COPP/SS/3/1964

REPORT
ON
SCIENCE EDUCATION
IN
SECONDARY SCHOOLS

COMMITTEE ON PLAN PROJECTS
GOVERNMENT OF INDIA
NEW DELHI
November 1964

LETTER OF TRANSMITTAL

Dr. K. N. Mathur,
Chairman.

D.O. No. ESE/V(92)/64.
Panel for Science Education in
Secondary Schools,
Committee on Plan Projects,
Planning Commission,
Link House,
3, Mathura Road,
New Delhi-1.

December 3, 1964.

Dear Shri Nandaji,

I have great pleasure in forwarding to you the Report of the Panel for Science Education in Secondary Schools. This Panel was set up in pursuance of a meeting held in the Planning Commission under the Chairmanship of Prof. M. S. Thacker, Member, Planning Commission and as an off-shoot of the earlier COPP Report or Science Laboratories and Equipment in High/Higher Secondary Schools. As you will kindly observe from the Report, it was a broad-based and composite Panel representing State Governments, Education Boards, Ministry of Education, Council of Scientific and Industrial Research, National Buildings Organisation, Indian Standards Institution and independent scientists.

2. The Panel examined the detailed proceeding for allotment of funds and procurement of equipment in secondary schools and has observed that the present procedure is quite unsatisfactory and results in various malpractices besides hampering class work considerably. The Panel has recommended a definite schedule so that the financial sanctions are issued to schools at least 6 months in advance of the start of the new academic session.

3. While adequate attention is being given to the teaching of science at all levels in the country, it is essential that the secondary schools should be properly equipped. The Panel has, therefore, drawn standard lists of equipment for science laboratories of secondary schools and suggested suitable grants for the purpose. These lists should serve as useful guides to the State Governments as also to the middle and high schools throughout the country.

4. The Panel is of the view that the manufacturers of scientific instruments in the country have adequate capacity for manufacturing most of the items of scientific apparatus for schools but they are reluctant to take up any large scale programme since, according to the prevailing system of lowest tenders, the manufacturers of quality products cannot compete with unscrupulous suppliers who would not hesitate to supply sub-standard products. To remedy this, the Panel has suggested that purchase standards should be framed and rate contracts fixed on quality basis. The Panel has also suggested that the State Governments should estimate requirements of scientific equipment on a five-year basis and the Planning Commission may then take up the question of increased production with the manufacturers.

5. You will be glad to know that the recommendations of the Panel have the concurrence of the Ministry of Education, who were represented on the Panel.

6. I may be permitted to take this opportunity to convey my personal gratitude for the keen interest that the Members of the Planning Commission, Shri Tarlok Singh, Prof. V. K. R V. Rao and Prof. M. S. Thacker have taken in the study at various stages. Prof. Thacker was originally responsible for setting up this Panel. I may also be permitted to put here the deep appreciation of the work of Shri Jagdish Singh, Member-Secretary of the Panel and his devoted workers but for whose initiative, resourcefulness and hard work this Report would not have been possible.

With my best personal regards,

Yours sincerely,

K. N. MATHUR.

Shri Gulzarilal Nanda,
Chairman,
Committee on Plan Projects,
Planning Commission,
New Delhi.

CONTENTS

CHAPTER I

INTRODUCTION

1.01. The rapid development of industry in the country since independence has brought out the urgent need for efficient scientific and technological man-power. The years following the Second World War have witnessed amazing advances in science and technology and these new developments have focussed attention on the need for better science education. During the last ten years or so there has been increasing awareness in the more advanced countries of the serious shortage of technically educated man-power and hence of the need for stepping up scientific and technical education as fast as possible. In U.S.S.R., U.S.A., and U.K. considerable attention has been given to school science and as a result the system of science teaching is undergoing drastic changes both in content and methodology.

1.02. Early in 1962, the Indian Parliamentary and Scientific Committee under the Chairmanship of Shri Lal Bahadur Shastri took up for study and examination the problem of science education in schools with a view to finding out how science courses are organised in the primary, middle and high/higher secondary schools in relation to policies and decisions arrived at the Centre and the States at the commencement of the Third Plan. The Committee felt that "there is a gulf between what is being taught and what ought to be taught". The Committee has recorded its awareness of the problem that "quite a number of school buildings are lacking in physical facilities of laboratory equipment, apparatus, library, etc., and the building itself has not been devised from a functional point of view in many cases" and recognized in this connection the work being done by the C[illegible] mittee on Plan Projects on school buildings, hostels, science labo[illegible] atories and equipment.

1.03. In the Third Plan considerable emphasis has been given to science teaching at the school level. According to the figures of the Planning Commission there were 17,217 high/higher secondary schools at the end of the Second Plan, of these 5,584 had science as an elective subject. The number of high/higher secondary schools is expected to increase to about 22,000 by the end of the Third Plan, out of which 9,474 should have science as an elective subject. Thus over 9,000 schools are expected to have laboratory facilities for the teaching of science at the end of the Third Plan. It is further proposed to strengthen 6,000 schools by providing additional science equipment to their laboratories. In addition, this year a crash programme has

been undertaken to provide science laboratories in all secondary schools which were opened by the end of the Second Plan. This programme provides 100 per cent assistance to States by the Centre outside their Plan ceilings. There is also a proposal to set up an Institute of Science Education in each State to undertake a programme of training of science teachers.

1.04. The University Grants Commission and the National Council of Educational Research and Training of the Ministry of Education have taken up the question of the revision of syllabi for science and general science at all levels, as also the improvement of the training of science teachers. The NCERT have set up only recently four Regional Colleges of Education where particular attention is being given to the training of science teachers. The Science Education Department of the NCERT in Delhi is actively engaged in studying prototypes of newer scientific equipment, now being used extensively in technically advanced countries like U.S.A., U.S.S.R. and U.K. The assistance of UNESCO experts has also been secured in making an assessment of the problems and finding out measures to accelerate the pace of development in the teaching of science at the school as well as university level.

1.05. While adequate attention is being given to the academic side of science teaching, certain administrative and financial hurdles need greater attention by the authorities concerned. The Committee on Plan Projects, which takes up studies in various sectors from the point of view of efficiency and economy, set up in 1962, a Panel for Science Laboratories and Equipment in High/Higher Secondary Schools, under the Chairmanship of Dr. K. N. Mathur, then Director, Central Scientific Instruments Organization of the Council of Scientific & Industrial Research, New Delhi. This Panel studied the practical problems of buildings and the supply of apparatus and equipment for science laboratories and other inter-related issues particularly in the Higher Secondary Schools of Delhi. Its Report, issued in November 1962, gave detailed specifications for the planning of laboratory buildings including the various services required in a laboratory. Besides, the Panel prepared an exhaustive list of the science equipment for Physics, Chemistry, Biology and Home Science laboratories for higher secondary schools.

1.06. This Report was the first attempt of its kind to present to the educational and administrative authorities concerned the basic requirements of science laboratories for Higher Secondary Schools. This Report has since served as a guide book for Delhi Administration and for the Central Schools Unit of the Ministry of Education (which is setting up all over India Central Schools conforming to the

syllabus of the Central Board of Secondary Education, Delhi. There has also been good demand for it from several States.

1.07. In this Report the Panel made certain important recommendations with regard to the need for laying down specifications and standards for equipment and apparatus as also for adopting a rational procedure for allotment of funds and procurement of science equipment. At a meeting held under the Chairmanship of Prof. M. S. Thacker, then Member (Education), Planning Commission, it was decided that the various issues raised in the Report should be taken up for detailed study and examination at an all-India level.

1.08. The Planning Commission, therefore, set up in May 1964, a broad-based and composite Panel, under the Chairmanship of Dr. K. N. Mathur, Scientist Emeritus, Council of Scientific & Industrial Research, with the following composition:

Chairman

Dr. K. N. Mathur, Scientist Emeritus, Council of Scientific & Industrial Research, New Delhi.

Members

(i) Prof. S. V. C. Alva, Department of Electrical and Communication Engineering, Indian Institute of Science, Bangalore.

(ii) Dr. R. C. Majumdar, Head of Physics Department, University of Delhi, Delhi.

(iii) Dr. P. D. Shukla, Joint Educational Adviser, Ministry of Education, New Delhi.

(iv) Shri K. Sachidanandam, Deputy Secretary, Ministry of Finance, New Delhi.

(v) Shri M. V. Patankar, Deputy Director (Engg.), Indian Standards Institution, New Delhi.

(vi) Dr. R. N. Rai, Head of the Department of Science Education, National Council of Educational Research and Training, H-2/3, Model Town, Delhi.

(vii) Shri Om Parkash, Head of the Central Science Workshop, Department of Science Education, National Council of Educational Research and Training, H-2/3, Model Town, Delhi.

(viii) Shri M. H. Pandya, Architect, Central Building Research Institute, Roorkee.

(ix) Shri J. L. Sehgal, Deputy Director (Designs), National Buildings Organisation, New Delhi.

(x) Dr. S. N. Saraf, Director, Education Division, Planning Commission, New Delhi.

(xi) Dr. B. Patnaik, Senior Specialist, Resources & Scientific Research Division, Planning Commission, New Delhi.

(xii) Shri D. I. Lall, Secretary, Central Board of Secondary Education, New Delhi.

(xiii) Shri S. C. Roy, Deputy Chief Inspector, Secondary Education, Education Directorate, Calcutta.

(xiv) Shri Arjan Singh Shante, Circle Education Officer (Patiala), Nabha (Punjab).

(xv) Shri R. Shanmugham, Principal, Govt.. Basic Training College, Orthanad, (Madras State).

(xvi) Prof. B. D. Karve, Member, Secondary School Certificate Board, Karve Nagar, Poona-4.

(xvii) *Shri S. D. Pant, Secretary, Board of High School and Intermediate Education, Allahabad.

(xviii) Shri B. L. Chadha, Consulting Architect, F-20, Shanker Market, New Delhi.

(xix) Shri Jagdish Singh, Committee on Plan Projects, Planning Commission (*Member Secretary*).

1.09. The Terms of Reference of the Panel are given below:—

(i) Laying down specifications and standards for science equipment and apparatus for high/higher secondary schools.

(ii) Standardisation of the procedure for allotment of funds and procurement of scientific equipment.

(iii) Preparation of standard lists of scientific equipment and apparatus for high schools.

(iv) Preparation of designs and lay-outs of science laboratories of high schools.

1.10. At the first meeting of the Panel held on the 6th May, 1964, Member (ES&IT), Planning Commission, Prof. V. K. R. V. Rao, emphasised the importance of the work of the Panel and mentioned that the Panel may also give attention to the following:

(i) to estimate the requirements of science equipment;

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*Shri S.D. Pant could not attend meetings of the Panel. Shri P.R. Chauhan, Additional Secretary, Board of High School and Intermediate Education, U.P. attended all the meetings on his behalf.

(ii) to determine the existing domestic supplies with a view to drawing up a project for stepping up domestic manufacture;

(iii) to draw up a list of apparatus and equipment needed with an idea of its costs; and

(iv) to lay down suitable norms and standards for science apparatus with a view to improve the quality of manufacture.

1.11. The Panel took up a detailed study of the various issues and constituted four separate Sub-Committees as follows:

SUB-COMMITTEE—I.

Laying down specifications and standards for science equipment and apparatus

1. Shri M. V. Patankar—*Convener*
2. Shri Om Parkash—*Member*
3. Dr. B. Patnaik—*Member*

SUB-COMMITTEE—II.

Standardisation of the procedure for allotment of funds and procurement of scientific equipment

1. Shri K. Sachidanandam—*Convener*
2. Prof. B. D. Karve—*Member*
3. Shri S. C. Roy—*Member*
4. Shri R. Shanmugham—*Member*
5. Shri Arjan Singh Shante—*Member*
6. Shri S. D. Pant—*Member*
7. Dr. M. C. Pant, Deputy Director, Department of Science Education, N.C.E.R. & T., Delhi—*Co-opted Member.*
8. Shri G. P. Dube, Additional Director of Public Instruction, Bihar, Patna.—*Co-opted Member.*

SUB-COMMITTEE—III.

Preparation of standard lists of scientific equipment and apparatus for high schools

1. Dr. R. N. Rai—*Convener*
2. Prof. B. D. Karve—*Member*
3. Shri Om Parkash—*Member*
4. Shri Arjan Singh Shante—*Member.*

SUB-COMMITTEE—IV.

Preparation of designs and layouts for science laboratories of high schools

1. Shri M. H. Pandya—*Convener*
2. Shri J. L. Sehgal—*Member*
3. Shri B. L. Chadha—*Member*
4. Shri V. N. Wanchoo, Reader, Department of Science Education, N.C.E.R. & T., Delhi—*Co-opted Member.*

The following were also co-opted to assist the Sub-Committees II and III in their work.

1. Shri T. P. Singh, Science Counsellor, Planning Branch, Delhi Administration, Delhi.
2. Shri Partap Singh Jain, Principal, Govt. Higher Secondary School, Rohtak (Punjab).
3. Shri J. N. Srivastava, Assistant Science Master, Govt. Intermediate College, Allahabad, U.P.

1.12. With a view to getting acquainted with the problem at an all-India level, information was collected from various States and Union Territories. In addition, a comprehensive questionnaire was sent to some 650 selected high/higher secondary schools in various States to get a detailed picture of the financial allocations vis-a-vis the number of pupils in the science classes, the difficulties, if any, about procurement of science equipment and its quality etc. Comments were also invited about any difficulties experienced as also suggestions for improvement. A brief summary of the main findings emerging from the data received from State Governments and schools is given in Appendices I & II.

1.13. Members of the Panel, drawn from different departments and from the States, with rich administrative and teaching experience, made valuable contributions to the deliberations of the Panel. The guidance given by the Members of the Planning Commission, Prof. M. S. Thacker, Shri Tarlok Singh and Prof. V. K. R. V. Rao, at the various stages of the work of the Panel, gave a sense of direction to its study. The support and assistance given by the Ministry of Education and by the National Council for Educational Research and Training facilitated greatly the work of the Panel and is gratefully acknowledged. The Panel is particularly grateful to the Central Building Research Institute (of the Council of Scientific & Industrial Research), Roorkee and the National Buildings Organisation (of the Ministry of Works & Housing) for permitting S|Shri M. H. Pandya (Architect) and J. L. Sehgal (Deputy Director, Designs), respectively, of their organisations to work on the Panel. Their varied experience in this field was of great help to us.

1.14. The Panel was ably assisted in its work by its Member-Secretary, Shri Jagdish Singh and wishes to place on record its high appreciation of the work done by him and his staff. The work of the Panel and its Sub-Committees could not have been completed in the short time available but for Shri Jagdish Singh's initiative, resourceful and excellent organisation of office work.

CHAPTER II

THE FINANCIAL PROCEDURE

The Present Position

2.01. The Mathur Report* had recommended that "the allotment of funds, both capital and recurring, should be made as early as possible so that the funds could be utilised before the end of the financial year. The schools should be given allotment of grants before they close for the summer vacation and they should be instructed to place orders for the equipment before the schools reopen. Steps will then be taken for obtaining the equipment soon after the reopening of the schools".

2.02. The present Panel studied the question of financial sanctions and procedure closely and collected data from various States (Appendix I) on the subject. Also some data has been gleaned from 147 replies received (Appendix II) from schools in answer to a questionnaire which was issued to selected schools in the various States and Union Territories of India.

2.03. It would be seen from the Appendix I that during the year 1963-64, Bihar State could sanction an amount of Rs. 1,000 only to each of the 150 non-government high schools for purchase of scientific equipment though they were planning to improve on this figure during the year 1964-65. In the case of Government schools, however, no provision was made during the previous two years since they had been sanctioned sufficient funds previously. In the case of Maharashtra and Gujarat States, there are no separate rules for payment of grants-in-aid for expenditure on science equipment. This is included in the general expenditure of the school and is held admissible for grants-in-aid purposes up to the limit of 12 per cent of the total direct expenditure of the school for the previous year. In Mysore State, no specific procedure is being followed for allotment of funds, sanctions depend on the availability of funds and the actual needs. While sanctioning grants to Government high schools a sum of Rs. 2,000 per annum is usually earmarked for the purchase of science equipment for the first three years. Similarly, for schools under private managements, sanctions are accorded subject to the availability of funds according to the grants-in-aid rules. In

*Report on Science Laboratories & Equipment in High/Higher Secondary Schools published by the Committee on Plan Project, Planning Commission, 1962.

