TO 56
      WRITE(NOUT,206) KP
      PRINT 206,      KP
      DO 54 I = 1,IR
      IF(NM(I) .GE. LABEL) GO TO 54
      WRITE(NOUT,207) NM(I),GNORED
      PRINT 207,      NM(I),GNORED
   54 CONTINUE
C
   56 END FILE NNEWTP
      REWIND NOLDTP
      REWIND NNEWTP
      REWIND NCOMTP
      PRINT 299,KP
      END FILE NOUT
      END FILE NOUT
      END FILE NOUT
      REWIND NOUT
      STOP
C
```

```
100 FCRMAT(I2,I8,4A10,2A10)
102 FCRMAT(4I1,I2,4XA1,9X9(I4,1X),14XA1)
103 FORMAT(2I1,1X2I1,2XA2,1X3A10)
104 FORMAT (I2,3X2A10,5XA3)
150 FCRMAT(2A1,8X)
151 FCRMAT(2A5)
200 FORMAT(1H1,54X22HCERN - HEALTH  PHYSICS/55X22(1H-)/61X5HTEL. I4,
   1 25XA10//59X13HFILM  RESULTS/20X11HDIVISION   A10//
   2 20X8HGROUP   2I1,3H - 2A10, 7X9HPERIOD   I2,5X4A10//
   3 79X19HDOSES  IN  MILLIREM/20X4HCODE,16X4HNAME,
   4 20X56HGAMMA   BETA  SLOW N  FAST N  TOTAL  3-MONTHS  12-MONTHS/
   5 20X100(1H-)/)
201 FCRMAT(1XA10,A2,2(1XA2),2(1X2I1),3X3A10,5XI6,A1,I6,I8,8X,I7,I10,
   1 A1,I1C/)
202 FORMAT(1XA10,A2,2(1XA2),2(1X2I1),3X3A10,5XI6,A1,I6,I8,I8,I7,I10,
   1 A1,I10/)
203 FCRMAT(/////)
204 FORMAT(1H1//////////10X2I1,1X2I1,5X3A10,10X15HLEAVING GROUP  ,2I1,
   11X20HDEFINITELY AT PERIOD,I4,4XA10//
   212X41HJ  PERIOD   GAMMA    BETA  SLOW N  FAST N/)
205 FCRMAT(1H1/5X65HLATE FILMS (GAMMA OR FAST NEUTRON) IGNORED DURING
   1THE RUN (PERIOD,I4,1H)/5X70(1H=)///)
206 FCRMAT(1H1/5X65H     FILMS (GAMMA OR FAST NEUTRON) IGNORED DURING
   1THE RUN (PERIOD,I4,1H)/5X70(1H=)///)
207 FORMAT(5XI6,5XA10)
209 FORMAT(1H1///45X31HUNREASONABLE  CORRECTION  CARDS/45X31(1H=)////)
210 FORMAT(4X2I3,2XA3,2(5X3A10),5X7HIGNORED/)
211 FORMAT(1HS,29X,2(1X2I1),
   1 5X24HHAD AN OVEREXPOSURE OF  I5,23H  MILLIREM FOR PERIOD  I2)
212 FORMAT(1HS,29X,2(1X2I1),
   1 5X35HHAD AN ADDITIONAL OVEREXPOSURE OF  I5,23H  MILLIREM FOR PERI
   2OD  I2)
215 FCRMAT(1HS)
222 FORMAT(5X3I8,A1,I7,2I8)
223 FORMAT(/21X4(8H  ------)/21X4I8,5X13HSUM OF YEAR =I7,2X8HMILLIREM)
224 FCRMAT(5X48(1H-))
299 FCRMAT(1H1/5X22HCALCULATION FOR PERIODI4,1X8HFINISHED)
300 FORMAT(1H1/5X41HCORRECTIONS  CONCERNING  GROUPS   PERIOD,I6,5XA10
   1/5X62(1H=)///)
301 FCRMAT(5X2I1,1X2I1,2XA2,5X3A10,5XA10/)
302 FCRMAT (1H1/5X21HLATE  FILMS    PERIOD,I6,5XA10/5X42(1H=)///)
303 FCRMAT(15X2I1,1X2I1,I5,3XA1,5XA10,9(I4,1X),5XA1)
304 FORMAT(1H1/5X18HFILMS  FOR  PERIOD,I6,5XA10,5X13HBACKGROUND = I3/
   15X60(1H=)///)

    END
```

```
      SUBROUTINE MESAGE(I,XMO,NOUT)
      DIMENSION XMO(2)
      WRITE (NOUT,200)
      PRINT 200
      GC TO (1,2,3,4,5,6,7,8,9,10),I
    1 WRITE (NOUT,2C5)
      PRINT 205
      RETURN
    2 WRITE (NOUT,219)
      PRINT 219
      RETURN
    3 WRITE (NOUT,218)
      PRINT 218
      RETURN
    4 WRITE (NOUT,216)
      WRITE (NOUT,217)
      PRINT 216
      PRINT 217
      RETURN
    5 WRITE (NOUT,212)
      WRITE (NOUT,213)
      PRINT 212
      PRINT 213
      RETURN
    6 WRITE (NOUT,2C6)
      WRITE (NOUT,207)
      PRINT 206
      PRINT 207
      RETURN
    7 WRITE (NOUT,2C8)
      PRINT 208
      RETURN
    8 WRITE (NOUT,2C9)
      PRINT 209
      RETURN
    9 WRITE (NOUT,210)
      WRITE (NCUT,207)
