lines, in normal stars, and then the special cases of expanding and rotating stars. These chapters on a subject which especially needed to be brought up to date and set in order, are particularly valuable. In addition ample space is given to the increasingly important study of band spectra and dissociative equilibrium of stellar compounds.

The chapters on stars with extensive envelopes and on nebulae are also worthy of being mentioned separately, for they include the interpretation of Wolf-Rayet stars and novae as stars which are continually ejecting matter, the new developments in the identification of lines arising from forbidden transitions and the explanation of nebular bright lines in terms of Rosseland's theory of cycles.

Both the student and the experienced astronomer will find this book a necessity for their libraries. For the former it provides a remarkably complete system of modern theoretical physics and its astrophysical application. The latter will find in it a coordinated picture of stellar atmospheres and the methods of analysis heretofore available only in piecemeal. It is a pleasure to know that "a second volume is planned to give a similar view of the internal structure of stars, analyzed in terms of nuclear physics and hydrodynamics." C. J. A. R.

REPORTS

THE WORK OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

EXPANSION of educational activities and enlargement of facilities for student welfare calling for a fund of $12,500,000 were proposed in a program of objectives presented by Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, at the autumn meeting of the corporation on October 14.

The program of development outlined by Dr. Compton will require a capital expenditure of $2,750,000 for new buildings and equipment and a capital fund of $9,750,000 to produce an annual income of approximately $390,000.

The major objectives of the plan, which will be brought to fulfilment as soon as possible, include a new dormitory to house 100 students; a large gymnasium or an addition to Walker Memorial, the student recreation center; a biological engineering laboratory; funds for research and fellowships, extension of the institute's high voltage research projects; a new aeronautical wind tunnel and a naval towing tank.

Expressing his belief that the country is now in a period of transition from depression to at least relative prosperity, Dr. Compton said:

> We should now pay active attention to the needs and opportunities with which we find ourselves confronted—needs and opportunities which have in part been disclosed by our intensive study in the past few years, in part have arisen through progress in science and engineering, and in part have sprung from the creative work of our own staff. Some of these opportunities show such promise that their neglect would be no less than educational sabotage.

Speaking of the increasing emphasis on graduate work and research as reasons for new facilities, he said that "graduate work in engineering was almost negligible in the period before the erection of our present educational plant. Graduate work in science did exist but only to a small fraction of its present importance. The plant, conceived as it was with great generosity and remarkable vision, and in spite of additions, has nevertheless become inadequate to the demands now made upon it by increased enrolment, graduate work and research."

The need for a more adequate development of Technology's research program was emphasized by Dr. Compton.

> No educational institution in my knowledge has ever approached its possibilities for contributing to public welfare by giving attention to the efficiency of its research program comparable to that which it gives to its teaching. No institution has such great possibilities in this direction as the Massachusetts Institute of Technology. I can imagine no investment for public welfare so likely to secure large returns as one which would permit the latent creative powers of this institution to become really active.
>
> If the Massachusetts Institute of Technology will really grapple with the opportunity here outlined, it will perform a new order of public service along the lines of its charter, which directs it to "aid generally by suitable means the advancement, development and practical application of science in connection with arts, agriculture, manufactures and commerce."

Dr. Compton's proposals were submitted to the corporation with his annual report in which he reviewed the operation of the institute in the past year and the successful solution of the many economic problems confronting educational institutions during the depression. In setting forth his proposals for the future, he divided the program into two parts, one dealing with educational activities and the other with student welfare.

STUDENT WELFARE

Outlining the urgent need for additional housing accommodations, he directed attention to the fact that there is a present unsatisfied demand for rooms for at

least 200 graduate and undergraduate students and added that the demand is likely to increase. He proposed as a beginning to erect a dormitory accommodating 100 students at a cost of approximately $500,000.

Turning to recreational and extra-curricular activities, the institute's president spoke of the lack of adequate facilities for recreation. With the institute's emphasis on recreational sports rather than highly financed and organized athletics, such facilities are especially necessary. The advantages of a large gymnasium, he said, would include its use as an auditorium. A new building would release the present inadequate gymnasium in Walker Memorial for use as a student theater and office space. The cost of such a project, he estimated, would be approximately $1,000,000. He suggests that a study be made to determine whether a gymnasium or an addition to Walker Memorial is the more desirable.

FELLOWSHIPS

Dr. Compton called for $60,000 a year for additional fellowships, which he said should be considered primarily as prizes and incentives or as providing opportunity for study and investigation of problems of exceptional interest.

These funds would be used for four classes of fellowships. One would be to assist graduate students who now do part-time teaching while working for advanced degrees. Under this plan they often have to spend from five to six years to complete their work. The new fellowships would make it possible to relieve promising men of some of the burden of earning their way in the last year of graduate work.

A second fellowship is desired for students who, having taken their graduate degrees, are engaged on research projects worthy of further investigation. This type of fellowship would permit a student to continue important research work a year after receiving his degree.

Still another class of fellowship is desired to extend and place on a more permanent basis the system of honorary sponsored fellowships which has been given a decidedly successful trial on a small scale in the department of business and engineering administration. Two ideas are basic to these fellowships, the one having to do with the selection of the fellows, and the other with the educational program made available to them. The fellows are selected from business and industrial organizations with cooperation of the management, and are preferably from two to five years out of college. Thus an exceedingly promising young employee is given leave of absence for one year by his employer in order to carry on, under the fellowship, advanced study of business and engineering administration leading to a master's degree at the institute.

