PROPOSALS FOR THE IMPROVEMENT OF GENERAL SCIENCE TEACHING IN THE SECONDARY SCHOOLS OF WEST PAKISTAN

By

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SCIENCE TEACHING

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TABLE OF CONTENTS

CHAPTERS PAGE

LIST OF TABLES

LIST OF FIGURES

PAGE

CHAPTER IV

Figure

PAGE

CHAPTER IV

Figure

CHAPTER V

Figure

PAGE

CHAPTER VI

Figure

CHAPTER VII

Figure

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ABSTRACT

The purpose of this thesis is to provide practical suggestions for the improvement of the teaching of general science in the secondary schools of Pakistan. The method is first to analyse the present conditions in order to bring out the shortcomings that exist in the teaching of general science today in the schools of Pakistan. In order to give some concrete basis for assertions concerning the conditions of science teaching in Pakistan, a questionnaire to thirty Pakistani students studying at the American University of Beirut was used. The responses to the questionnaire and information derived through other sources revealed that science teaching in the Pakistani schools emphasizes mainly memorization of text book facts and figures without attention to understanding. Science learning is heavily dependent on verbalism and little or no use is made of practical laboratory work. The use of reference materials, demonstrations and other audio-visual aids is negligible, making the learning dry and uninteresting.

It has been pointed out in this thesis that:

1) instead of the verbalistic memorization of the text book content, the goal of science teaching should be the acquisition of the major scientific concepts which lead to real understanding.

2) Science teaching without practical work puts too much reliance on the visualizing capacity of the learner in the absence of the concrete.

3) Inward visualization of theoretical learnings is likely to be very much clearer when the learner experiences them in practical situations.

4) Practical work is of very limited value unless the students formulate and do the experiments for themselves. Mechanical following of text book experiments is too unrelated to genuine scientific inquiry.

5) An individual science teacher can implement his science teaching with demonstrations and simple experiments so as to make science learning vital and meaningful to the students. Building an adequate supply of science teaching materials and equipment is therefore a necessity if science teaching is to be materially improved in Pakistani schools.

One task of this thesis has been to show how an individual science teacher can achieve this with very little expenditure of money. The absence of the use of reference materials in teaching makes the use of modern techniques of teaching like group and individual projects etc. almost impossible. Experience in teaching shows that these techniques not only make learning interesting but also speed up the process. These techniques call upon the students

CHAPTER I

INTRODUCTION

It was only a few years ago that general science was made a compulsory subject in the secondary school syllabus of Pakistan. The first students to be examined in general science were those who took the matriculation examination in 1955. Before this general science was available only as an elective. Very few schools were equipped to teach science.

The sudden inclusion of compulsory general science in the syllabus did not bring about any real change or addition to the traditional school program. The schools accepted this new obligation without going through much physical preparation at all. In fact most of them merely added science personnel to the teaching staff. The schools thus started teaching general science in the same traditional way as other subjects such as English and mathematics. Either it did not occur to them that some additional physical facilities are necessary for adequate science teaching, or they did not have the professional guidance or money for such additional facilities. The result is that most of the schools are teaching science today not only without any laboratory facilities but also without the help of any audio-visual materials such as models and charts. Even books are often lacking.

Some of the more fortunate schools do have a few chemicals and some equipment, but these schools are very few in number and are usually attended by selected students coming from wealthy homes. So the only way most students learn science is by verbalizing scientific terms, laws and theories without ever developing a real taste or feeling for science. The result is that science becomes a difficult subject to pass in the matriculation examination, and only those with strong memories can retain the textbook information long enough to reproduce it on the examination paper.

Building up an adequate supply of science teaching materials is a necessity if science instruction is to be materially improved in Pakistani schools, and this thesis proposes to demonstrate that this need not be costly. Furthermore this thesis proposes to demonstrate that the organization of the curriculum in use in the schools of Karachi causes much time to be wasted, and that a properly reorganized curriculum could be taught more efficiently in about half the time now alloted for science teaching, with a gain rather than a loss in material covered and comprehended. The official syllabus contains many meaningless repetitions. These repetitions are sometimes obvious, while sometimes the same content appears in a different phraseology. Sometimes related material is presented in such a disjointed, scattered fashion that the teaching time for it is possibly trebled. Much less time would be spent if topics were presented as single organized units.

It is also a purpose of this thesis to bring to the reader's notice the fact that the employment of some of the more modern techniques of teaching also speeds up the learning process. Special reference has been made to the use of both group and individual project techniques. In such practices

> "The emphasis shifts from the primary responsibility of the teacher to that of the pupil in the actual process of learning."[1]

In the group project technique the problem under study is divided up and student groups, temporarily independent, work on the various aspects according to their interests and later share their experiences with the entire class. This way not only is the monotony of continuous class lectures by the teacher avoided, but also more ground may be covered in the same time. This is primarily because the time wasted on the verbal recitation of the paragraph assignments of the textbook is saved.

It is believed that the entire general science curriculum now prescribed for classes VI, VII, VIII, IX, and X could be easily taught in two years. Classes VIII and IX are probably suitable years for studying such a general science curriculum. Students by this time are fourteen to fifteen years old and their attention span is long enough to be devoted to the work needed for scientific enquiry. In many other countries this is felt to be a suitable age for the study of science. Thus two academic years of study of general science with an average of four hours of work a week

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[1]Nelson L. Bossing, Teaching In Secondary Schools, 1952, p.120.

(instead of three hours a week for five years) is recommended. Some samples of the way the curriculum content may be organized and presented so as to achieve this more concentrated program are given in the final chapters of this thesis.

Statement Of The Problem And Need For The Study

One of the major purposes of the general science program of the secondary schools of Karachi is to let the students get the real feel of science through first-hand experience, so that they can learn to recognise scientific principles at work in their environment. They should also learn to live as harmoniously as possible in the changing scientific world. The most important learning activities for the understanding of science are those which help the students to develop concepts. It is only when the major concepts of science are clearly formed in the mind of the pupil that he begins to understand and feel the impact of the vast, facinating realm of science. The formation of a picture of the meaning of a relationship, situation or fact in the mind is called concept formation.

> "In science there are many words and terms such as fruits, seeds, atom, molecule, energy, work, friction etc. If a word is to be a tool it must mean something. The meaning of a word is a concept, Too frequently for the students these concepts are rather hazy and vague whereas they should be of very clearcut form in the mind. Much of this is the result of too much verbalism. Scientific terms are learnt and repeated without the pupils having the proper sensory experiences."[2]

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[2]Heiss, Obourn and Hoffman, Modern Science Teaching, 1954, p. 43.

Brandwein stresses the importance of concept formation in science learning. According to him

> "concept formation is the intent of science and concepts formed are its contents. When this intent and this content are fused in teaching, effective education in science is approached."[3]

If the teacher is to teach science with the aim of concept-formation he will have to change from the streotyped autocratic teacher of conventional times to a teacher who counsels and stimulates and serves as a guide to the self-enquiring students. Direct teaching, though it has its value, is given less prominence. Learning excercises and experiences (first-hand or otherwise) should be provided that will stimulate pupils to learn. This type of planning and teaching will eliminate much dry verbalism. The teacher helps a student most to form correct concepts when he allows the student to think through and solve his own problems. The clearest concepts are usually those which are formed through first-hand experiences. It is very difficult indeed for the learner to form concepts about various laws and theories of science unless he experiments and sees for himself. The need for this method of learning science through direct experience and conceptualisation is also stressed in the Karachi secondary school syllabus. The objective set up for the syllabus firmly advocates the use of teaching techniques which call for the avoidance of verbalistic learning and encourage maximum student participation. However, a careful examination of the syllabus introduction which follows will show that the carefully worded

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[3] Brandwein, Watson and Blackwood, A Book of Method, 1958, p. 109.

to carry on independent work according to their interests and later to share their experiences with the whole class.

It is believed that the present general science curriculum now prescribed for classes VI, VII, VIII, IX, and X could be taught in two years. This however calls for the reorientation of the present disjointed curriculum. Effective learning will take place only when the required content is presented as complete, interrelated units with the adoption of a reasonable time-schedule in place of the present practice of spreading a topic thinly over a five-year sequence. Another task of this thesis is to show how this can be done. Chapters IV, V, VI, and VII are sample units on selected topics in general science, namely Electricity and Magnetism, Heat, Sound and Plant Life. Each Unit carries with it detailed instructions for the teacher for the teaching of its contents as an inter-related unit. Instructions for making simple equipment and setting up inexpensive, locally available apparatus for practical demonstration and experimentation are included in all the units. It is felt that the best learning occurs when teacher and students build the equipment and perform experiments cooperatively.

It is further felt that the formal examinations presently given to the students by teachers and government test only the ability to memorise facts and figures, and not the ability to understand. Samples of tests prepared to examine the comprehension and the ability of the students to apply school science to everyday life accompany two of the units.

objectives are hardly in keeping with the syllabus requirements. The samples of the syllabus which appear in the last chapters will show that such objectives cannot hope to be achieved when teachers are obliged to follow such a limited, disorganized curriculum. It is nevertheless pertinent here to quote some of the objectives of the general science syllabus for classes VI-VIII of the Karachi Secondary Board Of Education in order to point out the direction which desirable science teaching should follow.

> "To arouse the interest of the pupil in relation to his environment and impart such knowledge of natural laws and their applications as would make him feel at home in the universe.
> "To stimulate his curiosity and lead him to inquire into the working of nature as he finds it: in other words, to develop in him the scientific attitude towards nature and its working in his every day experience - the attitude of observing, experimenting and generalising on the basis of ascertained facts.
> "Practical work with the full cooperation of the pupils should be aranged to give a realistic touch [sic!] to the study of the subject.
> "Many of the experiments can be performed by the boys with the help of the articles available in their homes or obtainable in the market very cheap. For instance ordinary bottles can be used in place of flask, rubber tubes in place of glass delivery tubes and suitable bottles for gas jars. Once pupils develop interest they will be able to make electrical cells, electrical bells and many other things of practical use in their daily life."[4]

As was said earlier in spite of all these well-intentioned aims, it is common knowledge that the actual science teaching in Pakistani schools falls far short of these objectives.

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[4]Prospectus, Curriculum and Syllabi For Secondary Schools Of Karachi, 1956, pp. 155-156.

A systematic analysis would help to pin-point the weaknesses that exist in the present condition of science teaching in Pakistani secondary schools. Once these weaknesses are detected, tentative solutions can be proposed for them.

The seven numbered paragraphs appearing below are an attempt to summarise the existing weaknesses of the science teaching in the secondary schools of West Pakistan today.

1) Science teaching is becoming more and more verbalistic, and the final goal seems to be the mechanical memorization of the textbook contents on the part of the students, whereas the goal of real science teaching should be the acquisition of the major scientific concepts which lead to real understanding.

2) Verbalistic practices are the result of the passive role that the students play in the teaching-learning situations. School science becomes more and more remote to them as they are given almost no opportunities to learn in any ways which call for direct participation.

3) The theories and principles of science are not well retained in the mind because the students have not been able to visualise the concepts in their minds.

4) Lack of any reference materials make the use of procedures like projects, reports, research etc. almost impossible.

5) The impoverished condition of the schools does not allow the acquisition of even the most basic scientific equipment for laboratory and demonstration work, which is available commercially. Simple equipment which perfectly illustrates the principles under study can be built by the teacher and students with very little expenditure.

The aims of this study may be summarized as follows:

1) To analyse the educational problems arising from traditional methods of science teaching used in Pakistan and to propose certain appropriate solutions.

2) To show how an individual science teacher can implement his science teaching with demonstrations and simple experiments so as to make science learning vital and meaningful to the students.

3) To explore ways in which simple science experiments with inexpensive materials can be performed. The use of simple articles in experiments and demonstrations is not only financially advantageous but also optimum for obtaining real understanding of scientific concepts. Equipment which is very complicated is not only too expensive for most of the schools to afford, but it also often hides what goes on inside it, and by its shiny appearance suggests that science is imported, finished, and unattainable by the ordinary person. A simple hand-made piece of equipment, on the other hand, not only illustrates the principles very clearly but also merges science with ordinary life. All of the suggestions made in this study are designed so that it is possible to put them into practice within the limited resources available to an average science teacher in the secondary schools of Karachi.

4) To demonstrate that the existing science syllabus can be re-organised to be taught more efficiently in about half the time now alloted for it.

5) To propose that the employment of some of the more modern

techniques not only result in more durable learning based on understanding but also speeds up the learning process.

Method of Study

In order to give some concrete basis for assertions concerning the conditions of science teaching in Pakistan a questionnaire was prepared and given to thirty Pakistani students studying at the American University of Beirut. The questions sought answers to questions in two main categories, as follows:

a) The conditions of science teaching in secondary schools, especially teaching techniques employed, facilities available, and qualifications of the teachers.

b) The attitudes of the science teachers towards science teaching and the students.

A detailed analysis of the responses to each question appearing in the questionnaire followed by comments, is given in Chapter II.

The content of a letter received from the director of Karachi board of secondary education in reply to the above enquiry has also been used to provide a basis for assertions about science teaching in Pakistan.

The simple experiments with illustrations and instructions which form the body of the sample units have been drawn from the resources found in the library of the American University of Beirut and from science textbooks in use in schools in Beirut.

The proposals given for improving the present science teaching conditions in schools of Pakistan are based on pertinent literature in the library of the American University of Beirut, and in part on direct personal teaching experience (in connection with practice-teaching work in the Department of Education) in the International College, a secondary school affiliated with the American University of Beirut, and in the American Community School of Beirut.

CHAPTER II

ANALYSIS OF PRESENT CONDITIONS OF SCHOOLS

Questionnaire Responses, Analysis, and Comments

The questionnaire was designed to obtain a sample of comments and views about the present condition of science teaching in the secondary schools of West Pakistan from students who had experienced them directly. Some of the questions concerned general conditions while others required more specific answers. The main stress was laid on the teaching methods employed and the attitudes of the teachers and students towards science teaching and learning.

The sample consisted of a total of thirty students of both sexes who studied science in high school in West Pakistan. These students are at present studying at the American University of Beirut. The sample was limited to those thirty five students who are at present studying at the American University from West Pakistan and who happened to have taken general science in secondary school. Of these, thirty responded. Their average age was 20.8 years, ranging from 18 to 24. The average number of years of science taken by them in high school was 4.26 years, the range being from 2 to 7 years. The secondary school syllabuses of West Pakistan generally prescribe about four years for the study of general science, so it is probable that some of the students reported more than the usual four years because they included some elementary school years as secondary school years. The secondary school syllabus of the Karachi board prescribes general science for classes VI, VII and VIII of the lower secondary and classes IX and X of the secondary school.*

Questionnaire Responses In Detail

The responses to each question appearing in the questionnaire are analyzed, commented upon and presented in tabular form in this section.

The responses to the question "Did your secondary science teacher/teachers seem to you to have had special training for teaching science?", appear in Table I.

TABLE I

RESPONSES CONCERNING APPARENT SCIENCE TEACHER TRAINING AS JUDGED BY THE STUDENTS

Response	Number of Responses	Percentage
Yes	19	63 %
No	11	37 %
Total	30	100 %

This question was most probably not accurately understood. The question was designed to find out whether the teacher seemed

*No reference has been or will be made in this thesis to the general science syllabus which it is planned to prescribe for the higher secondary classes, XI and XII.

to the students to have had teacher training, but was probably often understood to ask whether the teacher had a university degree in science. This belief is further supported by the responses of the same students to the questions inquiring about the kinds of teaching methods employed by their teachers. It is not consistent that well-trained teachers should be reported as resorting so completely to traditional practices. Thus it is reasonable to deduce that most of the positive responses affirm the academic qualifications of the teachers rather than their training in science teaching. It would indeed be foolish on anyone's part to claim that science can be well taught without the teacher having mastered the subject matter. However it is also true that perfect mastery of the facts and principles is only a poor qualification of a teacher if he lacks the art and techniques of good teaching. It should be added at once that teacher-training itself does not guarantee good teaching. In fact teacher-training programs in some countries are not very likely to be of great assistance to the teacher in the practical application of her mastery of subject matter. All that is done in some of the teacher-training colleges in Pakistan is the additional accumulation of verbalistic learning, with the subject this time being mainly education. This was the impression of some teachers who are now studying in the Education Department of the American University of Beirut and who have taken the nine-month teacher-training courses in Pakistan.