      PRINT 210
      PRINT 207
      RETURN
   10 WRITE (NCUT,201) XMO
      PRINT 201,XMO
      RETURN

  200 FCRMAT(1HS)
  201 FORMAT (1HS,30X50HTHE FAST NEUTRON DOSE IS RELEVANT TO THE MCNTH O
     1F ,2A10)
  205 FORMAT(1HS,16X
     189HOVEREXPOSURE  MEANS A DOSE GREATER THAN THE WEEKLY MAXIMUM PERM
     2ITTED DOSE OF 100 MILLIREM)
  206 FORMAT(1HS,27X89H*  FILM NOT RETURNED FOR THIS PARTICULAR WEEK - P
     1ERSONAL DOSE ASSUMED TO BE EQUAL TO THE )
  207 FCRMAT(1HS,30X89HMAXIMUM PERMISSIBLE DOSE, THIS VALUE WILL BE CORR
     1ECTED WHEN THIS MISSING FILM IS RETURNED)
  208 FORMAT(1HS,27X
     1 52H$  THIS NEWCOMER IS AT CERN SINCE LESS THAN 13 WEEKS)
  209 FORMAT(1HS,16X
     190HOVEREXPOSURE  MEANS A DOSE GREATER THAN THE MONTHLY MAXIMUM PER
     2MITTED DOSE OF 400 MILLIREM)
  210 FCRMAT(1HS,27X90H*  FILM NOT RETURNED FOR THIS PARTICULAR MCNTH -
     1PERSONAL DOSE ASSUMED TO BE EQUAL TO THE )
  212 FORMAT(1HS,27X79H++ FAST NEUTRON DOSE EXCEEDS THE MAXIMUM PERMITTE
     1D LEVEL FOR THE LAST 3 MONTHS,)
  213 FCRMAT(1HS,30X50HTHE LENS OF THE EYE CONSIDERED AS A CRITICAL ORGA
     1N)
```

```
216 FORMAT(1HS,27X66H+  DOSE EXCEEDS THE MAXIMUM PERMITTED LEVEL FOR T
   1HE LAST 3 MONTHS,)
217 FORMAT(1HS,30X50HTHE LENS OF THE EYE CONSIDERED AS A CRITICAL ORGA
   1N)
218 FORMAT(1HS,27X58H=  LAST  3 MONTHS DOSE EXCEEDS THE MAXIMUM PERMIT
   1TED LEVEL)
219 FORMAT(1HS,27X58H== LAST 12 MONTHS DOSE EXCEEDS THE MAXIMUM PERMIT
   1TED LEVEL)
    END
```

```
      SUBROUTINE DOSES (LD,IBCKGR,H,LG,LB,LS)
      DIMENSION LD(7),IDOSE(7)
      DATA (P=1HP)
      IF(LD(2) .NE. 0) GO TO 20
C
C     ONE DENSITY ONLY
C
      JD=LD(5)
      ASSIGN 1 TO JUMP
      GO TO 11
    1 LG=IDORND(ID)
      LB=0
      LS=0
      RETURN
C
C     SEVEN DENSITIES
C
   20 DO 2 K = 1,7
      JD=LD(K)
      ASSIGN 2 TO JUMP
      GO TO 11
    2 IDOSE(K)=ID
C
C     COMPUTATION OF DOSE COMPONENTS
C
      LS=AMAX0(0,IDOSE(6)-IDOSE(4))/2.1
      LB=0
      DIF1=IDOSE(3)-IDOSE(7)
      DIF2=IDOSE(1)-IDOSE(7)
      IF(DIF1 .LE. 0. .OR. DIF2 .LE. 0.) GO TO 22
      RATIO=DIF1/DIF2
      IF(RATIO .LE. 2.3) GO TO 27
      IF(RATIO .LE. 3.6) GO TO 28
      IF(RATIO .LE. 6.4) GO TO 29
      LB=1.9*DIF1
      GO TO 22
   29 LB=1.65*DIF1
      GO TO 22
   28 LB=1.35*DIF1
      GO TO 22
   27 LB=DIF1
   22 IF (IDOSE(5).EQ.0) GO TO 42
      DIF3 = FLOAT(IDOSE(7))/FLOAT(IDOSE(5))
      IF (DIF3.GT.1.5) GO TO 23
      LG=IDOSE(5)
      GO TO 32
   23 IF (DIF3.GT.5.) GO TO 24
      PB = FLOAT(IDOSE(5))/2.
      PL = FLOAT(IDOSE(7))/20.
      LG=PB+PL
      LG = AMAX0(LG,IDOSE(5))
      GO TO 32
   24 DIF4 = IDOSE(3)-IDOSE(1)
      IF (DIF4.GT.1.1) GO TO 25
      PB = FLOAT(IDOSE(5))/2.
      PL=FLOAT(IDOSE(7))/50.0
      LG = PB + PL
      LG = AMAX0(LG,IDOSE(5))
      GO TO 32
   25 LG = PL+DIF1
      GO TO 32
   42 LG = 0
   32 LG=IDORND(LG)
      LB=IDORND(LB)
      LS=IDORND(LS)
```

```
      RETURN
C
C     CONVERSION OF DENSITIES TO RADIUM EQUIVALENT DOSES
C
   11 ID=0
      IF(H .NE. P) GO TO 12
      IF(JD .LE. 10) GO TO 10
      D=0.01*FLOAT(JD-10)
      ID=(D/.4)*100000.
