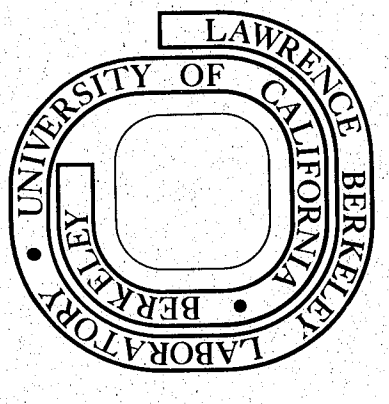
To be presented at the Biological Effects of Extremely Low-Frequency Electromagnetic Fields Workshop, Richland, Washington, October 16-18, 1978

MAGNETIC FIELD EFFECTS ON HUMANS: EPIDEMIOLOGICAL STUDY DESIGN

Thomas F. Budinger, Priscilla Wong, and Chi-Kwan Yen

October 1978

Prepared for the U. S. Department of Energy
under Contract W-7405-ENG-48



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Objectives

This report presents details of the study design and methods for a retrospective epidemiological study on the health effects, if any, of stationary and alternating magnetic fields produced by man-made devices such as cyclotrons, controlled thermonuclear reactors (CTR), high voltage-high current transmission lines, magnetohydrodynamic devices (MHD), energy storage systems, and isotope separation facilities. The magnetic fields to which the workers can be exposed are as high as 10,000 gauss and the anticipated increase in magnetic fields associated with the environment and transmission lines near these devices is a few times the natural earth magnetic field. Thus the objectives include acquisition of low exposure data which can be used to evaluate any risks to the population incidentally exposed to environmental increases in magnetic fields, as well as an acquisition of high exposure data to be used in determining allowable exposure standards for the technical personnel working at CTR and MHD facilities.

Two quite different exposure environments can be distinguished: alternating field and static field environments. This particular study is focused on the effects of steady magnetic fields and low frequency alternating fields such as might be found in a 60 Hz transmission line or the operation of a pulsed CTR device. The induced current effects of alternating fields on the human body with a conductivity of approximately 0.25 mhos m^{-2} are reasonably well known or at least there is a biophysical basis for analysis and prediction. On the other hand, the influences of static or very low frequency fields on the human subjects exposed over long time periods are neither known nor theoretically predictable.

From the present status of knowledge on biological effects of magnetic fields, it is not possible to extrapolate or rationally conclude maximum permissible exposure levels for magnetic device workers

and the population at large. There are no known previous studies of the effects of long-term exposure to magnetic fields involving large samples and matched controls, other than the Russian studies of limited scope reviewed by Sheppard and Eisenbud (1). Thus this human epidemiological study was commenced in 1977 in parallel with experimental studies on biological and medical effects of magnetic fields being conducted by Dr. T. Tenforde and co-workers at LBL, by investigators at Battelle Northwest and smaller projects at a number of laboratories around the world.

The data base for the exposed population is comprised of approximately 1,000 cyclotron and bubble chamber workers.

METHOD OF STUDY

Population Size

Our approach involves a study of 1,000 scientists and technicians who have been occupationally exposed to fields of at least 5 gauss for 1,000 days during their working career. This criterion is based on a typical exposure of a cyclotron or bubble chamber worker. The study includes acquisition of medical data from exposed subjects as well as from 1,000 matched controls from eight facilities in North America. Cases are distributed as follows:

1) Argon National Laboratory - 75
2) Brookhaven National Laboratory - 170
3) Lawrence Berkeley Laboratory - 238
4) Lawrence Livermore Laboratory - 75
5) National Accelerator Laboratory - 100
6) National Magnet Laboratory - 50
7) Oak Ridge National Laboratory - 200
8) Stanford Linear Accelerator - 100

If warranted, studies will extend to European laboratories where an estimated additional 1,000 cases are available. Other exposed individuals include induction furnace workers, and personnel involved in the separation and purification of chemicals such as chlorine and aluminum.

The studies of the latent effects from acute and very high exposures will involve subjects who have worked in fields greater than 400 gauss

at facilities such as the calutrons at Berkeley and Oak Ridge during World War II. In addition, individuals involved in calibrating large magnets and individuals exposed to very high fields around bubble chambers will comprise this high field exposure population.

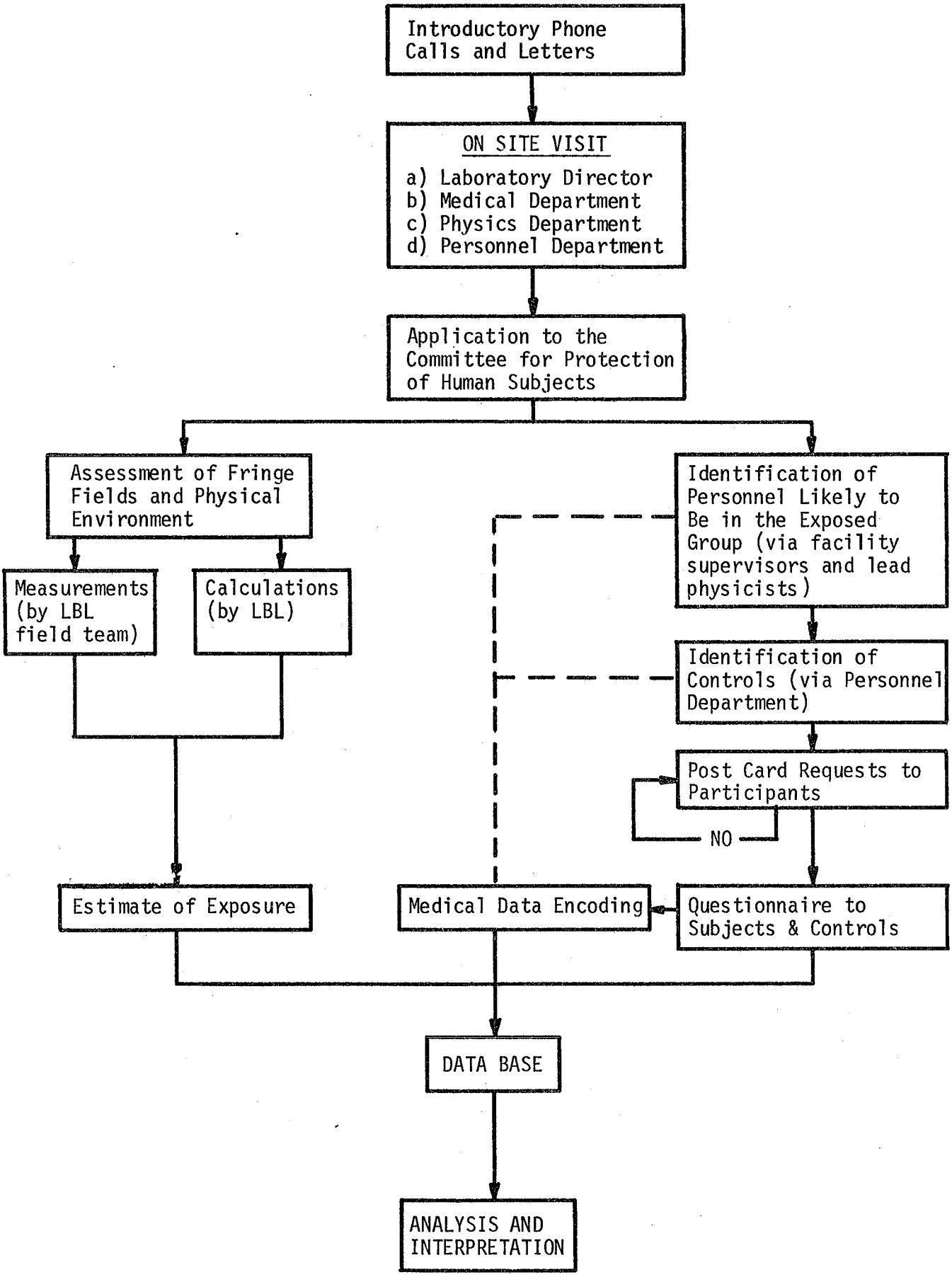
If necessary, an additional 100 or more exposed individuals can be obtained from CERN where a high proportion will be of the higher exposed category due to the presence of a large bubble chamber at that facility. Thus the data base is comprised of a total 2000 subjects:

matched controls - 1000
exposed subjects - 1000
(high field exposed subjects - 200)

Data Collection Procedure

The protocol for data collection in this survey is shown by the flow diagram on the following page. The flow diagram outlines the general scheme and major components of our interaction with each of the eight facilities. At present four of the facilities are formally involved in this study. Because federal employees of the Department of Energy are involved, the Office of Management and Budget and the officials of the Department of Energy (DOE) examined and approved the data collection forms and general protocol. Before initiation of our interaction with a DOE facility, the appropriate DOE field office is notified by DOE headquarters of the nature of our activities.

After introductory telephone calls and letters, an initial on site contact is made with the Laboratory Director and the Medical Director to explain the purpose of the program and make any changes in our protocol required by sensitive circumstances at that facility; e.g., it might be necessary or prudent to contact local representatives of a labor union. A second objective of our initial on site visit is to establish communication with scientific group leaders and supervisors in charge of facility operations, large magnets, bubble chambers and cyclotrons. These leaders are the major source of information with regard to exposed individuals in their particular groups and can provide information regarding the magnetic fields around the working areas. The physical measurements are made by previous field surveys or by our team in collaboration with the on site magnetic field measurement groups in the physics or health and safety departments.


Introductory Phone Calls and Letters
ON SITE VISIT
a) Laboratory Director
b) Medical Department
c) Physics Department
d) Personnel Department
Application to the Committee for Protection of Human Subjects
Assessment of Fringe Fields and Physical Environment
Measurements (by LBL field team)
Calculations (by LBL)
Identification of Personnel Likely to Be in the Exposed Group (via facility supervisors and lead physicists)
Identification of Controls (via Personnel Department)
Post Card Requests to Participants
NO
Estimate of Exposure
Medical Data Encoding
Questionnaire to Subjects & Controls
DATA BASE
ANALYSIS AND INTERPRETATION

In parallel with the above activities an application is made to the Committee for the Protection of Human Subjects at the facility in order to gain access to subjects and their medical data. The application is comprised of a statement of purpose, the data collection protocol and copies of post cards and questionnaires we wish to send to employees (Appendix A and Appendix B).

The procedure we will follow is to send out a post card to the homes of exposed subjects as well as the control subjects asking them to participate in this study (Appendix A). This is followed by a second post card. The individuals who give consent to participate in the study are sent questionnaires which will supplement the data extracted from medical charts and will provide vital work history data which is used to estimate the field exposure. The questionnaire as shown in Appendix B is tailored for the specific facility in that maps of accelerators and bubble chambers are provided to assist in identifying the physical work environment of each subject.

In the event that an individual was selected as a matched control and there is no response to our post cards or questionnaires, a short version of the questionnaire concerning magnetic exposure is sent to these control individuals to verify that they are indeed controls and do not belong to the exposed group.

Selection of Matched Controls

A group of matched controls is selected for each geographic location using the personnel department records. The selection is based on the age, sex, race, job classification, duration of employment and other factors including pay group category. Matching by race is important because of disease incidence dependence on race in some situations (e.g. hypertension). Personnel departments at DOE facilities have records which are sufficiently detailed to allow this identification to proceed efficiently by our team working in the personnel department. Computerized listings of a nonconfidential nature are used. Items such as pay and proficiency evaluations are not made available.

Field Exposure Estimates

The magnetic exposure history is obtained in several ways. In the questionnaire, subjects are asked to identify the areas where they

worked on a map of the facility. The magnetic field exposure is determined by actual measurements either by a member of the LBL team or by personnel at the local facility. For the facilities not in our operation, technical materials and journals are consulted to extract relevant information regarding field strength. To verify the estimate of field exposures and measurements some analytical calculations will be done by Mr. John Colonias using computer codes available at the LBL.

Anonymous Raw Data Encoding

Data are encoded for entry into computer files using a numerical code for the subject's identity. This raw data encoding is a vital aspect of this study. Unbiased data acquisition is required for both control and exposed populations. Only properly authorized staff members have access to the records at the facility and our staff members are fully cognizant of the confidentiality of physician/patient information and, in fact, are required to sign an oath of confidentiality. Under the condition that we do not receive permission from exposed individuals, some method must be available for collecting unbiased data. Special measures are taken to assure protection of any individual who may not wish to be identified with medical data collected on that subject in the past by the laboratory's medical department. A licensed physician on the staff of the laboratory involved supervises the encoding of data and assures that no connection can be made between an individual's identity and his medical data. The non-physician personnel who encode data and assist in interviews have had 8 or more years of experience with quantitative medical data. This scheme has worked well at the Lawrence Berkeley Laboratory of the University of California and at Brookhaven National Laboratory in our experience with over 500 individuals.