The next question on the list was phrased thus: "Did you use a separate laboratory for practical work in your school?". The following results were obtained.

TABLE II

RESPONSES CONCERNING THE USE OF A
SEPARATE LABORATORY FOR
PRACTICAL WORK

Response	Number of responses	Percentage
Yes	19	63 %
No	11	37 %
Total	30	100 %

Information obtained from the Karachi Board of Secondary Education also affirms such a condition. The "yes" responses do not, of course, reveal whether the available laboratory space is in proportion to the size of the school and how often is it used. In most of the schools the laboratory space can hardly be said to be adequate for even one small class at a time. When, as is common, the student body is large and the facilities meager, there is little but chaos and confusion during the laboratory hours. In such cases students possibly gain much more from a theoretical lecture than from a laboratory period.

The next question drew forth very revealing responses which not only shed light on the preceding analysis but also indicate the direction which the teaching-learning practices are inclined to follow. To the question "About how often were you asked to do practical work with your own hands in connection with science courses?", the following responses were obtained:

TABLE III

RESPONSES CONCERNING THE FREQUENCY OF PRACTICAL WORK UNDERTAKEN IN SECONDARY SCIENCE COURSES

Response	Number of responses	Percentage
Never	5	17 %
Once a year	4	13 %
Once a month	7	23 %
Once a week	8	27 %
More than once a week	6	20 %
Total	30	100 %

The table shows that more than half the students reported that practical science work by students was rarely or never undertaken in school. About 53 % of the responses fell in the category where there was practical work only once a month or less. About 33 % of the same category (five cases) reported never having done any practical work at all throughout their school life. As Brandwein, Blackwood and Watson point out,

> "perhaps it is better to think of science as a verb rather than as a noun. It might be better to think that science is more concerned with processes by

> which a body of reliable knowledge is obtained rather than the resulting body of knowledge itself. The educational implications of this attitude would be that science is consequently the ways in which scientists seek concepts."[5]

Scientific concepts are best sought and formed through first-hand experiences. Concept formation becomes easier when more than one sense is aiding the learner. Thus for example the learner with only the aid of verbal illustrations of the reaction of zinc with sulphuric acid will have a very poor concept of the whole reaction. On the other hand if he has had actual practice in making hydrogen in the laboratory, then he has a clear idea of how the reaction takes place, the nature of hydrogen gas and so on. This way, once he forms the concept, he is not likely to forget the reaction, though he might not be able to report it in the exact words of the book. Science teaching without practical work puts too much reliance on the visualizing capacity of the learner in the absence of the concrete. Science learning tends to remain purely verbal unless the learner is able to associate sense impressions with what has been learned. It is only then that he is able to put together the whole picture or pattern. Inward visualization of theoretical learnings is likely to be very much clearer when the learner experiences them in practical situations.

The next question invited responses concerning the character of the practical work that the students performed and also comments

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[5] Brandwein, Watson and Blackwood, _A Book of Methods_, 1958, p. 11.

about their overall reaction and attitude towards such practices. In addition to checking the check-list of types of practical work, respondents indicated whether the students were generally enthusiastic or unenthusiastic about their practical work and also gave their reasons for such enthusiasm or lack of enthusiasm. Of those who reported any practical work at all, more than half said that their practical work consisted solely of following experiments written out in the textbooks. This practice is generally followed by the majority of the schools in Pakistan. The next in succession was the teacher-planned experiments. Thirty seven percent said that they had followed this practice in laboratory work. Sixteen percent of the students reported to have done no practical work at all. This is not surprising, as there are numerous schools which have absolutely no facilities for practical work. Their only aim is to prepare students for the matriculation examination. Because the students are not examined in laboratory work the school administrations do not think it necessary to indulge in such expensive practices.

Eight percent of the sample reported having done practical work involving pupil-planned experiments. It is to be noted, however, that these students did not go to ordinary secondary schools. Two of them studied in Army Cadet school and one in the Experimental School set up by the Provincial Ministry of education. The table of responses appears below:

TABLE IV

RESPONSES CONCERNING THE NATURE OF PRACTICAL WORK

AND REACTIONS TO PRACTICAL WORK

Nature of activity	Number of Responses	Percentage
Followed experiments in text books	17	46 %
Followed teacher-planned experiments	12	32 %
Followed pupil-planned experiments	3	8 %
No practical work	5	14 %
Total	37	100 %
Students were enthusiastic about doing practical work	18	60 %
Students were unenthusiastic about doing practical work	7	23 %
No response	5	17 %
Total	30	100 %

The reasons for enthusiasm were given as follows:

1) Five students felt that the laboratory work became interesting because of their able teacher. The practical classes were always well planned in advance and the discussion and explanation which preceded practical work always aroused the curiosity of the students.

2) Two students felt that they were intensely interested in laboratory work as they themselves set up and planned the experiments. The teacher only acted as a guide.

They were very interested to see whether their experiments would prove to be successful.

3) Ten respondents gave the novelty of the experience as the reason for enthusiasm. They had so very few chances to do practical work that the enthusiasm was high whenever the students had the opportunity to avoid studying the usual theoretical matter. They were also curious to see the theory in practice. In the words of one of the students, "Great emphasis was given on the textbook and lectures whereas the students desired to do practicals with their own hands."

4) One student felt that students were interested in science as such because of the rapid progress that has been made in science, about which boys heard so much.

The reasons for <u>lack of enthusiasm</u> were given as follows:

1) Five students felt that lack of facilities and poor teaching techniques were the reasons for lack of enthusiasm. Students were never prepared before-hand. They knew nothing about what was going on. They only observed the teacher doing the experiments.

2) One student felt that the main reason for lack of enthusiasm was that they had to follow textbook experiments. They knew the answers from the beginning. It was very monotonous.

3) One student reported the cruelty of the teacher as being the main cause. He used corporal punishment frequently.

The worthlessness of practices such as following experiments in textbooks is apparent, and yet many schools today still follow this age-old practice. As Burnett points out, in such practices

> "the laboratories cannot be said to emphasize the development of scientific attitudes or critical abilities. A student is sent to the laboratory to find, with inadequate instruments, answers that he knows in advance or that he knows are in the teacher's notebook. The student does not determine the coefficient of expansion of a piece of metal by recourse to nature. On the contrary, he goes to the laboratory to see how closely he can get nature to conform to the "right" answer that is somewhere in an answer book. The answer is, for the student, an arbitrary and authoritarian answer. Thus laboratories are places where students often engage in the rather dubious game of checking as closely as they can against the (to them) arbitrary and unchallengeable authority of science."[6]

In the modern view, then, the laboratory is the place where the students find out answers for themselves and not a place where they tamely follow steps which lead to the already stated answer.

In reply to the next question, "In about what percentage of your assignments did your teacher provide you with or urge you to use science reference materials outside of the text books?", the response was six percent on the average, the range being from zero to 40 percent. It is to be noted here that twenty-one out of thirty students reported zero percent. This is very usual

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[1]Will Burnett, <u>Teaching Science In The Secondary School</u>, 1957, pp. 32-33.

in schools of Pakistan where great stress is laid on the text. In fact the textbook and the knowledge of the teacher are, in general the sole authorities for imparting knowledge to the ignorant students. The glaring shortcomings of the exclusive use of the textbook in teaching become clear when one considers the fact that the knowledge concerning any area has become too voluminous and too diversified for it to be condensed in any one textbook. As Bossing puts it,

> "It is almost impossible to find two textbooks in any given subject where the content is identical."[7]

If such is the case, then the exclusive use of any one textbook acquaints the student with a very limited area of knowledge. This way the student is never given the chance to come into contact with the representatives of varied viewpoints and a wider wealth of factual materials. This shortcoming is best overcome by encouraging and teaching the students the ability to search out, judge and select information and knowledge for themselves. The passive attitude which is now encouraged in school is likely to prove to be a great hindrance in students' future lives. In a world full of diversified opinions and attitudes there is no one authority that students will be able to look up to as the sole authority. They have to have the ability to search out information and judge its relative worth for themselves.

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[7]Nelson L. Bossing, Teaching In The Secondary Schools, 1952, pp. 33-34.

The next question asked for the percentages of class periods that the teachers devoted to various teaching methods. As was expected, a very high percentage was reported to be devoted to lecturing, and the time devoted to modern techniques of teaching was insignificant. The following table will clarify the point.

TABLE V

RESPONSES CONCERNING THE PERCENTAGES OF CLASS PERIODS DEVOTED BY SCIENCE TEACHERS TO VARIOUS TEACHING METHODS

Activity or method	Average percentages of class time (30 responses)
1) He delivered lectures	67 %
2) He used materials to demonstrate the lesson to the class	13 %
3) He checked whether the pupils were able to repeat the statements of the text book	13 %
4) He asked you to observe, experiment with your own hands and draw inferences	5 %
5) He conducted field trips	0.6 %
6) He organized group activities	0.5 %
7) Other activities	0.9 %

Three fourths of those who checked "other activities" reported their major activity to be "copying notes from the black board", or words to the identical effect.

This table is quite consistent with the time-honoured

Authoritarian teaching methods that are practiced in the schools of Pakistan. These older methods conceive the child to be

> " A pliable organism with great potentialities for receiving impressions from without through the sense mechanism who is chiefly to be taught as a passive recipient of verbal and visual impressions."[8]

The teacher imparts knowledge through lecturing and the child's part is just to listen passively, memorise and repeat accurately what he had learnt. This practice of exclusively depending on lecturing is based, according to Cronbach, on the

> "theory of learning by absorption. Such a theory stresses the importance of giving the students new interpretations. The teacher presents and the student is the listener, a reader or a note taker. The lecture method demands little practice by the student. This type of teaching ignores the following facts - a) people retain very little of what they see and hear unless they do something with the material. b) If the material is presented verbally, the person who remembers it may not recognise actual situations where the verbal principles apply. He can know the words describing the right actions without knowing how to act. c) Unless the person tries to make new responses using the information presented he may think he understands when he actually misinterprets the ideas or has forgotten an important part."[9]

Emphasizing the dynamic nature of teaching and learning, Yoakam and Simpson say that

> " teaching is not merely a process of imparting knowledge to students but it consists primarily in directing the pupil and encouraging him towards effort in learning. This guidance is done by suggestions rather than command, and by the creation of situations which naturally lead to desired types of activity. Good teaching

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[8]Yoakam and Simpson, Modern Methods And Techniques Of Teaching, 1948, p. 16.

[9]Cronbach, Educational Psychology, 1954, p. 56.

> opens up fields of investigation, it introduces new materials, it suggests methods of procedure and it aids the individual to estimate his progress."[10]

The next item in the questionnaire was a check-list to assess the students' impressions of their science teachers. The list included traits prevalent in teachers of rigid, authoritarian attitudes as well as traits of open minded, democratic teachers. The students were asked to check one or more of these traits which they thought were typical or their secondary science teachers. The most noticeable outcome was that more than three fourths of the students checked those items which are typical characteristics of a teacher of rigid, traditional, authoritarian practices. As the item moved in the direction of modern, open-minded, democratic practices there were fewer and fewer responses. The following table shows this in detail:

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[10] Yoakam and Simpson, op. cit., p. 11.

TABLE VI

RESPONSES CONCERNING STUDENTS' IMPRESSIONS OF

THEIR SCIENCE TEACHERS

Characteristic traits of teacher	Frequency of responses from thirty students	Percentage of responses
1) He behaved as though he knew everything	14	27 %
2) As a science teacher he could not make any mistakes and pupils had to accept anything told them as absolute truth	11	21 %
3) He made clear to us that no teacher's education can ever be complete; that a teacher needs to study all the time to keep up to date	10	20 %
4) He taught in a way that said "a teacher should always be willing to try out new methods and procedures, and should encourage experimentation and questioning attitude in pupils".	8	16 %
5) He taught in a way that said "a teacher should always have an open mind susceptible to new ideas and suggestions, and pay them due credit."	5	10 %
6) He let it be known that pupils need to study additional reference materials to supplement what they study in class	3	6 %
Total	51	100 %

Fourteen out of thirty students of the sample checked the item which said that their teacher behaved as though he knew everything.

These teachers have yet to realise and accept the stark reality that there has been so much advancement in every field of life (especially in science) in this modern world that it is impossible for any teacher to know even a particular part of his subject matter entirely, let alone the whole subject. The more one comes to know, the more there is to know. Most of these traditional teachers may have been teaching for a span of many years and they continue to teach in the same way year after year. They do not realise that since the time of their school days a great deal has been added to the store-house of knowledge. But very seldom do they care to discover it. To quote the letter received from the Director of Education, Karachi,

> "Reference books and magazines etc. are present in school libraries especially in government schools, but they are not generally consulted by students and very rarely by the teachers."

This is why in-service training becomes a necessity, if teaching is to be improved at all. In-service training is necessary not only for giving refresher courses in subject matter, but also to acquaint the teachers with new developments taking place in the fields of education and psychology. They acquaint the teachers with new methodologies of teaching and new ideas about the nature of the learner. Another cause of the all-knowing attitude that the teachers assume can be attributed to the insecurity that results when the teachers feel that they know very little. They find it to be easier to cling to the safety of the assumed attitude of knowing everything and to excercise their authority on that account.

They feel that the students would not respect them much if they felt that their teachers did not know the answers to all questions. This fear of being diminished in prestige in their pupils' eyes prompts them to assume such an attitude. They do not, however, stop to realize that students may ultimately have more respect for them when they come to realize that neither their teachers nor anyone else is infallible, and that their teachers are wise and humble enough to accept that fact.

The next question was designed to find out the approximate percentages of time spent in two basic methods of classroom presentation. The following table gives the approximate figures of the responses to the question "About what percent of your science learnings were presented in each of the following ways?"

TABLE VII

RESPONSES CONCERNING THE WAY SCIENCE LEARNINGS WERE PRESENTED IN CLASS

Nature of Science Learning	Average percentage given by (30 respondents)
1) Facts and statements learnt by heart without attention to understanding.	56 %
2) Materials learnt with emphasis on comprehension rather than memorization.	44 %

These thirty students felt that more than half their learnings were devoted to facts and statements to be learnt by heart without attention to understanding. It is felt that this figure would have been much higher but for the evident reluctance on the parts of the respondents to admit that they indulged in the practice of learning things by heart without understanding them. A possible reason for this may be that at the American University of Beirut the students have begun to realize that it is not a sign of intellect to indulge in such practices.

The numerous experiments conducted by James and Thorndike and their followers tend to reject the idea that there is any merit in the rote memorization of subject matter. As Skinner points out

> "teaching that emphasizes understanding of the meaning of the learning situations is more likely to be effective in adaptation to future needs than specific memorization of facts."[11]

Thus there is no merit in being able to repeat Boyle's law (or any other laws of science) exactly in the words of the textbook. It is of more value if a student understands what the law means and then is able to report it in his own words. But at this time one has to remember that the matriculation examiner may value the words of the book so much that the words of the student can never replace them. This is an evil that will only be eliminated as those in charge of examinations put more emphasis on understanding and less on memorization and verbalism.

The next question was closely related to the preceding one.

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[11]Charles E. Skinner, Essentials Of Educational Psychology, 1958, pp. 221-223.

The question was, "Estimate about what percentage of the materials in all your secondary science courses you really understood in school."