      GO TO 10
   12 IF(JD .LE. IBCKGR) GO TO 10
      D=0.01*FLOAT(JD-IBCKGR)
      IF(JD .LT. 100) GO TO 6
      IF(JD .LT. 200) GO TO 7
      ID = (D/0.02753)**1.7534
      GO TO 10
    7 ID = (D/0.005297)**1.2580
      GO TO 10
    6 ID = D/0.0014464
   10 GO TO JUMP, (1,2)
      END
```

```
      FUNCTION IDORND(IDOSE)
      ID=IDOSE
      IDORND=0
      IF(ID .LE.   10) RETURN
      IF(ID .LE.  100) GO TO 5
      IF(ID .LE.  500) GO TO 4
      IF(ID .LE. 1500) GO TO 3
      IF(ID .LE. 3000) GO TO 2
      IR=100
      GO TO 10
    2 IR=60
      GO TO 10
    3 IR=40
      GO TO 10
    4 IR=20
      GO TO 10
    5 IR=10
   10 IDORND = ((ID+IR/2-1)/IR)*IR
      RETURN
      END
```

```
      SUBROUTINE PERIOD (KP,KPER,KL,KWM)
      DIMENSION KY(36),KPER(52)
C     KL = 0  LAST PERIODS,  KL = 1  ACTUAL PERIODS
C     KY CONTAINS THE PERIODS FOR 1965, 1966 AND 1967
      DATA (KY =
C     1965
     1         1, 5, 9,14,18,22,27,31,36,40,44,49,
C     1966
     2        53,57,61,66,70,74,79,83,87,92,96, 1,
C     1967
     3         6,10,14,18,23,27,31,36,40,44,49,53)
C
      IF(KWM.NE. 12) GO TO 6
C
C     MONTHLY  PERIODS
C
      DO 1 K = 1,36
      K1=37-K
    1 IF(KY(K1) .EQ. KP) GO TO 2
      K1=0
    2 IF(K1 .LE. 12) GO TO 4
      DO 3 K = 1,12
      K2=K+KL+K1-13
    3 KPER(K)=KY(K2)
      RETURN
C
    4 PRINT 5, KP
      STOP
    5 FORMAT(5X20HUNREASONABLE PERIOD I4,5X17HEXECUTION DELETED)