Rajasthan, non-recurring grants of Rs. 3,000 for Physics, Rs. 1,500 for Chemistry, Rs. 2,000 for Biology and Rs. 2,000 for Home Science are sanctioned to each high school. In Madras State, grants for the purchase of science equipment and apparatus to the secondary schools are given ranging from Rs. 10,000 to 50,000, the Government's share varying from 50 to 75 per cent in the case of private schools (including laboratory buildings). In Jammu and Kashmir, aided schools are sanctioned 50 per cent of the expenditure on science equipment. In the Union Territory of Himachal Pradesh, a certain amount is placed at the disposal of high schools for the purchase of science apparatus. Heads of schools are required to prepare a break-up of this amount and a specific amount is set apart by the Headmaster in accordance with the requirements of the school. There is a scheme for the improvement of science laboratories in high schools. Under this scheme schools which require more than what can be purchased within their normal allocation are covered. Normally the schools get Rs. 600—1,000 by way of their normal allocation for science equipment and a few selected schools (about 10 a year) another Rs. 1,000 or so extra. In Tripura, funds are allotted for purchase of science equipment and apparatus to secondary schools according to the requirements of the institutions.

2.04. On an analysis of the data supplied by schools in response to the questionnaire, we find that in Andhra Pradesh no regular grants are given for purchase of science apparatus and equipment to Government high schools. In aided schools the management allots some amount in the budget subject to the condition that the State Government gives a matching grant. But it is reported that since the Government does not accord sanction in time the management share is also not utilised. Bihar, Gujarat, and Mysore State schools have reported that the grants are usually received at the fag end of the financial year and the time available for the purchase of equipment is very short. The Madras, Punjab, U.P., Maharashtra (Govt. schools), Himachal Pradesh and Tripura schools, from whom questionnaires have been received have not given any comments about the procedure for sanction of grants.

2.05. Out of 77 completed proformae received from high schools, detailed break-up of the expenditure incurred on science equipment and apparatus for the year 1963-64 has been given by 50 institutions. It is observed that most of the schools have not spent any amount for the purchase of equipment and apparatus. It is found that in certain cases no non-recurring grants have been received by the schools for purchase of equipment. In the 2 schools in Andhra Pradesh per capita expenditure on the purchase of equipment is 50 Paise and Rs. 3.66 respectively. In Bihar, of the 3 schools, 2 have

not purchased any equipment during the year 1963-64. Similarly in Gujarat, of the 5 institutions, 3 have not purchased any equipment but the remaining two have spent @ Rs. 6/- and Rs. 19/- per pupil respectively. There is thus a considerable variation in per capita non-recurring expenditure. So far as recurring expenditure is concerned the position again is far from satisfactory. 20 per cent of the institutions are spending less than 50 paise per student per year; 24 per cent of the schools spend from Re. 1 to Rs. 2 per year and only 6 per cent of the schools spend more than Rs. 5 per year. The minimum per capita recurring expenditure is 15 Paise in a school in Andhra Pradesh and the maximum is Rs. 9.80 in one of the schools in Gujarat. The following table shows the recurring expenditure incurred by schools:

Per capital expenditure	*Percentage of schools*
Less than 50 paise	20
50 Paise to Re. 1	30
Re. 1 to Rs. 2	24
Rs. 2 to 3	10
Rs. 3 to 5	10
Rs. 5 to 6	6

2.06. The Panel gave a good deal of thought to the present procedure with regard to the allotment of funds to schools particularly for science equipment and apparatus and the pattern of expenditure. The following issues are involved:

A. Allotment of funds.

B. Rules governing the purchase of equipment.

C. Provision for science equipment and apparatus.

We shall now examine each of these problems separately.

Allotment of funds:

2.07. The normal practice in the States is that funds are allotted after the budget has been voted by the State Legislatures. In most of the States, the schools are required to submit proposals to the State Education Departments for scrutiny which, in due course, submit these proposals to the State Finance Departments. This process generally takes more than 6—9 months with the result that if a school applies for grant in April, the earliest optimistic estimate for receipt of the sanctions would be September or October and in a number of cases it may not be earlier than December or January. On receipt of sanctions the whole process of inviting quotations from the firms

starts and the supplies are expected to be completed before the close of the financial year.

2.08. On the face of it the present procedure for issue of sanctions, which takes a period of 6—9 months, is unsatisfactory and results in various malpractices. Besides, it hampers the class work considerably. The question of the allotment of funds before the budget is voted by the State Legislature was discussed at some length. We have been informed that provisional allotment could always be made in anticipation of the budget being voted and is the normal practice in some States.

2.09. The Panel, therefore, strongly recommends as follows:—

"The Education Department of each State should frame proposals for the new academic year at least 9 months before the start of the academic session furnishing full details. The State Finance Department should finish their scrutiny of proposals within a maximum period of 3 months so that the Education Department, in its turn, is in a position to accord financial sanctions to schools at least 6 months before the start of the new academic session to enable them to complete formalities and to procure science equipment in time for the new session."

Rules governing the purchase of equipment:

2.10. According to the procedure laid down by the Central and State Finance Departments, quotations are to be invited from approved firms and the lowest tender is usually accepted unless there are sufficient grounds for rejecting it. The position regarding scientific apparatus is rather peculiar since the prices of the same item vary considerably from firm to firm particularly because there are no standard norms and specifications laid down for science apparatus. The desirability of laying down such norms was considered in great detail by the Panel. Discussions were held with the Director of the Indian Standards Institution in Delhi. The recommendations of the Panel on this subject are given in Chapter III, para 3.11. Since laying down of such norms is bound to take considerable time, the Panel recommends that the State Governments may consider the following possibilities:

(a) Till such time as the purchase specifications are laid down by the concerned agency, in the interest of ensuring the purchase of quality products at reasonable prices, the State Education Department may make purchases for scientific equipment on State/Regional/District basis. Almost all the

State Governments have set up emporia for their products and science apparatus manufactured in the State may also be displayed in these emporia and steps taken to establish their branches at the district level to enable the schools to examine the articles of apparatus closely and select the most suitable apparatus.

(b) In the case of new schools, it may be advisable for the State Education Departments to select dependable suppliers and approve their prices and the schools may be directed to obtain supplies (including glass-wares and chemicals) from such approved suppliers. It would ensure a check on the quality of products if the particular section of the department has technically trained personnel to test the products.

2.11. The Panel gave considerable thought to the desirability of establishing a Central agency for the purchase of science equipment. The views of schools, to whom the proformae were sent, were also obtained on the subject. Out of 147 replies received from such schools, the heads of 130 institutions favoured the idea of setting up of a central agency for the supply of quality equipment to schools. After studying the various implications involved in the proposal, the Panel came to the conclusion that it would perhaps be premature to think of establishing such an agency for this purpose. The Panel, however, urges upon the State Governments to estimate the requirements of scientific equipment sufficiently in advance so that at the start of the academic session of the school, the required items of apparatus and equipment are readily available to the schools. It should not be difficult for each State Government to visualise the approximate needs of the State on an annual basis. Each State should then be able to plan this even on a five-year basis in accordance with their proposals for the Five-Year Plans. If this is done the State Governments could intimate the requirements to the suppliers sufficiently in advance.

2.12. We have been informed by the representatives of manufacturers of scientific equipment and apparatus that they would welcome this proposal since it will enable them to plan their manufacturing programme properly. Some of the representatives of the manufacturers of scientific instruments have assured us that they have adequate capacity for manufacturing most of the items of scientific apparatus for schools but they are always reluctant to take up any large scale programme since, according to the prevailing system of

lowest tenders, the manufacturers of quality products cannot compete with unscrupulous suppliers who would not hesitate to supply sub-standard products. If reputed manufacturers can be assured of definite purchase of the material of standard quality, they would be able to meet the demands of schools adequately. The Council of Scientific & Industrial Research, New Delhi have under publication a Directory of Scientific Instruments Manufacturers in India which the State Governments may refer to for this purpose.

2.13. One of the measures suggested to us was the rate contract system as it prevails in the Directorate General of Suppplies & Disposals of the Government of India. When the National Council of Educational Research & Training (NCERT) of the Ministry of Education have laid down purchase specifications for scientific apparatus and equipment such rate contracts would greatly facilitate the purchase of equipment.

2.14. When standards are available it would be possible for the ISI to adopt them for their quality control scheme, which is rigidly controlled by them. When this happens it would only be necessary for the educational authorities to insist that purchases of such equipment should only be made from manufacturers who accept the ISI Quality Control Scheme. This should, in the view of the Panel, ensure the supply of dependable quality equipment.

Provision for science equipment and apparatus:

2.15. From the figures given earlier in this Chapter, it is clearly evident that grants for science apparatus and equipment are sanctioned mostly on an *ad-hoc* basis depending on the availability of funds. On account of the importance attached to the teaching of science, there is a noticeable tendency in some of the State Governments to hurriedly extend science to as many schools as possible but the equipment provided to such schools is lamentably inadequate. Instances have come to our notice where meagre amounts of Rs. 500 to 1,000 were sanctioned for new science laboratories. The Panel considers it essential that the teaching of science should not be introduced in new schools without adequate provision for equipment and laboratory buildings.

2.16. During the course of discussions at the meetings of the Panel, it was suggested that we should lay down a minimum amount for non-recurring as well as recurring expenditure for Science laboratories of middle and high schools. This is all the more necessary in view of the increasing importance being given to science teaching

both at the middle and high school levels. The Panel has tried to work out with the help of the Principals and teachers who were associated with the work of the Panel, the recurring and non-recurring cost of equipment and apparatus on the basis of standardised lists of equipment for middle and high schools referred to in Chapter III. Quotations for various items of apparatus were, therefore, obtained from several sources in different States and averages were worked out. The Panel has come to the conclusion that a minimum amount of Rs. 3,000 for a middle school and Rs. 9,000 for a high school would be required for setting up a reasonably well-equipped laboratory for science teaching. We, therefore, recommend to the State Governments that if science teaching is to be introduced as a subject in a middle school, a minimum amount of Rs. 4,000 (including Rs. 1,000 earmarked for workshop tools) and in the case of high schools, a minimum amount of Rs. 10,000 (including 1,000 earmarked for workshop tools) should be sanctioned to the schools. This grant may, however, be spread over 2 years. In case the subject of Biology is also introduced in a high school an additional amount of Rs. 3,000 should be provided. It may be emphasised here that the above figures are exclusive of the cost of building and laboratory furniture which should be provided for separately.

2.17. The Panel also gave thought to the question of replacement of science apparatus and to the recurring expenditure involved in consumable articles like chemicals and glass-wares. On the basis of the figures worked out by the Principals and science teachers associated with the work of the Panel, it is recommended that an annual grant of Rs. 10/- per student should be sanctioned for each school for replacement and other recurring expenditure for high school science. In the case of middle schools, Rs. 2/- per student per year would be adequate.

2.18. Where Science Fees are charged from students, the Panel strongly recommends that the entire amount so collected should be allowed to be retained by the schools for their science laboratories and not credited to Government Treasury. The amount so collected should be adjusted against the grants for recurring expenditure.

CHAPTER—III

SCIENCE APPARATUS & OTHER EQUIPMENT

Lists of apparatus and equipment

3.01 The provision of adequate equipment and apparatus for science laboratories in the *sine qua non* of science teaching in schools. The Report of the Indian Parliamentary and Scientific Committee states that "complaints were made that laboratory equipment and apparatus is not either sanctioned in schools according to some standards or where it is sanctioned there are difficulties in securing this".* The Mathur Report gave detailed lists of science apparatus and equipment for higher secondary schools which were of considerable help to such schools as also to the State Education and Finance Departments. The present Panel has drawn up similar lists for Physics, Chemistry and Biology laboratories of high schools which are given in Appendix III. These lists are based on the syllabi of Maharashtra and U.P. Boards of Secondary Education and indicate generally the minimum equipment that a high school should have. Necessary modifications may be made to suit local requirements. A list of equipment required for science teaching in middle schools, as prepared by the National Council of Educational Research & Training, is given in Appendix—IV.

3.02 The numbers of items of apparatus are given for a class of 40 students working in two batches of 20 each for practical work in high schools. A proportionate increase or decrease may be made in accordance with the number of students in each batch.

3.03 The items of science apparatus have been broadly divided into "Demonstration apparatus" and "Experiments". Each of these sections has been further categorised as "essential" and "desirable". The "essential" items are to be supplied to each school immediately when science is introduced in class IX. In the case of new schools, the supply of these items can be spread over the first two years so that by the time the students of class IX are promoted to class X, full equipment is available to them. The "desirable" items of equipment may be supplied, in instalments, during the subsequent two or three years.

*Report of the Indian Parliamentary and Scientific Committee on "Science Education in Schools", May 1964, page 26.

3.04 We have been informed that practical work is not given much importance in High School syllabi and according to the prevailing practice in certain States practical work does not form part of high school examination. The Panel expresses the hope that the Boards of Secondary Education will soon introduce a system of evaluation of students' practical work in the laboratories. The list has, therefore, been prepared with a view that it would be adequate for individual experiments by students and also meet the requirements of practical examination when introduced.

3.05 Those items of apparatus which can be easily improvised in high schools are given in Appendix V. In the case of middle schools, those items which could be improvised are indicated by an asterisk. It will not mean, however, that such equipment will be excluded from the list to be purchased since some pieces will be necessary as samples. The items suggested for improvisation are only suggestive and not exclusive. For the purpose of improvising apparatus in the schools locally, it has been suggested earlier (Chapter II, para 2.16) that each school should have a small workshop. The Panel attaches great importance to the setting up of such workshops in schools. A list of tools and implements required for such a workshop is given in Appendix VI—A.

3.06. The Panel would like to stress that adequate facilities should be provided to science teachers and students for working on hobbies during school hours and in their spare time. Due appreciation and recognition should be given to teachers who have the inclination and the capacity for making simple items of scientific apparatus. It would also be necessary to impart requisite workshop training to science teachers in the Training Institutions. Refresher courses for the subjects as well as for the workshop training should be arranged periodically for teachers on a regional or district basis.

Need for standardisation

3.07 The Mathur Report had also stated "that the laying down of specifications and standards for equipment and apparatus will greatly improve the quality of instruments at present being supplied to schools and recommends that the necessity for making these specifications may be brought to the notice of the Indian Standards Institution and the Central Scientific Instruments Organization with the request that they may expedite the laying down of standards for at least those items of science apparatus which are already being manufactured in the country". The present Panel studied the question carefully and discussed this with the authorities of the Indian Standards Institution with a view to finding out how far they could assist

in a project of this nature. The Panel was informed that the Indian Standards Institution was so heavily committed at present that it would not be possible for them to take up any additional work of this nature for several years to come. They were, however, prepared to offer technical guidance and training facilities to the staff of any organisation which may take up the project.

3.08. The ISI furnished the information that out of the list of items of science apparatus supplied to them, Indian Standards were already available for 60 of them; standards for 45 items were under active preparation and some 70 items would be taken up by the ISI under its normal programme. About 300 items were of a nature that formulation of standards was either not possible or unnecessary. For the remaining items, the Indian Standards Institution's point of view was that if their standardisation was taken up in the usual set procedure of the ISI, it would take them at least 3 to 4 years to complete the work.

3.09. The consensus of opinion in the Panel discussions appeared to be that the procedure needed to be simplified and only "purchase standards" need be laid down. This would not come in the way of pinning down the manufacturers to one rigid model. The manufacturers on the other hand, may be encouraged to supply improved models which may be submitted for tests by a Government recognized organization. A trial order for a few pieces could then be placed on the manufacturers and the instruments thus supplied may be sent to certain schools for trials. If satisfactory, the models could be approved.

3.10. A recommendation on which considerable emphasis is laid by the Panel is that the school teachers and students should be encouraged to improvise simple scientific instruments themselves since it will give a very practical bias to learn science at the secondary school stage. Students would, thus, be able to learn more from assembling simple apparatus themselves than through a ready made model.

3.11. The Panel accordingly recommends as follows:

(a) The National Council of Educational Research & Training may be requested to set up, on a high priority basis, a semi-autonomous agency for undertaking the work of laying down norms and standards for science apparatus.

(b) In the training programme for secondary school teachers, adequate emphasis should be given to the imparting of training in workshop methods so that teachers and students could make parts of simple science equipment themselves and undertake simple repairs.

(c) Teachers' Training Institutions should be provided with appropriate workshops to impart the necessary skills to the prospective science teachers. A list of tools and implements to be provided in each workshop is given in Appendix VI—B.

(d) Annual grants for science laboratories should include adequate provisions for buying raw materials and the necessary tools for the workshop.

CHAPTER—IV

PLANNING OF LABORATORIES

Basic Requirements

4.01 Since the main function of a science laboratory is to impart scientific education in an efficient way, its design should, therefore, be based on functional requirements and be as flexible as possible. In determining the total area for a laboratory, the Panel took the following factors into consideration:

(a) the number of pupils working at a time;

(b) the minimum space necessary for each pupil for comfortable working;

(c) limitation of the number of science teachers in secondary schools;

(d) need for ancillary accommodation for storage;

(e) designing the science class room and laboratory in such a way that it could be used for science teaching for middle as well as for high classes; and

(f) imperative need for economy.

Functional Planning

4.02 It is considered advisable that the laboratories should be located on the ground floor and as far as possible at the end of the row of class rooms.