The average of the percentage responses was 59 %, the range being from 10 to 90 %. The majority fell between 50 and 60 %. It is felt that the numerical responses to this question were not adequately estimated by the students. A point was made to ask a further oral question to these students, after they had given the percentages for this question. They were asked how much of the school science they remembered immediately after they left school. Most of them said very little. This condition is not consistent with many of the percentages of understood science given by the students. When facts and figures are learnt which carry no meaning to the learner they are easily forgotten with the passage of time. As Munn points out, experiments have shown that forgetting is least when principles underlying certain learning situations or problems are learnt with understanding rather than by memorization without understanding.[12]

The last question asked whether the classroom activities ever motivated the students to carry out further individual work outside the school. The responses were very revealing of the motivational power of the teaching-learning situations in the classroom. The following table shows clearly that it is very seldom that a student is motivated enough to carry on an outside project of his own. Thus in response to the question, "About how often did

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[12] Norman L. Munn, Psychology, 1956, p. 274.

the classroom activities motivate you to carry out further individual work outside the school without any suggestions from the teacher?", the following results were obtained:

TABLE VIII

RESPONSES CONCERNING HOW OFTEN STUDENTS WERE MOTIVATED TO CARRY OUT FURTHER SCIENCE ACTIVITIES OUTSIDE THE CLASS

Response	Distribution of frequencies	Percentages
Never	15	50 %
Once a year	4	13 %
Once a month	7	24 %
Once a week	3	10 %
More than once a week	1	3 %
Total	30	100 %

A good science teacher should be able to rouse the curiosity and appeal to the romantic imagination of the youngsters so that they can hardly sit still for their eagerness and intense desire to manipulate impressions and puzzle out the answers to questions to which they have no ready-made ones. One of the greatest shortcomings of our teachers is that they are not ready or willing to draw out the answers to scientific questions from the students. It is after all, much easier to tell them the answer. It needs patience and sympathetic guidance and possibly some extra work to let the students find out for themselves. What our teachers do not realize is that it is only for a very short while that the youngsters have someone to tell them the answers. When the students leave the school and go out in life they will not know how to find answers for they have had no training in solving their own problems. The youngsters come to school with great stores of eagerness and curiosity. Our teachers, instead of developing these native endowments in the right direction, treat them as nuisences and crush them in their very bud. To be a scientist one has to be trained in the scientific method, which is nothing but a systematic search for truth. Scientists do not have ready-made answers to their problems; if they did, they would not be scientists. Thus the whole aim of science teaching and learning is lost if the learner is not motivated enough to find out for himself and seek answers to the problems to which he has no answers.

In summary, the questionnaire results clearly tend to support the view that science teaching conditions in the secondary schools of West Pakistan are far from satisfactory. The teachers are still generally using the traditional methods of imparting textbook knowledge. According to widely accepted educational views held today, such practices are neither sound nor acceptable if education is to furnish youth with both adaptive and reconstructive ability for living in the contemporary world.

CHAPTER III

INTRODUCTION TO THE CHAPTERS DEALING WITH THE SAMPLING OF POSSIBLE ACTIVITIES WITHIN SOME SELIECTED UNITS OF STUDY.

The first two chapters of this thesis have been mainly concerned with the analysis of the poor conditions of general science teaching in the secondary schools of Pakistan. Suggestions for improvement have also accompanied the analysis. The two main proposals for improving the teaching of general science, aside from those for improving the psychological atmosphere of the classroom, were:

1) The reorganisation of the present fragmentary curriculum to achieve unity and wholeness with meaningful connections amongst the fields of study.
2) The building up of an adequate supply of inexpensive or free science teaching materials.

Chapters IV, V, VI, and VII are devoted to sampling of possible activities within some sellected units of study which will serve to illustrate how the present fragmentary curriculum can be reorganised so as to achieve the above aims.

Consisting as it does of a random collection of disjointed topics devoid of meaningful connections, the present curriculum can hardly be said to be an aid to the individual teacher. All that it states are the topics to be covered in a particular class. It fails to specify how much of a given topic is to be covered. No mention of the way the teacher is to teach these topics has been made. No thought has been given to provide instructions for the actual teaching of the course. The following sample, which is the complete text concerning sound in the General Science syllabus of Class X will serve to illustrate the shortcomings of the syllabus:

> "Sound - Production and propagation of sound in various media. Vibration - Transverse and Longitudional waves. Frequency and pitch, Amplitude and intensity. Velocity of sound in open air echoes."[13]

It has been emphasized before that it is only when the students see the meaningful connections and are able to gain an idea of the entire unit of learning that comprehension takes place. According to modern pedagogy the fragmentary approach is subject to criticism if comprehension is a primary consideration. The sample units in the following chapters have been prepared with the aim of achieving a unified picture with meaningful connections between topics of study.*

The new pedagogy recognises the need for activity in effective learning. Verbal learning dealing with theory and obstractions tends to lead to rote memorization without understanding. Activity in learning means that the pupil to a large extent is directly involved in the learning process. Projects which involve constructing apparatuses, preparing charts, etc. as proposed in the sampling of

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[13] Prospectus Curriculum And Syllabi, for secondary school of Karachi, 1956, p. 65.

*The introductory paragraph to each of the units will further illustrate the point.

possible activities within the sellected units of study of chapters IV, V, VI, and VII offer excellent opportunities for pupil involvement in the learning process.

The evil of mechanical following of varified practical data to reach already stated conclusions has been emphasized in the second chapter of this thesis. Such mechanical practical learning activities in no way calls for the purposeful involvement of the learner in the process of scientific enquiry. The realization of the main objectives of this thesis - to teach science through scientific enquiry - is entirely dependent on the type of use the teacher makes of the sample units of study. These units are merely suggested sampling of possible activities within some sellected units, they are in no way complete or to be followed mechanically by the teachers. They are to serve only as examples of the varieties of ways a teacher can organise units of study with meaningful connections, by overcoming the fragmentary, disjointed approach (which characterizes the present curriculum in use) and make the study of general science vital and living to the learner.

The second objective of the sample units is to show the many kinds of experiment and other learning activities in science which can be developed so that pupils will learn by seeing and doing.

The instructions appearing in the units are only examples with rich creative possibilities. They are to serve as examples to inspire the teachers and students in creative thinking, doing and constructing, making science learning rich and interesting with actual practical work. The example of one of the ways that a piece of equipment can built, is to inspire teachers and students to test out their creative abilities in both thinking and doing. This is the main purpose for which the practical instructions for creating and constructing scientific apparatus and equipment were included in the units of study.

It has been pointed out before that science teaching without practical work puts too much reliance on the visualizing capacity of the learner in the absence of the concrete. This also tends to lead to mere verbalism. This outcome can be minimized by the use of audio-visual aids. As Bernard points out,

> "One of the ways to make learning concrete and meaningful is through audio-visual aids . . . . Globes, maps, diagrams, experimental apparatus, demonstration materials, pictures, models and slides add greatly to the meaningfulness of the verbal descriptions. . . . The more sensor avenues that are utilized in learning the more effective learning will be."[14]

The sample units of this thesis provide teachers with instructions for constructing equipment, preparing diagrams and otherwise enriching class instructions with audio-visual materials.

Also, the sample units have been prepared to actualize some of the specified objectives of the general science curriculum quoted in Chapter I. A careful examination of these objectives, basically sound as they may be reveals misconceptions of the principles of modern pedagogy on the part of the formulator. For example, one of the objectives urges the teacher to arrange practical work with the

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[14]Ibid., pp. 285-286.

cooperation of the pupils to give a "realistic touch" to the study of the subject. This is a very limited approach. It suggests that practical work is to be quite secondary in importance. It is apparently to be sparingly used by the teacher to "sugar-coat" the main theoretical study of the subject. Good science teaching does not aim at providing a "realistic touch" to learning; rather it attempts to make the whole learning process real to the pupil.

Each one of the sample units have been organised in different styles to provide the teacher with a variety of examples. The nature and the body of each one of the units are the result of the definite objectives (of teaching-learning practices) that the writer consistently followed in developing them. To serve one example the objectives have been spelled out in detail in the unit on Heat. This has been done on the assumption that the individual teacher and students would make only examplary use of them and draw out their own objectives and aims of study depending on the nature of study, learning environment, aims and values.

As is to be expected as a concomitant of a traditional curriculum, the formal examinations and tests are prepared mostly to examine the students in their verbal memory of text book facts and figures. No attempts are made to test their comprehension or to see whether they can apply the facts learnt to actual situations. Samples of problematic tests that can be prepared to test the ability of the students to apply theory to practice and to test their degree of comprehension, have been prepared as parts of two of the sample units, the units on Electricity and Magnetism,and Heat. These tests also serve the same purpose of being merely examples of the way the teachers and students can construct tests which serve two purposes - to develop in students critical thinking with depth in comprehension, formation of true accurate concepts and to examine their ability to apply learnt science to daily life.

Finally it is strongly emphasized that the sample units are in no way to be used as arbitrary textual materials to be implicitly followed step by step.

CHAPTER IV

A SAMPLING OF POSSIBLE ACTIVITIES WITHIN A UNIT ON ELECTRICITY AND MAGNETISM

It is recommended that instead of treating "Electricity" and "Magnetism" as two separate units, they be organized so as to be taught as a single unit where the relationship that exists between them can be well brought out and impressed upon the students. It is, however, difficult to explain this curious relationship theoretically; practically, however, this relationship is obvious. A heavy weight should be put on practical work so that the students directly experience science through performing experiments. Every topic introduced should be explained with the aid of diagrams, demonstrations, building and making equipment under study - or conducting experiments. Modern educational practices recommend maximum student participation in the teaching-learning processes for desirable and lasting learning outcomes. The use of the "project method" of study also necessitates the same. Teaching-learning is directed and organised so that the students themselves build equipment, prepare charts, diagrams, conduct experiments etc. in the course of their study. This not only gives them a wider and richer opportunity for understanding the subject-matter under study but by deeply involving the students in the learning process ensures interest.

In this proposal the topics in connection with electricity and magnetism that were haphazardly scattered through the syllabuses meant for classes VI to X have been brought together in one complete unit. This unit is complete in the sense that those topics which are missing from the official syllabus, but which are needed to make meaningful connections between topics have been inserted.

UNIT

WHAT ARE ELECTRICITY AND MAGNETISM?

A. <u>Subunit</u>

<u>What Is A Magnet?</u> - <u>Natural And Artificial</u>.

Activities:

1) Demonstrate the effect of bar or horse-shoe magnets on iron or nickel. Establish the fact that magnets attract anything made of iron or nickel.

2) Demonstrate the fact that a magnet has two poles and the like poles repel while the unlike poles attract each other. This can be demonstrated easily with the help of either a floating magnet or two bar magnets.

2a) To secure a floating magnet magnetise a steel needle as shown in Figure 2 and thrust it through a slice of cork cut from a bottle stopper. Float the cork in a basin of water. It will come to rest with the needle pointing north. (The surface tension of the water will tend to draw the cork to one side of the dish. This can best be prevented by placing a teaspoonful of detergent in the water and mixing it). The polarity of the magnets will be further established while demonstrating magnetic lines of force.

<u>Note-</u>

If the demonstrations are performed flat on the table and are not visible to the whole class it is helpful to place a fairly large mirror at approximately a 45 degree angle at the back of the demonstration table. This enables the students to get a fairly good view of what is going on and avoids crowding and chaos round the table.

2b) Place a bar magnet on a smooth surface. Place a compass needle near one of its poles. Note the direction in which the needle points. Now move the compass round the magnet and note the direction in which the compass needle points at different positions. The compass needle being a magnet points its north towards the south pole of the magnet and vice versa.

2c) Suspend a bar magnet from its center with a string tied to a wooden stand.* Bring another bar magnet near one of its poles. (See Figure 1). Note how the like poles (north and north and south and south) move away from each other and unlike poles (north and south) attract each other.

*Making a multipurpose wooden stand - cut two stips of wood planks 'A' and 'B' 14" x 2" x 1", from a ply-wood packing case. Screw 'A' perpendicularly to a rectangular base 'C' of about 16" x 8". See Figure 1. Now fix two fairly large screws 1½" from the top of 'A' and about 1" apart. Now drill corresponding holes in pairs on the plank 'B' as shown in figure. These holes will permit 'B' to be fixed on the screws of 'A' according to the desired lengths. Hooks as shown can be fixed on B for various purposes.

3) Making a compass - How does a compass work?

Magnetise a sewing needle by the following method-

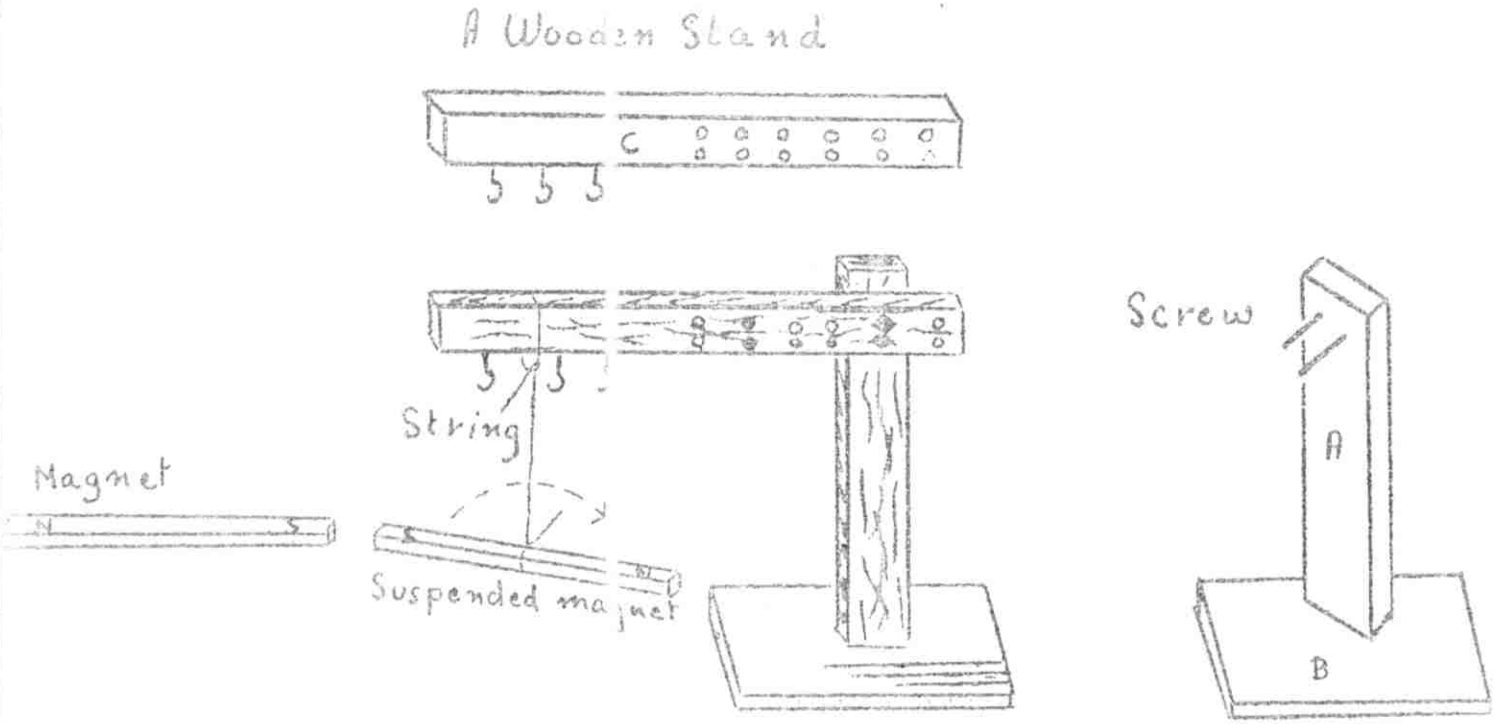
A Wooden Stand
C
String
Magnet
N
S
S
N
Suspended magnet
Screw
A
B

Fig. 1

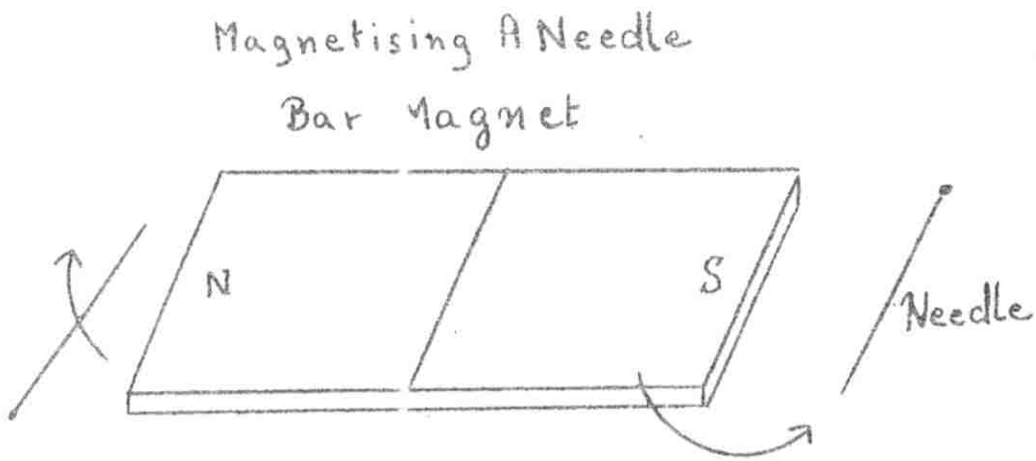
Magnetising A Needle
Bar Magnet
N
S
Needle

Fig. 2

Stroke one end of a large sewing needle slowly from the middle to the end against one pole of a permanent magnet. See Figure 2. Repeat this several times. Now take the other end of the needle and stroke it against the other end of the magnet. Now test the needle with some iron filings to see whether it is magnetised. (The stroking should always be in one direction).