C
C     WEEKLY  PERIODS
C
    6 K2=KP+KL-53
      IF(K2 .GE. 0) GO TO 10
      K1=-K2
      DO 7 K = 1,K1
    7 KPER(K)=K+K2+99
      K1=K1+1
      DO 8 K = K1,52
    8 KPER(K)=K+K2
      RETURN
   10 DO 9 K = 1,52
    9 KPER(K)=K+K2
      RETURN
      END
```

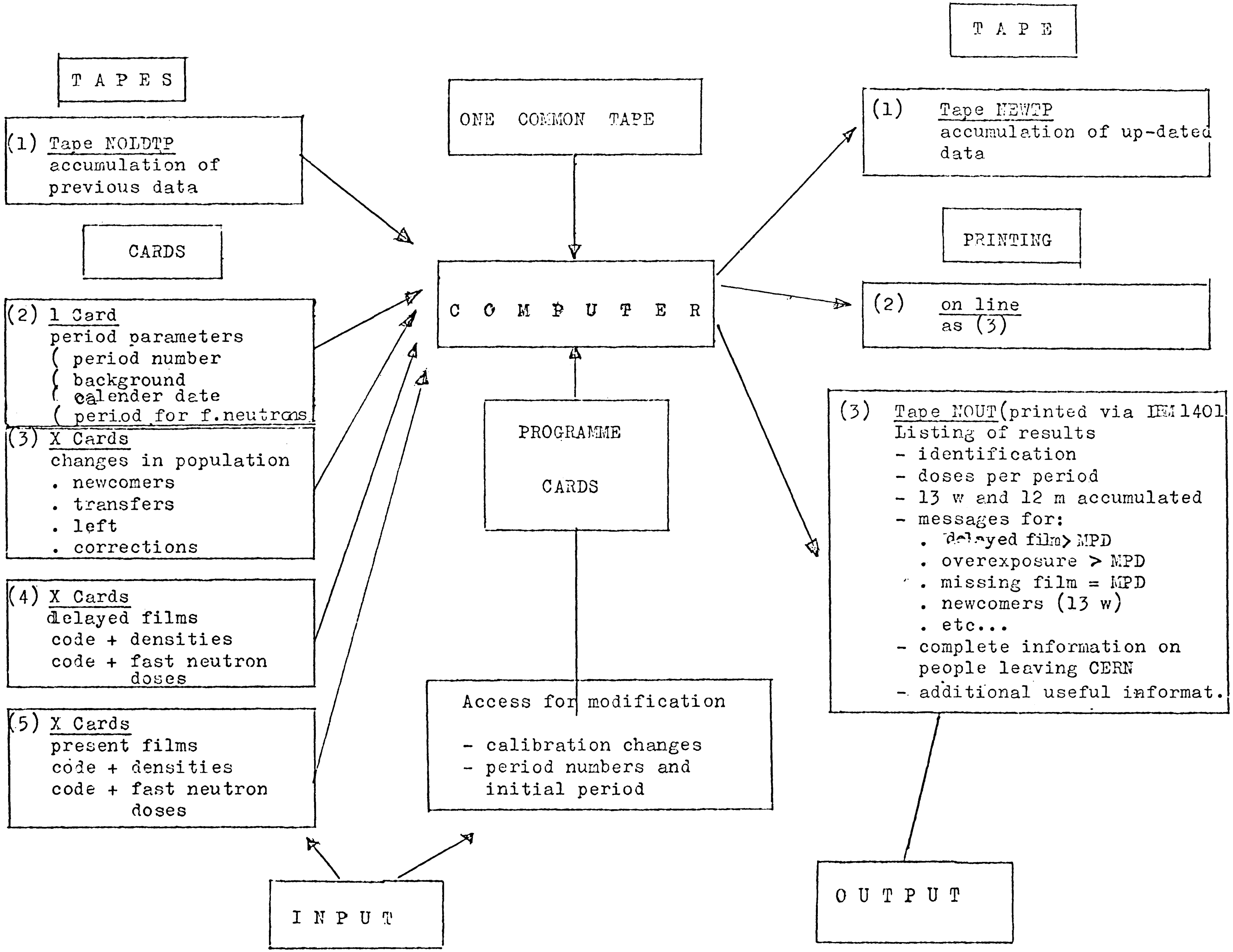

Fig. 1. Block diagram of the complete system

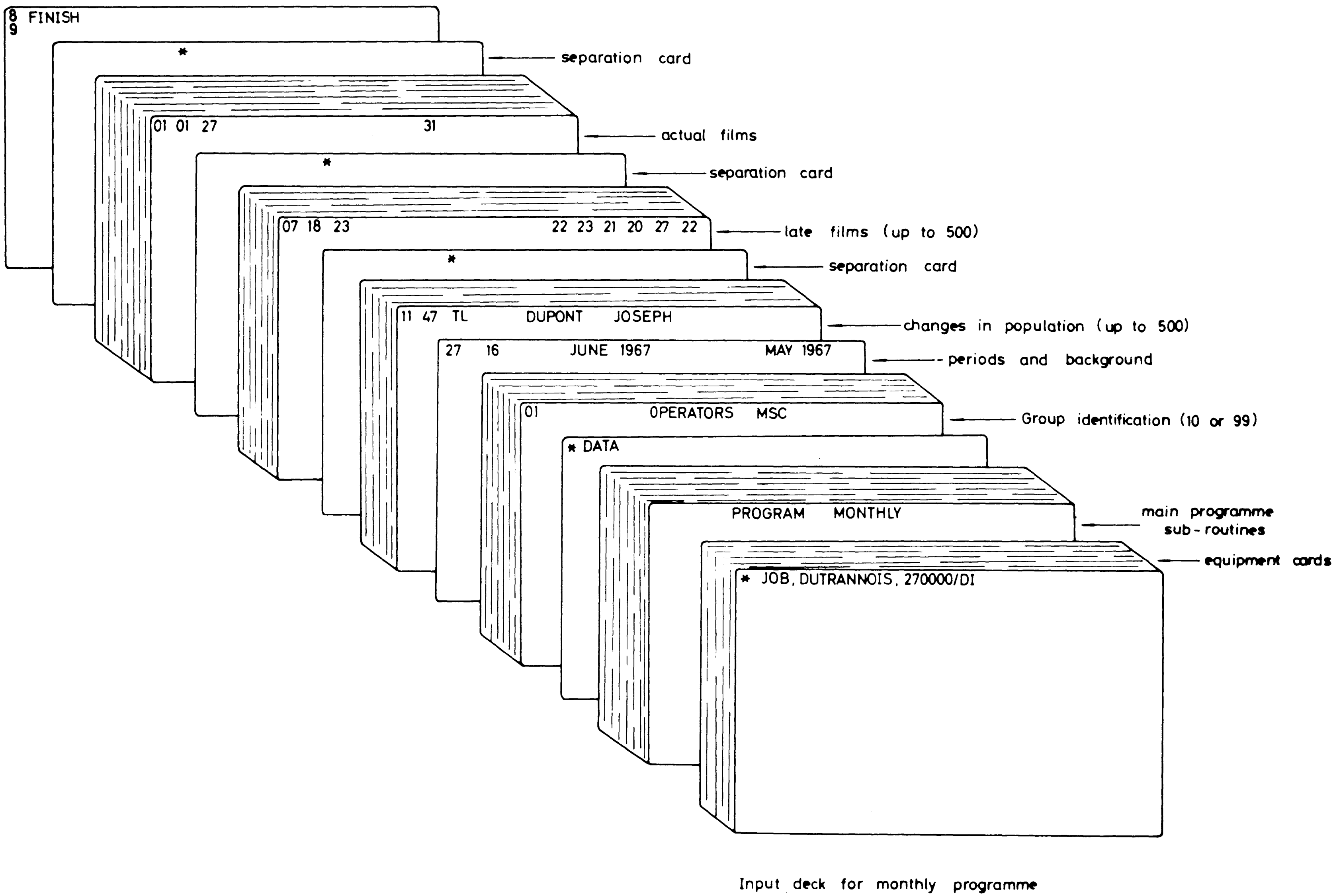

Fig. 2. Job deck for monthly programme

CERN - HEALTH PHYSICS

TEL. 2155 03/07/67

FILM RESULTS

DIVISION TES

GROUP 07 - MODEL PERIOD 30 FROM 19 JUNE TO 25 JUNE 1967

	CODE	NAME		GAMMA	BETA	DOSES IN MILLIREM SLOW N	FAST N	TOTAL	13-WEEKS	12-MONTHS
OVEREXPOSURE	07 01	CESAR	JULES	440	0	50	20	510	2080	4120
	07 03	LEGAULOIS	ASTERIX	20	140	0	40	60	1290	3030
	07 04	SOMEBODY	JIM	30	0	30		60	1240	4510
	07 05	LITTLEGHOST	ELMER	50	0	0		50	1240	2520
	07 07	TIFCSI	ALFREDO	100•	0	0		100	1390	2230
OVEREXPOSURE	07 08	VON BISZU	KARL	100	160	0	20	120	210$	210
	07 09	AIRELLE	OSCAR	70	0	0		70	2950	3950
OVEREXPOSURE	07 10	SASKATCHE	VAN	100	0	0	40	140	820	2680
	07 13	NESS	ELIOT	30	30	0		30	640	3040
■	07 14	CAPONE	ALPHONSO	80	0	0		80	3500	4180
■■	07 21	NEBRASKA	TED	40	0	0	20	60	960	21180
OVEREXPOSURE ++	07 22	LEPERE	GEORGETTE	120	0	0		120	2940	4180
	07 23	PROVENCE	MIREILLE	50	70	0	40	90	1230	3150

THE FAST NEUTRON DOSE IS RELEVANT TO THE MONTH OF MAY 1967