Laboratory space

4.03 Keeping in view the requirements described above, the Panel gave considerable thought to the space requirements of a science laboratory and the various items of furniture. More and more emphasis is now being given to the teaching of science in middle classes. According to the syllabi framed by the N.C.E.R. & T., the middle school students are required to do simple experiments and handle equipment in the laboratory. These syllabi have been enforced in certain States. So there is a need for planning the laboratory of a high school in such a way that it could also be used for middle classes.

4.04 It is also now an accepted fact that the practical and theory work in science subjects should not be treated separately. In a "Report on Science Teaching in Schools" submitted by the UNESCO

Experts Team to the National Council of Educational Research and Training, it has been recommended that teaching rooms provided for each science subject in secondary schools should be utilised both for the teaching of theory as well as for practical work. The Panel gave full consideration to this view and came to the conclusion that on account of limited financial resources, it would not be possible, at present, to have separate laboratories for each science subject at the high school level.

4.05 Keeping in view the need for economy the Panel considered that a space of 76.8 Sq. mts. (825 Sq. ft.) would be reasonably adequate for theory and practical work in science for a class of upto 42 students working at a time. A suggested layout of the laboratory is given in Plate—I. In schools where the number of students is large and more than one laboratory room is needed, the Panel recommends that the design given in Plate II should preferably be adopted. This will provide another laboratory measuring 45.6 Sq. mts. (490 Sq. ft.) as an extension of the laboratory-*cum* theory room with a common store-*cum*-preparation room. The area per student in these two layouts works to 19·6 Sq. ft. and 20·4 Sq. ft. respectively.

4.06 Since the space requirements for experiments at middle and high school level is comparatively small, a store-*cum*-preparation room measuring 15 Sq. mts. (160 Sq. ft.) is considered adequate. This has been provided in both the layouts as shown in Plates I and II.

4.07 As suggested in the UNESCO Experts Team Report, the students of all the classes would come to the science laboratory for theory-*cum*-practical work. It would thus be easier for the teacher to demonstrate an experiment to the students and for the students to carry it out in full view of the teacher. The tables, as provided in Plate I, are of such dimensions that two students can easily do practical work on one table. Since all the students face the teacher, the working of each student could be easily supervised.

4.08 The extension shown in Plate II can be set apart for laboratory work in Chemistry, if so desired, by providing a small square sink in the middle of each table. If this arrangement is adopted, the other laboratory can be used for Physics and Biology both.

Laboratory Furniture

4.09 Laboratory tables being the most important item of furniture, need careful consideration. The size and design of these should allow of easy working, providing adequate elbow room for two students, while at the same time being not wasteful of space.

The Panel recommends a standard size of 4′×1′-9″ for a laboratory table as indicated in Plate I (detailed layout given in Plate III as recommended by the UNESCO Experts Team). This table would be especially convenient even for purely theory work. Plate III shows also the provision of an under-shelf for keeping books by the students.

4.10 A square table, with each side 3′-4″, has been suggested in Plate II for practical work by a group of four students. If used for Chemistry work, such tables should be given a good finish of acid-resistant paint. The cost of smaller tables suggested here would be more economical as compared to large cumbersome tables usually provided in science laboratories. We have purposely avoided the provision of shelves in the tables since they serve no useful purpose while adding considerably to the cost.

4.11 The teacher's table is of the size 8′×2′-6″ on a platform raised to a height of 7″ from the room level. The teacher's table should be provided with a sink. Sinks are however, not provided on individual laboratory tables but are located on the side wall. A sink is also considered desirable in the store-*cum*-preparation room.

4.12 Each laboratory as well as the store-*cum*-preparation room are recommended to be provided with wall shelves as well as R.C.C or stone ledges for balances as shown in Plates I and II. The laboratory should also be fitted with a well-made chalk* board at least 8′-0″ long and 3′-0″ wide. The other fittings, namely a railing along the wall for hanging charts or pictures, shelves for display of material have been indicated in Plate I. While cup-boards are not recommended for student's tables, an adequate number of cupboards and drawers should be provided in the store-*cum*-preparation room for storing chemicals, glass-wares, equipment etc. A cupboard and drawers might also be provided in the teacher's table.

4.13 Since no separate dark room has been provided, provision of thick dark curtains should be made for windows for Physics experiments needing a darkened room. They will also be useful for audio-visual programmes such as projection of films, slides etc.

Laboratory lighting

4.14 The factor of light, apart from affecting visual and physical comfort of students, involves the question of economy also in respect of the size and type of windows and of the disposition of light fittings. The chief purpose of lighting is to provide comfortable

*The UNESCO Experts Team recommended green or dark brown colour in preference to black which they consider dull and tiring for the eyes.

visual observation for laboratory work and the conservation of vision of the students. It is desirable to make maximum use of day-light by proper location of doors, windows and sky-lights. Windows are best placed at a sill height of 0.91 m. (3 ft.) from the finished floor level, as this would give a good distribution of light over the laboratory tables whose height has been suggested as 2'-6". Windows should preferably open outside. To save on capital as well as recurring expenses artificial lighting needs to be provided only for occasional work, for instance, during certain hours in winter and monsoon months.* Windows and doors should be so disposed as to provide as evenly distributed illumination as possible. A window area of 15-20 per cent of the floor area is considered to be adequate for general laboratory work. In terms of lumens, the amount of day-light illumination of the order of 15 to 20 lumens per sq. ft. is considered to be adequate. The following reflectance standards are recommended for obtaining a desirable brightness level inside the laboratories :—

Ceilings . .	85% of the total amount of light received by the surface. This could be achieved with good white washing.		
Walls . . .	60%	Do.	(Light colours to prevent too much glare).
Floors . . .	15 to 30 %	Do.	

4.15 Light and colour are closely inter-related so that in determining a suitable colour scheme inside the laboratory, the reflectance value should always be taken into account. Light coloured walls are recommended since white colour is not suitable for laboratory walls as it causes glare and shows dirt very prominently.

Laboratory Services

4.16 After establishing the general layout of the laboratories, it is essential to decide, as soon as possible, on the number and positions of water and electricity points. No gas points in high school laboratories are considered necessary as small heating requirements in this case could be met by spirit or kerosene burners.

4.17 The Panel recommends the following service facilities:

(i) 4 nos. water points with sinks 12"×9"×6" (deep) for a science laboratory as indicated in Plate I. One water tap with sink to be provided on the teacher's table and one in the store-*cum*-preparation room. In case of Plate II (Extension Block), two sinks in wall and one on the teacher's table have been provided.

*Adequate lighting will be essential for schools working on double shift basis.

(i) The Teacher's table should be provided with one 10 amp. electric socket for power and three 5 amp. sockets for visual-aid experiments.

Note :—Recommendations regarding services (except sinks) are for places where electricity, proper water supply and drainage systems are available. In other places the electrical requirements will have to be limited to storage batteries. Water supply requirements may be obtained through tube-wells and hand pumps. Where even these facilities are not available, water can be stored in raised drums which should be provided with taps.

Materials and methods of Construction

4.18 For the purpose of maximum economy in building construction, locally available materials should be employed as far as possible and the use of scarce materials like steel and cement may be reduced as much as possible through rationalised structural designs such as prefabrication, precasting etc. The Central Building Research Institute, Roorkee and the National Buildings Organisation of the Ministry of Works and Housing, who have actively collaborated in these studies; would be glad to advise the State Govts. on this subject.

4.19 Internal wall faces should be plastered light and finished in light colour wash. The ceiling should be white-washed. The floor finish should preferably be in grey cement or terrazzo laid in situ or tiles, where they are cheaper.

CHAPTER—V

OTHER RECOMMENDATIONS

Estimating the Total Requirements of Science Apparatus

5.01 In his introductory speech at the first meeting of the Panel, Member (ES&IT), Planning Commission, Prof. V. K. R. V. Rao had suggested that the requirements of science apparatus and equipment need to be estimated on a long-term basis with a view to drawing up a project for stepping up indigenous manufacture where necessary. It will be appreciated that the total requirements of scientific apparatus for school teaching can be realistically worked out on an all-India basis only if we know how many schools are likely to introduce science teaching as (i) general and (ii) elective subject during the present Plan period and in the Fourth Plan. These figures are not yet available. As soon as these figures are available, it will be possible to draw up an estimate of the requirement of science equipment during the Fourth Plan. The State Governments have also not been able to furnish exact information on their programmes of conversion of schools to science teaching. It will need considerable amount of effort and time before any figures for Fourth Plan requirements could be worked out.

5.02 The Panel, therefore, recommends that either the Ministry of Education or the Education Division of the Planning Commission may take suitable steps to collect data on this subject.

5.03. With regard to the determination of the existing domestic sources of supply of scientific apparatus, it may be stated that the Council of Scientific & Industrial Research has been engaged on collecting information and a Directory of Scientific Instruments Manufacturers is in course of publication.

5.04 As already stated previously, the view-point of the manufacturers of scientific apparatus is that they are fully equipped to supply almost all the items of science apparatus required for school education. They cannot, however, plan any large scale expansion of capacity unless they know what additional demand is likely to arise during the next 5-10 years. The Panel, therefore, recommends that the Ministry of Education may ask the State Governments to estimate their requirements of science apparatus and equipment during the next Plan period. Thereafter, the Planning Commission may take up the question of increased production with

the manufacturers direct or through the Council of Scientific and Industrial Research.

Need for a Special Officer to look after Science Education

5.05 The Panel has felt that while the Union Ministry of Education, the University Grants Commission and the Education Departments of State Governments are all keen about improving the teaching of science in schools, more positive steps are needed to provide proper guidance for science education by the States.

5.06 The Panel was made aware of the fact that, during the Fourth Plan, the Union Ministry of Education have formulated proposals whereby a subject inspector will be appointed in each State Education Department to look after the improvement of the subject concerned. We greatly welcome the proposal and would like to suggest strongly that as far as science teaching is concerned, an officer of the rank and status of Additional or Deputy Director of Education should be appointed in each State. This officer should himself have high qualifications and the requisite experience in teaching of a science subject. He may be further assisted by Science Inspectors who may look after the work at district level and ensure proper standards of science teaching.

CHAPTER—VI

SUMMARY OF RECOMMENDATIONS

Financial Procedure

1. The Education Department of each State should frame proposals for the new academic year at least 9 months before the start of the academic session furnishing full details. The State Finance Department should finish their scrutiny of proposals within a maximum period of three months so that the Education Department, in its turn, is in a position to accord financial sanctions to schools at least 6 months before the start of the session to enable them to complete formalities and to procure science equipment in time for the new session.

(Chap. II, Para. 2.09)

2. When science teaching is to be introduced in a high school, a minimum amount of Rs. 10,000 (including Rs. 1,000 for workshop tools) may be earmarked for setting up a reasonably well-equipped laboratory for Physics & Chemistry. In case the subject of Biology is also introduced, an additional amount of Rs. 3,000 should be provided.

(Chap. II, Para. 2.16)

3. For middle schools, a sum of Rs. 4,000 (including Rs. 1,000 for workshop tools) for science equipment is considered essential.

(Chap. II, Para. 2.16)

4. An annual grant of Rs. 10 per student should be sanctioned for replacement and other recurring expenditure for science practicals in high schools. In the case of middle schools, Rs. 2 per student per year for the recurring grants and replacement would be adequate.

(Chap. II, Para. 2.17)

5. Where science fees are charged from the students, the amount so collected should be allowed to be retained by the schools for their science laboratories which should be adjusted against their grants for recurring expenditure.

(Chapter II, Para. 2.18)

6. Annual grants for science laboratories should include adequate provision for buying raw materials and the necessary tools for the workshop.

(Chap. III, Para. 3.11(d))

Science Equipment

7. State Education Department may make purchases for scientific equipment on State/Regional/District basis till such time as the purchase specifications are laid down by the concerned agency in the interest of ensuring the purchase of quality products at reasonable prices.

(Chap. II, Para 2.10)

8. The emporia set up by State Governments for their products should also display, along with other products, scientific equipment manufactured in the State.

(Chap. II, Para. 2.10)

9. The emporia should have branches at District level also to enable the schools to examine the articles of apparatus closely and select the most suitable apparatus.

(Chap. II, Para 2.10)

10. In the case of new schools, the State Education Department should select dependable suppliers and approve their prices and thereafter schools may be directed to obtain supplies (including glass-wares and chemicals) from such approved suppliers. This would ensure a check on the quality of products.

(Chap. II, Para. 2.10)

11. Each State should be able to plan their approximate needs on a five year basis in accordance with their proposals for the Five-Year Plans. If this is done, the State Governments could intimate their requirements to the suppliers sufficiently in advance.

(Chap. II, Para. 2.11)

12. The Council of Scientific and Industrial Research, New Delhi have under publication a Directory of Scientific Instruments Manufacturers in India which the State Governments may refer to, when considered in relation to supply of quality equipment.

(Chap. II, Para. 2.12)

13. The lists of equipment for Physics, Chemistry and Biology laboratories of high schools have been prepared on the basis of the syllabi of Maharashtra and U.P. Boards and indicate generally the

minimum equipment that a high school should have. Necessary modifications may be made to suit requirements of syllabus of the Board concerned.

(Chap. III, Para. 3.01)

14. The lists of equipment required in middle schools, as prepared by the National Council of Educational Research and Training, is considered essential.

(Chap. III, Para. 3.01)

15. The 'essential' items of apparatus, as mentioned in the lists of equipment and apparatus, should be supplied immediately, when science is introduced in Class IX. The 'desirable' items of equipment may be supplied in instalments during the subsequent two or three years.

(Chap. III, Para 3.03)

16. In certain States, practical laboratory work does not form a part of high school examination. In view of more emphasis being given to the teaching of science in secondary schools, it is hoped that the Boards of Secondary Education will soon introduce a system of evaluation of students' practical laboratory work.

(Chap. III, Para. 3.04)

17. Students should be encouraged to make simple scientific instruments themselves since it will give them a practical bias to learn science at the secondary school stage.

(Chap. III, Paras 3.05 and 3.10)

18. Each middle and high school should have a workshop attached to it for which a grant of Rs. 1,000 should separately be sanctioned.

(Chap. III, Para 3.05 and Chap. II, Para 2.16)

19. Adequate facilities should be provided to science teachers and students for working on hobbies during school hours and in their spare time. Refresher courses for the subject as well as for workshop training should be arranged for teachers periodically on a regional or district basis.

(Chap. III, Para. 3.06)

20. The National Council of Educational Research and Training may be requested to set up, on a high priority basis, a semi-autonomous agency for undertaking the work of laying down norms and standards for science apparatus.

(Chap. III, Para 3.11(a))

21. In the training programme for secondary school teachers, adequate emphasis should be given to the imparting of training in

workshop methods so that teachers and students could make parts of simple science equipment themselves and undertake simple repairs.

(Chap. III, Para. 3.11(b))

22. Teachers' Training Institutions should be provided with appropriate workshops to impart necessary skills to the prospective science teachers.

(Chap. III, Para. 3.11(c))

Planning of Laboratories

23. The laboratories should always be located on the ground floor and, as far as possible, at the end of the row of class rooms.

(Chap. IV, Para. 4.02)

24. It is considered that a space of 76.8 sq.m. (825 sq. ft.) would be reasonably adequate for theory and practical work in science for a class of up to 42 students working at a time.

(Chap. IV, Para. 4.05)

25. Where the number of students is large, it is recommended that another laboratory measuring 45.6 sq. m. (490 sq. ft), as an extension of the laboratory-*cum*-theory room with a common store-*cum*-preparation room, may be provided.

(Chap. IV, Para. 4.05)

26. A store-*cum*-preparation room, measuring 15 sq. m. (160 sq. ft.) is considered adequate.

(Chap. IV, Para. 4.06)

27. The tables, as provided in the laboratory-*cum*-theory room, are of such dimensions that two students could do practical work on one table. In this case, since all the students face the teacher, the working of each student could be easily supervised. The extension provided in Plate II, can be set apart for laboratory work in Chemistry, if so desired, by providing a small square sink in the middle of each table. When this arrangement is adopted the other laboratory can be used for Physics and Biology both.

(Chap. IV, Para. 4.08)

28. In the case of laboratory tables, it is suggested that the standard size of 4'-0" x 1'-9", as recommended by the UNESCO Experts Team, may be adopted.

(Chap. IV, Para. 4.09)

29. The size of the teachers' table should be 8'-0" x 2'-6" and kept on a platform raised to a height of 7" from the room level.

(Chap. IV, Para. 4.11)

30. There should be adequate provision for wall shelves as well as R.C.C. or stone ledges for balances as shown in Plates I and II.

(Chap. IV, Para. 4.12)

31. The laboratory should be fitted with a well-made Chalk Board at least 8′-0″ long and 3′-0″ wide.

(Chap. IV, Para. 4.12)

32. Since no dark room has been provided, provision for thick dark curtains should be made for windows for Physics experiments needing a darkened room. These could also be used for audio-visual programmes such as projection of films, slides etc.