Suspend the magnetised needle from a thread. The thread should be tied around the needle in such a position that the needle hangs in a horizontal position. Put a drop of rubber cement or gum on it so that the knot is firm. Fasten the other end of the thread on the centre of the inside part of a cap of a jar with help of wax or rubber cement. Place the cap or the jar with the suspended needle inside. See Figure 3. The closed jar keeps the air's movements from affecting the needle. Now bring the north pole of a bar magnet near the jar, it will attract the south pole of the needle and vice versa.

4) Why is the earth called a huge magnet with magnetic poles? When a bar magnet is freely suspended as in Figure 1, it is seen that its poles point to a definite direction.

4a) What is meant by the north seeking pole and the south seeking pole of a magnet?

4b) How do the actions of a "dipping needle" confirm the belief that earth is a magnet?

5) What is meant by magnetic lines of force? Note the pattern of iron filings (Figure 4) sprinkled over a glass plate which is placed

Making A Compass

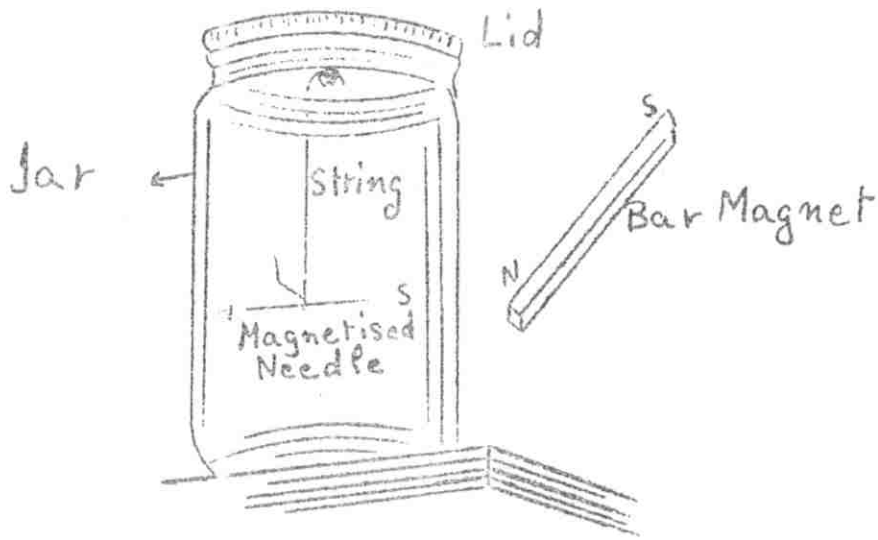

Fig. 3

Magnetic Lines Of force

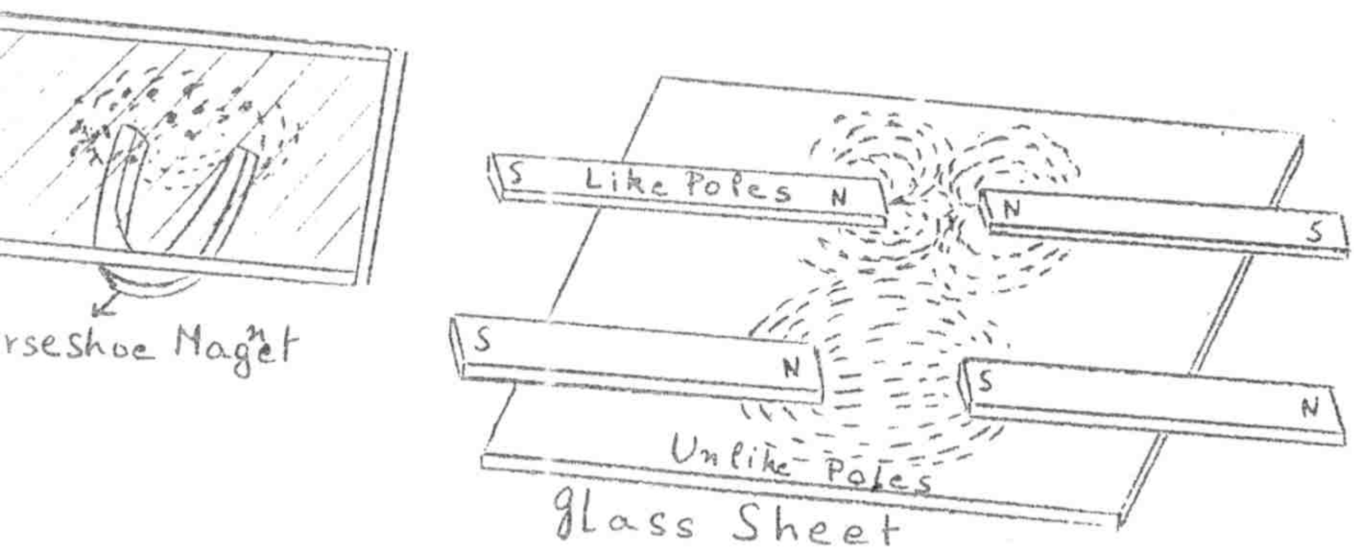

Fig. 4

Making A Compass

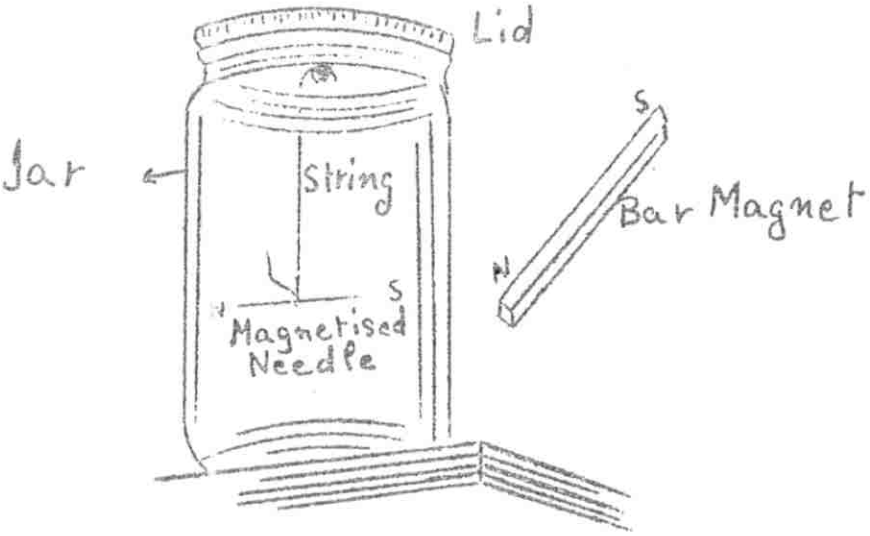

Fig. 3

Magnetic Lines Of force

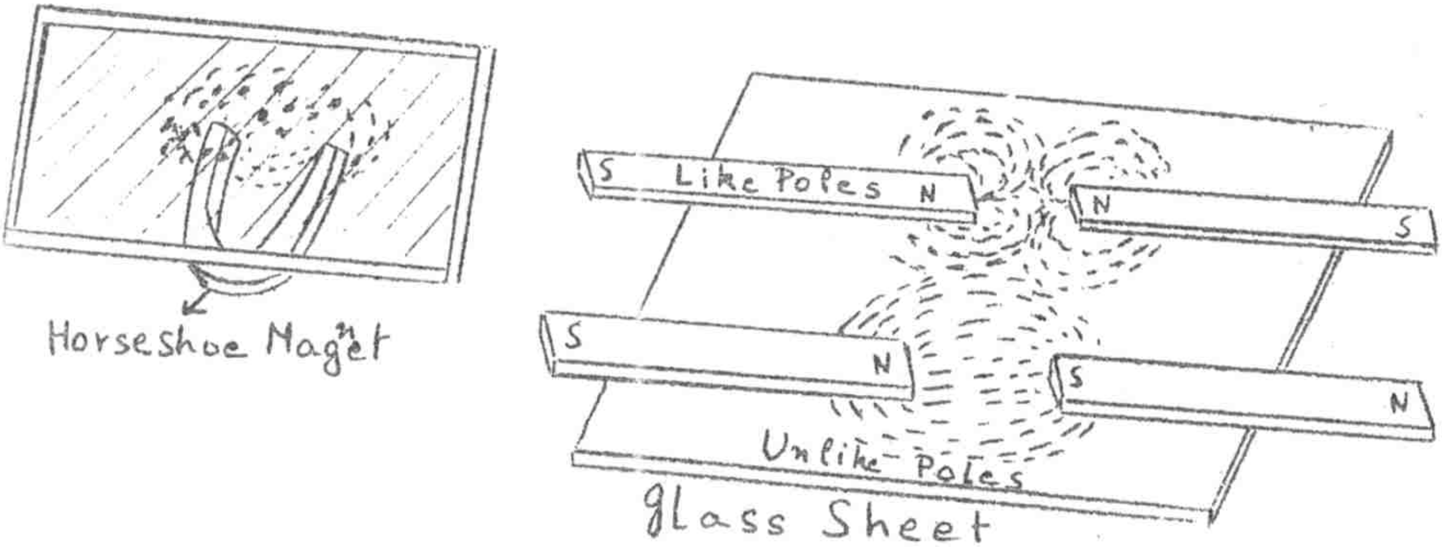

Fig. 4

over magnets in various arrangements.

i) A single bar magnet.

ii) A horse-shoe magnet.

iii) Two bar magnets with like poles facing each other.

iv) Two bar magnets with two unlike poles facing each other.

Make a permanent record by distributing the filings on a sheet of paper coated with paraffin. The paper is first dipped in melted paraffin and placed on the glass plate when the paraffin has solidifed. When the filings are in place, the sheet is carefully warmed by being placed on hot metal (hot plate).

6) Magnets are strongest at the poles. Examine the arrangments of iron filings in Figure 4. More iron filings are attached to the ends of the magnets with fewer and fewer towards the middle.

7) What is meant by induced magnets? Touch a soft iron nail on one pole of a strong permanent magnet and let it hang. Now touch the other end of the nail to some small iron tacks. The nail attracts the iron tacks like a magnet. Now remove the permanent magnet from the nail. The iron tacks fall off the end of the nail showing that the nail loses its magnetic power when it is no longer touching the permanent magnet.

8) Can magnetic force pass through certain substances? Attach a horse-shoe or a bar-magnet to any kind of a support as in Figure 5, so that the poles are pointing downwards toward the desk. Fasten a thread to a paper clip and fasten the other end of the thread to a wooden board on the desk, adjusting its length so that the paper clip is about one quarter inch under the magnet. The

magnetic force will hold the clip suspended in the air.

Now hold a glass plate between the clip and the magnet. The magnetic force still holds the clip. Try out the experiment with other materials like, paper, wood, a lid of tin can, or other metals etc. and see whether the magnetic pull passes through all the materials alike.

9) How is magnetism explained? What is the theory? Figure 6 explains the molecular theory of magnetism diagrammatically.

9a) Magnetise a steel needle as in figure 2. Test for polarity. Now break the needle in half with a pair of pliers and test each half for polarity. Each half will have a north and a south pole.

9b) Fill a test tube with iron filings. Holding the tube horizontally and carefully stroke it against a strong bar magnet. Bring the tube near a compass. The tube will act like a magnet. Now mix up the filings by shaking the tube and bring it again near a compass. It will have lost its magnetism. These filings act as the molecules of a piece of iron.

10) How can magnets lose their force?

Application of Heat and force (striking).

B. Subunit

Static Electricity.*

1) What is static electricity?

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*Note- Static electricity experiments work best on dry days. When the moisture content of the air is high, the air becomes a relatively good conductor of electriciy, and static charges built up on various objects easily leak off. Cold dry days are best for the activities on static electriciy. Heating the object before rubbing will give good results.

Magnetic Force Pass Through Certain Substances

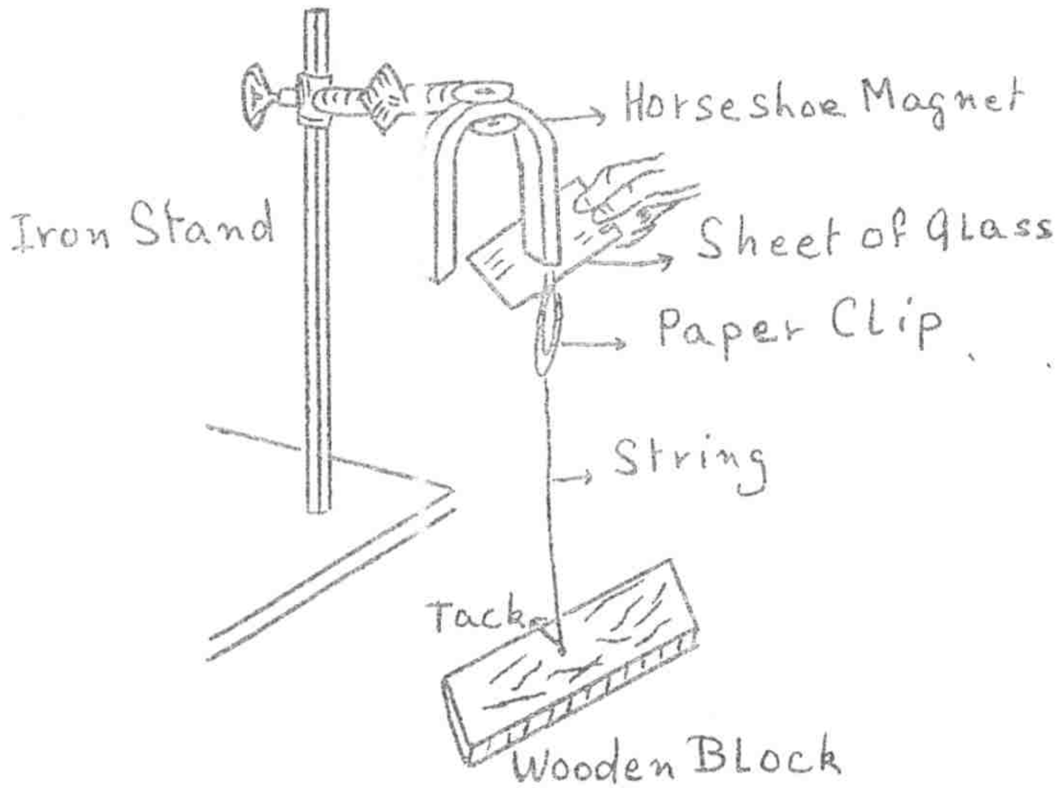


Fig. 5

The Molecular Arrangment In Magnets

Fig. 6

1a) If a stick of sealing wax is rubbed vigorously with a piece of silk it will attract tiny bits of paper.

1b) Cut a piece of newspaper about 20" x 2" and lay it on the table and stroke it hard 20 times with a woollen sock, glove or cloth. Fold the newspaper exactly into half and hang it from a ruler. The two hanging strips will swing away from each other.

1c) Blow up a balloon and rub it vigorously on a piece of wool. Place the balloon on the wall; it will stick to the wall.

1d) Rub a glass rod with silk and suspend it from a string. Now rub a hard rubber rod with wool and bring it near the suspended glass rod; the two rods attract each other.

2) How do scientists explain the charges that is built up in the objects in each of the above experiments?

3) How does an atom of a body become electrically charged?

3a) The structure of an atom in ordinary state and when carrying an electrical charge is diagramatically shown in Figure 7.

3b) Production of static electrical charge is diagramatically shown in Figure 8.

4) How can static electricity be generated? Making an electrophorus- See Figure 9.

