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THIS IS COPY 6 OF 7 SERIES A.

December 9, 1946.

Colonel K. D. Nichols
P. O. Box 2610
Washington, D. C.

DOCUMENT NUMBER DEC 9

Dear Colonel Nichols:

As you know, Dr. Oppenheimer and I have discussed the problem of a short-term development of power reactors and have consulted with other members of the Laboratory. I have not included any provision for a development along these lines as a part of the program of the Radiation Laboratory. The reasons for this may call for a word of explanation.

We are convinced of the overwhelming importance from many points of view of the rapid development of the power reactor and believe that it should be possible to carry on this development with the purpose of having a reactor in successful operation within a year.

We have, however, very much hoped that it would not be necessary to undertake this work in Berkeley. It is true, from the point of view of personnel and facilities, and the location of suitable nearby sites, that such a possibility may seem attractive. But in conjunction with the other parts of the Laboratory, for which we are surely uniquely qualified, a further undertaking of this magnitude would make for a concentration of effort which is undesirable from the viewpoint of public policy and which would, no doubt, interfere both with the studies of fundamental physics on which we should now be embarking and with our effectiveness in the training of graduate students and scientists of other institutions.

For these reasons we have hoped that another solution, and perhaps a more effective one, could be found for what appears to us an urgent problem. Should this not be the case, it is clear the budget I am now submitting to you would need considerable expansion. It appears unlikely that a project to design and put into operation a power reactor would be accomplished with an expenditure of less than $2,000,000 for the first decisive year but, you will recognize, many details of the technical program as well as a careful exploration for suitable sites, will be required before a significant estimate could be given.

Sincerely yours,

Ernest O. Lawrence
Director

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December 9, 1946

Colonel K. D. Nichols
P. O. Box 2610
Washington D. C.

DOCUMENT NUMBER DEC 9-A

Dear Colonel Nichols:

In response to a request from your representative at Berkeley, a preliminary estimate of budget requirements for the year 1947-1948 for the work now proceeding under Contract W-7405-eng-48, has been prepared.

Appended is an outline of the principal lines of research to be followed, and some comments on items included in the budget.

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The estimate which follows is presented in three parts, the first an indication of the anticipated cost of a laboratory program making full use of existing facilities and based upon new physics and chemistry work resulting chiefly from the operation of the two accelerators, the 184" Cyclotron and the Synchrotron.

The second part is an appraisal of the probable cost for continuation of construction and development work on the full-scale Linear Accelerator. This portion of the estimate is based upon the assumption that a construction directive which is now pending will authorize this work to begin from funds which are available for the purpose in the 1946-1947 contract appropriation.

The third part represents anticipation of certain construction projects which may be necessary or advisable to be undertaken during the coming year, and which relate directly to the laboratory program.

I - General Laboratory Program

Payroll	$ 2,400,000
Overhead Reserve	
Expense and Equipment	1,600,000
184" Cyclotron Improvements	200,000
Synchrotron Improvements	100,000
Project 48A (Divisions I and II)	215,000
Project 48C	35,000
Unallocated	500,000
	$ 5,650,000

II - Linear Accelerator Development

Completion of first section	$ 500,000
Commencement of second section	1,000,000
	$ 1,500,000

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III - Anticipated Construction

Separations Unit	$ 250,000
Health and Safety Service facilities	80,000
General Laboratory facilities	400,000
	$ 730,000

These estimates do not include the reserve for possible terminal expense of $1,300,000 which was established by Modification No. 11 of the contract, on the assumption that it will be carried forward into the 1947-1948 year. It is recommended that additional provision of $100,000 be made for restoration, including decontamination, of Gilman Hall at such time as this University building is no longer used for Project 48B work. It is also assumed that a new appropriation for the Welfare Fund (Modification 6) is not required.

In addition to forecasting Project 48 requirements, this estimate includes provision for Projects 48A (Divisions I and II) and 48C. It is believed that the work heretofore done under Project 48B logically combines with the chemistry program of the Laboratory, and its continuation as a separate project may be somewhat artificial. It is assumed that the ship decontamination work undertaken under Division III of 48A will have been completed, so far as Laboratory participation in this work is concerned, by the end of the current year, so that no provision is made for a continuation of this program in the next budget period.