(Chap. IV, Para. 4.13)

33. The following reflectance standards are recommended for obtaining a desirable brightness level inside the laboratories:

Ceiling	. 85% of the total amount of light received by surface.	
Walls	. 60%	Do.
Floors	. 15 to 30%	Do.

(Chapter IV, Para. 4.14)

34. The following service facilities are recommended :—

(i) Four water points with sinks 12″ x 9″ x 6″ (deep) for a science laboratory as indicated in Plate I. One water tap with sink may be provided on the teachers' table and one in the store-*cum*-preparation room.*

(ii) The teachers' table should be provided with one 10 amp. electric socket for power and three 5 amp. sockets for visual-aid experiments.

(Chap. IV, Para. 4.17)

35. For the purpose of maximum economy in building construction, locally available material should be employed as far as possible and the use of scarce material like steel and cement may be reduced as much as possible.

(Chap. IV, Para. 4.18)

36. Internal wall faces should be plastered light and finished in light colour wash. The ceiling should be white-washed. The floor finish should preferably be of grey cement or terrazzo laid *in situ* or tiles (where they are cheaper).

(Chap. IV, Para. 4.19)

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*In the extension block, two sinks in wall and one on the teachers' table are recommended

Other recommendations

37. For drawing up of total requirements of science equipment during the Fourth Plan, either the Ministry of Education or the Education Division of Planning Commission may take suitable steps to collect data from the State Governments on their programmes of conversion of schools to science teaching and other schemes for the improvement of science and arrive at the exact requirements of science equipment.

(Chap. V, Para 5.02)

38. For increased production of science equipment, it is recommended that the State Governments may estimate their requirements during the next Plan period and thereafter the Planning Commission may take up the question of increased production with the manufacturers direct or through the Council of Scientific and Industrial Research.

(Chap. V, Para. 5.04)

39. The creation of a separate branch of Science Education in each State Department of Education under a Special Officer (who should be of the status and rank of Additional or Deputy Director) would strengthen considerably the steps that are being taken at various levels for improvement of science teaching. This officer should have high qualifications and requisite experience in teaching of a science subject. He may be further assisted by Science Inspector who may look after the work at district level and ensure proper levels of science teaching.

(Chap. V, Para. 5.06)

APPENDIX I

Procedure for Recurring and Non-Recurring grants in different States (as received from States|Union Territories)

ASSAM

An allotment of Rs. 50,000 is placed at the disposal of the Secretary, Managing Committee of each higher secondary school to purchase science equipment. The break-up of Rs. 50,000 is as follows:—

	Rs.
(*a*) Gas plant	4,000
(*b*) Chemistry	
(*i*) Apparatus	4,000
(*ii*) Chemicals	3,000
(*c*) Physics	10,500
(*d*) Biology	8,500
(*e*) Furniture and fittings including water supply system, pipe lines, sinks, gas connection	20,000
G. TOTAL	50,000

BIHAR

Aided Schools

1. During the year 1963-64, a sum of Rs. 1,50,000 was provided for purchase of equipment to the non-Govt. schools. This amount was sanctioned to 150 high schools at a rate of Rs. 1,000 per school for purchase of equipment.

2. For the year 1964-65, there is a proposal to sanction Rs. 1,00,000 for scientific equipment to different non-Govt. high schools. Besides, Rs. 3,75,000 has been provided in the budget for the current year (1964-65) for improving science teaching. This grant is to be sanctioned on a lumpsum basis to the schools recognised after 31st March, 1957.

3. As regards higher secondary and multipurpose schools, non-recurring grants for science equipment were sanctioned at a rate of Rs. 40,000 per school uptil 1955-56. For conversion of high schools to multipurpose/higher secondary schools, grants of Rs. 50,000 (half

of which to be met by the school authorities) were sanctioned in the 2nd Plan period. In the Third Plan, total estimated cost has been raised to Rs. 75,000 and it has been decided that two-third of this cost would be met by the Govt. and one-third by the school.

Govt. Schools

4. For Govt. schools separate lumpsum provisions were made in the Five Year Plan budget for meeting the cost of additional requirements of building, furniture, equipment etc., and allotment of funds was made after assessing the requirements of each school. For the last two years, no provision could be made for Govt. schools as they had been sanctioned sufficient funds previously.

GUJARAT

1. There are no separate rules for payment of grant on expenditure of science equipment but such expenditure is included in the general expenditure of the school and is held admissible for grants-in-aid purposes up to 12 per cent of the total direct expenditure of the school. Over and above 12 per cent grants are paid at 25 per cent if funds permit.

2. In the Third Five Year Plan, Government have included a scheme of strengthening of science teaching in secondary schools under which grants for science equipment, books etc., are paid in order to strengthen the science laboratories of schools as the Managements find it difficult to provide funds for this purpose to the fullest extent. Grants are paid at 45 per cent and 50 per cent respectively to the schools in urban and rural areas. Grants for starting of Science Clubs are also paid to the extent of Rs. 1,200 for a single school. These grants are sanctioned by the Directorate and the funds are placed at the disposal of the District Educational Inspector concerned who takes necessary steps for making payments etc.

JAMMU & KASHMIR

The grants for the purchase of equipment to Government schools are sanctioned in time and no difficulties are experienced by the State Government. Regarding the aided schools, 50 per cent of such expenditure is met by the Government.

MAHARASHTRA

1. In this State, grants are paid to the schools started under the Multipurpose Scheme one year in advance before the courses are started so as to enable the schools to complete preliminaries like construction of buildings, purchase of equipment etc.

2. In the case of other schools, the grants are paid on the expenditure actually incurred during the preceding years. The expenditure on science equipment such as school laboratory and other teaching aids is shown under ordinary expenditure for the year and is admissible for maintenance grant, provided it is up to the limit of 12 per cent of the total actual expenditure (exclusive of expenditure on equipment). Expenditure on equipment exceeding this limit is held eligible for *ad-hoc* grants upto 25 per cent of such expenditure. These grants, however, can be given subject to the availability of funds—*vide* Rule 114 of the Grants-in-aid Code which is as under :—

> "Expenditure on equipment such as school furniture, library, laboratory, workshop, audio-visual and other teaching aids including equipment on crafts etc., will be shown under ordinary expenditure for the year and will be admissible for maintenance grant, provided it is upto the limit of 12 per cent, of the total actual expenditure (exclusive of expenditure on equipment). Expenditure on equipment exceeding this limit will be eligible for *ad-hoc* grants upto 25 per cent of such expenditure. These grants will be given subject to such conditions as the Department may impose and subject to availability of funds".

3. There is no guarantee that funds for paying *ad-hoc* grants at 25 per cent are always available. During the Third Plan, there was a scheme for payment of *ad-hoc* grants for science equipment. However, due to financial stringency arising out of national emergency, it has not been possible to provide the necessary funds so far.

MADRAS

The grants for the purchase of science equipment and apparatus to the secondary schools are given, ranging from Rs. 10,000 to Rs. 50,000, the Government's share varying from 50 per cent to 75 per cent in the case of private schools (including laboratory buildings).

MYSORE

No specific procedure is being followed for allotment of funds. The distribution is based on the availability of funds and actual needs. While sanctioning grants to Govt. high schools, a sum of Rs. 2,000 per annum for the first three years is usually earmarked for the purchase of science equipment. Similarly for schools under private managements as and when funds are made available under the Plan, the same will be distributed to schools according to their needs as per Grants-in-aid rules.

RAJASTHAN

Funds are allotted for non-recurring expenditure as indicated below. Additional funds are provided if enrolment increases.

Secondary Schools *viz.* High Schools upto Xth Class

Science Group	*Non-recurring*
Physics :	
Apparatus & Chemicals	Rs. 3,000
Chemistry	
Apparatus & Chemicals	Rs. 1,500
Biology	
Apparatus & Chemicals	Rs. 2,000
Fittings and furniture for one laboratory (Physics, Chemistry and Biology)	Rs. 3,000
Home Science Group :	
Equipment and appliances	Rs. 2,000
Higher Secondary Schools *i.e.* upto XI class	in addition to the above *i.e.* for High schools.
Science Group (Apparatus & Chemicals)	
Physics	Rs. 5,000
Chemistry	Rs. 4,000
Biology	Rs. 4,000
Fittings and furniture for each Laboratory (Physics, Chemistry and Biology)	Rs. 9,000 (@ Rs. 3,000 for each Laboratory)
Home Science Group :	
Equipment and appliances	1,000

For procurement, tenders are invited from the firms and they are approved by a Selection Committee.

UTTAR PRADESH

Aided Schools

(A) For development of Science teaching in Government aided Higher Secondary Schools—

	Boys Rs.	*Girls* Rs.
(*i*) Grant for science laboratories for Inter-colleges recognised for Inter-classes in Science	15,000	15,000
(*ii*) Grant for Science equipment (Intermediate College)	10,000	15,000
(*iii*) Grant for science equipment (High School)	2,000	3,000
(B) Expansion and improvement of science teaching in High Schools—		
Grant for science equipment	2,250	2,700
(C) For introduction of General Science in Senior Basic Schools	3,500	3,500

Government Schools: *Non-recurring grants*

For introduction of Science in certain Government Higher Secondary Schools (Intermediate Colleges) with classes :—

(i) IX—XII . . . Rs. 40,000
(ii) XI—XII . . . Rs. 30,000

2. For expansion and improvement of science education in Govt. schools, a provision of a recurring expenditure of Rs. 90,000 is made each year for sanctioning additional contingencies to Govt. schools.

3. During 1963-64, additional contingencies amounting to Rs. 90,000 were sanctioned for 36 Govt. Intermediate Colleges whereas non-recurring expenditure amounted to Rs. 2,95,000.

4. For recurring grants, amounts of Rs. 5 and Rs. 10 have been fixed per student for classes IX—X and XI—XII respectively.

WEST BENGAL

The following non-recurring grants are sanctioned when schools are upgraded to class XI schools. These grants are sanctioned by the State Govt. with the concurrence of the Finance Department and on the recommendation of the Director of Public Instruction.

Courses	Grants for	Amount
		Rs.
(A) Science (Physics, Chemistry and Biology).	(*i*) Laboratory buildings .	55,000
	(*ii*) Equipment . . .	40,000
	(*iii*) Furniture . . .	10,000
		1,05,000
(B) Improvement in Science Teaching (General Science)	(*i*) Science Room . . .	7,500
	(*ii*) Equipment and Furniture .	7,500
		15,000

HIMACHAL PRADESH

In the budget allocation, a certain amount is placed annually at the disposal of the high/higher secondary schools for the purchase of science apparatus. The heads of the schools concerned are required to prepare a break-up of this provision allotted to them. A specific amount is set apart by the Headmaster for the purchase of equipment in accordance with the requirements of the schools.

2. In addition, there is a scheme under the Third Five Year Plan for the improvement of science laboratories in high schools. Under this scheme, schools which require more than what can be purchased by them out of their normal allocations are covered. Poorly equipped laboratories are improved. Usually the schools get between Rs. 500 to 1,000 by way of their normal allocation for science equipment and selected few (about 10, every year) another Rs. 1,000 or so extra.

TRIPURA

Funds are allotted for purchase of science equipment and apparatus to secondary schools according to the requirements of the institutions.

APPENDIX II

Procedure for financial sanctions for purchase of Science Equipment and Apparatus in Schools

A questionnaire for collecting information on purchase of scientific apparatus and equipment in High/Higher Secondary Schools/ Intermediate Colleges was sent to heads of 651 institutions located in different States and Union Territories. Statewise breakup of the replies received from 147 institutions is as under :—

State	Number of questionnaires	
	Sent	Received
1. Andhra Pradesh	52	14
2. Assam	16	3
3. Bihar	47	13
4. Gujarat	39	10
5. Jammu & Kashmir	12	1
6. Kerala	43	16
7. Madhya Pradesh	52	8
8. Madras	56	14
9. Maharashtra	81	18
10. Mysore	36	8
11. Orissa	27	3
12. Punjab	45	14
13. Rajasthan	30	2
14. Uttar Pradesh	55	7
15. West Bengal	10	4
Union Territories :		
1. Delhi	24	4
2. Himachal Pradesh	9	4
3. Manipur	8	2
4. Tripura	9	2
TOTAL	651	147

A summary of the replies and suggestions received from these institutions is given below:—

ANDHRA PRADESH

(i) No regular grants are given for purchase of science equipment & apparatus to secondary schools.

(ii) In aided schools, the Management allocates some amounts in the budget subject to the condition that the State Government gives a matching grant, but as the Government does not accord sanction in time, the Management share is also not utilised.

(iii) The procedure should be simplified. When the Management allots funds, Education Department should automatically sanction matching grants.

ASSAM

Only 3 replies have been received. It is gathered that the sanctions for the purchase of equipment are accorded in time and the schools are in a position to purchase equipment effectively.

BIHAR

The grants are usually sanctioned at the fag end of the financial year but they are actually received in the next financial year. A better method will be to give the sanction in the beginning of the financial year on the basis of the results and requirements of the schools.

GUJARAT

Replies have been received from 10 institutions. Sometimes the grants are sanctioned very late and the time available for the purchase of equipment is very short, so the purchases are made in a great hurry. At least six months should be given to utilise the amount sanctioned for the purchase of equipment.

JAMMU & KASHMIR

Only one reply has been received. It is gathered that sanction for the purchase of equipment is accorded in time and is in accordance with the needs of the laboratory and capacity of funds available.

KERALA

Grants are sanctioned by the District Education Officer sufficiently in advance and the schools are able to procure equipment in time.

MADHYA PRADESH

The Government places funds at the disposal of Divisional Superintendent of Education, who in turn sanctions the required amounts to schools in time. Thereafter schools purchase the necessary

equipment after obtaining the approval of Divisional Superintendent of Education. The following suggestions have been offered:—

(i) The Principals should be empowered to spend Rs. 500/- annually out of the sanctioned grants without obtaining administrative approval.

(ii) Non-Government institutions should also be considered like Government institutions for the sanctioning of grants.

(iii) The Education Department has formulated many rules about grants which are as a matter of fact, impracticable. Duplicate stock registers have to be maintained. A booklet, containing prices of articles at old rates, has been issued by the Education Department, while there are at present considerable changes in prices. This list may be revised and brought up to date.

(iv) The financial sanctions should be accorded during summer vacation so as to enable the institutions to place orders and get material before the new academic session starts.

(v) Permission to purchase equipment of superior quality, though at a higher price than those of inferior quality, be granted.

MADRAS

(i) All the 14 institutions are satisfied with the procedure for allotment of funds.

(ii) Science fee @ Re. 1/- per year (*i.e.* Rs. 0-50 per session) per student is collected. This amount is spent by the Principals in the purchase of equipment.

MAHARASHTRA

(i) The stanctions are accorded in time to aided schools for the purchase of equipment on the basis of expenditure incurred by them in the previous year.

(ii) To some of the institutions quarterly grants are sanctioned @ 45% on the basis of the previous year's expenditure.

(iii) No separate grants are given to schools for the purchase of science equipment.

MYSORE

The grants are sanctioned very late usually at the end of the financial year and the schools have very little time left to purchase

the required equipment and so the purchases are made in hurry without judging quality of equipment etc. The schools have made following suggestions:—

(i) The allotment of funds should be communciated to the schools by the end of October each year to enable them to select the equipment.

(ii) If possible the quotations should be called by the Deptt. from reputed firms and the lowest prices and the names of firms be intimated to the institutions.

(iii) Half of the grant should be released in advance, remaining may be released after the production of purchase receipts.

ORISSA

Of the 3 institutions (two aided and the other Government managed) from whom the replies have been received, the aided institutions have reported that no grants for the purchase of equipment are sanctioned for the institutions. The Government managed institution has stated that a lump-sum grant is sanctioned after a period of 6-7 years and has suggested that annual grants should be given.

PUNJAB

The grants are sanctioned well within time, and there is sufficient time left to purchase the material. It would be better if the sanctions are accorded at the beginning of the financial year, so that the schools are in a position to utilise the amounts properly.

RAJASTHAN

Only 2 institutions (one Government and the other aided) have replied to the questionnaire. It has been reported that the financial sanctions are accorded in time by the Education Deptt. *i.e.* by the end of May every year.

UTTAR PRADESH

Only 7 institutions have sent the questionnaire stating that the procedure for financial sanction should be revised in such a manner that sanctions are accorded early before the start of new session and there is enough time left to make purchases of costly and durable equipment. It has further been suggested that grants should be raised in view of high prices of goods and increase in number of science students.

WEST BENGAL

Only 4 replies have been received. They have pointed out that grants are generally received at the fag end and as such hurried purchases are effected during the stipulated time. It has been suggested that grants should first be divided under different heads such as on Physics, Chemistry and Biology and should not be at flat rate. Grants should also match with the number of pupils and sanctioned at the beginning of the session.

DELHI

Only 4 questionnaires have been received. It has been suggested that the grants should sanctioned in August or September to enable the institutions to purchase equipment effectively.