Fasten a glass rod to a metal disk (the top of a can will do) with a bit of candle wax. If a glass rod is not available, a stick of sealing wax will do. The aim is to have a handle which is an insulator. Now take an old phonograph record and place it on a table over some support. Rub the record with wool vigorously. Take the metal disk by the handle and place it flat on the record. Now touch your finger to the disk for an instant. The idea is to cause the electrons to run off the disk to the ground through the finger and

Structure Of An Atom Becoming Electrically Charged

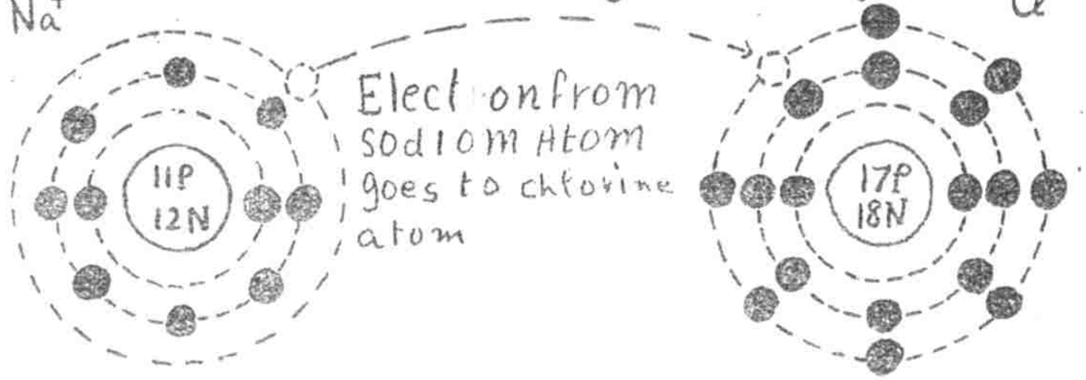


Fig. 7

A Comb Becomes Electrically Charged When Rubbed With A Piece Of Wool

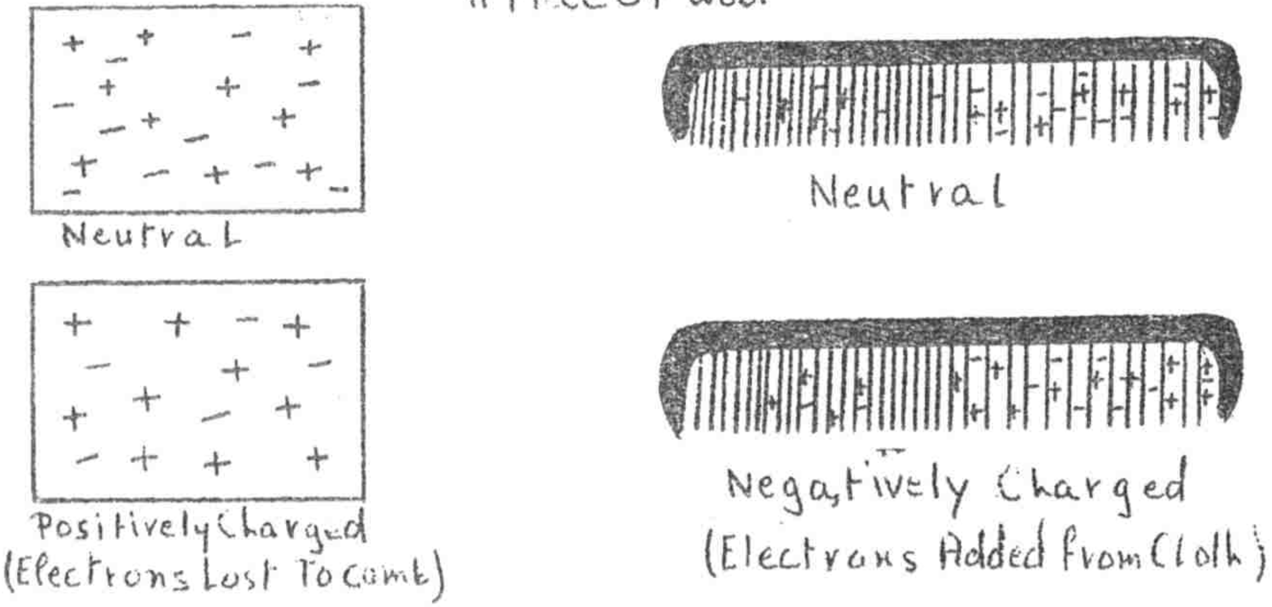


Fig. 8

body. Now raise the metal disk by the handle and touch it to your nose. A shock will be felt. If the metal disk is perfectly flat, this device will build up higher static electricity charges than rubbing combs or rods.

5) How can a detector of static electricity be made? Making an electroscope -- See Figure 10.

Materials-

Piece of heavy metal foil.

Large bottle with a cork.

2 pieces of thin metal foil (aluminum foil from a cigarette package will do) about 1 inch by $\frac{1}{4}$ inch, with a small hole near the end of each.

Heavy copper wire.

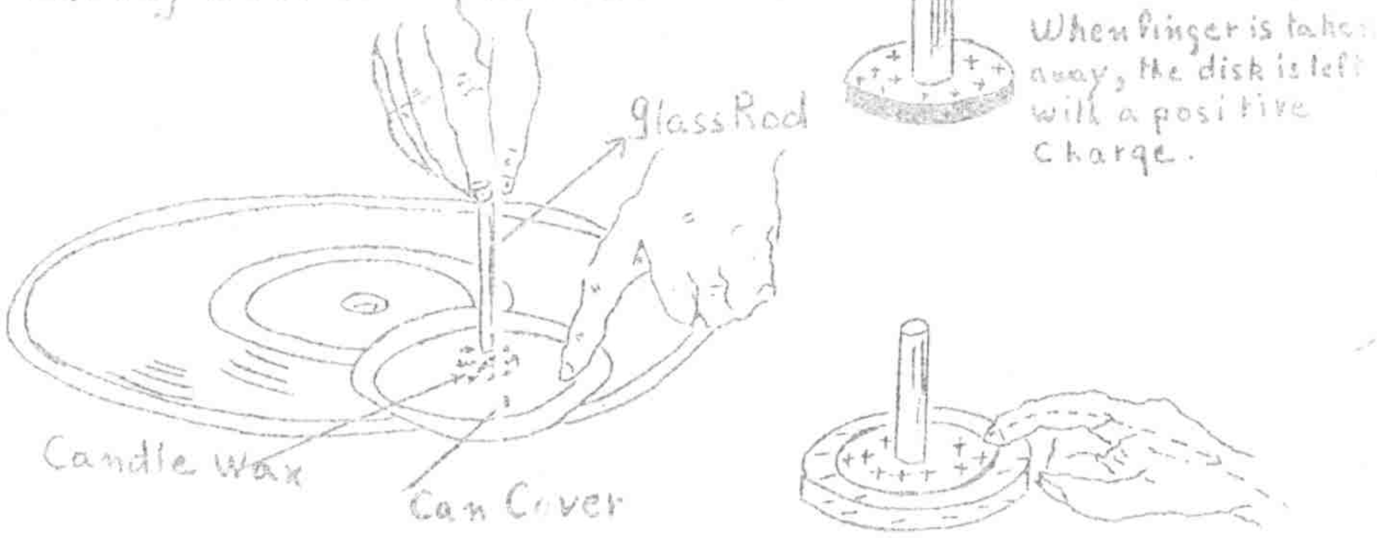
Pound the heavy metal foil into a ball as in the diagram and press it around the top of the copper wire. Hang the two pieces of foil, each with a hole, from a wire hook. Put the whole thing inside the bottle. Now charge up a rubber rod as in experiment 'a' of Subunit 2, and touch it to the top. Electrons from the negatively charged rubber rod stream down the copper wire into the thin foil. The two pieces of foil will spring apart since both become negatively charged.

5a) How are electrical charges built up in the clouds?

5b) How is lightning caused?

5c) How does a lightning rod prevent a building from being struck by lightning?

Making An Electrophorus



Negative charge on phonograph record repels electrons, which streams through the body to the ground

Fig. 9

Making An Electroscope

Homemade Galvanometer

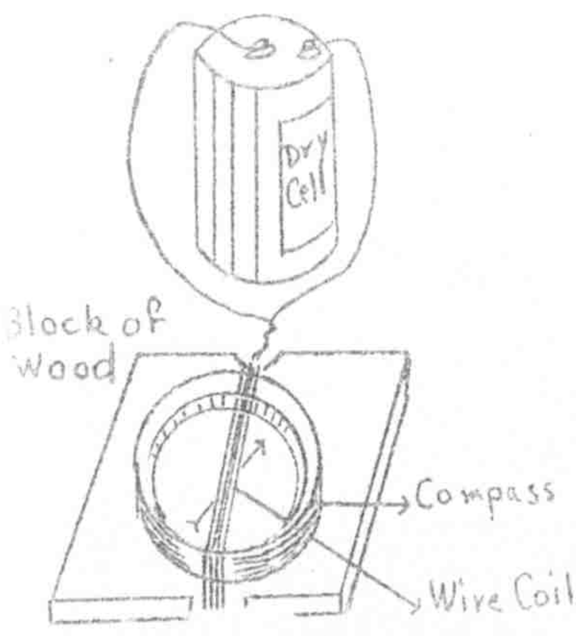


Fig. 11

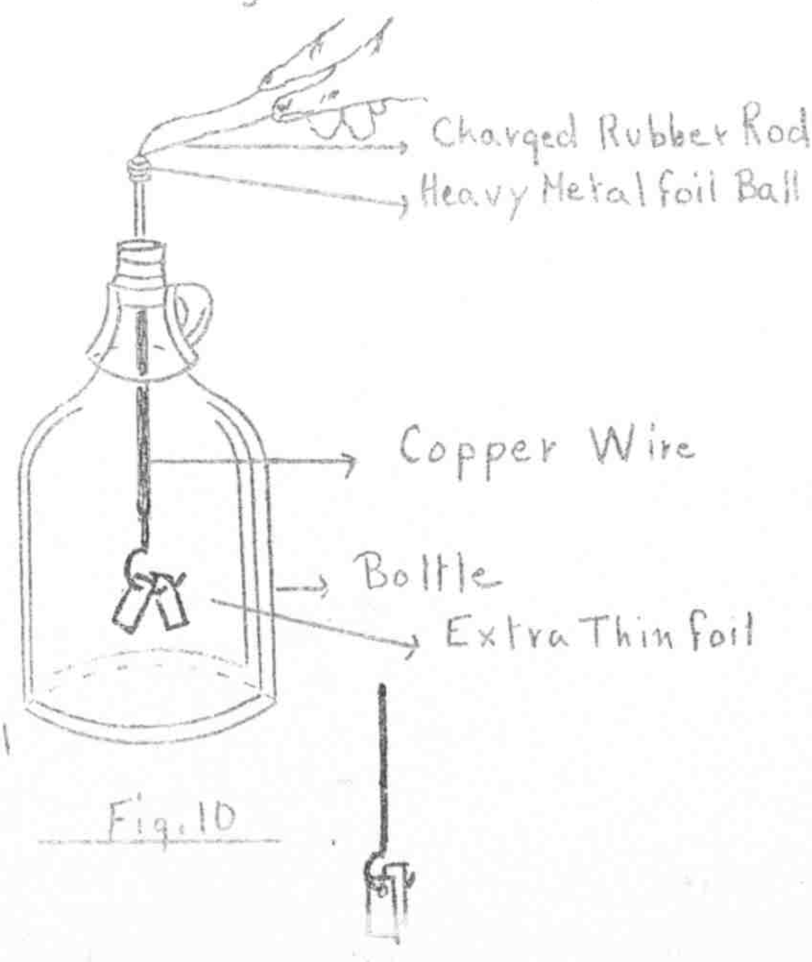
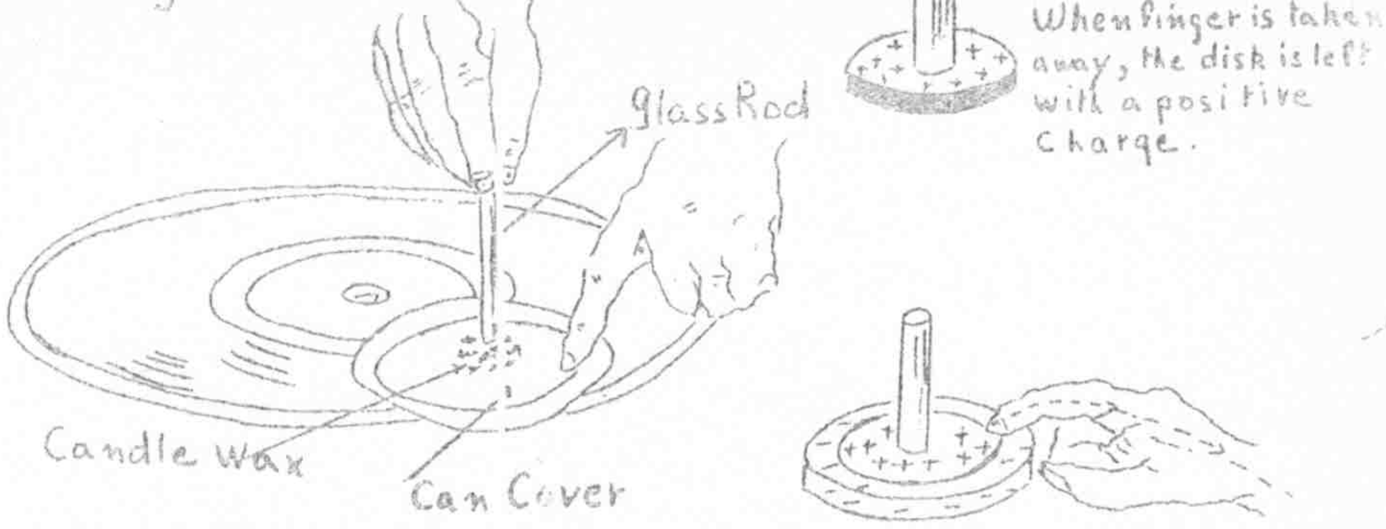


Fig. 10

Making An Electrophurus



Negative charge on phonograph record repels electrons, which streams through the body to the ground

Fig. 9

Making An Electroscope

Homemade Galvanometer

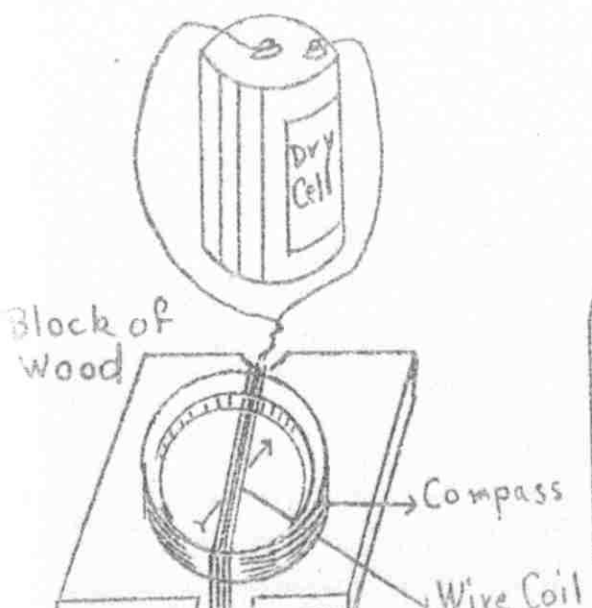


Fig. 11

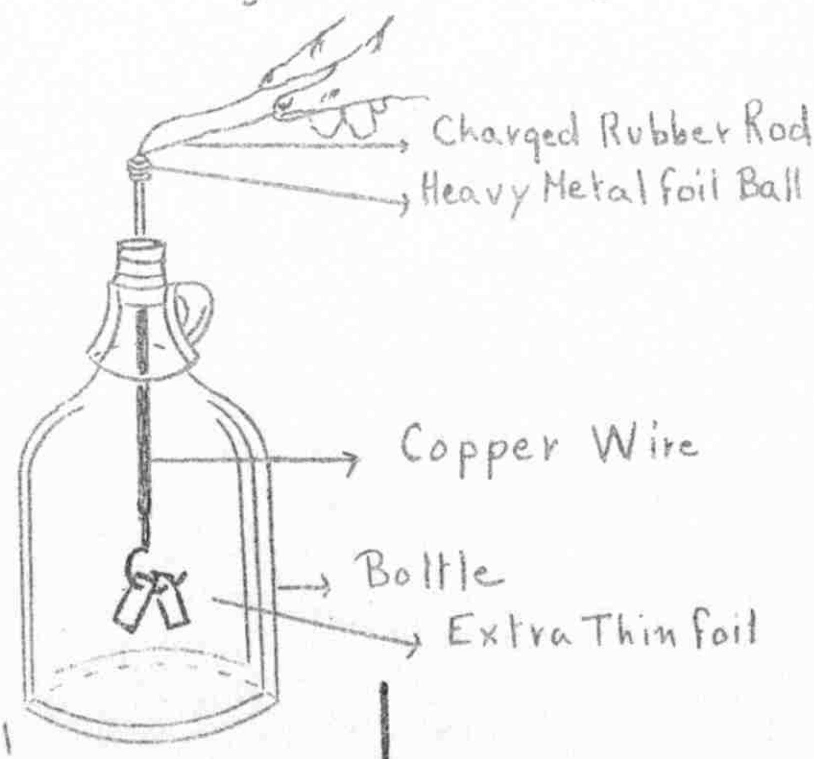


Fig. 10

C. Subunit

Current Electricity.