To avoid knowledge of whether an individual is in the exposed or control group the data are initially encoded without an indentification number being assigned. After encoding a group of individuals the supervising physician encodes an identification number on each data sheet corresponding to a particular subject. The key to the code is held by the custodian of medical records at the Lawrence Berkeley Laboratory. Since part of the team involved in identifying both the exposed and control population are the same as those encoding the

data, it is not possible to positively insure that there is no prior knowledge of which individuals are exposed and which are control in every case. Since we are operating without a priori knowledge of whether the exposure will lead to beneficial or detrimental health effects, this potential biasing is not considered to be a serious defect in our design.

The data are obtained by the epidemiology team on-site as this not only provides access to medical records and personnel for interviews but also insures a greater confidentiality in that all records remain in the respective medical departments.

Extent of Data and Format

Numerical codes are used to describe qualitative and quantitative data. Past medical history, physical exam values, and magnetic field exposure data are encoded. This scheme has been used for occupational health data encoding (2) as well as for epidemiological analyses of leukemia and thyroid cancer patients studied at Donner Laboratory by our team over the last 10 years.

The format for data encoding is shown as Appendix C. The dictionary for the numerical codes is shown in Appendix D.

Present Status of Data Collection

To date, the team has collected data from the Lawrence Berkeley Lab (LBL), the Brookhaven National Lab (BNL) and preliminary contacts have been made with the Francis Bitter National Magnet Laboratory (NML) at MIT, the Lawrence Livermore Laboratory, and the Los Alamos Meson Facility (LAMF). Since the data collection team is in residence at LBL the data collection there is near completion. Initial visits of one or two days were made to BNL in April of 1978 and to NML in October, 1978. The numbers of exposed subjects identified so far in these facilities are: LBL-238, BNL-170 and NML-over 30.

Consent forms sent to exposed subjects and prospective controls number 1200 at LBL and 1000 at BNL. Questionnaires sent to personnel number 678 at LBL and 376 at BNL by 1 October, 1978.

Medical data have been abstracted and encoded for 222 subjects and 139 matched prospective controls at LBL; and 148 exposed and 30 matched controls at BNL.

DATA ANALYSIS AND INTERPRETATION

Data Analysis System

The computerized data encoding and analysis system is complete. The data are encoded on the form shown in Appendix C, are keypunched, and an error detection routine is used for checking for missing data, appropriate range of values, consistency, the proper sequence of data cards, etc. The method of data output includes graphics such as histograms, scatter plots, data tables and contingency tables organized by simple user commands. Statistical tests such as correlation coefficients, student-T tests and chi-square analyses are performed as desired. Data are entered, examined and corrected via CRT terminal or through remote job entry. Output is provided by line printer.

Statistical Considerations

In any epidemiological study it is important to know the sample size needed to obtain a significant result. The relationship between the sample size needed to demonstrate an increase or decrease in the disease incidence is given by Snedecor and Cochran (3):

$$n = \frac{(Z\alpha + Z\beta)^2(P_1q_1 + P_2q_2)}{\delta^2}$$

n = number of subject/control in each population

P_1 = incidence of disease in control

$q_1 = 1 - P_1$

P_2 = incidence of disease in subjects

$q_2 = 1 - P_2$

$\delta = P_2 - P_1$

α = significance level of the test desired (usually set at 90%)

$\beta = 2(1 - P)$, where P is the desired probability of obtaining a significant result, given that the difference between subject and control is δ. P is usually set at 90%.

Z_α = normal deviate of α.

Z_β = normal deviate of β.

The value of the normal deviate is determined by reference to appropriate statistical tables. The normal deviate defined for a gaussian distribution is the integration limit required to give an area equal to

the desired probability in a test or decision. In our case we wish to have a confidence or significance level of 90%.

In this study we anticipate a maximum sample size of 1,000 exposed subjects with 1,000 matched controls. We are particularly interested in malignancies and cardiovascular system diseases which have incidences in our population age group of 3×10^{-3} and 10×10^{-3}. These incidences are the P_1 values in the recipe above and correspond to the column headings in the tables below.

Under conditions where the exposed population can have either increased or decreased incidence of disease, a two-tailed test is required. Table 1 gives the number of individuals required under various conditions of disease incidence and increase or decrease in incidence in the exposed population.

Table 1
Two-Tailed Test, P = 90%, α = 90%

Incidence Change	CONTROL OR NATURAL INCIDENCE			
	1 in 1000	2.5 in 1000	5 in 1000	10 in 1000
50%	86,000	34,400	17,200	8,600
100%	25,800	10,300	5,160	2,580
200%	8,600	3,440	1,720	860
500%	1,370	900	500	240

If we have a priori knowledge that the exposed population will have an increased or a decreased incidence, then the one-tailed test applies as shown in Table 2.

Table 2
One-Tailed Test, P = 90%, α = 90%

Incidence Change	CONTROL OR NATURAL INCIDENCE			
	1 in 1000	2.5 in 1000	5 in 1000	10 in 1000
50%	66,000	26,400	13,200	6,600
100%	19,800	7,900	3,960	1,980
200%	6,600	2,640	1,320	660
500%	1,060	740	370	190

As can be seen from these tables, with an exposed sample size of 1,000, we will require a three-fold increase or decrease in incidence of cardiovascular disease before a firm conclusion can be made that there is a health effect from magnetic field exposures of the type we are examining. The confidence levels for various effects shown in the data will be reported at the conclusion of the study.

Method of Data Analysis and Reporting

The analysis of these data will be made by three independent groups as follows:

The LBL group analysis will be made initially by Thomas F. Budinger, M.D., Ph.D. The design of the study has been made such that until necessary the analyst is not aware of the identity of the group of exposed or control individuals. The second analyst is Ralph Buncher, Ph.D., Professor of Epidemiology, University of Cincinnati. A third epidemiologist will be selected by the Department of Energy and the Public Health Service. The analysis will commence in October, 1979, when an adequate data base has been collected. The findings will be reported in terms of factual data and statistical conclusions. The full report on 2000 subjects is expected to be available in 1980.