HIMACHAL PRADESH

Only 4 replies have been received. They are satisfied with the procedure of allotment of funds. A lump-sum amount is placed at the disposal of the institutions and the purchases are made according to requirements. In case of short-falls, additional special grants are sanctioned.

MANIPUR

Only 2 institutions have sent reply to the questionnaire. The procedure for the allotment of funds takes a lot of time, as after the allotment of Grant by Education Department, approval is given by Chief Commissioner, then it is sent to Finance Secretary who forwards it to A.G., Assam for sanctioning authority of drawing grant-in-aid. The institutions are, therefore, left with no time to make the purchases. It has been suggested that Director of Education or Inspector of Schools should be authorised to make necessary allotment of funds to each school.

TRIPURA

Only 2 institutions have sent reply to the questionnaire. The procedure for allotment of funds is reported to be quite satisfactory.

APPENDIX—III

List of Science Equipment and Apparatus for High Schools

A—*PHYSICS*

Sl. No.	Name of the Article	Quantity	
		Essential	Desirable
(1)	(2)	(3)	(4)
	Demonstration (Apparatus)		
	Mechanics		
1	Wooden Vernier Calliper (model)	1	..
2	Wheel and axle	1	..
3	Pulleys (different type)	1 (set)	..
4	Inertia apparatus (ball and spring type)	1	..
5	Barker's Mill	1	..
6	Centre of gravity toys	1 (set)	..
7	Guinea and feather apparatus	..	1
8	Levers of different kinds	1 (set)	..
9	Laws of parallelogram of forces apparatus (complete)	1	..
10	Inclined Plane (complete)	1	..
11*	Apparatus to show that liquids seek their own level	1	..
12	Hydrometer for light & heavy liquids	1 (set)	..
13	Nicholson's Hydrometer with jar	1	..
14	Hydrometer for battery testing	1	..
15	Lactometer	1	..
16*	Pascal's law apparatus	1	..
17	Hydraulic Press (working model)	1	..
18	Submarine (model)	..	1
19	Flushing siphon	..	1
20	Aneroid barometer	1	..
21	Tube and cup for simple barometer	1 (set)	..
22	Fortin's barometer	..	1
23	Syringe	1	..
24*	Cartesian diver	1	..
25*	Rain Gauge	1	..
26	Vacuum pump (piston type) with one bell jar of 25 cm. diameter	1	..
27	Suction and force pumps (working model-transparent)	1 (set)	..
28	Aeroplane (working model)	..	1
29	Rocket model	..	1
	Heat		
30	Alcohol thermometer (large size)	1	..
31	Clinical thermometer	1	..
32	Six's maximum and minimum thermometer	1	..
33	Differential air thermoscope	1	..
34	Linear expansion apparatus (pointer type)	1	..
35	Ball and ring; Bar and gauge	1 (each)	..
36	Compound bar of brass and iron (with handle)	1	..

*May be improvis

(1)	(2)	(3)	(4)
37	Boyle's law apparatus complete	1	..
38*	Dry and wet bulb hydrometer	1	..
39*	Ingen Hausz's apparatus or Edsar's apparatus for showing conductivity	1	..
40	Rods of different metals, 60 cm. length and 0·5 cm. diameter	1 (set)	..
41	Leslie's cubes	1 (set)	..
42	Davy's safety lamp	1	..
43*	Convection apparatus	1	..
44	Thermos flask	1	..
45*	Thermo-couple	1	..
46	Crooke's radio-meter	1	..
47	Steam Engine (working model)	1	..
48	Fire alarm (working model)	1	..
49	Refrigeration (model)	..	1
50	Air conditioning (model)	..	1
	Light		
51	Convex Mirror (15 cm. aperture)	2	..
52	Parabolic mirror	1	..
53	Optical bench with accessories (Metallic)	1	..
54	Lenses of different types (set of six)	1	..
55	Telescope astronomical (magnifying power × 15)	1	..
56	Microscope compound (magnifying power × 50 × 100)	1	..
57	Binocular (magnifying power × 20)	..	1
58*	Periscope (model)	1	..
59*	Kaleidoscope	1	..
60	Hollow glass slab	1	..
61	Two mounted thin plane mirrors (15 & 10 cm)	1	..
62	Mounted thick mirror (hinged) for multiple images	1	..
63	Hollow glass prism	1	..
64*	Newton's colour disc with rotating wheel	1	..
65	Colour slides for showing the mixing of colours	..	(1 set)
66	Human eye (working model)	1	..
67*	Pin hole camera	1	..
68	Box camera	1	..
69	Simple model for showing the persistence of vision	1	..
70	Optical disc to demonstrate laws of reflection and refraction (Hartle's Disc)	1 (set)	..
71	Hollow cube with air cell attached for showing total internal reflection of light	1 (set)	..
72	View master	..	
	Sound		
73	Demonstration apparatus for wave motion	1	..
74	Parabolic reflector (metallic) with adjustable stand	1	..
75	Tuning forks-complete set of eight	1 (set)	..
76*	Resonance tube apparatus	1	..
77	Toothed wheel apparatus	1	..
78	Siren with indicator	..	1
79	Sonometer	1	..
80	Adjustable organ pipe (open and close)	1 (set)	..
81	Galton whistle	..	1
82	Ripple tank (P.S.S.C. type)	1	..
83	Gramophone	..	1
84	Amplifying unit	..	1
85	Bell jar (15 c.m. diameter) with electrical bell	1	..

*May be improvised.

1	2	3	4
	Magnetism & Electricity		
86	Magnetic compass	1	..
87	Mariner's compass	..	1
88	Magnetic D.p needle	1	..
89	Magnetic globe (medium size working model)	..	
90	Different types of magnets (including natural and oxide magnets)	1 (set)	..
91	Metallic conductors of different shapes (mounted)	1 (set)	..
92	Leyden jar with removable coatings	1	..
93*	Pith ball pendulum	2	..
94	Faraday's butterfly net	1	..
95	Van de Graff generator (working model)	..	1
96*	Apparatus to demonstrate the magnetic effect of current	1	..
97	Galvanoscope	1	..
98	Electromagnet (ordinary U shaped)	..	1
99*	Cells :		
	(*a*) Voltaic	1	..
	(*b*) Daniel	1	..
	(*c*) Bunsen	1	..
	(other cells included in laboratory apparatus)		
100	Resistance box, open view	1	..
101	Different types of keys	1 (set)	..
102	Rheostat	1	..
103	Demonstration board for series and parallel circuits	1	..
104	Moving magnet and coil galvanometer, open view (working model)	1 (each)	..
105	Joule's calorimeter	..	1
106	Nichrome wire coiled round a mica sheet (heating element)	1	..
107	Dynamo AC/DC (working model)	1	..
108	Electric motor AC/DC (working model)	1	..
109	Simple transformer	1	..
110	Spintharsicope	1	..
111	Demonstration apparatus for induced currents	1	..
112	Barlow's wheel	1	..
113*	Voltameter	2	..
114	D. C. Voltameter 0—1·5 volts	1	..
115	D.C. Ammeter 0—1 amp.	1	..
116	Model of a telephone set	1	..
117*	Model of a telegraph set	1	..
118	Crystal detector with headphones	..	1
	Experiments		
	Mechanics		
119	Matallic spherical bob with a hook	12	..
120	Metallic cylinder (small size—assorted metals for use with callipers)	12	.
121	Spring and pans for Hooke's law verification	12	..
122	Wooden bridges for R.D. experiment	6	..
123	R.D. bottles	12	..
124	Hare's apparatus on stands	9	..
125	U-tubes on stands	6	..
126	Over-flow vessels (unbreakable plastic or metallic)	12	..

*May be improvised.

1	2	3	4
	Heat and Light		
127	Calorimeter with stirrer and jacket	6	..
128	Steam generarors	6	..
129	Hypsometer (with copper tubes)	6	..
130	Plane mirror strips with a support to the verticle	24	..
131	Concave mirror 5 cm and larger aperture (of different focal lengths)	12	..
132	Glass slabs (preferably 8 cm x 12 cm)	6	..
133	Lenses, double convex, 5 cm. aperture (of different focal lengths) Double concave, 2·5 cm aperture (5 to 7 cm. focal length)	12 4	.. ..
134	Suitable holders and uprights for lenses and mirrors (wooden with V slots)	24	..
135	Glass prism 90° isosceles	2	..
136	Glass prism—60°	6	..
137	Candle stand with wire gauze fittings	12	..
138	Ground glass screen	6	..
	Magnetism and Electricity		
139	Magnets in pairs, different sizes (oxide magnets)	12 pairs	..
140	Magnetic needle on pivot	12	..
141	Magnetic needles (for lines of force)	12	..
142	Steel knitting needles	24	..
143	Aluminium leaf electroscope, simple	6	..
144	Electro-phorous	6	..
145	Glass rods	12	..
146	Ebonite rods	12	..
147	Catskin pieces	12	..
148	Flannel or nylon pieces	12	..
149	Proof plane	6	..
150	Cells :		
	(*a*) Leclanche	12	..
	(*b*) Dry cells with terminal screws	6	..
151	Single-way key (plug type)	6	..
152	Lead accumulator, 2 volts	4	..
153	Ammeter D.C., 0—1·5 amp.	4	..
154	Voltmeter, D.C., 0—3 volts	4	..
	Voltmeter, D.C., 0—10 volts	..	1
155	Voltmeter for mains (AC/DC) 0—300 volts	..	1
156	Rheostat—1 amp, 36 ohms.	4	..
157	Electric bell	6	..
158	Torch bulb (1·5 volts) with holders	12	..
159	Miniature switches	12	..
160	Cut-outs	12	..
	Equipment Common to All Units in Physics		
161	Physical balance with weight box	6	..
162	Spring balance; 100 gm	6	..
	250 gm	6	..
	500 gm	6	..
163	Triple beam balance	..	1
164	Metre scales; Half	12	..
	Full	12	..
165	Vernier callipers	6	..
166	Screw gauge	6	..
167	Stop clock	1	3
168	Stop watch	1	..
169	Spirit Level	2	..

(1)	(2)	(3)	(4)
170	Drawing boards (medium size)	12	..
171	Set squares (for black board)	1 (set)	..
172	Pairs of Compass (Geometrical)	12	..
173	D.C.C. copper wire 22-24-26 S.W.G. . . .	500 gm.	..
174	Nichrome wire 28-30-32 S.W.G. . . .	250 gm.	..
175	Flexible wire (Plastic covered)	25 meters	..
176	Plumb line	6	..
177	Battery charger with a metal rectfier . . .	..	1

B. *CHEMISTRY*

Sl. No.	Name of the Article	Quantity	
		Essential	Desirable
1	2	3	4
	Demonstration (Apparatus)		
1	Chemical Balance (in case) & weight box	1	..
2	Eudiometer tubes	1	..
3	Bell Jar (20 cm diameter)	1	..
4	Funnel separating	1	..
5	Calcium chloride tubes	4	..
6	Thermometers (marked ½° C)	2	..
7	Mercury trough	1	
8	Filter pump (metallic)	1	..
9	Crystal models (glass/wooden/plastic)	1 (set)	..
10	Copper still for distillation of water	1	..
11	Platinum wire (5 cm. fused in glass)	3	..
12	Water still (for distillation of water)	1	..
13	Glass cutter for rods	2	..
14	Photographic developing kit	1	..
15	Leibig's condenser	2	..
16*	Fire extinguisher (Demonstration model)	1	..
17*	Atomic model	1 (set)	..
18	Mineral collection	1 set)	..
19	Alloys	1 (set)	..
	Apparatus for Experiments		
20	Beaker with lip		
	(*a*) 100 cc.	48	..
	(*b*) 250 cc.	48	..
	(*c*) 500 cc.	..	6
21	Flask flat bottom		
	(*a*) 100 cc.	12	..
	(*b*) 250 cc.	48	..
	(*c*) 500 cc.	6	..
22	Distilling flask round bottom 300 cc.	..	2
23	Crystalising dish 10 cm diameter	..	2
24	Woulfle's bottle 250 cc.	24	2
25	Bottles narrow mouth mushroom stopper 500 cc. (Polythene)	24	..
26	Bottles reagent with names (Polythene or glass)	48	..
27	Measuring jars		
	(*a*) 10 cc.	..	2
	(*b*) 50 cc.	6	..
	(*c*) 100 cc.	12	..
	(*d*) 500 cc.	..	2
	(*e*) 1000 cc.	..	2
28	Bottles reagent 8 oz., 16 oz. with wide mouth	48	..
29	Bottles reagent 2 oz.	48	..

*May be improvised.

(1)	(2)	(3)	(4)
30	Funnels (7·5 cm diameter)	24	2
31	Funnel for burettes (Polythene)	4	2
32	Retort 500 cc.	12	3
	Retort 250 cc. with long necks	12	..
33	Pneumatic trough (rectangular tin with behive arrangement)	24	2
34	Mortar and pestle		
	(*a*) 10 cm dia.	3	1
	(*b*) 25 cm. dia.	..	1
35	Calcium chloride tubes		
	(*a*) U—type 15 cm. approx.	..	2
	(*b*) U—type with side tubes	..	2
36	Glass filter pump	..	1
37	Test tubes 12·5 cm. × 1·6 cm.	2 gross	
38	Test tubes, hard-glass 1·5 cm × 1·9 cm	24	..
39	Glass tubing assorted	13 kg.	..
40	Glass rod assorted	3 kg.	..
41	Burette with stop-cock 50 × 1/10 cc.	12	2
42	Pipette		
	(*a*) 10 cc.	12	..
	(*b*) 20 cc.	12	..
	(*c*) 25 cc.	..	1
	(*d*) 50 cc.	..	1
43	Thermometer 350°C (Reading 1°C)	..	1
44	Fitter paper circular pieces 12·5 cm.	600	..
	do. 15·0 cm.	300	..
	do. Plain	2 quire	..
45	Rubber tubing assorted	30 meters	..
46	I.R. connection tubing	15 meters	..
47	Cork-borers, set of three	12 sets	..
	Cork-borers, set of six	..	1
48	Cork-ordinary assorted (Velvet)	6 gross	..
49	Cork presser	2	..
50	Berenger Balance with weights	2	..
51	Clay pipe triangle	24	..
52	Deflagrating spoons with tin caps	24	..
53	Foot bellows	..	1
54	Pinch Cock assorted	12	..
55	Retort stands (with heavy base)		
	(*a*) large	..	2
	(*b*) Small	22	..
56	Additional rings for retort stand	12	..
57	Wooden clamp	..	1
58	Funnel stand; double	12	3
59	Burette clamps	12	..
60	Thistle funnels 2·5 cm. diameter (Preferably Polythene)	24	..
61	Asbestos sheet 25 cm × 25 cm.	24	..
	do. (large size)	..	1
62*	Diffusion apparatus (porous-pot, tube etc.)	..	1
63	Glass trough, large, 45 cm dia.	..	2
64	Copper flask (2 litres)	..	1
65	Watch glasses	24	..
66	Bunsen Burners (if gas supply is available) otherwise Spirit Lamps	24	..
67	Flame spreader for bunsen burner	12	..
68	Spatulas (metal)	..	1
	Spatulas (horn double)	12	..
69	Book of labels	24	..

*May be improvised.

(1)	(2)	(3)	(4)
70	Litmus books (red & blue)	2 gross	..
71	Tripod stands	24	..
72	Crucible tongs	24	..
73	Porcelain dishes to cm. dia.	24	..
74	Graduate flasks		
	(*a*) 100cc.	..	2
	(*b*) 200cc.	..	2
	(*c*) 250cc.	..	2
	(*d*) 1000cc.	..	2
75	Water baths with rings	2	2
76	Crucible with lids and clay pipe triangle	8	..
77	Small U-tubes, height to cm. diameter 1·3 cm.	6	..
78	Wire gauze spoons for sodium	6	2
79	Triangular files and round files	24 each	..
80	Gas collecting jar (15 cm) with round glass cover (Small size)	60	..
81	Spare covers for gas jars	48	..
82	Brushes for test tubes	4 dozen	..
83	Test tube holder	24	..
84*	Test tube-stand	24	..
85	Cobalt glass	12	..
86	Petridishes 8·5 cm. dia.	24	..
87*	Sand bath	12	..
88	Thermometer,—10 C to 110C	24	..
89	Drying cones	12	1
90	Wire gauze (asbestos covered)	24	1

* May be improvised.