The following are essential facts connected with the production and flow of current electricity which are not all included in the official syllabus but are considered to be basic to the study of the rest of the Unit. Those marked with an asterisk have been added by the writer.

1a) How can the presence of electricity be detected? Making an electric current detector*- See Figure 11.

Wrap a few turns of copper wire around a pocket compass held to a board in the manner shown. As soon as the circuit is connected, the compass deflects, showing the pressence of a magnetic field, created by the current.

1b) What causes electricity to flow?

2a) How can an electrical system be compared with a hydraulic system.*

2b) How is the flow of electrons maintained continuously?

3) What are some of the common electrical units?

3a) Volt and voltmeter.

3b) Ampere and Ammeter.

3c) Ohm and Ohm's law.*

4) What are the laws of resistance?*

4a) Law of lengths.*

4b) Law of diameter.*

4c) Effect of temperature.*

4d) The resistance depends upon the material.*

5) How can current electricity be produced?

6) How can current electricity be produced chemically?

6a) Making a chemical cell - See Figure 12.

Materials -

A drinking glass.

A Chemical Cell

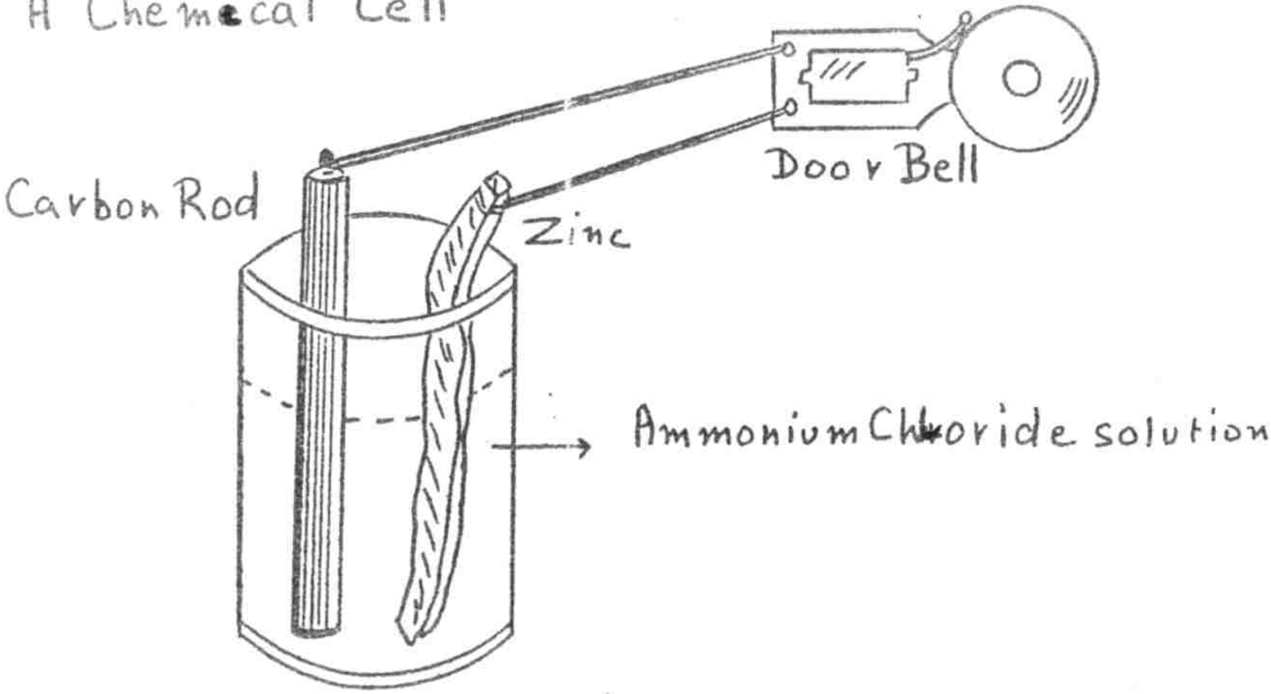


Fig. 12

A Vinegar Cell

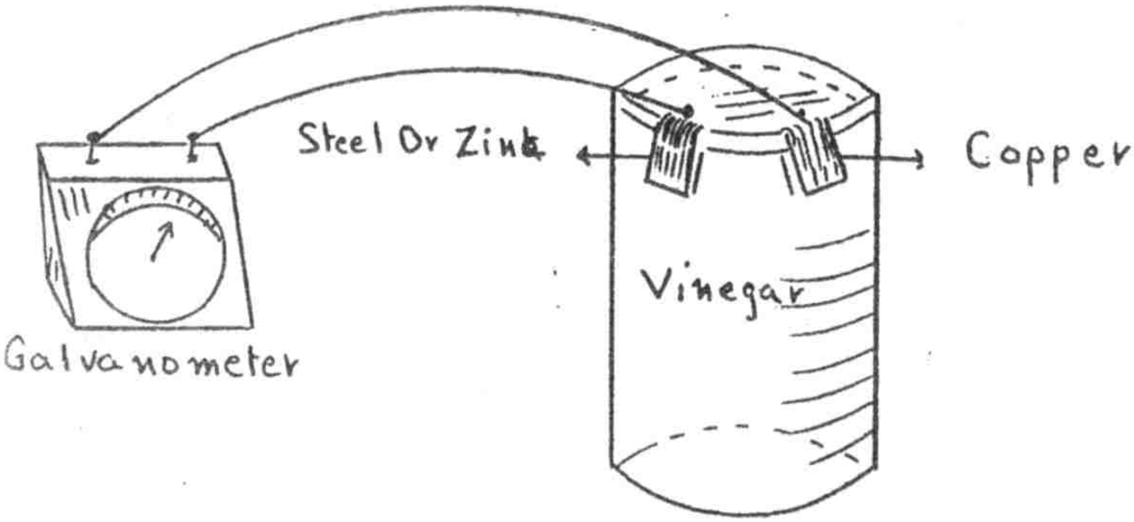


Fig. 13

A piece of zinc)
) both secured from an old flashlight battery.
A piece of carbon)

Ammonium chloride.

Pour about a tablespoon of Ammonium chloride into the glass. Fill the glass with water and stir. Now place the zinc and carbon rod into the the solution taking care that they do not touch each other. Connect the two plates to a flashlight bulb or a doorbell with copper wires, completing the circuit. At once the action of the chemical cell will be visible.

How does the cell work?

6b) Making a vinegar cell -- See Figure 13.

If a small piece of copper and steel or zinc are placed in a glass full of vinegar, a small electrical cell will be formed which can be tested with a galvanometer.

7) How can a storage cell be made?

Flashlight batteries and similar dry cells will generally keep working until the solution has evaporated or until zinc has been used up. Then they must be thrown away. Storage batteries have an advantage over dry cells in that they may be used until they are too weak to work and then may be "charged" again so that they are as good as new.

Making a storage cell[15] -- See Figure 14.

Two strips of clean lead 2" x 6" are placed in a solution of sulfuric acid (1 part acid 10 parts water). The strips are

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[15] Will Burnett, Teaching Science in the Elementary School, 1957, p. 245.

Electrolysis Of Tablesalt Solution

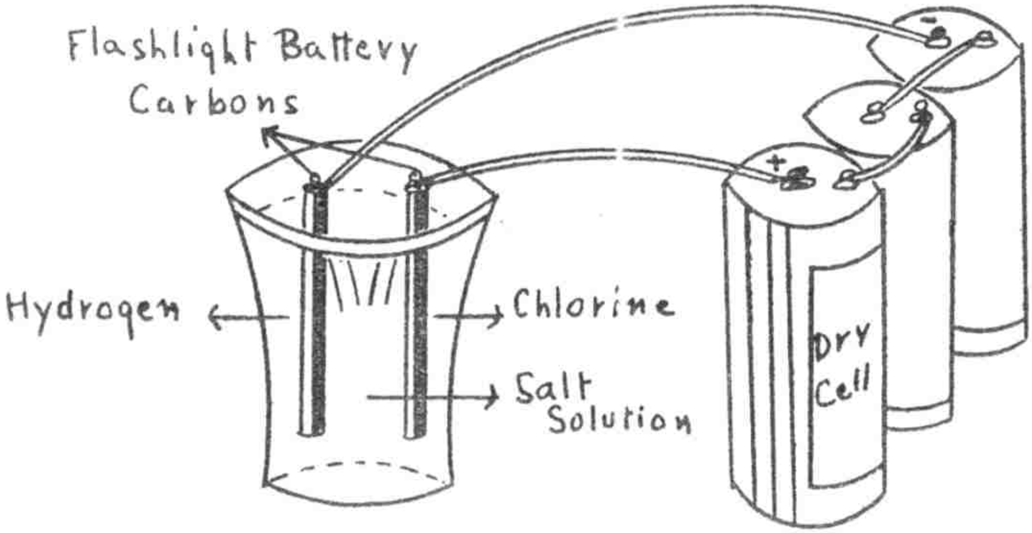

Fig. 15

Homemade Storage Battery

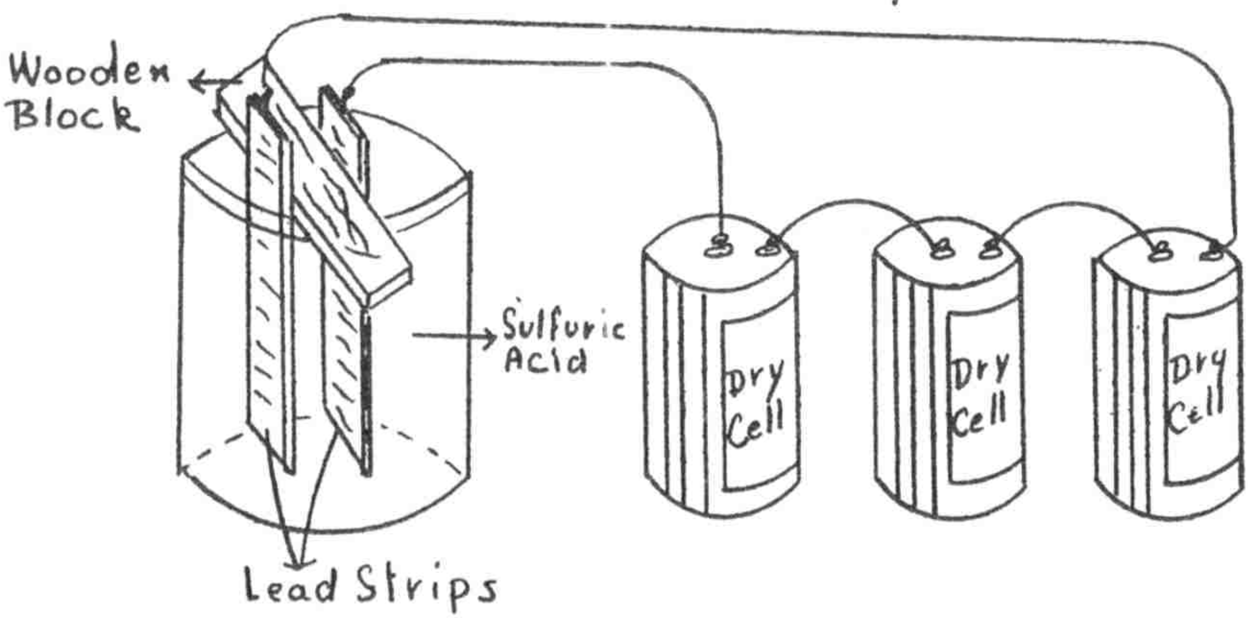

Fig. 14

supported by a block of wood to which they are attached. A source of direct current 6v to 12v is connected (car battery or other dry cells connected in series) and the cell is charged for 10 minutes. The voltage of the cell is then checked, and the appearance of the plates noted. With sufficient charging the cell will operate an electric bell.

7b) Use charts showing the structure and action of dry cells. (Leclanche cell, storage batteries) Such charts can be made by the students as projects. Good charts may be kept in the laboratory for permanent use.

8) What is meant by electro-chemistry?

8a) What happens when electric current passes through water containing acids or alkalies? Making of chlorine, hydrogen and caustic soda from Salt Solution - See Figure 15.

Materials-

3 dry cells connected in series.

2 carbon rods taken from old batteries.

Copper wire.

Glass tumbler with strong table salt solution.

Connect the batteries in series. Take the two carbon rods and twist bare copper wire around each of the carbon rods (if the rods are fitted with brass caps on the top, they will be good electrical connections). Connect the carbon rods to the terminals of the battery and place them in the salt water solution in the tumbler. The rods should be about an inch apart from each other. Do not immerse the terminals in the solution, only the carbon should be immersed. At once rising of gas bubbles become noticeable. Those rising from the rod connected with the negative terminal of the battery are hydrogen while those from the positive are chlorine. The peculiar disagreeable odour of chlorine becomes distinct.

8b) How can the principle of electric cells be used in electro plating? Uses of electroplating Experiment[16]-- See Figure 16. Scrub a silver coin very thoroughly with soap and water and wash it in clear water. Scrape the end of a two foot copper wire to take out the insulation and wrap it firmly round the coin. Dissolve all the copper sulfate that will go in the solution contained in a glass tumbler as shown in the figure and add about a teaspoon of sulfuric acid. Now suspend the coin in the solution by wrapping the wires once around a ruler. Now take another length of copper wire and wrap one of its scraped ends around the copper strip and suspend the strip in the solution. (Bend the copper strip so that it also hangs from the ruler). Connect both wires to two dry cells connected in series, taking care that the coin is connected to the negative terminal and the copper strip to the positive terminal of the battery. Otherwise the desired electroplating will not take place. After 10 minutes or so lift out the coin, which will be coated with copper.

Note -A similar experiment can be done for silver plating, using silver chloride solution.

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[16] Atkin and Burnett, Electricity and Magnetism, 1958, p. 54.