The budget represents the entry of the Laboratory on a full-scale program of research in fundamental science pertaining to the atomic energy program, as will be indicated by the outline which is attached. With the operation of the 184" Cyclotron this fall and the hoped-for operation of the Synchrotron by next spring, the Laboratory will have passed through a phase of activity following the end of the war which was largely characterized by construction effort, and entered into a new phase in which a comprehensive research program is to be centered upon and implemented by the new scientific tools which are at hand. It is this major shift in emphasis which creates very great uncertainties in budget planning at this time.

It may well be that developments in the next eighteen months may indicate that the budget is insufficient. On the other hand, it may equally well be that some of the amounts indicated are more than will actually be required. The estimates in considerable measure are based on the present operations of the project, and reflect the costs of goods and services in December, 1946. The budget may therefore be considered in this light and, as I have said at the outset, is preliminary.

Sincerely yours,

Ernest O. Lawrence
Director

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RESEARCH PROGRAM - CONTRACT W-7405-ENG-48 - 1947-1948

PHYSICS

DOCUMENT NUMBER DEC 9-B

The coming year is visualized as a period in which the Laboratory will be in a position to devote a preponderant share of its attention, energies and facilities to work in areas of new science in the field of nuclear physics.

The major construction program pursued in the past year has resulted in the completion and operation of the 184" Cyclotron, opening most promising lines of research to physics and chemistry alike. A similar expansion of scientific opportunity may be anticipated when the Synchrotron goes into operation in the spring of 1947.

The program for 1947-1948 will therefore be centered upon the operation of these two accelerators. The new knowledge of nuclear physics which seems certain to be the product of these two machines - in fact, which has already been gained in early work of the 184" Cyclotron - may be expected to stimulate new work in the fields of related work in organic and inorganic chemistry as well as in medical and biological work which directly relates to the atomic energy program.

While the construction phase of Laboratory work since the war is to be subordinated in 1947-1948 to this new work, the program and budget provide for completion of the first unit, consisting of eight 40-foot sections, of the Linear Accelerator by a group headed by Dr. Luis W. Alvarez. Present expectations are that much of this work on what has been considered to be a "first" section, designed for 300 Mev. protons, will be completed during the current fiscal year, utilizing funds which were provided for this purpose. Present plans call for operation of this first section by January, 1948. While the decision to proceed with a second section, designed for the range of 1,000 Mev, logically awaits operation of the first section, it is well to make budget provision for this work in advance. The spring of 1948 could be utilized for a major portion of this work, with completion possible in the fall of the same year.

The current status of this program is that more than a year of endeavor has verified theoretical predictions on all points which were earlier considered controversial. A 40-foot model is about ready to operate; if such operation justifies, and there is now no reason to be dubious, it is intended that ground be broken in mid-April of 1947 for the first eight-unit section.

184" Cyclotron. This instrument first operated with 200 Mev. deuterons a little less than a month ago. The construction work was considered essentially complete by December 1, 1946. Results of early operation have exceeded expectations to the point that chemists have been afforded a wealth of new work, and physicists are confronted by an array of problems, first among which are the qualitative determination of observed phenomena and the selection of the most interesting and accessible fields of research. Obviously it is hardly practical at this point to predict in detail the work to be done in the next eighteen months. As

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experimental results become available, and as operating experience is accumulated, the research program will take shape along lines of making most effective use of the equipment and the available research time.

In its initial operations, the instrument has used an internal beam. A deflector system is scheduled for completion early in 1947, and it is expected that a conversion to the acceleration of protons of perhaps 350 Mev. may be accomplished during the coming summer. Such a conversion will chiefly involve the dee structure and the radio-frequency system but will not require substantial alteration of the rest of the equipment.

Budget provision has been made for modification and improvement of this cyclotron, even though now no specific plan is outlined. In this regard, the budget allowance may be considered a reserve against the possibility that such work may become extremely desirable as research progresses. This view is borne out by past experience in the operation of cyclotrons.

Synchrotron. Construction of the building for this instrument is approaching completion. The assembly of the instrument itself has been beset by all of the difficulties encountered in the past year by the industries which are the principal suppliers of components and services - electrical, steel and non-ferrous metals, transportation, and the like. Nevertheless, the group working under the direction of Dr. E. M. McMillan has been able to progress constructively toward the solution of some of the problems of operation which may be expected to be encountered. It may be expected that final assembly will proceed rapidly as present delivery schedules are met. Final tests and operation are expected by spring of 1947. Initial operation is planned for 300 Mev. electrons.