C. *BIOLOGY*

Sl. No.	Name of the Article	Quantity	
		Essential	Desirable
(1)	(2)	(3)	(4)
	I—*Apparatus*		
1	Microscope with ocular objectives 10 x 40 x and two eye pieces	1	..
2	Dissecting microscope with rack and pinion (magnifying power x 10)	6	..
3	Reading glass 3" diameter	2	..
4	Magnifiers single folding	2	..
5	Eye-piece x 10 with pointer	1	..
6	Klinostat	..	1
7*	Simple auxonometer (with lever arrangement)	1	..
8*	Simple respiroscope	1	..
9*	Simple potometer	1	..
10	Light screen	2	..
11	Beranger's balance (with wt. box)	1	..
12	Thermometers,—10°C to 110°C	2	..
	II—*Laboratory Equipment*		
13	Dissecting trays and dissecting boards	20	..
14	Dissection instruments	1 set	..
15	Bone cutter	2	..
16	Big Scissors	2	..
17	Hammer (small)	3	..
18	Mounted Needles	72	..
19	Brushes camel hair	12	..
20	Razor	1	..
21	Insect drying box	2	..
22	Herbarium mounting sheets	100	..
23	Herbarium Press 20" x 12"	1 pair	..
24	Drying papers	100	..
25	Sharpening cone	1	..
26	Strop	1	..
27	Dessicator	1	..
28	Cork borer	1 (set)	..
29	Retrot stand (with clamps and boss heads)	3	..
30	Funnel stands (Wooden)	3	..
31	Insects-collecting nets	2	..
32	Test-tubes stand	2	..
33	Pins (various sizes)	2 packets	..
34	Entomology pins (or insect pins)	1 gross	..
35	Spirit lamp	1	..
36	Rubber tubing (assorted)	5 yds	..
37	Scalpels	2	
38	Cork bark (assorted)	6 do	..
39	Forceps—12·5 cm and 40 cm.	2	..
40	Pinch cock (screw type)	3	..
41	Vasculum	1	..
42	Flower pot 8 (assorted, earthenware 8"x10")	24	..
43	Watering can (with rose)	1	..

*May be improvised.

(1)	(2)	(3)	(4)
44	Mugs (enamel)	2	..
45	Buckets	2	..
46	Refuse box with lid	1	..
	III—Glass Ware and Museum Ware		
47	Bell jar 20″ x 12″ (50 x 30 cm)	1	..
48	Glass plate 14″ x 14″ (35cm x35 cm)	1	..
49	Aspirator, 5 litres	1	..
50	Funnel, 4″ diameter (10 cm)	2	..
	Funnel, 3″ diameter (7·5 cm)	2	..
51	Beakers, 1/2 litre	3	..
	Beakers, 1/4 litre	3	..
52	Battery Jars, Cylindrical (1 litre capacity)	1	..
53	Museum Jar, 8″ x 2″ assorted (20 x 5 x 20 cm) (with rectangular lid)	48	
	Do. Cylindrical with backelite screw caps	24	..
54	Thistle funnel	3	..
55	Gas Jars (with lids)	2	..
56	Microscope slides, 3″x1″ (7·5x2·5 cm)	1 Gross	..
57	Cover Glasses 7/8″ x 7/8″ (2·2 x 2.2 cm)	12	..
58	Watch glass, 3″ diameter	12	..
59	Hard glass test tubes	12	..
60	Test tubes (ordinary)	72	..
61	Reagent bottles with stoppers, narrow mouth 250 cc. capacity	6	..
62	Drop bottles	12	..
63	Stain bottles	12	..
64	Winchester bottles (2½ litre capacity)	3	..
65	Glass tubings (assorted)	2 lbs.	..
66	Finger bowls	6	..
67	Circular glass troughs	2	..
68	Enamel tray 12″ x 9″ (30 x 23 cm)	1	..
69	Enamel tray 9″x6″ (23 x 15 cm)	1	..
	Botany IV Charts		
70	Cell division, mitosis	1	..
71	Structure of dicot stem	1	..
72	Structure of monocot stem	1	..
73	Structure of leaf	1	..
74	Structure of dicot root and monocot root	1	..
75	Structure of root tip	1	..
76	Parts of a typical plant	1	..
77	Typical flower and its parts	1	..
78	Fruits—different kinds of fleshy and dry fruits	1	..
79	Seed—dispersal of seed	1	..
80	Germination epigeal and hypogeal	1	..
81	Monocot seed and parts	1	..
82	Dicot seed and parts	1	..
83	Algae Chlamydomonas Spirogyra	1	..
84	Mushroom	1	..
85	Bacteria	1	..
86	Moss-life history	1	..
87	Fern-typical fern and its parts	1	..
88	Vegetative propagation—grafting etc.	1	..
89	Food chain	1	..
90	Different kinds of leaves and their modifications	1	..

(1)	(2)	(3)	(4)
91	Nitrogen cycle in nature	1	..
92	Amoeba—structure and reproduction	1	..
	Zoology		
93	Life cycle of malarial parasite	1	..
94	Liverfluke	1	..
95	Tape worm	1	..
96	Cell-typical	1	..
97	House fly—life history	1	..
98	Mosquito—life history-culex and anophales	1	..
99	Butterfly—life history	1	..
100	Frog		
	Organs in situ (dissection)	1	..
	Alimentary canal	1	..
	Venous System	1	..
	Arterial system	1	..
	Urinogenital system (Male and Female)	1	..
	Brain-different views and parts	1	..
	Nervous system	1	..
	Skeletal system	1	..
	Heart and its structure	1	..
	Heart T. S.	1	..
	Eye	1	..
	Ear	1	..
	Buccal cavity	1	..
	Life history	1 (14 in all)	..
101	Various insects	1	..
102	Poisonous and non-poisonous snakes	1	..
103	Birds with various kinds of beaks and feet	1	..
104	Mammals of India—different kinds	1	..
	V—*Slides*		
	Botany		
105*	Typical cell and content	1	..
106	Root tip L.S. for mitosis (onion)	1	..
107	Root T.S. & L.S of dicot root	2	..
108	Stem T.S. L.S. of dicot stem	2	..
109	Leaf structure of typical leaf	1	..
110*	Chlamydomonas	2	..
111*	Spirogyra	2	..
112	Agarecus T.S. of gill	2	..
113	Moss L.S. of capsule	2	..
114	Root nodule of leguminous plant	2	..
115	Flower bud T.S.	1	..
	Zoology		
116*	Amoeba	2	..
117*	Blood of frog	2	..
118*	Blood of man	2	..
119	Bone T.S. (frog)	2	..
120	Earthworm T.S.	2	..
121*	Hydra-whole mount	1	..
122	Hydra T.S. L.S.	1	..

*May be improvised.

(1)	(2)	(3)	(4)
	VI—*Skeletons & Models*		
123*	Skeleton Articulated (frog)	4	..
	Skull disarticulated (frog)	2 sets	..
124*	Frog's brain	1	..
125*	Bird's brain	1	..
126	Human Skeleton (Plastic Model)	1	..

*May be improvised.

D. *Items Common for Physics, Chemistry and Biology experiments*

Sl. No.	Name of Article	Quantity (Essential)
(1)	(2)	(3)
	Chemicals	
1	Acid, hydrochloric pure	5 kg.
2	Acid, nitric pure	2 kg.
3	Acid, sulphuric pure	5 kg.
4	Acid, sulphuric commercial	10 kg.
5	Acid, glacial acetic	500 gm.
6	Alum (potash) crystalline	1 kg.
7	Ammonium carbonate	500 gm.
8	Ammonium chloride	2 kg.
9	Ammonium dichromate	250 gm.
10	Ammonium hydroxide	1 kg.
11	Ammonium sulphate	250 gm.
12	Ammonium nitrate	250 gm.
13	Barium chloride, crystal	100 gm.
14	Barium nitrate	100 gm.
15	Bleaching powder	500 gm.
16	Bone charcoal	100 gm.
17	Borax pure	500 gm.
18	Boric acid	250 gm.
19	Calcium carbonate (marble chips)	5 kg.
20	Calcium chloride, granulated pure	1 kg.
21	Calcium hydroxide	2 kg.
22	Calcium oxide (good quality lime)	2 kg.
23	Calcium sulphate (Plaster of Paris)	2 kg.
24	Campher	50 gm.
25	Carbon disulphide	1 kg.
26	Chalk precipitated	500 gm.
27	Cobalt nitrate, crystal	100 gm.
28	Copper foil, thin	250 gm.
29	Copper turnings	1 kg.
30	Copper oxide, powdered	50 gm.
31	Copper carbonate	100 gm.
32	Copper sulphate, crystal	2 kg.
33	Ether	500 gm.
34	Glycerine	1 kg.
35	Iron fillings, coarse	1 kg.
36	Iron filling, fine and clean	500 gm.
37	Iron chloride, ferric	200 gm.
38	Iron oxide, ferric	200 gm.
39	Iron sulphate	1 kg.
40	Lead shots	1 kg.
41	Lead nitrate	500 gm.
42	Litmus granules	100 gm.
43	Lead carbonate	200 gm.
44	Lead oxide (litharage)	250 gm.
45	Magnesium powder	50 gm.
46	Magnesium ribbon	300 gm.
47	Magnesium sulphate	500 gm.
48	Magnesium chloride	150 gm.
49	Mangnese dioxide	2 kg.
50	Mercuric oxide, red	500 gm.
51	Mercuric sulphate	250 gm.
52	Mercury	4 kg.

(1)	(2)	(3)
53	Methyl orange, dry	20 gm.
54	Paraffin	1 kg.
55	Phenelphthalein	20 gm.
56	Phosphorus, red	20 gm.
57	Phosphorus, yellow	100 gm.
58	Potassium bromide	250 gm.
59	Potassium chlorate	1 kg.
60	Potassium chloride	250 gm.
61	Potassium dichromate	500 gm.
62	Potassium hydroxide, pellets	1 kg.
63	Potassium nitrate, crystal	1 kg.
64	Potassium iodide	100 gm.
65	Potassium permanganate	500 gm.
66	Potassium sulphate	200 gm.
67	Pyrogallol, crystal	50 gm.
68	Silver nitrate	100 gm.
69	Sodium metal	100 gm.
70	Potasium metal	100 gm.
71	Sodium bicarbonate	1 kg.
72	Sodium carbonate	1 kg.
73	Sodium chloride	4 kg.
74	Sodium hydroxide	2 kg.
75	Sodium nitrate	500 gm.
76	Sodium nitrite	500 gm.
77	Sodium sulphate	500 gm.
78	Sodium thio-sulphate (hypo)	1 kg.
79	Sulphur flower	100 gm.
80	Sulphur roll	2 kg.
81	Turpentine Oil	5 litre
82	Wool-glass (fine)	50 gm.
83	Wool-Steel	250 gm.
84	Zinc dust	500 gm.
85	Zinc granulated	2 kg.
86	Zinc sulphate	100 gm.
87	Zinc carbonate	200 gm.
88	Zinc Oxide	100 gm.
89	Graphite	100 gm.
90	Acid oxalic	250 gm.
91	Lamp black	50 gm.
92	Iodine resublimed	50 gm.
93	Bromine	25 gm.
94	Citric acid	50 gm.
95	Tartaric acid	50 gm.
96	Ethyl Alcohol	500 gm.
97	Chloroform	500 gm.
98	Idoform	100 gm.
99	Iron sulphide	1 kg.
100	Mercuric sulphide	200 gm.
101	Sodium silicate	1 kg.
102	Antimony powder	1 kg.
103	Ores of metals	1 set
104	Fluorescein	50 gm.
105	Lycopodium powder	10 gm.
106	Starch	50 gm.
107	Glucose	200 gm.
108	Lead acetate	200 gm.
109	A set of metal specimen	1 set
110	Rectified spirit	5 litre
111	Canada balsam	100 gm.
112	Iodine crystals	100 gm.
113	Mercuric chloride	250 gm.
114	Agar agar shreds	200 gm.

(1)	(2)	(3)
115	Formali (commercial formaldehyde)	5 litres
116	Clove oil	100 cc.
117	Xylol	500 gm.
118	Cobalt chloride	200 gm.
119	Paraffin wax commercial	20 Kg.
120	Bosin	10 gm.
121	Methylene blue	5 gm.
	Tools	
1	Pliers, assorted	3
2	Screw drivers, assorted	4
3	Hammers, assorted	3
4	Files, assorted	4
5	Chisels, assorted	3
6	Hand drill	1
7	Bench vice, 10 cm. gap.	1
8	Grinder	1
9	Metal cutting saw with spare blades (Hack-saw)	1
10	Plane, medium size	1
11	Nail puller	1
12	Soldering iron with a set of bits (75 watts) (provided electricity exists)	1
13	Metal Scale	1
14	Glass cutting pencil, simple	1
15	Flat file 15 cm.	4
16	Triangular file	2
17	Saw (set of three)	1 set
	Audio-visual Aids	
18	Slide-cum-film strip projector	1
19	Screen adjustable on stand	1
20	Epidiascope (desirable)	1
	Miscellaneous	
1	Grease	2 kg.
2	Insulating tape, roll	1
3	Lead shots (assorted)	1 kg.
4	Bucket (Galvanised)	3
5	Scissors—medium and large size	1 each
6	Inelastic cotton-thread reel	6
7	Wooden blocks, assorted	48
8	Wooden screens (to screen heat radiation)	6
9	Candles, medium size	2 pkts.
10	Brushes for cleaning glasswares	24
11	Laboratory-trough (metallic)	4
12	Drawing pins	1 pkt.
13	Al-pins	200 gm.
14	Emery paper, assorted	12
15	Sand paper, assorted	24
16	Trey, enamelled (medium size)	8
17	Oil stove	4
18	Electric heater	2
19	Pneumatic trough iron (25 × 10 cm.)	12
20	Knife	2
21	Lamp chimney	4
22	Cork borer sharpner	2
23	Procelain tiles (9 cm. × 9 cm.)	12
24	First Aid kit	1
25	Fire extinguishing equipment including bucket etc.	one set

APPENDIX—IV

List of Science Equipment for a Middle School Laboratory (based on Syllabus prepared by National Council of Educational Research and Training)

Sl. No.	Name of the Item	Number/Quantity
(1)	(2)	(3)
1	Agar agar	200 gms.
2	Ammeter	1
3*	Asbestos sheets 6″×6″	3
4*	Beehive shelves	2 numbers
5	Basin (enamel) 12″	2
6	Barometer tube	1
7	Baloons (assorted)	12 dozen
8	Bar & gauge apparatus	1
9	Beakers (assorted)	12 dozen
10	Balance (physical) in glass-case	2
11	Bell Jars 8″×4″	2
12	Beuxite	500 gms.
13*	Ball of Wood	1
14	Bottles n.m.	12 dozen
15	Bottles-specimen-2 oz. (seed collection)	36 dozen
16	Bottles—W.M.	12 dozen
17	Bucket	1
18	Binding Screws	12 dozen
19	Balance (grocer's)	1
20	Compound bar (thermostat)	1
21	Corks (assorted)	12 dozen
22	Corks (assorted) 1 holed	12 dozen
23	Corks (assorted) 2 holed	12 dozen
24	China Dish	3
25	Crucible	3
26	Condenser Leibig's 20″	1
27	Condenser(Electrical)	1
28	Chimneys—lamp	3
29	Callipars in and out with verrier	1
30	Candles	12 dozen
31	Convection current apparatus	1
32	Coal	1 kg.
33	Cubes of different metals 1 cm.	1 set
34	Cork borer	1 set
35	Clips	6
36	Clips-crocodile	6
37	Camera-box	1
38	Callipers-in and out	1 set
39	Cells, dry-large	4
40	Disinfectants:—	
	Dettol	1 bottle
	Lysol	1 bottle
	Phenol	1 bottle
	Tincture of iodine	1 bottle
	Alum	500 grams
	Boric Acid	250 grams
	Potassium Permanganate	100 grams
	Carbolic Acid	250 grams

*May be improvised.

(1)	(2)	(3)
41	Dynamo-working model	1
42	Drilling machine with bits	1
43*	Deflagrating spoon	2
44	Detergents	1 box
45*	Duster-piece of cloth	2 boxes
46	Flasks R.B. 250 c.c./4, 500 c.c./2	6
47	Flasks F.B. 250 c.c./4; 500 c.c./2	6
48	Flasks Conical 250 c.c./4; 500 c.c./2	6
49	Fuse assorted capacity	4
50	First Aid Box	1
51	Flannel Cloth 2′ × 1′	1
52	Funnels: small 3, large 3	6
53	Funnels thistle	3
54	Filter paper (circular pieces)	100
55	Files, flat 1, triangular 3	4
56	Forceps	2
57*	Funnel stand	2
58	Electric wire	
	(*i*) Double cotton covered	750 gm.
	(*ii*) Flexible plastic covered	10 yards
59	Electric bell	1
60	Electric motor	1
61	Electric bulbs (assorted)	4
62	Eye-model	1
63	Ear-model	1
64	Gas jars	6
65	Gas jar covers	6
66	Ground glass sheets	2
67*	Glass plates	2
68	Glass slabs 4″ × 2½″ × ½″	2
69	Glass panes (coloured) 8″ × 4″	7
70	Glass rod (assorted sizes)	1 lb
71	Gramophone model	1
72	Glass tubing	1 lb.
73	Glass tumblers	2
74	Globe-diam. 10″	1
75	Gypsum	500 gms.
76	Diamond Glass cutter	1
77	Glass slides (for microscope)	12
78	Glass slide covers	12
79	Graduated cylinders—50 cc. 100, 250, 500 cc./2 each	8
80	Garden implements (spade, shovel, pickaxe, digging fork, Iron-basin)	6 sets
81	Heart-model	1
82	Hand lens-diam. 2½″	1
83	Hammer	1
84	Hand saw	1
85	Hydrometer	1
86	Iron filings	250 grams.
87*	Iron wool	500 grams.
88	Inflator football	1
89	Induction coil	1
90	Inclined plane—with all accessories	1
91	Iron wire galvanized (assorted diam.)	250 gms.
92	Ink filler	1
93	Jars with lid (for insect collection)	3
94	Kettle	1
95	Knife	1
96	Knife-table	1
97	Lens-concave aperture 5 cm. f=25 cm.	2

*May be improvised.