Electroplating A Silver Coin

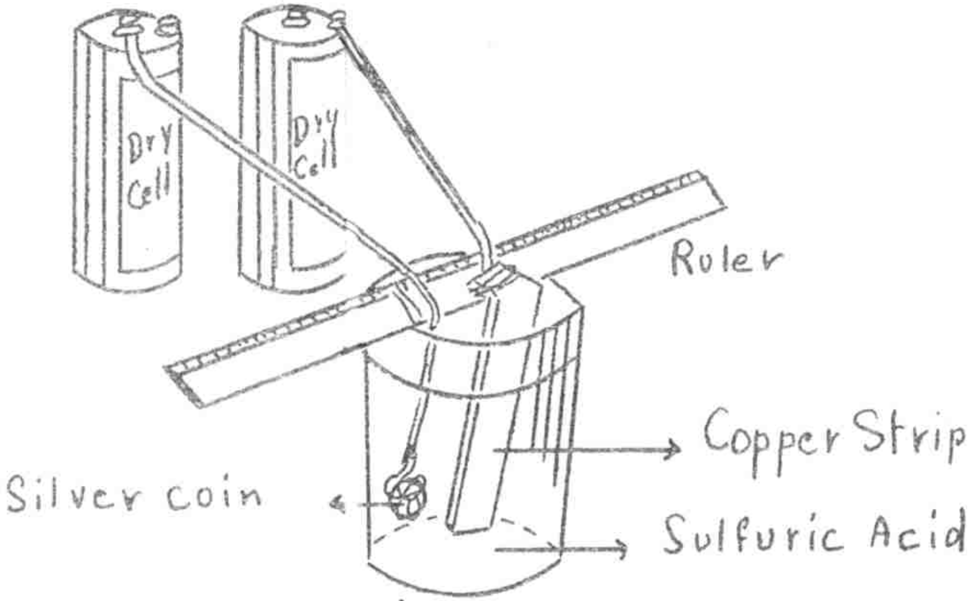

Fig. 16

Heating Effect Of Electricity

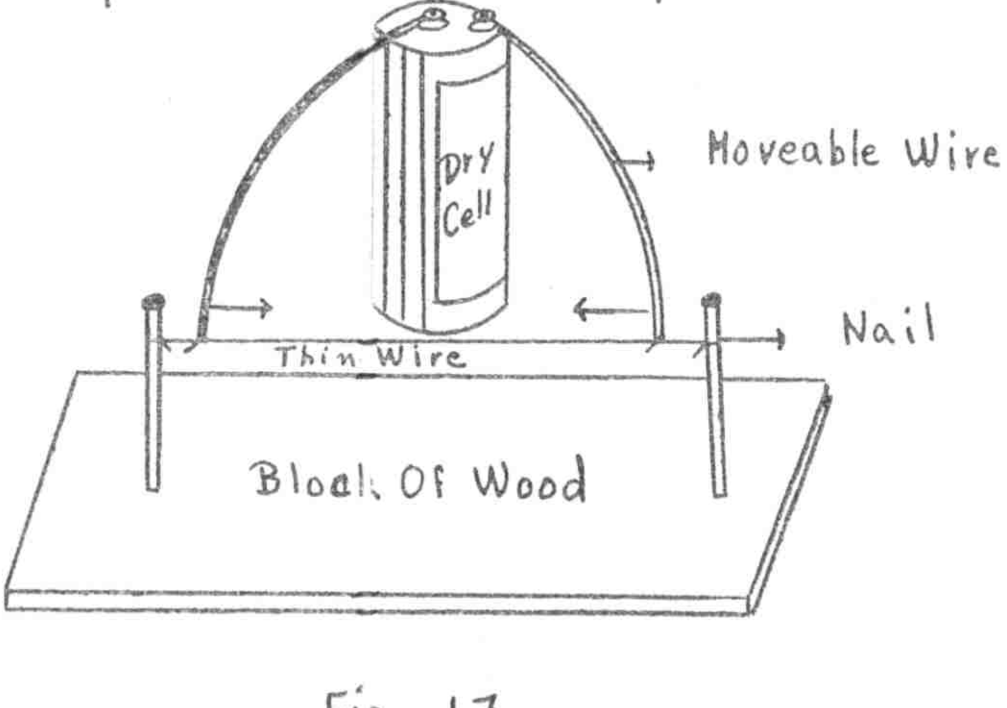

Fig. 17

Electroplating A Silver Coin

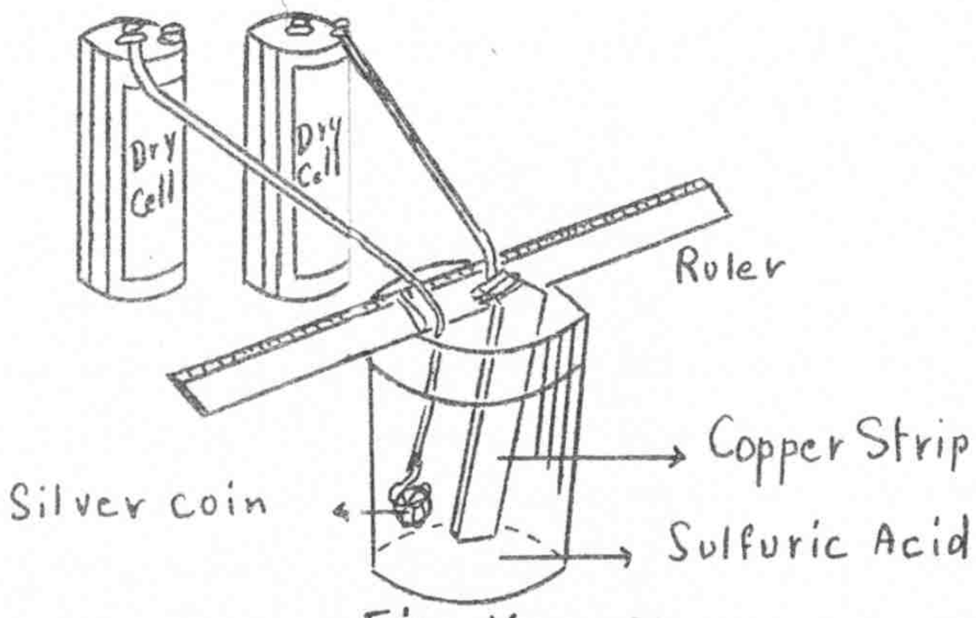

Fig. 16

Heating Effect Of Electricity

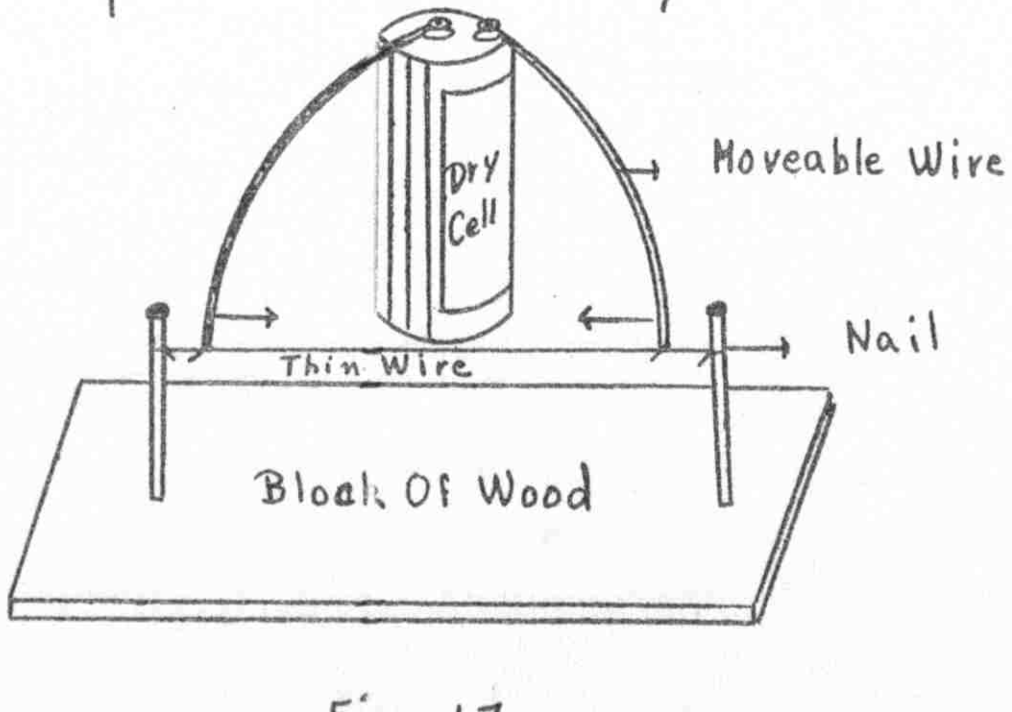

Fig. 17

9) How do electrical heating devices work?

9a) Under what condition will a dry cell heat a wire red hot?

Experiment[17] - See Figure 17.

Stretch a piece of fine bare copper wire two feet long between two nails driven in a wooden board. Take two lengths of larger insulated copper wire 2 feet in length and connect them to a dry cell. The ends of the wires must be scraped clean from insulation. Press the free ends of the two insulated wires against the small wire near the ends. Let someone test the temperature of the small wire by touch. Now gradually slide the larger copper wire closer together along the smaller wire. The wire soon starts to get hotter. Continue to move the wires closer. The small part where electricity is flowing becomes red hot.

From the above experiment bring out three important principles.

9b) When the same amount of electricity is flowing through several wires, the one with most resistance will be heated the most. When much electricity is flowing through a wire, the wire is heated more than when only a little is flowing.

9c) For each electrical situation there is a certain length of wire that will become red hot or white hot.

Have the students work on projects as to how electric toasters, irons and stoves are designed and built and demonstrate to the class, how

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[17]Beauchamp, Mayfield and West, Everyday Problems in Science, 1946, p. 557.

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[17] Beauchamp, Mayfield and West, <u>Everyday Problems in Science</u>, 1946, p. 557.

the heating effect of electricity works in each of these household items.

10) How does electricity produce light?

10a) Perform experiment '9a' in a dark room. The thin copper wire will begin to glow once it becomes red hot, if it is kept for sometime it will burn out and oxidise.

10b) Place a burned out incandescent bulb in a pail of water and carefully break out the top glass globe (The water prevents shattered glass from flying). Explain how incandescent bulbs light without burning out. Study how the bulb is made.

11) How do switches work as a device to close and open circuits?

Making a switch - See Figure 18.

Cut a narrow strip of tin from a tin can. Wrap the scraped end of an insulated wire round the head of an iron nail and hammer this through one end of the strip of tin into a wooden board. Wrap another bared wire around the head of another nail and hammer it on the board in such a position that it touches the tin strip when it is pressed down. Now connect this into a circuit with a dry cell as shown in figure. The bulb will light and go off as the tin strip is pressed down and let off, to establish and break the circuit respectively.

12) How do fuses save overloaded circuits from completely burning out?

12a) Explain how a short circuit occur. See Figure 19. Connect a bulb with a dry cell. Remove the insulation from both wires about halfway from the dry cell to the bulb. Now lay the heavy copper wire across the two wires so that it touches the bare parts. Press the

A Switch

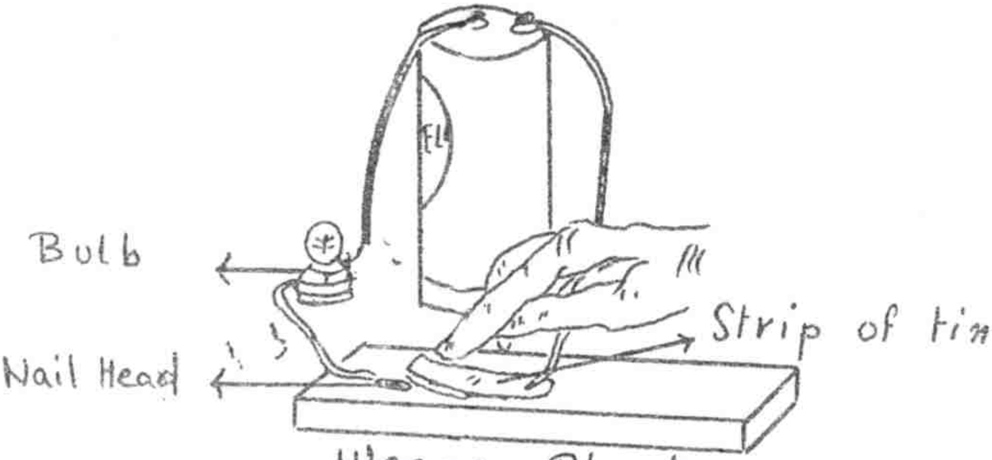

Fig. 18

Illustrating A Short Circuit

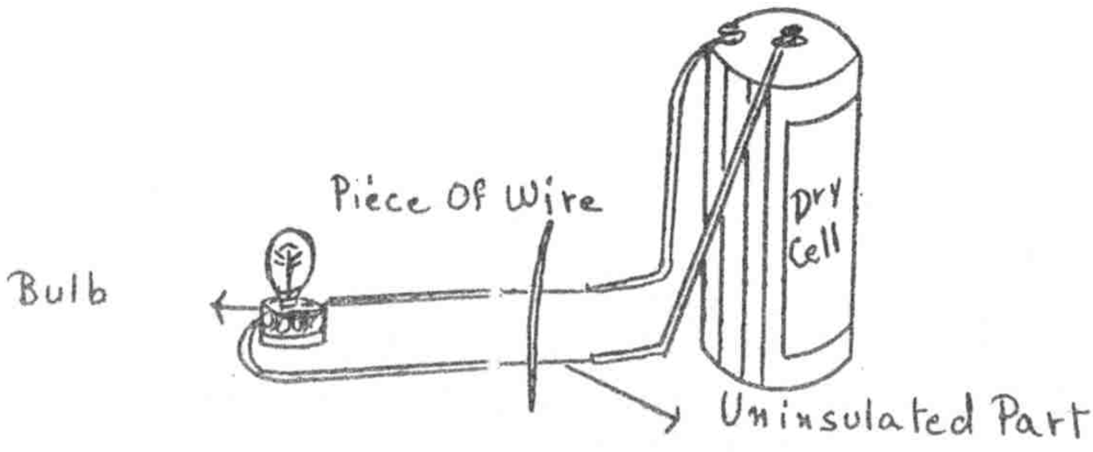

Fig. 19

heavy wire against the two wires of the circuit to make a good contact. The bulb goes out.

12b) Secure a fuse and crack it open. Secure the wire. The wire even melts with a match flame. Explain how short circuits melt fuses.

D. <u>Subunit</u>

<u>Electromagnetism</u>

1) Magnetic effect of an electric current.

1a) Connect a dry cell with two wires and scrape off the insulation from about four inches of one of the wires. Bend the scraped end so that it can be in connection with the end of the other wire as shown in the Figure 20. Place some iron filings or little bits of iron on a paper and place the exposed wire down until it touches the iron filings. Now make a contact with two wires completing the circuit. Now touch the iron filings with the connected wire and lift the wire up, the iron filings will rise also. Break the circuit, the filings drop down. A magnetic field is induced when electric current flows through a conductor.

1b) Take a large nail and wrap around it forty or fifty turns of insulated copper wire leaving two ends free as shown in Figure 21. Scrape the free ends and connect them to a dry cell. The nail acts as an electromagnet and lifts up bits of iron. Disconnect the circuit and the bits of iron falls off. The stronger the current that passes in the wire and the heavier the wrapping around the nail the stronger the electro-magnet.

Magnetic Effect Of An Electric Current

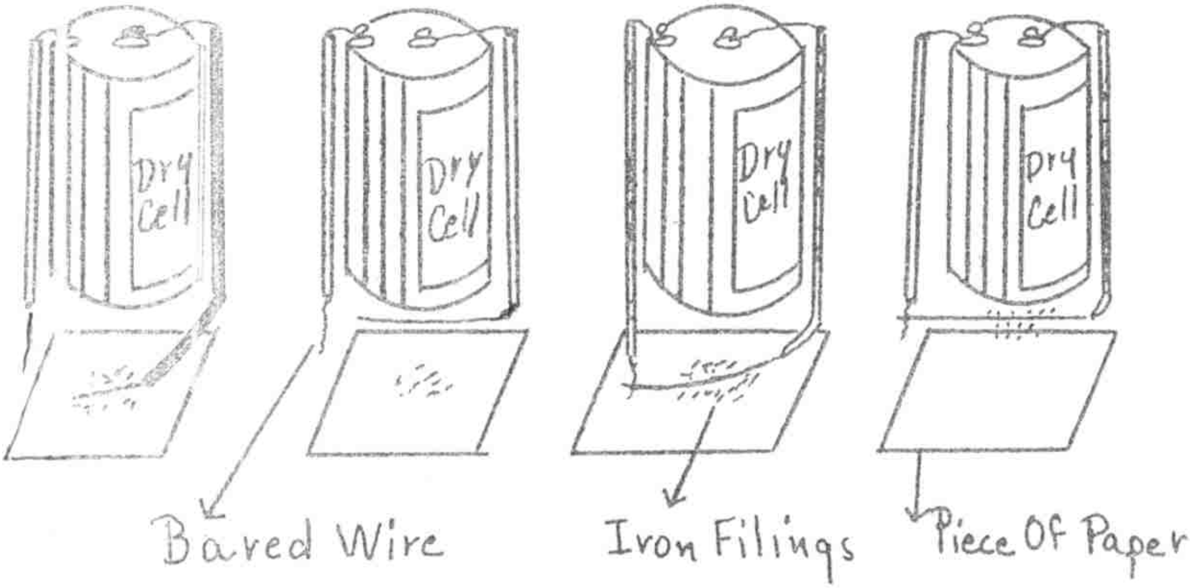

Fig. 20

An Electromagnet

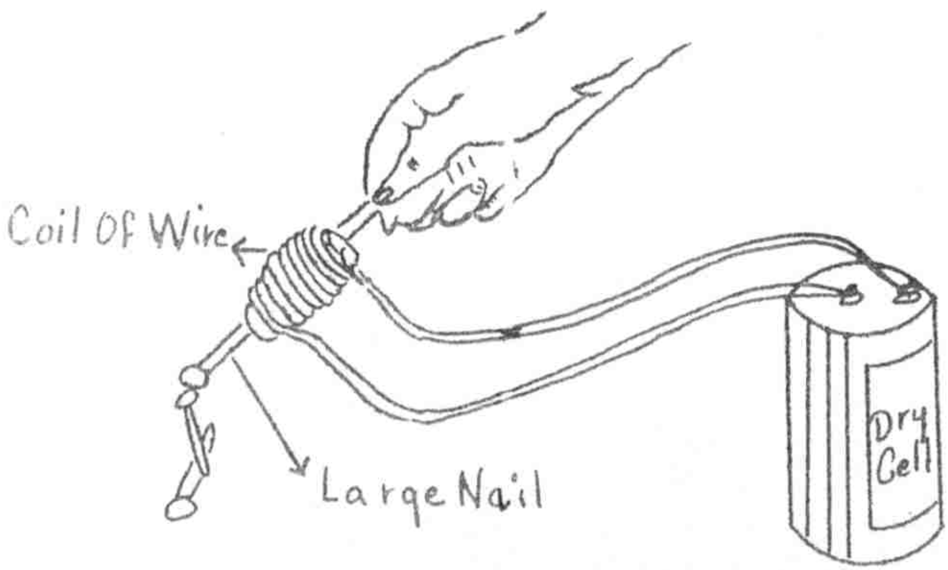

Fig. 21

1c) Test the poles of the electro-magnet in the above experiment with a compass. Now change the direction of the flow of current by changing the connection in the dry cell. Test the polarity again, it will be changed. Bring out the advantages of an electro-magnet:

1) It is a very strong magnet.
2) It can be magnetised and demagnetised by connecting or breaking the circuit.
3) The polarity of the magnet can be changed.