This plan carries into the training of young men for business positions something of the same advantageous experience gained by the young doctor or the young lawyer in his period of interneship or apprenticeship, when he has opportunity to observe the work of the best men in his profession. Hitherto such an advantage has not been given the young apprentice in a business organization, since he commonly comes early into contact only with the lowest grade of business executive. The experience of the small group of honorary fellows during the past five years and their very remarkable record of success immediately following their fellowship year are ample evidence of the soundness of this educational program. Funds for the fellowships are essential, however, since the young men who can best benefit by this program are in general unable at this critical stage in their careers to make the combined sacrifice or loss of earnings for a year and payment of tuition.

The fourth type of fellowship would supplement the institute's undergraduate scholarship and loan plan, and would be awarded as scholarship aid to students in their senior year.

AERONAUTICAL ENGINEERING

The remarkable progress of aeronautical engineering in recent years was indicated in Dr. Compton's report by the statement that airplane speeds have increased so rapidly that the institute's big wind tunnel, built in 1923, is now inadequate for the purpose for which it was designed. He said:

> The Institute had the first course in aeronautical engineering in America, and the first wind tunnel. It has a notable record of achievement and an able staff. Lack of this modern facility should not be allowed to relegate the department to a less effective position. A unique design of wind tunnel is planned, which will gain the advantages of a very large tunnel with enormous wind velocity through the expedient of operating at an adjustable air pressure within the tunnel. By this means the cost of a satisfactory tunnel can be brought down to $125,000.

TOWING TANK

In a somewhat analogous category with the wind tunnel is the need of a model towing tank for the department of naval architecture and marine engineering. This has long been a subject of intense interest to the institute, dating back at least to the time when the late President Stratton and John R. Freeman made intensive studies and preparations for the installation of a combined hydraulic laboratory and towing tank. Unfortunately circumstances have thus far prevented the consummation of their well-laid plans.

Much of the most valuable work on hull design of ships and in the scientific study of the phenomena of ships afloat has been done with the aid of towing tanks which

are much smaller and less expensive than the tank originally projected for the institute. Encouraged by this fact, and convinced that a department of naval architecture and marine engineering so prominent as the institute's should not be handicapped by lack of this essential piece of equipment for teaching and research, favorable consideration has recently been given to the advantages which would be offered by a small tank costing perhaps $35,000.

In view of the institute's increased responsibility in the training of naval constructors, who now spend all three years of their post-graduate work at the institute, and in view of the general tendency to give more scientific attention to ship design, I recommend that steps be taken to provide a naval towing tank.

High Voltage Laboratory

Significant opportunities would be opened up in our teaching and research program by the provision of suitable facilities for experimental and developmental work in the field of high voltage electricity. In this, both the electrical engineering and physics departments are intensely interested.

There are definite industrial trends toward the use of even higher voltage; there are many important practical problems to be solved and a great virgin field for scientific and industrial pioneering. The physicist is especially interested in the use of high voltage to explore the inner nuclei of atoms, those tiny citadels which for centuries withstood the efforts of the alchemists.

This new field may well prove to be as far-reaching in its scientific and practical influence as were those which were opened up by the discovery of the electron a century ago. The institute is now in the unique position of having on its staff probably the most competent men in the world in fundamental aspects of the high voltage field, and it is also in the position of having developed the equipment for producing direct current of ten times higher voltage than any which have hitherto been achieved. All this opens up a very large field for research and for thesis work by graduate students, provided the necessary facilities can be secured.

It appears that a reasonably active prosecution of this program will require the construction of some $340,000 worth of buildings and equipment, and an annual operating budget of $50,000, or the income from $1,250,000. This figure, while large, is exceedingly small in relation to the value of some of the industrial possibilities in the high voltage program.

Biological Engineering

Prospects of future developments of great importance in the field of biological engineering involving a carefully planned approach to biological and medical problems, and calling for the cooperative efforts of biologists, physicists, chemists and engineers, were indicated in Dr. Compton's plan for a new laboratory building to house the department of biology and public health. The cost of the building he estimated would be approximately $750,000, and an annual fund of $80,000 would be required for its satisfactory operation.

After reviewing the work of the department, which has made many important and pioneering contributions in the field of public health, food technology and medicine, Dr. Compton outlined some of the opportunities for advances in the new field of biological engineering through combined cooperative research in various branches of science and engineering. Citing the results of cooperative projects already undertaken at the institute, he said:

> It has been generally agreed by scientists that the biophysical and biochemical approach to biological and medical problems is one which offers tremendous possibilities. In fact it is probable that this line of approach is the one most likely to lead to a fundamental understanding of the complex problems here involved. I believe that there is much promise in a type of approach to applied biology which could be carried out in the environment of the Institute, with its biology department free to call for advice on a wider variety of scientific and engineering specialists than can be found in any other institution.

Research Funds

The greatest need of the institute, Dr. Compton told the corporation, is at least $200,000 annually or a capital endowment of $5,000,000 for important research.

Types of research which would be possible if funds are provided might include, he said, such important investigations as the effects of low temperatures, the production of powerful magnetic fields, concrete construction, housing, meteorology and development of new uses for agricultural products.

> These are only a few outstanding examples of the needs and opportunities in the institute's research program. They are projects which may well involve considerable groups of men. In addition, however, there are many other such group programs, as well as individual investigations. Every graduating senior, every candidate for a master's degree, every candidate for a doctor's degree, carries on some type of investigation. The increasing importance and the great educational value of all this work is my reason for placing a fluid research fund at the forefront of the larger program.

In the course of his formal report to the corporation on the operation of the institute during the past year Dr. Compton reported an increase of more than $15,000 in investment income and student fees over the preceding year, bringing the total operating budget to $2,714,301. Capital and miscellaneous gifts amounted to $429,533. The institute closed its year with a small balance of less than $5,000, which was applied to reduce the cumulative deficit. The market value of endowment funds increased during the year from $32,562,000 to $36,530,000.