07 22 HAD AN ADDITIONAL OVEREXPOSURE OF 1920 MILLIREM FOR PERIOD 19

OVEREXPOSURE MEANS A DOSE GREATER THAN THE WEEKLY MAXIMUM PERMITTED DOSE OF 100 MILLIREM

• FILM NOT RETURNED FOR THIS PARTICULAR WEEK - PERSONAL DOSE ASSUMED TO BE EQUAL TO THE MAXIMUM PERMISSIBLE DOSE, THIS VALUE WILL BE CORRECTED WHEN THIS MISSING FILM IS RETURNED

++ FAST NEUTRON DOSE EXCEEDS THE MAXIMUM PERMITTED LEVEL FOR THE LAST 3 MONTHS, THE LENS OF THE EYE CONSIDERED AS A CRITICAL ORGAN

■■ LAST 12 MONTHS DOSE EXCEEDS THE MAXIMUM PERMITTED LEVEL

■ LAST 3 MONTHS DOSE EXCEEDS THE MAXIMUM PERMITTED LEVEL

$ THIS NEWCOMER IS AT CERN SINCE LESS THAN 13 WEEKS

Fig. 3. Example of output for one group (weekly) for a given period

0/ 14 SOMEBODY JIM LEAVING GROUP 07 DEFINITELY AT PERIOD 30 03/07/67

J	PERIOD	GAMMA	BETA	SLOW N	FAST N
1	78	0	0	0	0
2	79	100	0	0	0
3	80	50	0	0	0
4	81	70	0	40	0
5	82	0	0	0	0
6	83	360	0	0	0
7	84	0	0	0	0
8	85	90	120	0	40
9	86	50	0	0	0
10	87	30	0	0	0
11	88	0	0	0	0
12	89	0	0	0	0
13	90	0	0	0	0
14	91	160	340	60	30
15	92	80	90	0	0
16	93	50	0	0	0
17	94	0	0	0	0
18	95	0	0	0	0
19	96	0	0	0	0
20	97	0	0	0	0
21	98	100	0	40	0
22	99	50	0	0	0
23	1	80	440	0	70
24	2	100	0	0	0
25	3	180	0	0	120
26	4	80	0	40	0
27	5	100	0	0	0
28	6	50	0	0	0
29	7	0	0	0	0
30	8	50	440	0	0
31	9	50	0	0	0
32	10	160	0	0	20
33	11	0	0	0	20
34	12	0	0	0	0
35	13	140	0	20	0
36	14	100	0	0	0
37	15	50	0	0	80
38	16	0	0	0	0
39	17	360	0	0	0