(1)	(2)	(3)
98	Lens convex, aperture 5 cm. f=25 cm.	2
99	Lens Plano concave, aperture 5 cm. f=25 cm.	2
100	Lens Plano convex, aperture 5 cm. f=25 cm.	2
101	Litmus powder	250 gms.
102	Litmus paper (blue 2, red 2)	4 books
103	Lime stone	500 gms.
104	Lever—3 orders	1 set
105*	Liquid level apparatus	1
106	Lactometer	1
107	Microscope, Mag. 100 x.	1
108	Measuring jars 100 cc./1, 250 cc./1,500 cc./1	3
109	Magnet Alnico	1
110	Mathematical Instruments	1 set
111	Mortar and Pestle 4"	1
112	Mug-enamel	1
113	Museum jars 20 × 5 cm.	6
114	Minerals box	1
115	Matches (safety)	2 boxes
116	Magnetic needle (pivoted)	2
117	Mariner's compass	1
118	Mirror plane	1
119	Mirror convex, diam. 10 cm.	1
120	Mirror concave, diam. 10 cm.	1
121	Meter scales 100 cm.	2
122	Meter scales 500 cm.	2
123	Permanent Magnets—Bar 4"	2
124	Magnets horse shoe 4"	2
125	Electro magnets, bar shaped or horse shoe	1
126	Marble chips	500 gms.
127	Nails assorted sizes	500 gms.
128*	Newton's colour disc (mounted)	1
129	Oils (vegetable)	250 gms.
130	Oil Engine—model	1
131	Pins (safety)	12
132	Pins (for light experiments)	12
133	Prism equilateral 2"	2
134	Pump lift (working model)	1
135	Pump force	1
136	Plastic rods	3
137	Porcelain dish	3
138*	Pulleys single	1
139	Pulleys parallel double	1 set
140	Pulleys parallel triple	1 set
141	Pulleys serial double	1 set
142	Pulleys serial triple	1 set
143	Pliers-cutting	1 set
144	Petridish	2 sets
145	Pruning knife	1 set
146	Plaster of Paris	1 kg.
147	Ring and ball expansion	1 set
148	Retrot stand with clamp and Boss-head	2 sets
149	Rubber tubing assorted diam	10 meters
150	Rubber Ball	1
151	Rock specimen	1 box
152*	Silk cloth, 1/2 metre square	1 piece
153	Switches-electric, various types	2 each
154	Sugar	250 gms.
155	Shells	250 gms.
156	Spouting cylinder-metal	1
157	Spirit denatured	1 bottle
158	Spring Balance—500 grams	1
159	Screw model with nut	1

*May be improvised.

(1)	(2)	(3)
160	Screws assorted	12
161	Screw Driver	1
162	Solder	500 gms.
163	Soldering iron or bolt	1
164	Sand paper	2 sheets
165	Syringe-glass	1
166	Soap	1
167	Scissors	2
168*	Spirit lamp	2
169	Sonometer	1
170	Spatula (spoon)	2
171	Spirit level—8″	1
172	Steam Engine Model	1
173	Trough glass 10″ diameter	2
174	Tongs	2
175*	Test tube holder	2
176	Torch	1
177	Twine Ball	1
178	Test tube brush	2
179	Test tube stand	2
180*	Tin can	2
181	Thermometer 0-100° C	1
182	Thermometer 0-212° F	1
183	Thermometer Clinical	1
184	Thermometer Max. & Min (Six's.)	1
185	Thermometer alcohol	1
186	Rice/Wheat flour	250 gms.
187	Rock specimen (granite, quart, sandstone, mica, marble, slate stone)	1 box
188*	Rubber bands	6
189	Corks assorted sizes	12
190	Cork borer set	1
191	Rods of diffet. metals of same dimensions	6
192	Rain gauge	1
193	Rubber rods	2
194	Thermos flask	1
195*	Thermos flask broken	1
196	Tuning forks	1 (set)
197	Telegraph model	1
198	Telephone model (working)	1
199	Turbine model	1
200	Translucent paper (butter paper)	1 sheet
201	Transformer-model	1
202	Test tubes assorted sizes	48
203*	Tripod stand	3
204	U-tubes—12″ on stand	2
205*	Voltameter—on stand	1
206	Voltameter	1
207	Vaseline (White)	250 gms.
208*	Wind mill model	1
209	Water wheel overshot	1
210	Water wheel undershot	1
211	Wax sealing-rods	2
212	Wheel and axle mounted	1 (set)
213	Wire gauze	3
214	Wind vane	1
215	Weight Box 500 grams	2
216	Weights (brass) 500 gms.	1 (set)
217	Water bath 6″	1

*May be improvised.

(1)	(2)	(3)
218	Watch glass	3
219	Weights up to 5 kg.	1 (set)
220	Brewers Yeast	250 gms
221	Zinc coated iron sheets (galvanized) 6" × 6"	4

Charts

1	Aluminium-manufacture of electrolysis
2	Atom—structure of
3	Animals
4	Balanced diet
5	Blast furnace
6	Bessemer Converter
7	Birds
8	Circulation of blood
9	Condenser (electric)
10	Chain reaction
11	Cow mouth parts
12	Cow digestive organs
13	Cell division
14	Digestive organs
15	Day and Night
16	Dispersion of light
17	Disease producing bacteria
18	Elements
19	Earth-worm body structure
20	Eye-structure
21	Excretory system kidneys, skin and lungs
22	Eclipses
23	Fish—body structure
24	Fish—kinds of
25	Frog metamorphosis
26	Flower—parts of
27	Fertilization in flowers
28	First Aid:
	(*a*) Fire hazards
	(*b*) Electric shock
	(*c*) Drowning
	(*d*) Fractures
	(*e*) Cuts and Wounds bleeding
	(*f*) Artificial respiration
29	Flowers types
30	Heart structure
31	Heredity
32	Horse mouth parts
33	Horse digestive organs
34	Induction coil—structure
35	Long sight } Sight defects
36	Short sight }
37	Malaria and prevention
38	Movements of the Solar System
39	Nutritive constituents
40	Non-flowering plants
41	Nervous System
42	Nitrogen Cycle in nature
43	Oil engine structure
44	Ores and the elements they yield
45	Phases of the moon
46	Plant—parts of
47	Pollination
48	Postures

(1)	(2)	(3)
49	Roots types of	
50	Root nodules of leguminose plants	
51	Reptiles	
52	Snakes	
53	Stems—types of	
54	Snail—structure of	
55	Safety First	
56	Seed dispersal	
57	Relation between occupation and food requirement s	
58	Rules of the road	
59	Reflection of light	
60	Refraction of light	
61	Rocket Engine	
62	Respiratory movements	
63	Reflex action	
64	Solar System	
65	Seasons—how caused	
66	Seed structure	
67	Self pollination devices to prevent	
68	Steam Engine	
69	Sensory organs	
70	Skin—structure	
71	Turbine	
72	Tides, how caused	
73	Vitamins	
74	Ventilation	
75	Vegetables	
76	Wind mill	
	Chemicals	
1	Sulphuric acid (conc.)	500 gms.
2	Hydrochloric (conc.)	500 gms.
3	Nitric acid (conc.)	500 gms.
4	Sodium hydroxide (sticks)	500 gms.
5	Potassium hydroxide (sticks)	500 gms.
6	Ammonia liquor (0·88)	500 gms.
7	Sodium carbonate	500 gms.
8	Sodium bicarbonate	500 gms.
9	Sodium chloride	500 gms.
10	Magnesium chloride	500 gms.
11	Magnesium sulphate	500 gms.
12	Calcium chloride	500 gms.
13	Calcium sulphate	500 gms.
14	Marble chips	500 gms.
15	Lime stone	500 gms.
16	Shells	500 gms.
17	Potassium ntrate	500 gms.
18	Potash alum	500 gms.
19	Potassium permanganate	250 gms.
20	Potassium chlorate	500 gms.
21	Manganese dioxide	500 gms.
22	Magnesium wire or ribbon	250 gms.
23	Sodium metal	250 gms.
24	Mercuric Oxide	100 gms.
25	Zinc-granulated	1 kg.
26	Red Phosphorus	25 gms.
27	Yellow Phosphorus	25 gms.
28	D.D.T.	1 kg.
29	Bleaching powder	500 gms.
30	Plaster of paris	500 gms.

APPENDIX—V

Items of Apparatus to be improvised locally by Science Teachers in High Schools

Sl. No.	Apparatus	Item No. in the lists (given in Appendix III)
(1)	(2)	(3)
	A—*PHYSICS*	
	Mechanics	
1	Apparatus to show that liquids seek their own level	11
2	Pascal's law apparatus	16
3	Cartesian diver	24
4	Rain Gauge	25
	Heat	
5	Dry and wet bulbs hygrometer	38
6	In-gen Hausz's apparatus	39
7	Convection apparatus	43
8	Thermo-couple	45
	Light	
9	Periscope (small)	58
10	Kaleidescope	59
11	Newton's colour disc with rotating wheel	64
12	Pin hole camera	67
	Sound	
13	Resonance tube apparatus	76
	Magnetism and Electricity	
14	Pith ball pendulum	93
15	Apparatus to demonstrate the magnetic effect of current	96
16	Cells	99
17	Voltameter (Copper)	113
18	Model of a telegraph set	117
	B—*CHEMISTRY*	
1	Fire extinguisher (Demonstration Model)	16
2	Atomic Model	17
3	Diffusion apparatus (porous-pot)	62
4	Test tube stands	84
5	Sand bath	87
	C—*BIOLOGY*	
1	Simple auxionometer (with lever arrangemet)	7
2	Simple respiroscope	8
3	Simple potometer	9

(1)	(2)	
	Slides (Botany)	
4	Typical cell and content	105
5	Chlamydomonas	110
6	Spirogyra	111
	Slides (Zoology)	
7	Amoeba	116
8	Blood of frog	117
9	Blood of man	118
10	Hydra-whole mount	121
	Skeleton and Models	
11	Skeleton articulated (frog) Skeleton disarticulated (frog)	123
12	Frog's brain	124
13	Bird's brain	125

APPENDIX—VI(A)

Tools and Implements required for Workshops attarched to High Schools

Sl. No. (1)	Description of tool (2)	Quantity (3)
B 1	Hammers ball pein 8 oz.	2
2	Hammers cross pein 8 oz.	2
3	Hammers cross pein 4 oz	2
4	Hammer claw	1
5	Screw driver heavy duty 12″	1
6	Screw driver light duty 8″	2
7	Screw radio repairers thin 6″ with insulated blade	3
8	Screw driver (watch makers set of 3)	1 set
9	Pliers combination Mechanics 6″	3
10	Pliers long tapered nose 6″	2
11	Pliers needle nose round 4″	2
12	Cutting pliers 6″	2
13	Adjustable crescent wrench 10″	1
14	Adjustable crescent wrench 4″	1
B 15	Pipe wrenches 10″	1 (desirab'e)
B 16	Double ended spanners whitworth sires 1/8′ to 3/8′	1 set
17	Hacksaw frame (hand) 12″ with 24 blades-12″ × ½″×28 teeth	2
18	Fretsaw frame (wood) with blades	1
19	Panel saw wood 20″	1
20	Tenon saw 12″	1
21	Kay hole saw adjustable	2
22	Block plane metal 6″-2″ blade	2
23	Smoothing plane 10″-2″ blade	1
24	Side plane 6″	1
25	Chisels wood 1/2, 1/2″, ¾″ 1″	2 each
26	3/8″ cold chisels metal cutting	3
27	Hand drilling machine geared capacity 1/4″ drill	2
28	Twist drill bits parallel shank 1/16″, 3/32″, 1/8″, 5/32″, 3/16″, 7/32″ and 1/4″	1 set
29	Carborundom sharpening stone 6″×2″ (one side medium other side fine)	2
30	Sheet Metal Snipes (cutter or shears) 3″ cut	2
31	Scissors ordinary 10″	1
32	Scissors small pointed	1
33	Tweezers 6″	2
34	Centre Punch (Small)	3
35	Tweezers 4″	2
B 36	Crow bar small 24″ Carbon Steel	1
37	Clue pot double walled	1
38	Glass cutting pencil (diamond)	1
B 39	Circular washer cutter for leather, plywood, cardboard etc.	1
B 40	Hand driven (geared) bench grinding stone	1
41	(*a*) Soldering iron (electric where supply is available)	2
	or	
	(*b*) Burner where electricity is not available	1
42	Rosin cored solder wire	1 Lb.
43	Fluxite Soldering paste	1 tin.
44	Half Round wood rasp 10 or 12″	1
45	Flat Bastered file 10″	1
46	Half Round file 6″ (fine & medium)	2
47	Triangular file 4″ (fine & rough)	2

(1)	(2)	(3)
48	Round file 4″ (medium and rough)	2
49	Assorted needle files 16	4
50	Sheetmetal workers dividers	2
51	Wall Boards for tools	2
52	Work table heavy size 6′ x 2½ (or as according to space)	1
B53	Carpenters vice 6″ (to be fitted on work table)	1
54	Bench fitters' vice 2″ jaw (to be fitted on work table)	2
55	Jack knife	1
56	Tin opener	1
57	Leather punches set of 3	1 set
58	Ratchet brace carpenters with cutter bits	1
B 59	Hand vice small	1
60	'C' clamps—4″	2
61	Scriber steel	2
62	File handles	6
63	Wood mallet	2
64	Try squares 6″	2
B 65	Slide Bevel	1
B 66	Pin vice	1
67	Oil can (small)	2
B 68	Carpenter cramp 2½″	1
B 69	Multimeter (smaller or minor) (with 4 voltage and 3 or 4 ampere range A.C. and D.C.)	1 (desirable)
70	Folding rule carpenters 24″	1
71	Bevel Point skiving knife	1
72	Archimedian drill with set of bits for fine holes or watch-maker drills	1

NOTE:—

(*i*) Items marked 'B' may be purchased if adequate funds are available.

(*ii*) The items mentioned in the list would also be adequate for the workshops attached to Higher Secondary Schools.

(*iii*) Work-shop tools are strongly recommended for Middle Schools, if funds are available.

APPENDIX—VI (B)

Tools and Implements required for Workshops attached to Teachers Training Institutions

The following items are recommended in addition to the tools and implements already included in the school list (Appendix VI-A).

S. No	Description of Tool	Quantity
1.	'Wolf' electrical drill with a stand and lever to serve .	1
*2.	Cheap Indian made lathe complete with electrical drive size 3 or 4 ft. and 4-1/2 centre height with S.C. chuck and other usual accessories and a lamp	1
3.	Double ended bench grinding wheel for sharpening tools 1/3 H.P. motor and 6" × 3/4 grinding wheels suitable for hardened steel tools	1
4.	Light type of wood planner for 8" planks	1
5.	Spirit or petrol burner high temperature flame similar to Barthels for brazing small components like wires strips etc.	
	or	1
	Blow lamp (kerosene oil) with inclined burner . . .	1
6.	Turning Tools or high speed steel bar 1/2" or 5/8" square feet	6
7.	Knurling tool with holder	1
8.	Small forge with anvil and blower set	1
9.	Taps and dies B.A. threads with holders No. 6—No. 10 set	1
10.	Taps and dies m.m. size threads set	1
11.	Taps and dies set whitworth threads 1/16 to 1/4" set .	1
12.	Set of tongs and hot chisels, hammer etc. for smithy-set .	1

*Lathes made at Indo-German Prototype Centre, Okhla Industrial Estate are recommended).