ACKNOWLEDGEMENTS

The cooperation of laboratory directors, medical directors and facility scientists has been outstanding. This program was initiated at the suggestion and encouragement of Dr. Walter Weyzen and Dr. Edward Alpen. Individuals who have assisted significantly in the design and initial data gathering are Dr. James Born, Dr. Ralph Buncher, Dr. Robert Loutitt, Mr. John Colonias, Mr. James Miller, Ms. Dorothy Carpenter, Ms. Patricia Garbutt and Ms. Mary Graham.

REFERENCES

1. Sheppard, A.R. and M. Eisenbud. Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency. New York: New York University Press, 1977.

2. Barr, G. The Effects of Routine Occupational Radiation Exposure in Workers at the Lawrence Radiation Laboratory, Berkeley. (Ph.D. thesis), Lawrence Berkeley Laboratory Publication UCRL-17573, 1967.

3. Snedecor, G.W. and W.G. Cochran. Statistical Methods. Iowa State University Press, 1967.

This work was supported by the U. S. Department of Energy.

APPENDIX A

The Division of Biology and Medicine of Lawrence Berkeley Laboratory, California, is conducting a multi-center survey on the effects of magnetic and electromagnetic fields on human health for DOE. Other national laboratories are cooperating in this effort and an opportunity is being offered to employees of your laboratory to participate in this study. At present we do not expect any harmful or beneficial effects can be associated with exposures to magnetic fields; yet, no carefully controlled data collection has been completed to date. We need information from you which will be used to compile statistical data. To keep identities anonymous, a coded number will be used instead of names.

If you would like to participate in this study by filling out a health and occupational history questionnaire, please sign and return this self-addressed card. In a few cases we might wish to conduct a personal interview. Your participation is entirely voluntary, and you should be assured that lack of participation will not prejudice your employment

_____ Date

_____ Signature

XBG 505

(Please fold over and staple)

Research Medicine Group
Division of Biology and Medicine
Donner Laboratory
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

(Address Label)

APPENDIX B

Date _____ No. _____

QUESTIONNAIRE ON MAGNETIC EFFECTS EPIDEMIOLOGY

WHY IS THIS QUESTIONNAIRE IMPORTANT?

The following questionnaire relates to possible occupational or incidental exposures you might have had to magnetic and electromagnetic fields during the course of your present or past employment. Even if you have not been exposed, we need your response as you serve as a member of the control population. We have no strong evidence that there has been beneficial or detrimental effects of magnetic fields experienced by cyclotron workers, power station operators, radar technicians, etc., except under most unusual circumstances where there are thermal injuries. Such would not be the case in the magnetic fields found around accelerators or bubble chambers. The purpose of this questionnaire is to establish whether there are any long-term health-related effects because it is anticipated that non-polluting sources of electrical energy will involve exposure of some of the population to somewhat higher fields than the earth's natural magnetic field.

WHY SHOULD UNEXPOSED PERSONS RESPOND?

The results of this study will be the health statistics of persons exposed. To arrive at a meaningful conclusion concerning these statistics, we must compare the data to information from persons of a comparable geographic and age distribution.

ARE ALL OF THE QUESTIONS RELEVANT?

We anticipate that approximately 2,000 responses will be encoded for statistical analysis. Family history questions are relevant in that there is frequently a predisposition to certain diseases if they are present in the family, and we might find a positive or negative correlation based on the past magnetic field exposure history of an individual that would be modified by his family history. The physiological and metabolic response of individuals under various medications might be modified by magnetic field exposures. The risk of diseases, such as cancer and arteriosclerosis, due to tobacco smoking might obscure risks of increased disease from magnetic field exposures.

Questions regarding psychiatric history are relevant in that modern medical theories propose a chemical and, to some extent, genetic basis for some psychiatric disorders; environmental factors also have to be considered. Therefore, these responses are dealt with in the same objective fashion as responses regarding diabetes and heart disease.

If, in answering this questionnaire, you feel some of these questions might invade your privacy, we ask that, before you decline to answer, you personally call Dr. James Born, who is responsible for the protection of human rights and patient privacy on this program. Information related to him will be encoded by him under the anonymous number which has been assigned to you. The coding connection between names and numbers is under his sole control. He can be contacted by calling collect (415) 642-2314 at Lawrence Berkeley Laboratory or at his home (415) 848-8918.

WHO SEES THESE DATA?

The only person who can connect the actual data with your name is James Born, M.D. and in his absence, the Project Director, Thomas Budinger, M.D. The analyzed data, without name or code identifier, will appear as a public document showing the findings for both exposed individuals and the control population. You will receive this information for your own perusal at the end of the survey. The immediate distribution of this information will be to the Department of Energy officials. Under federal law there can be no connection between your name and these data.

Form Approved
OMB No. 038-S77014

QUESTIONNAIRE

Please check the appropriate answer.

1. Have you WORKED in or in close proximity to any of the following installations with magnetic or electromagnetic fields? If yes, please estimate average time spent at each and designate appropriate day, week, or month; also mark the locations of your activities during these times (using 1, 2, 3, etc.) on the diagrams of the facilities on page 9.

Yes	No	Installation	Average Time Spent: Hrs.		Day/ Week/Month	Period	Location (from page 9)
☐	☐	a. accelerators – D.C.					
		name ________	____	per	________	19 __ to 19 __	________
☐	☐	b. accelerators – pulsed					
		name ________	____	per	________	19 __ to 19 __	________
☐	☐	c. accelerators – linear					
		name ________	____	per	________	19 __ to 19 __	________
☐	☐	d. bubble chamber(s)					
		________	____	per	________	19 __ to 19 __	________
☐	☐	e. high voltage lines – distance from line voltage					
		________	____	per	________	19 __ to 19 __	________
☐	☐	f. power station – size of plant					
		________	____	per	________	19 __ to 19 __	________
☐	☐	g. electromagnetic radiation including radar and microwave					
		________	____	per	________	19 __ to 19 __	________
☐	☐	h. radio transmitting station					
		________	____	per	________	19 __ to 19 __	________
☐	☐	i. induction furnaces or heating devices					
		________	____	per	________	19 __ to 19 __	________
☐	☐	j. other installations					
		________	____	per	________	19 __ to 19 __	________

2. Have you ever been exposed to very high electromagnetic fields or magnetic fields above 100 gauss? If yes, please indicate field strength, duration, and parts of body exposed. If field strength is unknown insert "?"