40	18	180	0	60	0
41	19	240	0	0	0
42	20	0	0	0	0
43	21	0	0	0	0
44	22	0	0	0	0
45	23	0	0	0	0
46	24	0	0	0	0
47	25	30	70	0	0
48	26	100	0	0	0
49	27	50	0	20	20
50	28	380	100	40	30
51	29	30	0	0	0
52	30	30	0	30	0
		2000	610	170	170

SUM OF YEAR = 2340 MILLIREM

Fig. 4. Example of output for a person leaving CERN (weekly)

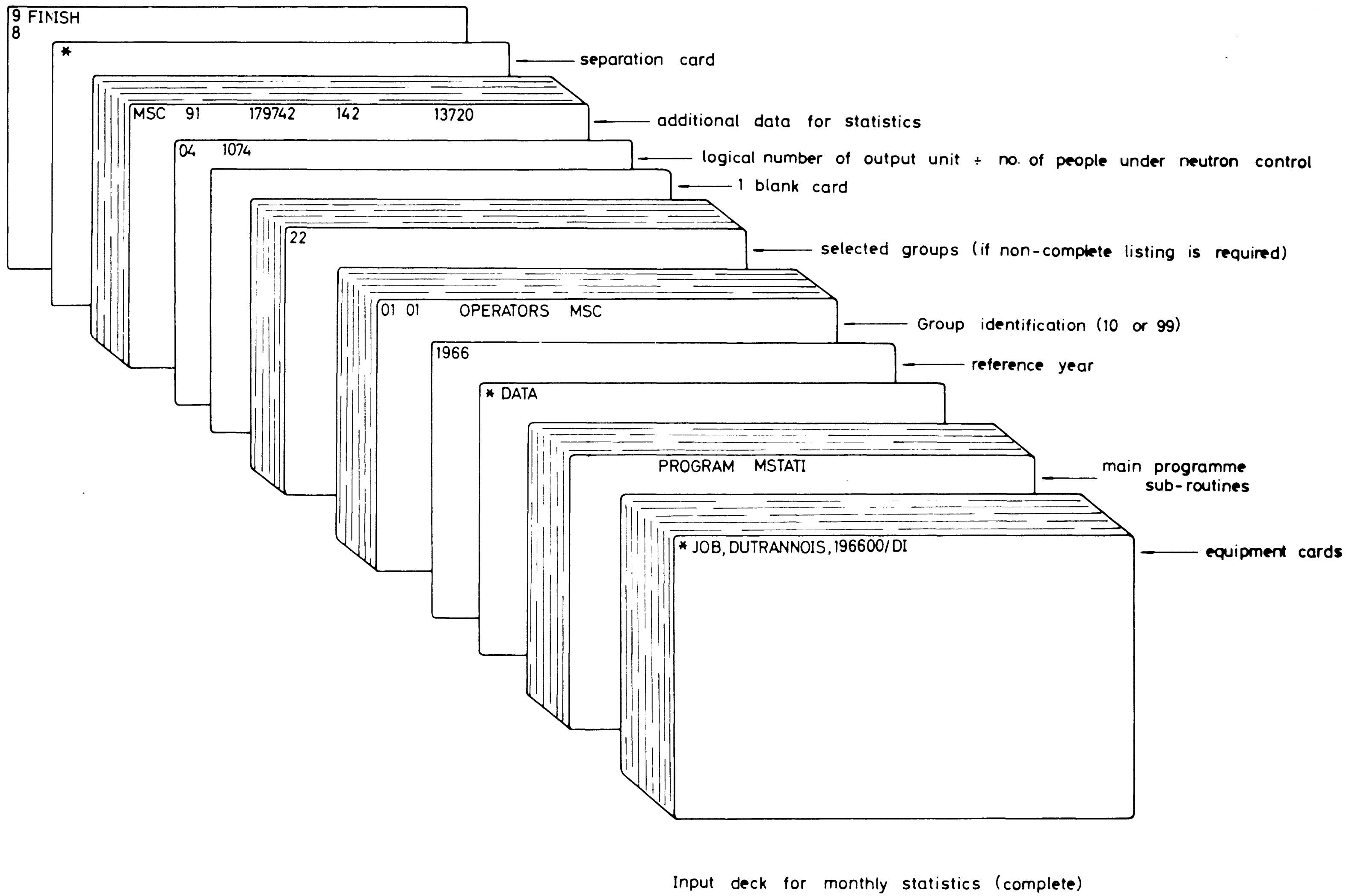

Fig. 5. Job deck for monthly statistics.

02 09 [redacted] [redacted] RADIO - FREQUENCE MSC 1966

WEEK	GAMMA	BETA	SLOW N	FAST N	TOTAL
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	60	0	0	0	60
8	40	0	0	0	40
9	90	0	0	0	90
10	10	0	0	0	10
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	80	0	0	0	80
15	220	0	0	0	220
16	0	0	0	0	0
17	10	0	0	0	10
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	20	0	0	0	20
24	110	0	0	0	110
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	120	0	0	0	120
29	80	0	0	0	80
30	0	0	0	0	0
31	0	0	0	0	0
32	0	0	0	0	0
33	80	0	0	0	80
34	20	0	0	0	20
35	100	0	0	0	100
36	100*	0	0	0	100
37	0	0	0	0	0
38	0	0	0	0	0
39	0	0	0	0	0
40	50	0	0	0	50
41	20	0	0	0	20
42	0	0	0	0	0
43	0	0	0	0	0
44	0	0	0	0	0
45	0	0	0	0	0
46	0	0	0	0	0
47	20	0	0	0	20
48	0	0	0	0	0
49	0	0	0	0	0
50	0	0	0	0	0
51	20	0	0	0	20
52	300	0	0	0	300
	1550	0	0	0	1550

ESTIMATED TOTAL YEARLY DOSE 1450 MILLIREM

NUMBER OF FILMS NOT RETURNED 1

CORRESPONDING TO 100 MILLIREM

Fig. 6. Example of statistics: annual doses per individual.