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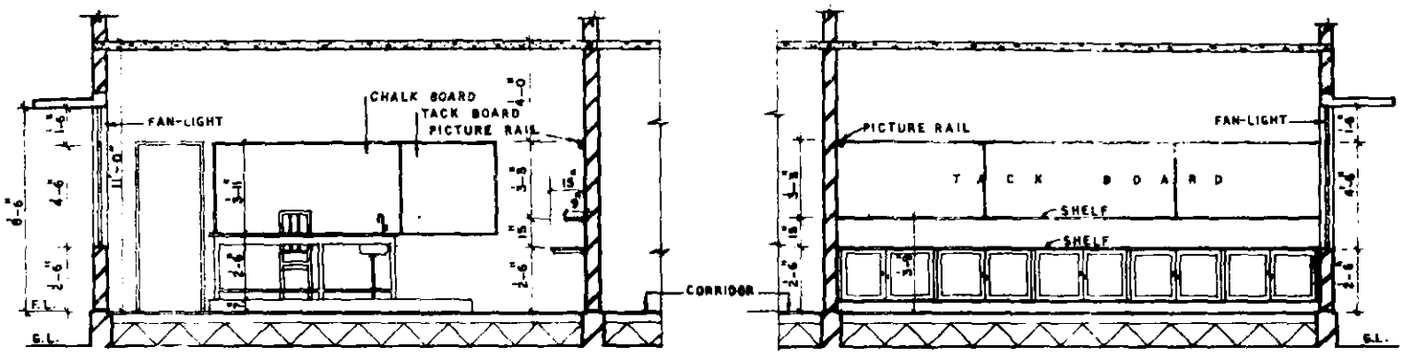
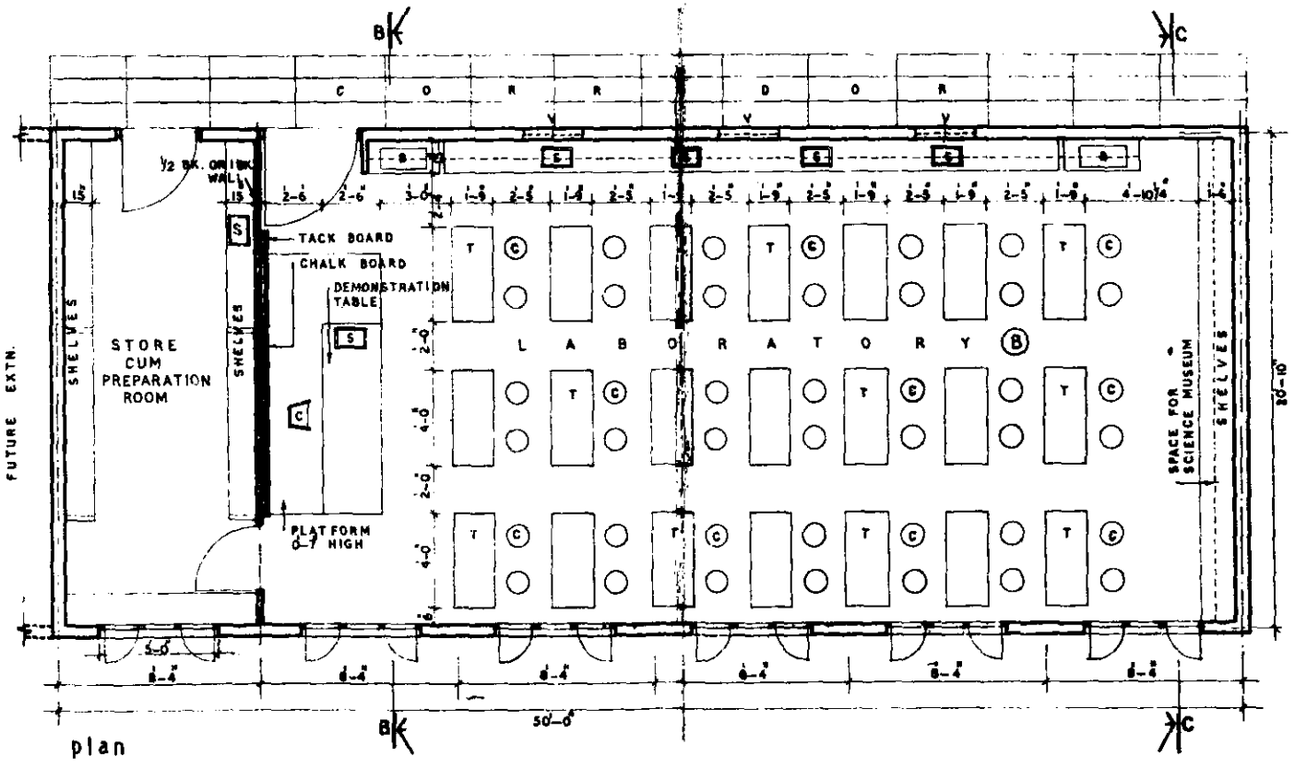


section at BB

section at CC



plan

PLATE I

NOTES

1. PLATES I & II SHOW ALTERNATE ARRANGEMENTS OF FENESTRATION THE ARRANGEMENT THAT SUITS THE CLIMATIC CONDITION, STRUCTURAL SYSTEM & GENERAL COMPOSITION OF THE DESIGN MAY BE FOLLOWED.
2. LABORATORIES SHALL HAVE BEAR NORTH–SOUTH ORIENTATION WITH VARIATION UPTO 30° ON EITHER SIDE TO HAVE THE ADVANTAGE OF PREVAILING BREEZE.
3. SPACING OF BEAMS/TRUSSES MAY BE EITHER 6'-4" OR 12'-6" AS IS ECONOMICAL FROM STRUCTURAL CONSIDERATION.
4. THE FIGURES DO NOT SHOW SIZES OF STRUCTURAL MEMBERS WHICH SHALL BE CALCULATED TO SUIT THE STRENGTH OF MATERIALS.
5. ALL SHELVES EXCEPT THOSE FOR DISPLAY SHALL HAVE HARD IMPERMIABLE SURFACE.
6. ADEQUATE TACK BOARDS SHALL BE PROVIDED FOR DISPLAY OF CHARTS ETC.
7. 4" HIGH SKIRTING SHALL BE PROVIDED IN LABORATORIES & STORES AND WALLS UPTO 3'-0" HEIGHT MAY PREFERABLY BE FINISHED IN OIL PAINT.
8. ALL WINDOWS SHALL HAVE IRON GRILL.
9. ALL VENTILATORS SHALL HAVE FLY-WIRE ON THE EXTERNAL FACE.
10. THE FIXED SHUTTER SHALL PROVIDE REBATE FOR OPENABLE SHUTTER OF WINDOWS & MULLION SHALL BE AVOIDED.
11. HEIGHT OF WINDOWS TO BE REDUCED TO DOOR HEIGHT LEVEL WHERE VENTILATORS INSTEAD OF FANLIGHTS ARE PROVIDED.
12. VENTILATORS SHALL BE PROVIDED AS CLOSE TO CEILING AS POSSIBLE.
13. FOR LONGITUDINAL SECTIONS AND FLOOR AREAS SEE PLATE II.
14. HEIGHT OF PRACTICAL TABLES IN LAB 'A' SHALL BE 2'-9" AND IN LAB 'B' 2'-6".

CONVERSIONS

FEET	MTS.
0'-1"	= 0.025
0'-1½"	= 0.038
0'-2"	= 0.051
0'-3"	= 0.076
0'-4"	= 0.10
0'-6"	= 0.15
0'-9"	= 0.23
1'-0"	= 0.30
2'-0"	= 0.61
2'-6"	= 0.75
3'-0"	= 0.91
4'-0"	= 1.22
5'-0"	= 1.52
8'-0"	= 2.44

REFERENCES

S —— SINK
B —— BALANCE
T —— PRACTICAL TABLE
C —— SEAT

N

*AREAS

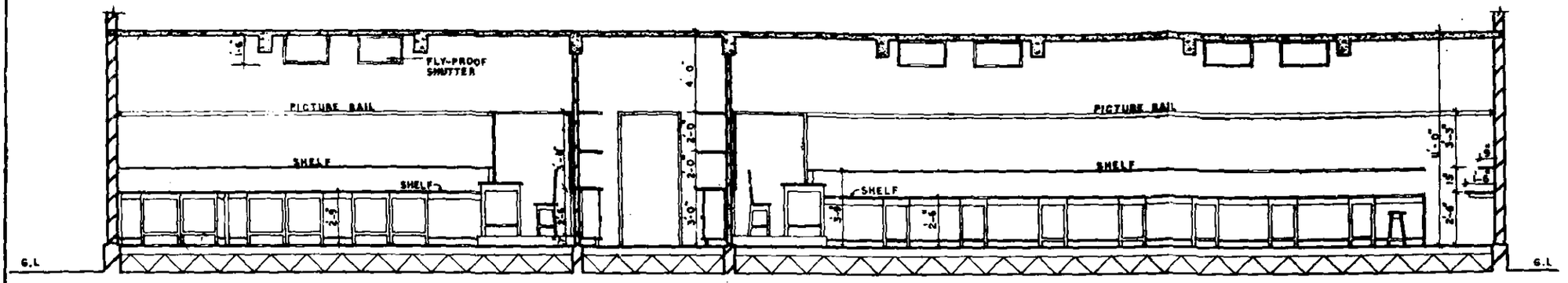
	TOTAL		/SEAT	
	SQ. FEET	SQ. MTS.	SQ. FEET	SQ. MTS.
LABORATORY B.....	625.0	58.0		
STORE.....	160.0	15.0		

1:50 / 2 3 4 5 6 7 8 FEET

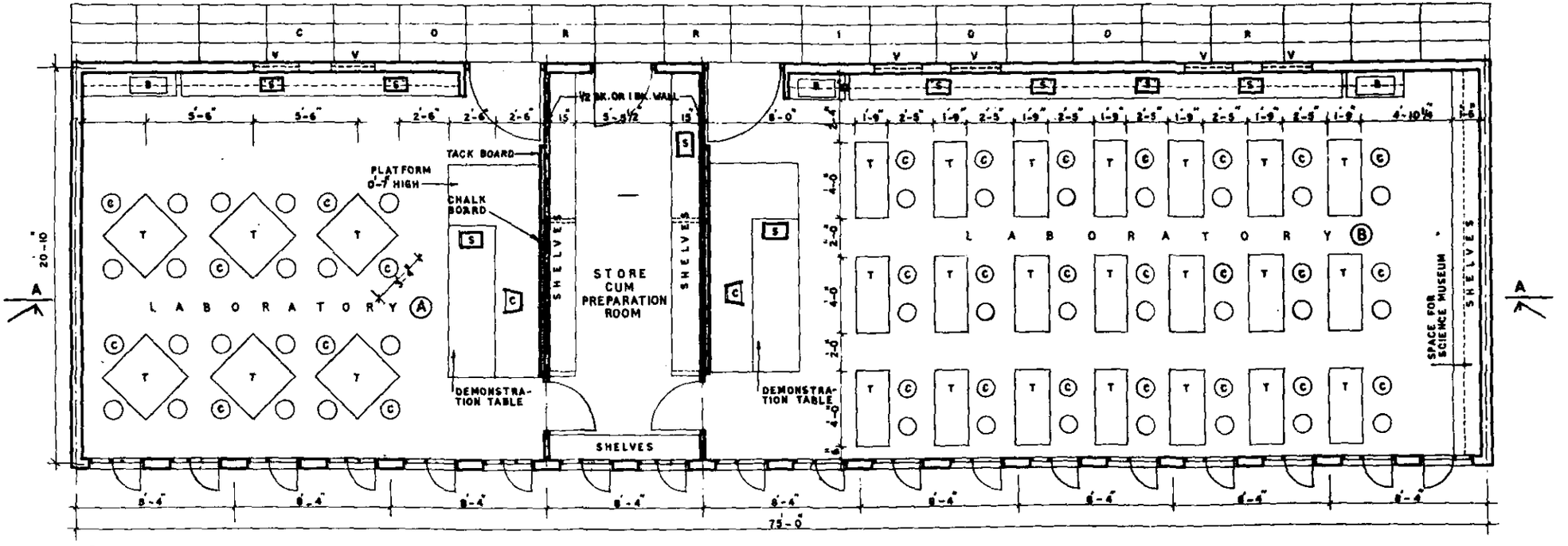
SCIENCE LABORATORY IN HIGH SCHOOLS

SUGGESTED LABORATORY DESIGN

(PREPARED IN "NATIONAL BUILDINGS ORGANISATION" FOR THE PANEL FOR SCIENCE EDUCATION IN SECONDARY SCHOOLS, COMMITTEE ON PLAN PROJECTS, PLANNING COMMISSION.)



section at AA



PLAN

*NOTE
FOR CROSS SECTIONS, REFERENCES, CONVERSIONS & NOTES SEE PLATE I.

*AREAS

	TOTAL		/SEAT
	SQ. FEET	SQ. MTS.	SQ. FEET.
LABORATORY A.....	490·0	45·5	20·4
LABORATORY B.....	825·0	76·8	19·6
STORE.....	160·0	14·9	2·4

SCIENCE LABORATORY IN HIGH SCHOOLS

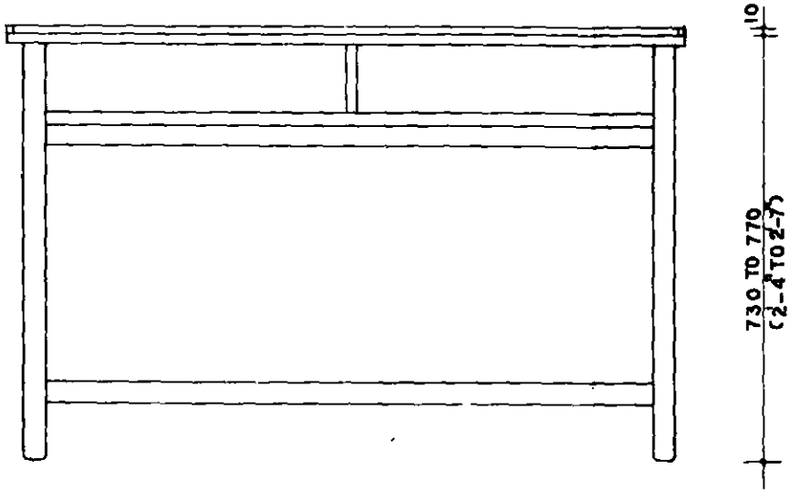
SUGGESTED LABORATORY DESIGN

N

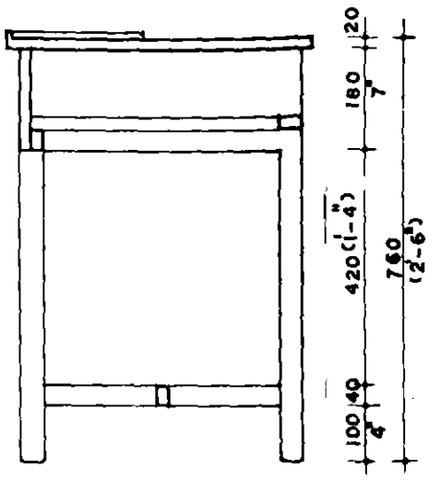
1:50 1 2 3 4 5 6 7 8 FEET 15

(PREPARED IN "NATIONAL BUILDINGS ORGANISATION" FOR THE PANEL FOR SCIENCE EDUCATION IN SECONDARY SCHOOLS, COMMITTEE ON PLAN PROJECTS, PLANNING COMMISSION)

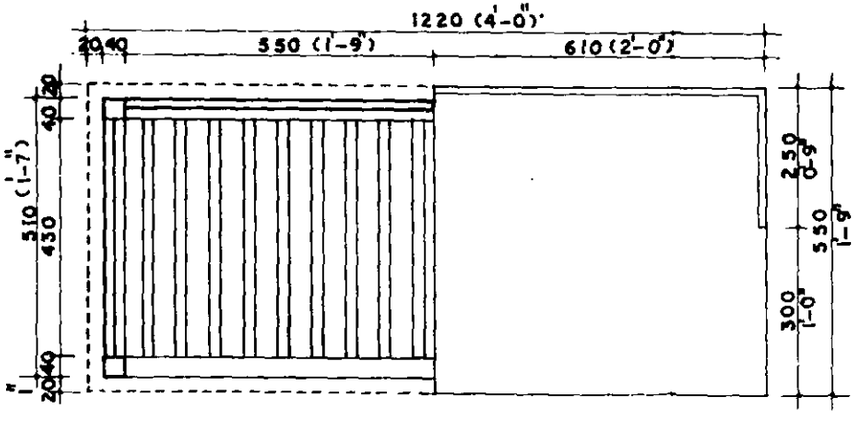
PLATE III



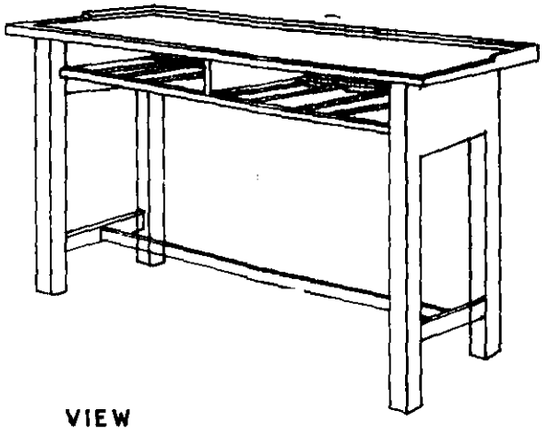
FRONT ELEVATION



SIDE ELEVATION



PLAN



VIEW

note:- all dimensions are in m.m.

LABORATORY TABLE

AS RECOMMENDED BY UNESCO EXPERTS TEAM