	Field Strength (specify units)	Duration	Head Only	Hands Only	Whole Body	Date
Magnetic – D.C.	____	____	____	____	____	____
Magnetic – Pulsed	____	____	____	____	____	____
Electromagnetic	____	____	____	____	____	____

Did you experience any physical or psychological effects?

____
____
____
____
____
____
____
____
____
____
____
____
____
____
____

3. Have you ever worked in a place where you were OFTEN or DAILY around:

	Occupational	Non-occupational
Radioactivity (please specify: _____)	____	____
Ultraviolet radiation	____	____
Chemicals, cleaning fluids or solvents	____	____
Insect or plant sprays	____	____
Ammonia, chlorine, ozone or nitrous gas	____	____
Engine exhaust fumes (more than 2 hours a day)	____	____
Plastic or resin fumes	____	____
Asbestos, cement or grain dusts	____	____
Silica, sandblasting, grinding or rock drilling dust	____	____
Extreme heat	____	____
Lead fumes or metal fumes	____	____
Very loud noises	____	____
Beryllium	____	____
Other toxic substances (please specify: _____)	____	____

Yes No

☐ ☐ 4a. Have you ever had a job-related injury at this institution?

Please specify: _____

_____

☐ ☐ 4b. Have you ever received compensation due to occupational injury?

☐ ☐ 4c. Have you ever had serious injuries which are NOT job-related?

Please specify: _____

_____

_____

Yes No

☐ ☐ 5a. Are you currently under a physician's care for anything? If yes, please specify:

_____

_____

☐ ☐ 5b. Are you presently taking any medication regularly? If yes, please specify:

_____

_____

☐ ☐ 5c. Do you consider your health to be good? If no, please explain:

_____

_____

6. Have you ever had an operation on any of the following?

Yes No

☐ ☐ Appendix

☐ ☐ Benign tumor (including skin moles)

☐ ☐ Malignant tumor (cancer) please specify: _____

☐ ☐ Gall bladder

☐ ☐ Stomach

☐ ☐ Kidney

☐ ☐ Colon (large bowel)

☐ ☐ Thyroid

☐ ☐ Breast

☐ ☐ Rupture (Hernia)

☐ ☐ Tonsils

☐ ☐ FOR MEN ONLY: Prostate

☐ ☐ FOR WOMEN ONLY: Uterus (womb) removal

☐ ☐ Any other operations? Please specify: _____

_____

7. Please check if you presently have or in the past have been told that you had any of the following:

	Now	In the past	When first occurred
Cancer – specify: _____	___	___	19 ___
Congenital heart disease	___	___	19 ___
Rheumatic heart disease	___	___	19 ___
Heart attack	___	___	19 ___
Stroke	___	___	19 ___
High blood pressure	___	___	19 ___
Leukemia	___	___	19 ___
Anemia	___	___	19 ___
Thrombophlebitis	___	___	19 ___
Other blood diseases	___	___	19 ___
Diabetes	___	___	19 ___
Thyroid diseases	___	___	19 ___
Liver disease	___	___	19 ___
Drug allergy	___	___	19 ___
Migraine headaches	___	___	19 ___
Skin problems	___	___	19 ___
Cataract (caused by _____)	___	___	19 ___
Detached retina	___	___	19 ___
Asthma	___	___	19 ___
Osteoporosis	___	___	19 ___
Arthritis	___	___	19 ___
Tuberculosis	___	___	19 ___
Neurological disorder (including seizure)			
Specify: _____	___	___	19 ___
Psychiatric disorder	___	___	19 ___
Temporary psychiatric care	___	___	19 ___

8. Please check if any blood relatives (parents, siblings, children, grandparents) have had any of the following:

Yes		Relations
☐	Cancer – specify: _____	_____
☐	Thyroid diseases	_____
☐	Leukemia	_____
☐	Other blood diseases	_____
☐	Diabetes	_____
☐	Heart diseases	_____
☐	High blood pressure	_____
☐	Migraine headaches	_____
☐	Neurological disorders (including seizure)	_____
	Specify: _____	_____
☐	Psychiatric disorders	_____

9. Have you ever had radiation therapy?

Yes	No		Head and neck	Other parts of body (specify)	When
☐	☐	a. X-ray	___	_____	19___
☐	☐	b. Other radioactive material. Specify:	___	_____	19___

_____

Yes No

☐ ☐ 10a. Have you ever been rated up or refused for insurance? Please explain:

_____

_____

☐ ☐ 10b. Were you ever refused induction or separated from military service for:

1) Medical or

2) Psychiatric reasons?

11. Have you at any time in the past smoked cigarettes for at least one year? Please indicate in the appropriate column.

	Now	Not smoke now but in the past
Less than one pack a day	____	____
More than one pack a day	____	____
How many years have you smoked cigarettes regularly?	____ yrs.	____ yrs.

12. Do you use alcoholic beverages?

Yes
- ☐ Socially
- ☐ Daily
- ☐ Irregularly
- ☐ None at all

Yes No
☐ ☐ 13. Do you have a hearing problem?

Yes No
☐ ☐ 14. Have you wanted children but were unable to have them? If yes, please explain:

_____

_____

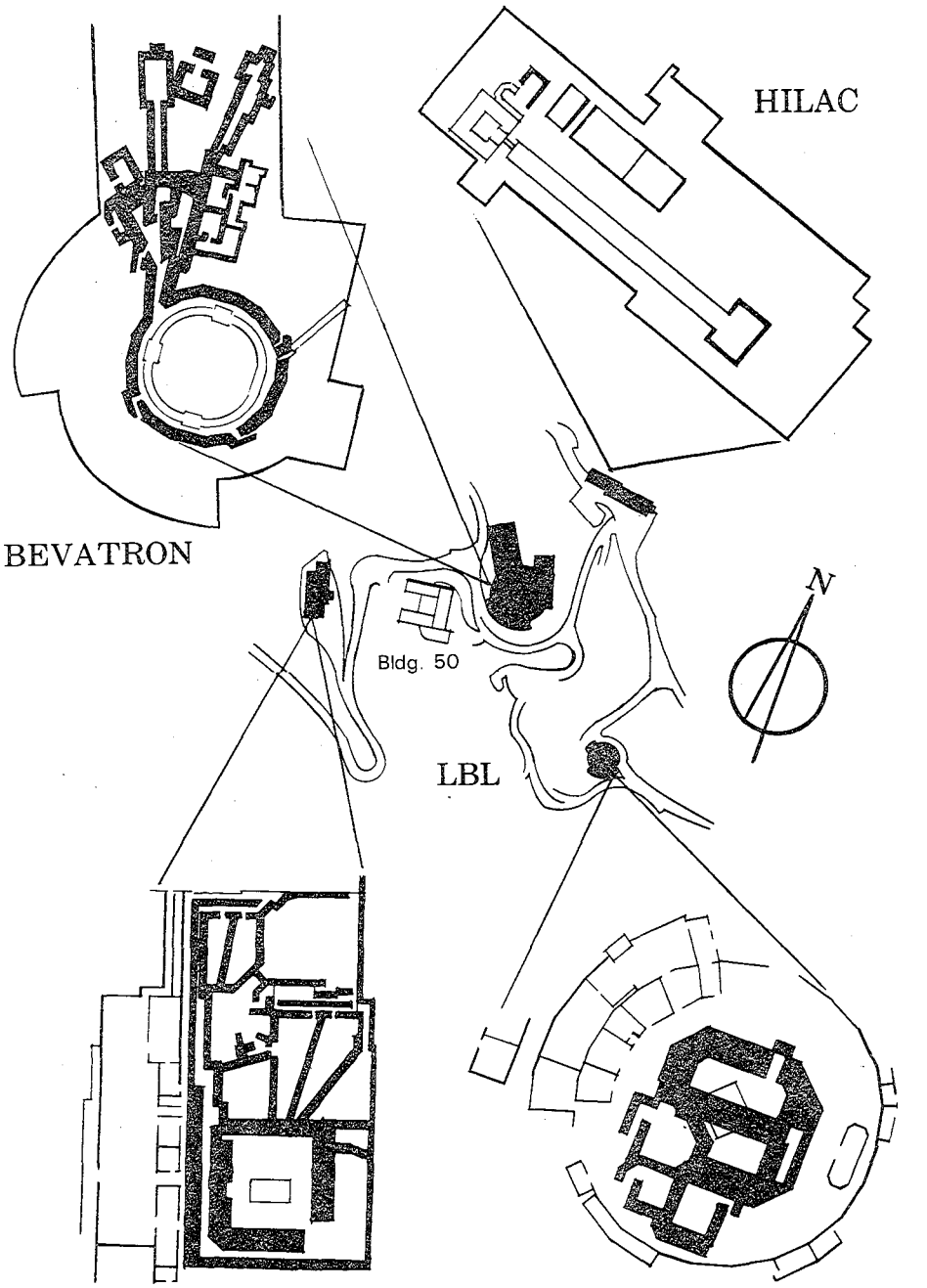
_____

_____

_____

_____

We wish to express our appreciation for your consideration, time and cooperation regarding this study. Would you kindly staple and return.



Epidemiology of Magnetic Effects on Humans

EDP Coding Sheet - Employee Medical Records

Name of Institution: _____

1	CARD NO.	CARD NO.	CARD NO.	CARD NO.
2-6	ENCLOSED I.D. NO.	ENCLOSED I.D. NO.	ENCLOSED I.D. NO.	ENCLOSED I.D. NO.
7-12	BIRTH DATE	BIRTH DATE	BIRTH DATE	BIRTH DATE
13-18		EXAM. DATE	EXAM. DATE	START DATE
19		WEIGHT	POP. CODE	POP. CODE
20		BLOOD PRESSURE S. / D.	URINALYSIS	
21			MORPHOLOGY	SEX
22			HGB	RACE
23-25				JOB CLASS.
26		CHEST X-RAY	HMT	
27-29		PULSE	RBC	HEIGHT
30-31				BLOOD GROUP
32-38		POSITIVE FINDINGS		
39	NO. OF TYPE			#abn. Blood
40	TYPE			#abn. Urine
41	DIRECTION		PLATELET	NO. OF INJURIES
42-47	MAGNITUDE	FLAG 1 2 3 4 5 6 7	WBC / SEG / BAND	NO. OF OTHER COMPLAINTS / FAMILY HISTORY
48	PART OF BODY			CUMMULATIVE RADIOACTIVE DOSAGE
49-51	PULSE WIDTH			
52-53				
54-57	REPETITION RATE OR FREQUENCY			
58-61	DURATION	MEDICAL HISTORY	EOSINOPHIL / BASOPHIL / LYMPHOCYTE	MEDICAL HISTORY
62-63	LAST TIME EFFECTS			
64-72				
73		EKG	MONOCYTE	
74		SEROLOGY		
75		HEARING		
76		V.C		
77		TONOMETRY		
78-80		BLOOD SUGAR		

MAGNETIC EXPOSURE

APPENDIX C

APPENDIX D

FORM OF DATA ENCODING SYSTEM

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APPENDIX F

FORM OF DATA ENCODING SYSTEM

CARD NO.	COLM. NO.	VAR. NO.	VARIABLE	CODE	DESCRIPTION
1-8	1	1	CARD CODE	1	CARD NO. 1 FORMAT
				2	CARD NO. 2 FORMAT
				3	CARD NO. 3 FORMAT
				4	CARD NO. 2 FORMAT
				5	CARD NO. 3 FORMAT
				6-8	CARD NO. 6 FORMAT
	2-7	2	I. D. NO		XXXXX1 = SUBJECTS
					XXXXX2 = CONTROLS
	8-9	3	BIRTH YEAR		
	10-11	4	BIRTH MONTH		
	12-13	5	BIRTH DAY		
1	14-15	6	START YEAR		
	16-17	7	START MONTH		
	18	8	POPULATION CODE	3	SUBJECT
				4	CONTROL
	21	10	SEX	1	MALE
				2	FEMALE
	22	11	RACE	1	CAUCASIAN
				2	ASIAN
				3	BLACK
				4	SPANISH (HISPANIC)
				5	AMERICAN INDIAN
	23-25	12	JOB CLASSIFICATION		3-DIGIT CODE ACCORDING TO JOB DUTIES
	28-30	14	HEIGHT		CM.
	31	15	BLOOD GROUP	1	O
				2	A
				3	B
				4	AB
	39	23	NO. OF ABN. BLOOD		0-9 TIMES
	40	24	NO. OF ABN. URINE		0-9 TIMES
	41-42	25	NO. OF INJURIES		0-99 TIMES
	43-44	26	NO. OF COMPLAINTS		0-99 TIMES
	45	27	FAMILY HISTORY	1	CANCER