For the reasons that have been stated in discussion of the 184" Cyclotron research program, but to an even more pronounced degree, it is early to outline a program of research for this instrument, or to do more than surmise as to its effect on the programs in chemistry and other fields. It is reasonable to expect that its first operation will be accomplished with somewhat more difficulty than was the case with the 184" Cyclotron, and that somewhat more time may be required to achieve steady operation. By the same token, it may be anticipated that the same excitement may pervade the Laboratory as in the case of the 184" Cyclotron, as these problems are met and rich new veins of research are opened in physics and chemistry. The difficulties which stand in the way are perhaps more imaginary than real, but it is well in considering the operation of an instrument as new as the Synchrotron to take them into account.

It will be noted that the budget makes allowance of $100,000 for Synchrotron improvements. Here again, this is at present a reserve against the contingency that actual operation may demand major modifications or improvements.

Instrumentation. This will obviously be an important aspect of the Laboratory program, not only in relation to the work of the accelerator groups, but in other work as well. There will be a greatly increased requirement for conventional laboratory instruments, but beyond that it is certain that there will also be need for instruments of novel character, requiring extensive investigation by physicists skilled in such work, as well as for technical assistance of a high order of competence. This activity may well assume the character of a research program in itself.

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CHEMISTRY

The programs for inorganic chemistry, the separation of isotopes and, to a degree, health physics, overlap sufficiently that they should be considered together.

The interdependence of nuclear chemists and physicists is most clearly indicated in the program of the Laboratory. Operation of the big cyclotron has already produced much new chemistry as well as physics. Additional facilities provided by the Chemistry Annex, a project-equipped University building, which will be available in the spring of 1947, will enable the chemists to undertake some of the more pressing work resulting from cyclotron operations.

The chemists, in turn, will place great reliance upon the assistance of physicists in their study of the known trans-uranium elements, and in their quest for the identification of additional elements, as well as in extensive chemistry research which depends upon the availability of stable and radioactive isotopes of all of the elements. This work suggests a number of practical considerations, including its application to the metallurgy of alloys used in pile construction and operation.

This chemistry will be implemented by the move of the IC magnet from its original location in the 184" Cyclotron building to a new location adjoining the Chemistry Annex, which will be accomplished this winter

Work has been in progress with the JA electro-magnetic separator to service the requirements of the chemists for isotopes of rare elements. This separator is not entirely suited to the purpose, and a decision will eventually have to be made whether to move JA to a location adjacent to IC and the Chemistry Annex or to design and build a more suitable unit.

It is proposed to combine the research heretofore done under Project ASB with the Laboratory chemistry program directed by Dr. Glenn T. Seaborg. Dean W. H. Latimer has suggested that the solvent extraction work, which is nearing completion, be taken over by General Electric for development. Under such a circumstance, Project ASB studies to be continued by Dr. Seaborg and his associates would include the basic chemistry of the heavy elements and an expansion of studies of metals, refractories and high temperature thermodynamics. The latter program would include the systematic tabulation of free energies, entropies, vapor pressures and melting points, carried up to 3000° K. Dr. Latimer believes the work should be continued on phase diagrams of metal and refractory systems of importance to pile development. The program also includes studies on heat transfer and diffusion at high temperatures.

The importance of the Health Physics service in such a program is evident, as well as in connection with the welfare of personnel engaged in accelerator operation at energies higher than have been known in the Laboratory heretofore. The plans of the Chemistry Annex have included a health physics facility, primarily for safeguarding the health of those engaged in chemical experimentation in that building and the present chemistry laboratories which it adjoins. It is clear that when the Laboratory program is in full-scale operation, a material expansion

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of Health Physics facilities will become most advisable. It is with this in mind that budget provision has been made for health and safety service facilities.

Organic Chemistry. The organic chemistry work directed by Dr. Melvin Calvin, at one time considered a high priority program in its need for additional laboratory facilities at the 184" Area, has reasonably immediate hope of a solution of its space problems in the impending transfer of administrative offices from the Donner Laboratory of the campus to new locations in re-erected barracks buildings on the hill. This will free considerable space in the Donner Laboratory for the development of laboratories suited to this work, and is also a happy solution of the space problem in that it will place this group in close proximity to the metabolic work directed by Dr. J. H. Lawrence. This will be to the benefit of the programs of both groups.

The production of labelled compounds for use in biological work, an important aspect of Dr. Calvin's program, will require the handling of large quantities of Carbon 14 and other materials obtained through the Isotope Distribution branch.