DIVISION MSC YEAR 1966

GROUP 01 - OPERATION

			1 ST QUARTER	2 ND QUARTER	3 RD QUARTER	4 TH QUARTER	YEARLY	AVERAGE PER WEEK	DOSE IN MILLIREM
01 1	[redacted]	[redacted]	0	0	0	0	0	0	FAST NEUTRON
			0	0	0	140	140	2	SLOW NEUTRON
			0	0	0	220	220	4	BETA
			20	30	190	240	480	9	GAMMA
			20	30	190	380	620	11	TOTAL
01 2	[redacted]	[redacted]	0	0	0	50	50	0	FAST NEUTRON
			0	0	0	0	0	0	SLOW NEUTRON
			0	0	0	0	0	0	BETA
			250	670	1010	1300	3230	62	GAMMA
			250	670	1010	1350	3280	63	TOTAL
01 3	[redacted]	[redacted]	0	0	0	0	0	0	FAST NEUTRON
			0	0	0	0	0	0	SLOW NEUTRON
			0	0	0	0	0	0	BETA
			150	550	920	160	1780	34	GAMMA
			150	550	920	160	1780	34	TOTAL
01 4	[redacted]	[redacted]	0	0	0	0	0	0	FAST NEUTRON
			0	0	0	0	0	0	SLOW NEUTRON
			0	0	0	0	0	0	BETA
			1140	650	1110	620	3520	67	GAMMA
			1140	650	1110	620	3520	67	TOTAL
01 5	[redacted]	[redacted]	0	0	0	0	0	0	FAST NEUTRON
			0	0	0	0	0	0	SLOW NEUTRON
			0	0	0	0	0	0	BETA
			620	1180	1630	20	3450	66	GAMMA
			620	1180	1630	20	3450	66	TOTAL

Fig. 7. Example of statistics: quarterly doses per individual per group

DIVISION MSC YEAR 1966

GROUP 14 - ATELIER

The doses received by the people are confidential and therefore the names have been deleted.

	Maximum weekly dose in millirem			Number of time the maximum weekly dose was exceeded			Number of missing films per year
	Fast neutron	Gamma	Total	For fast neutron	For total dose	In per cent	
04 01	0	560	560	0	13	25	
04 03	0	480	480	0	8	15	
04 04	0	680	680	0	10	19	
04 06	0	520	520	0	2	3	
04 07	0	1480	1480	0	13	25	1
04 08	0	760	760	0	4	7	
04 09	0	30	30	0	0	0	1
04 10	0	960	960	0	7	13	
04 11	0	280	280	0	5	9	
04 12	0	920	920	0	4	7	1
04 13	0	500	500	0	11	21	1
04 16	0	1200	1200	0	5	9	
04 17	0	720	720	0	5	9	1
04 18	0	560	560	0	6	11	
04 19	0	0	0	0	0	0	

Fig. 8. Example of statistics: maximum doses per individual per group

DIVISION MPS YEAR 1966

GROUP	NUMBER OF MEMBERS	TOTAL YEARLY DOSE PER GROUP	AVERAGE YEARLY DOSE PER MAN	AVERAGE MONTHLY DOSE PER MAN	MAXIMUM MONTHLY DOSE IN GROUP	ALL DOSES IN MILLIREM	NUMBER OF OVEREXPOSURES NEUTRON	NUMBER OF OVEREXPOSURES GAMMA	OVEREXPOSURE FACTOR IN PERCENT
10 - LINAC	33	3870	117	9	440	FAST NEUTRON			
		4970	150	12	340	GAMMA			
		8840	267	22	490	TOTAL	2	3	0
11 - CONTROLE	47	1300	27	2	140	FAST NEUTRON			
		12580	267	22	1040	GAMMA			