CARD NO.	COLM. NO.	VAR. NO.	VARIABLE	CODE	DESCRIPTION
1	46	28		2	THYROID DISEASE
	47	29		3	BLOOD DISEASE
				4	DIABETES
				5	HEART TROUBLE
				6	HIGH BLOOD PRESSURE
				7	TUBERCULOSIS
				8	EPILEPSY OR FITS
				9	GOUT
				31	LEUKEMIA
				21	THYROID CANCER
	48-50	30	CUMMULATIVE RADIOACTIVE DOSAGE		ROENTGEN
	51-53	31	MEDICAL HISTORY		3-DIGIT CODE FROM INTERNATIONAL CLASSIFICATION OF DISEASES
	54-56	32			
	57-59	33			
	.				
	.	TO			
	.				
	75-77	39			
	78-80	40	INFORMATION SOURCE	1	QUESTIONAIRE + MED. FILES
				2	INTERVIEW AND 1
				8K.	MEDICAL FILES ONLY
2	2-13	2-5			SAME AS CARD 1 / 2-13
	14-15	6	EXAM. YEAR		
	16-17	7	EXAM. MONTH		
	18	8	POPULATION CODE	3	ALWAYS FOR SUBJECTS
				4	ALWAYS FOR CONTROLS
	19	9	URINALYSIS NO. 1	8K.	NOT DONE
				1	NORMAL
				2	SUGAR PRESENT
				3	ACETONE PRESENT
				4	EXCESS WBC
				5	EXCESS RBC
				6	CASTS PRESENT
				7	CRYSTALS PRESENT
				8	PROTEIN PRESENT
				9	SPECIFIC GRAVITY ABNORMAL
	20	10	URINALYSIS NO. 2		SAME CODE AS 2 / 19

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APPENDIX F

FORM OF DATA ENCODING SYSTEM

CARD NO.	COLM. NO.	VAR. NO.	VARIABLE		CODE DESCRIPTION
2	20	11	MORPHOLOGY	1	NOT TESTED
				1	NORMAL
				2	SICKLE CELL
				3	OTHER ABNORMALITY
			MALE FEMALE		
	22-24	12	HGB 130-175, 120-150		DECIAML (* .10)
	25-26	13	HMT 39-51, 36-46		UNIT
	27-28	14	RBC		100 THOUSAND (* 100000)
	40-41	20	PLATELETS		10 THOUSAND (* 10000)
	42-43	21	WBC 4(000)-12(000)		THOUSAND (* 1000)
	44-45	22	SEG 50-70		UNIT
	46-47	23	BAND 0-5		UNIT
	58-59	29	EOSINOPHIL 0-7		UNIT
	60-61	30	BASOPHIL 0-1		UNIT
	62-63	31	LYMPHOCYTE 25-30		UNIT
	72-73	36	MONOCYTE 0-10		UNIT
3	2-13	2-5			SAME AS CARD 1 / 2-13
	14-17	6-7			SAME AS CARD 2 / 14-17
	18-20	8	WEIGHT		KG.
	21-23	9	SYSTOLIC BLOOD PRESSURE 100-200		
	24-26	10	DIASTOLIC BLOOD PRESSURE 60-110		
	27	11	CHEST X-RAY	8K.	NOT DONE
				1	NORMAL
				2	ABNORMALITY - LUNGS
				3	ABNORMALITY - CP ANGLES
				4	ABNORMALITY - GREAT VESSELS
				5	ABNORMALITY - BONY THORAX
				6	ABNORMALITY - DIAPHRAGMS
				7	ABNORMALITY - HEART
				8	ABNORMALITY - MEDIASTINUM
				9	VISIBLE SCARRING
	28	12	CHEST X-RAY		SAME CODE AS 3 / 27
	29-31	13	PULSE		COUNTS/MINUTE
	32-34	14	POSITIVE FINDINGS		SAME AS 1 / 51-77
	35-37	15			
	38-40	16			
	41-43	17			
	44	18	FLAG	8K.	NO CONTINUING CARD
				1	CONTINUING CARD
NO.	NO.	NO.			FOR ADDITIONAL INFORMATION
3	45	19	PHYSICIAN'S CARE/ MEDICATION (1)	0	GOOD HEALTH
				1	PHYSICIAN'S CARE
				2	MEDICATION
				3	1 AND 2
				4	HEALTH NOT GOOD
				5	1 AND 4
				6	2 AND 4
				7	3 AND 4
	46	20	MILITARY REJECTION OR DISCHARGE/ INSURANCE RATE (2)	0	NO
				1	DUE TO MEDICAL OR PSYCHIATRIC REASON
				2	INSURANCE RATED UP
				3	1 AND 2
	47	21	RADIOACTIVE THERAPY (3)	0	NONE
				1	X-RAY TO HEAD AND NECK AREA
				2	X-RAY TO OTHER PARTS OF BODY
				3	1 AND 2
				4	OTHER RADIOACTIVE MATERIAL TO HEAD AND NECK AREA
				5	OTHER RADIOACTIVE MATERIAL TO OTHER PARTS OF BODY
				6	4 AND 5
				7	1 AND 4
				8	2 AND 5
				9	3 AND 6
	48	22	ALCOHOLIC BEVERAGES (4)	0	NONE AT ALL
				1	IRREGULARLY
				2	DAILY
				3	SOCIALLY
	49	23	INJURY/COMPENSATION (5)	0	NONE
				1	JOB-RELATED INJURY
				2	COMPENSATION DUE TO 1
				3	NOT JOB-RELATED INJURY
				4	1 AND 3
	50	24	SMOKING HABITS(6)	0	NEVER SMOKED
				1	PRESENT LIGHT < 10 YEARS
				2	PRESENT LIGHT > 10 YEARS
				3	PRESENT HEAVY < 10 YEARS
				4	PRESENT HEAVY > 10 YEARS
				5	PAST LIGHT < 10 YEARS
				6	PAST LIGHT > 10 YEARS
				7	PAST HEAVY < 10 YEARS
				8	PAST HEAVY > 10 YEARS
				9	SMOKER