BIOLOGY

Project 48A. Research in the two divisions of this project, directed by Dr. J. G. Hamilton and Dr. J. H. Lawrence, will substantially represent continuation of the programs outlined for the year 1946-1947, but with some minor shifts in emphasis indicated by research results and possibilities. These programs include:

1. Studies of the metabolism in animals and man of the principal fission products and of such fissionable elements as uranium and plutonium, and possibly others, such as protactinium, thorium and neptunium.

2. Fission product tracer studies. These represent the less abundant of the fission species, of short half-lives and secondary importance, the metabolism of which requires study in animals and, if possible, in man. Such study has to a considerable extent been deferred by work of greater urgency.

3. Metabolic studies of substances used in pile construction, radio-activity of which is induced in operation. Although not directly produced by fission, these substances, such as chromium, iron and nickel, may offer serious health hazards.

4. Investigation, by means of tracer techniques, of the metabolism of beryllium.

5. Development of methods for treating plutonium poisoning. This is an important aspect of the 48A program, and relates directly to the work of the health physics service at Berkeley, as well as to the protection of workers in other parts of the Manhattan project who are coming in contact with this poisonous substance. The work may be expanded to include other members of the group of fissionable elements.

6. Investigation of the behaviour of the fissionable elements and of fission products in soils and plants.

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7. The biological effects of fission recoils. In its practical aspects, this program bears on the health hazards which may menace workers with U 235 or plutonium whose work exposes them to thermal neutrons.

Project 48C. The portion of the program of this project which is devoted to the study of effects of radioiodine in man will be expanded. This will make necessary, in addition to existing personnel and facilities, a qualified chemist and a laboratory for his work.

Radioiodine is one of the fission products freed in the atmosphere in regions adjacent to piles. It is also set free with great activity at the time of bomb explosions. It therefore is important to study its effects on humans. Opportunity for such study is found in the course of treatment of hospital patients for thyroid disturbances of either benign or malignant character.

Other aspects of importance in the 48C program are the observation of the effects of total body radiation from external and internal sources. In this work, advantage is taken of the availability of human subjects who are under treatment with X-rays to the entire body, or with radio-active phosphorus or some other radio-active isotope. These studies are made in the course of treatment administered for the patient's condition.

GENERAL

The Laboratory program appears to fall into two classes of outline. The first is one in which research lines are relatively clearly drawn, following a pattern established by results of past research, including the uncertainties which they have made more evident. This is generally true of the work in medicine and biology.

The second, and by far the major, category of programs falls chiefly in the areas of physical science which will become clearly delineated only as the research progresses. It is most difficult and unprofitable at this point in their development to outline programs for research with the giant accelerators. It may be useful to speculate on the nature and extent of such research undertakings, but it is best done with the reservation in mind that, if the experience of the past is a reliable guide, some of the most interesting and fruitful work will be done along lines which are now so indefinite and unclear as to defy their inclusion in a formal research program.

The Laboratory looks forward to increased participation in its program by visitors from other institutions and laboratories. There is much that new viewpoints can contribute to the Laboratory, and there may be much that the Laboratory can do to contribute to the research, planned or in progress, of other institutions, particularly in relation to the salient features of this program. The assistance given to other organizations engaged in the development of accelerators should be continued and, if possible, expanded.

The Laboratory also looks forward to participation in its program of an increasing number of graduate students, engaged in work in which they may learn and grow, believing that the effort on the part of the Laboratory staff will represent a sound investment in the scientific future of this nation.

Berkeley, California
December 9, 1946

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Payroll, 1/1 - 6/30/47	$1,100,000	$25,000	$27,500	$14,800	$36,000	$8,575	$1,211,675
Overhead Reserve 1/1 - 6/30/47	275,000	6,250	6,875	3,700	9,000	2,144	302,919
Construction - Total Items							
Synchrotron Building	61,052						61,052
Administration Buildings	66,000						66,000
Magnet Relocation	70,000						70,000
Barracks erection	3,200						3,200
Linear Accelerator	800,000						800,000
Operating Expense	180,000	2,000	2,500		1,900	250	186,650
Materials, Equipment and Services	600,000	6,490	9,375	26,200	25,800	5,639	673,704
Totals	$3,155,252	$39,740	$46,250	$44,700	$72,700	$16,608	$3,375,200

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