		13880	295	24	1070	TOTAL	0	1	0
12 - OPERATEURS	17	1610	94	7	160	FAST NEUTRON			
		5190	305	25	220	GAMMA			
		6800	400	33	220	TOTAL	0	0	0
13 - PLANNING+HYDROGENE	12	460	38	3	50	FAST NEUTRON			
		770	64	5	80	GAMMA			
		1230	102	8	90	TOTAL	0	0	0
14 - SEPARATEURS+VIDE	21	910	43	3	50	FAST NEUTRON			
		30250	1440	120	1040	GAMMA			
		31160	1483	123	1040	TOTAL	0	14	5

Fig. 9. Example of statistics: results per group in a division

DIVISION MPS YEAR 1966

GROUP	REPARTITION OF DOSE IN PER CENT
10 - LINAC	7.7
11 - CONTROLE	12.1
12 - OPERATEURS	5.9
13 - PLANNING+HYDROGENE	1.1
14 - SEPARATEURS+VIDE	27.1
15 - SECTION INSTALLATION	14.9
16 - RADIO FREQUENCE	9.9
17 - POWER HOUSE	1.1
18 - GENERATEUR - SUD	1.0
19 - GENERATEUR - EST	.7
20 - MISCELLANEOUS	.5
21 - ATELIER MA - EE - MS	18.1

NUMBER OF MISSING FILMS 77

Fig. 10. Example of statistics: dose distribution per group in a division

YEAR 1966

DIVISION	NUMBER OF MEMBERS	TOTAL YEARLY DOSE PER DIVISION	AVERAGE YEARLY DOSE PER MAN	AVERAGE MONTHLY DOSE PER MAN	MAXIMUM MONTHLY DOSE IN DIVISION	ALL DOSES IN MILLIREM
DI	102	6420	62	5	250	FAST NEUTRON
		14000	137	11	720	GAMMA
		20420	200	16	720	TOTAL
MPS	284	11860	41	3	440	FAST NEUTRON
		103140	363	30	1080	GAMMA
		115000	404	33	1080	TOTAL
MSC	114	1790	15	1	40	FAST NEUTRON
		152020	1333	111	1400	GAMMA
		153810	1349	112	1400	TOTAL
NP	317	24060	75	6	1200	FAST NEUTRON
		19050	60	5	800	GAMMA
		43110	135	11	1230	TOTAL
TC	190	7190	37	3	80	FAST NEUTRON
		9750	51	4	520	GAMMA
		16940	89	7	520	TOTAL

Fig. 11. Example of statistics: results per division for the whole CERN

CERN YEAR 1966

DIVISION	REPARTITION OF DOSE IN PER CENT
DI	4.1
MPS	23.0
MSC	30.7
NP	8.6
TC	3.4
NPA	3.4
ISR	1.4
SB	24.3
CC	1.1

Fig. 12. Example of statistics: dose distribution per division in CERN

TOTAL FOR CERN RADIATION WORKERS 1966

TOTAL NUMBER OF RADIATION WORKERS IN 1966 = 1502
NUMBER OF PERSONS UNDER FAST NEUTRON CONTROL 854

	GAMMA	FAST NEUTRON	TOTAL
TOTAL YEARLY DOSE	425420	74970	500460
AVERAGE YEARLY DOSE PER MAN	283	87	333
AVERAGE MONTHLY DOSE PER MAN	23	7	27
MAXIMUM MONTHLY DOSE RECORDED	1860	8700	8720

ALL DOSES IN MILLIREM

NUMBER OF MISSING FILMS 657 OR 3.0 PER CENT

Fig. 13. Example of statistics: total doses in CERN

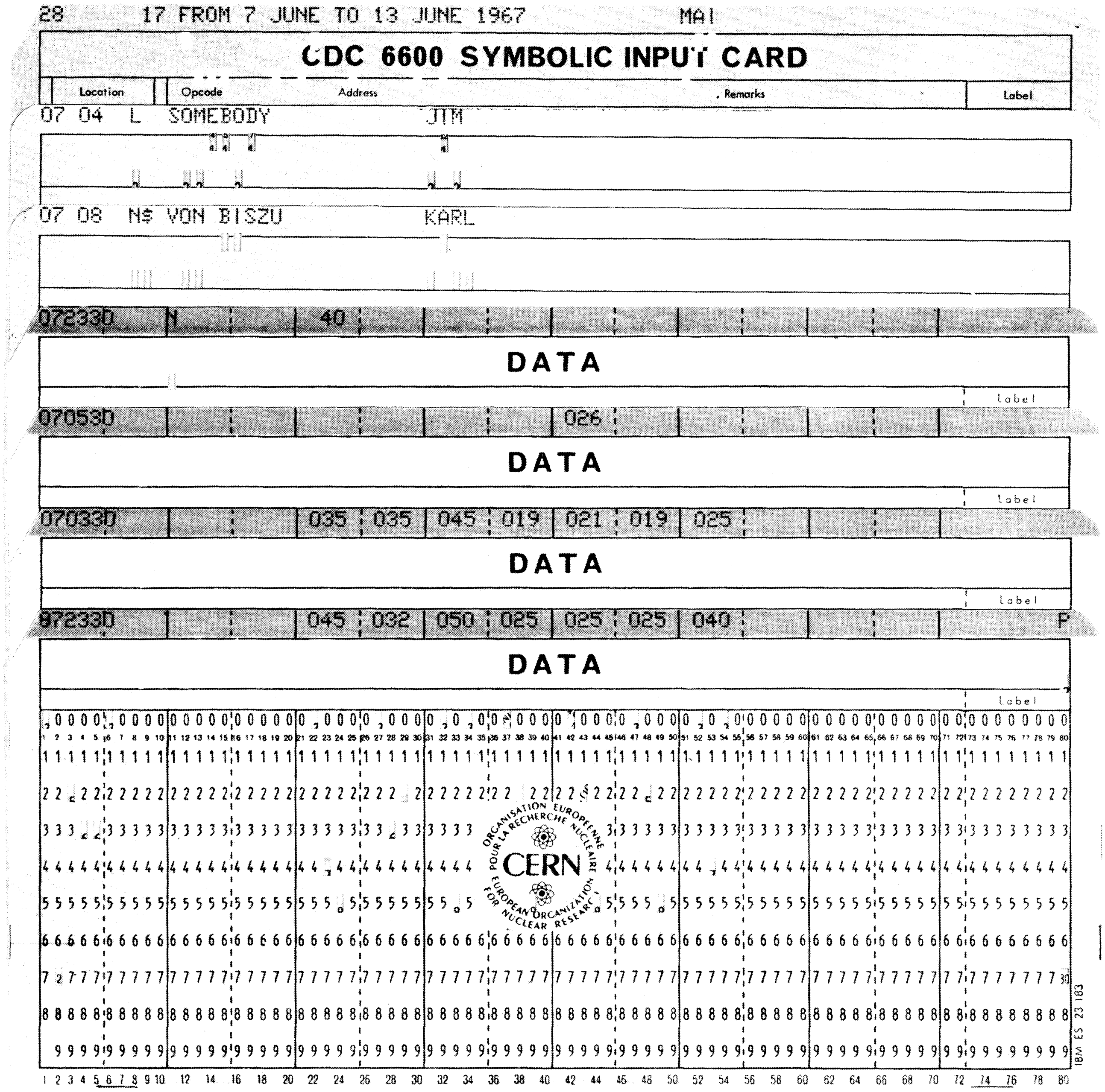

Fig. 14. Examples of data cards.