APPENDIX D

FORM OF DATA ENCODING SYSTEM

CARD NO.	COLM. NO.	VAR. NO.	VARIABLE	CODE	DESCRIPTION
3	51-52	25	WORK WITH TOXIC	00	NONE OF THE MENTIONED
	53-54	26	MATERIAL (?)	01	RADIOACTIVITY
	55-56	27		02	ULTRAVIOLET RADIATION
				03	CHEMICALS, CLEANING FLUIDS OR SOLVENTS
				04	INSECT OR PLANT SPRAYS
				05	AMMONIA, CHLORINE, OZONE, OR NITROUS GAS
				06	ENGINE EXHAUST FUMES (MORE THAN 2 HOURS A DAY)
				07	PLASTIC OR RESIN FUMES
				08	ASBESTOS, CEMENT, OR GRAIN DUSTS
				09	SILICA, SANDBLASTING, GRINDING OR ROCK DRILLING DUST
				10	EXTREME HEAT
				11	LEAD FUMES OR METAL FUMES
				12	VERY LOUD NOISES
				13	BERYLLIUM
				14	OTHER
	57-59	28	MEDICAL HISTORY		SAME CODE AS CARD 1 / 51-77
	60-62	29			
	63-65	30			
	66-68	31			
	69-71	32			
	72-73	33	EKG	10	NORMAL
				20	ABNORMAL
				30	BORDERLINE
	74	34	SEROLOGY	1	NEGATIVE
				2	POSITIVE
	75	35	HEARING	1	NORMAL
				2	LOSS
	76	36	VITAL CAPACITY	1	NORMAL
				2	ABNORMAL
	77	37	TONOMETRY	1	NORMAL
				2	ABNORMAL
	78-80	38	BLOOD SUGAR		MG. PERCENT
6	2-13	2-5			SAME AS CARD 1 / 2-13
	14-17	6-7	QUESTIONAIRE DATE		SAME FORMAT AS 1 / 14-17
	39	14	MAGNETIC INFO. CARD CONTINUATION FLAG	BK.	NO FOLLOWING CARD
				1	CARD FOLLOWING (TYPE 6)
NO.	NO.	NO.			
6	40-41	15	TYPE OF FIELD	00	NONE
				01	MAGNETIC FIELD - D. C.
				02	MAGNETIC FIELD - AGS ACCELERATORS (BEVATRON, SYNCHROTRON, ETC.)
				03	MAGNETIC FIELD - PULSED (TOKAMAK, DOUBLETS, MIRROR, ETC.)
				04	RF (LINAC,HILAC)
				05	HIGH VOLTAGE LINES
				06	ELECTRIC FIELDS
				07	MICROWAVE RADIATION
				08	RADIOTRANSMITTING STATION
				09	INDUCTION FURNACES OR HEATING DEVICES
				10	ELECTROSTATIC
				11	BUBBLE CHAMBERS
				12	VERY HIGH FIELD (DC)
				13	VERY HIGH FIELD (AGS)
				14	V.H.F. ELECTROMAGNETIC
				15	POWER STATION
	42	16	DIRECTION OF FIELD	1	VERTICAL
				2	HORIZONTAL
				3	UNKNOWN
	43-47	17	MAGNITUDE IF COL. 40-41 IS		UNITS MAXIMUM
			01 - 02		GAUSS 50KG
			03		GAUSS 50KG
			04		WATTS BLANK
			05		KV BLANK
			06		VOLTS BLANK
			07		WATTS BLANK
			08		BLANK
			09		MVA BLANK
			10		BLANK
			11 - 14		GAUSS 50KG
			15		WATTS BLANK
	48	18	PARTS OF BODY EXPOSED	1	HEAD ONLY
				2	UPPER LIMBS
				3	1 AND 2
				4	LOWER LIMBS
				5	WHOLE BODY
	49-53	19	PULSE WIDTH		MSEC. (* .00001)
	54-57	20	REPETITION RATE OR FREQUENCY		IF COL. 40-41 IS **02** IF COL. 40-41 IS **03**
	58-62	21	DURATION OF EXPOSURE		NO. OF WORK DAYS (* .10) (MAX.=33YR.

CARD NO.	COLM. NO.	VAR. NO.	VARIABLE	CODE	DESCRIPTION
6	63	22	TIME OF LAST EXPOSURE	0	NONE
				1	1940 < < 1944
				2	1945 < < 1949
				3	1950 < < 1954
				4	1955 < < 1959
				5	1960 < < 1964
				6	1965 < < 1969
				7	1970 < < 1974
				8	1975 < < 1979
	64	23	EFFECTS EXPERIENCED NO. 1	0	NONE
				1	MAGNETIC PHOSPHENE
				2	METALLIC TASTE
				3	DIZZINESS
				4	HEADACHE
				5	STRESS
				6	TINGLING FEELING
				7	IRRITABILITY
				8	
				9	
	65	24	EFFECTS EXPERIENCED NO. 2		SAME CODE AS 4 / 63
				99	WORK WITHOUT SHIELD (BOTH COLM. 64-65)
	66	25	STERILITY	0	NOT ANSWERED
				1	YES
				2	NO
	67	26	SOURCE OF INFO.	1	QUESTIONNAIRE
				2	INTERVIEW
	68	27	CUMULATIVE MG. EXPOSURE	0	DO NOT ACCUMULATE
				1	ADDITIVE
				2	FIND HIGH AND LOW
	69-70	28	PER CENT ERROR IN DURATION		0-99 PERCENT
CALCULATED VALUES					(XX)=TYPE FD. 8 TOTAL IN GAUSS-DAYS
		34	BUBBLE CHAMBER - LOW		BT4(LOW)=(11)(LOW)
		35	BUBBLE CHAMBER - HIGH		BT5(HIGH)=(11)(HIGH)
		36	ALL FIELDS - LOW		BT6=(01)+(02)+(11)(LOW)
		37	ALL FIELDS - HIGH		BT7=(01)+(02)+(11)(HIGH
		38	D. C. AND AGS FIELDS		BT8=(01)+(02)
		39	D. C. FIELD ONLY		BT9=(01)+(01)
		40	AGS FIELD ONLY		BT0=(02)+(02)

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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