These three principles operate in many electro-magnetic devices.

2) How does an electric bell work?

Making an electric bell - See Figure 22.

Materials-

A wooden board 12" x 6".

A dry cell, copper wire.

Two medium sized nails wrapped with copper wire, leaving two ends free.

Two strips of tin cut from a can.

The armature 6" x 1½", the spring 2" x 1", cut in shape as in the diagram.

A piece of circular tin taken from the cover of a can to act as the gong.

Nails, two wooden blocks 2" x 2".

Mount the two connected nails wrapped with copper wire between the two wooden blocks and hammer it to about the centre of the large wooden block. Take the tin strip which is to act as the armature and

An Electric Bell

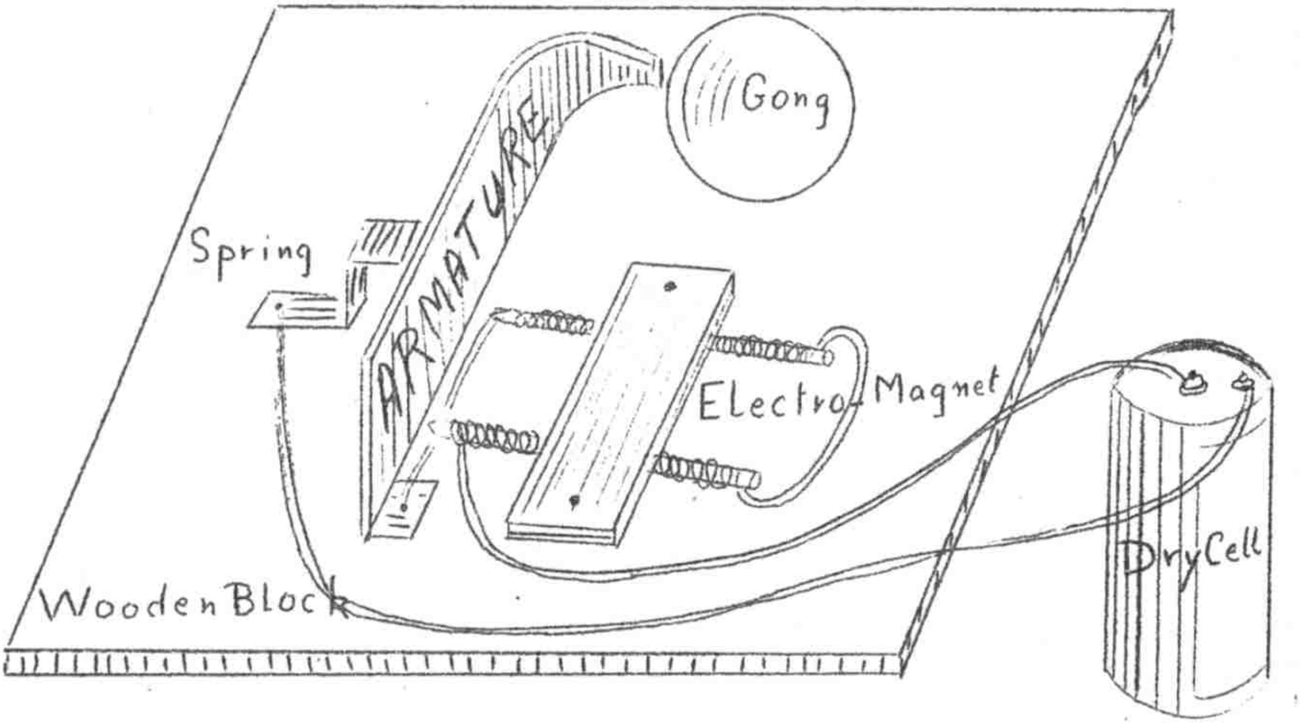

Fig. 22

A Telegraph Set

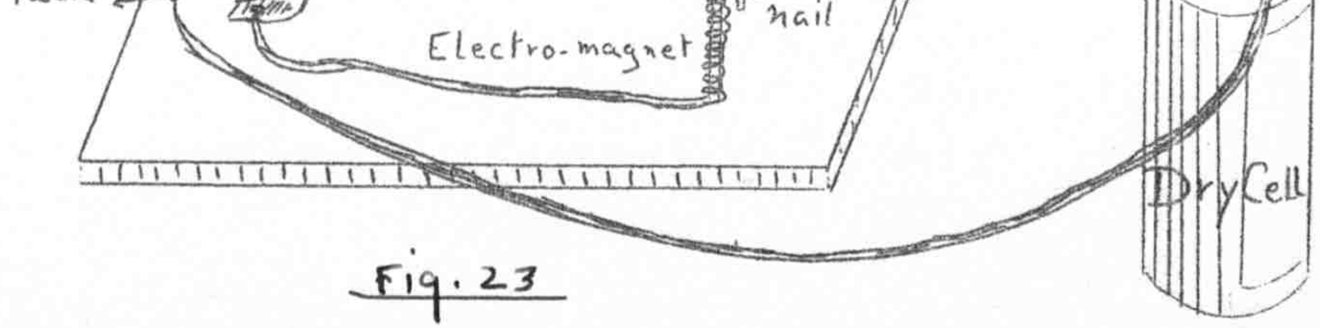

Fig. 23

hammer it down just infront of the electro-magnet (nails just fixed). Now stand the circular tin strip very near to the head of the armature (barely touching). Now mount the other tin strip which is to act as the spring on the other side of the armature opposite the electro-magnet. The pointed head of the spring should lightly rest on the armature. Now complete the circuit in the following fashion.

Take one end of the wire wrapped round the nails and connect it to one terminal of the dry cell. Take the other free end and connect it to the armature on the nail which holds it to the board. Now take another length of wire and connect the other terminal of the dry cell and the spring on the nail which holds it to the board. The armature starts to strike the gong as soon as the circuit is complete.

Note - 1) The tin strip which is the armature must have a springing, elastic quality.

2) Care should be taken to see that insulation is scraped off the wire where the connections are made.

3) How does a telegraph set work?

Making a telegraph set - See Figure 23.

From a tin can cut a strip in a T shape about eight inches long. Bend this strip as is shown in the diagram, and nail it to a wooden board. Take two medium sized nails and wrap insulated wire round one in clockwise fashion and in another in anticlockwise fashion. Hammer both of them to the board just below the T-shaped tin strip. Bend the head of a long nail and hammer it in the position as shown so that the 'T' shaped strip is between the electro-magnets and the bent nail.

Now cut another strip of tin about four inches long to serve as the key with which to send the messages and nail it to the board as shown. Wrap the scraped end of a wire round the head of a nail and hammer it down on the board just below the sounding key. Now connect the circuit in the following fashion:

Take the free end of the wire wrapped round one nail of the electro-magnet and connect it to one of the terminal of a dry cell. The other free wire of the second nail should be connected with the sounding key where it is nailed on board. Take a length of wire and connect the other terminal of the dry cell with the nail which is just below the sounding key. Now whenever the sounding key is touched to the nail the 'T' shaped strip produces the similar sound.

4) How does an electric motor operate?

4a) The main principle of the electric motor of rotation can be shown by hanging one permanent bar magnet in horizontal position by a string and rotating it by moving another magnet round it.

4b) Constructing a home-made electric motor.[18]

Examine Figure 24 very carefully for making each part as is shown and then essemble them together.

<u>Directions for making the rotating part of the motor-</u>

Materials-

A long nail, A bottle cork 2" long 1" in diameter.

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[18]Will Burnett, <u>Teaching Science in the Elementary School</u>, 1957, p. 262.

A Homemade Electric Motor

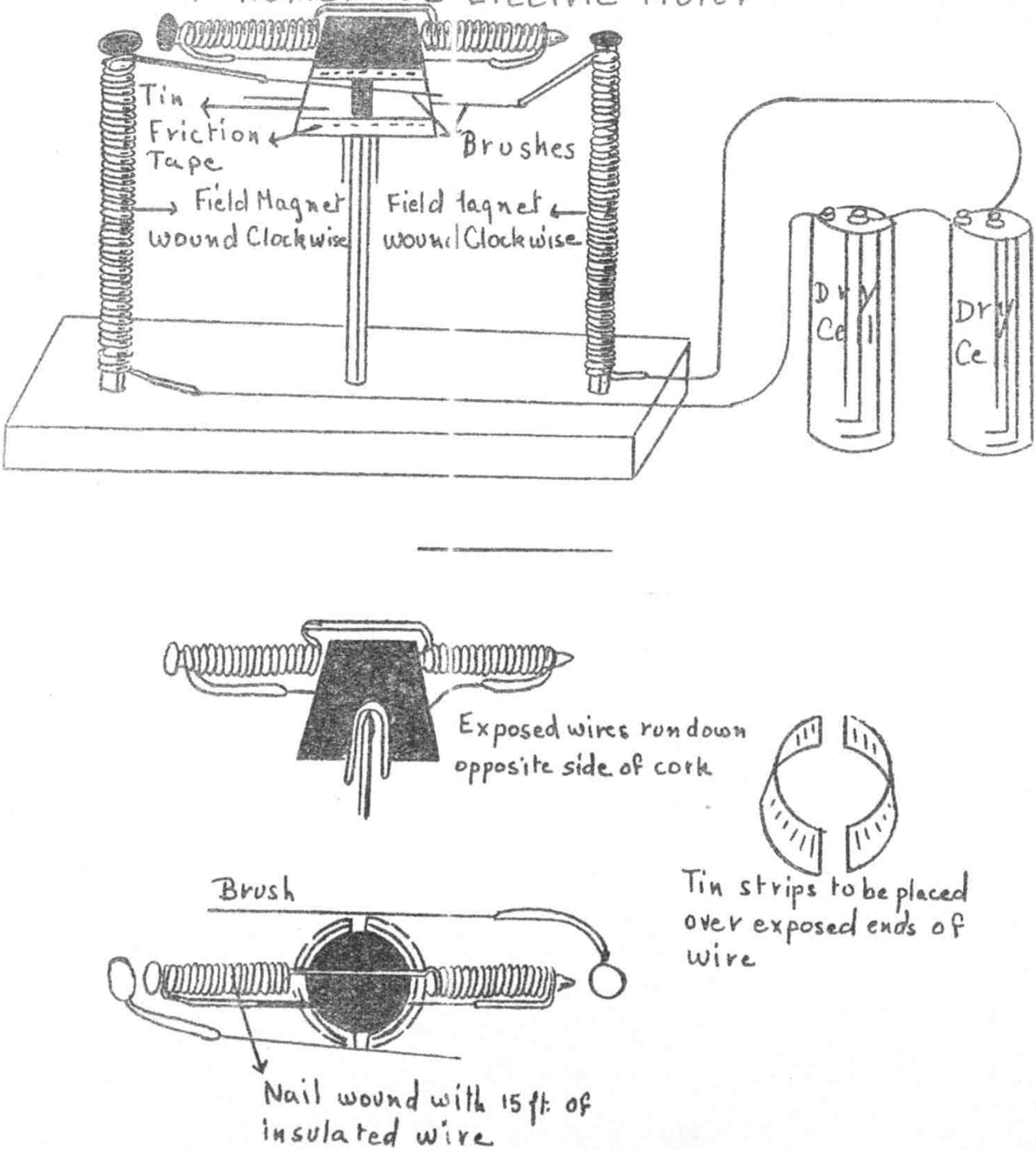

Fig. 24

2 strips of tin cut from a can.

A thin glass tube.*

Make an electro-magnet by winding insulated wire around a medium sized nail. Be sure to wind the wire all in the same direction. Scrape off the insulation from about two inches of both the ends of the wire. Now take the two tin strips. These should be about three fourths of an inch wide and just long enough so that when they are bent along the outside of the cork there will be a slight gap between them on both sides. Attach the electro-magnet on the top of the cork in a horizontal position. Now take the free-scraped ends and lay them alongside the cork, so that they run down opposite sides. Place one piece of tin over each wire and fasten them to the cork with adhesive tape making sure that the wire and the tin make good electrical contacts. If a soldering iron is available it is better to solder the wires to the tin strips to ensure good contacts. It is important that the gaps between the tin strips lie at right angle to the axis of the nail as in the figure. The armature is now completed.

<u>Directions for making the rest of the motor.</u>

To make the field magnets between which the armature will rotate, wind insulated wire round two large nails taking care that the wire is wound in the same direction in both the nails and leaving two ends free. This will enable the current to enter from the bottom of one of these nails and move to the top and the top of the other nail and move to the bottom. This makes the top of one a north pole and the top of the other a south pole.

Now drive the nails into the baseboard so that the head of each is at the horizontal level with the armature nail and is as close to the armature nail as possible without touching it. Remove the insulation from the upper free ends of each field magnet and bend this in such a way that each end rub lightly against the tin strip. It is also important that these wire brushes touch the gaps in the tin strips exactly at the same moment when the armature rotates. See figure. *In order to prevent much friction when the armature rotates drive a thin glass tube with a smooth closed end into the base of the cork as shown in figure. The closed end can be made by heating the glass tube in fire.

The head of the nail on which the whole armature rests should be filed to a sharp point. This way much friction is avoided.

Now attach the other wire ends of the field coils to two or three dry cells connected in series. Slight adjustment of the brushes may be necessary if the motor is to run well. The armature starts whirling as soon as the circuit is complete.

4c) How does the motor work?

4d) What is the function of a motor in an electrical device?

5) How can magnetism be used to produce electricity?

5a) Wrap 100 turns of insulated copper wire around a large nail in one direction. Leave about 2 feet of wire free at each end. Fasten the free scraped ends to the terminals of a galvanometer. Now bring the north pole of a magnet rapidly from one end of the nail to the other. The galvanometer needle deflects showing that current has been induced. Move the magnet the other way, the needle deflects in the opposite direction. Now take the south pole of the magnet and repeat the experiment. The needle deflects in the opposite direction when the polarity of the magnet is changed.

This experiment can be done also with just a coil of wire and moving a bar magnet to and fro through the coil.

Note-

1) The more are the turns in the wire coil the larger the induced current.

2) The stronger the magnet the larger the induced current.

3) In a generator it is only important that one part moves. It can either be the coil or the magnet. The main principle is cutting the magnetic lines in the field which sets up an induced current in the conductor.

5b) How can a home-made generator be made? See Figure 25.

The electric motor illustrated can be easily changed into an electric generator. The two brushes should be removed from their position in the motor and fastened together. The field magnets should then be connected to the dry cells.

In order to find out whether electricity is produced or not when the armature is rotated within the field magnets connections should be made between the galvanometer and the rotating armature as shown in the figure. When the armature is rotated by hand the galvanometer

Homemade Electric Motor Modified Into A Generator

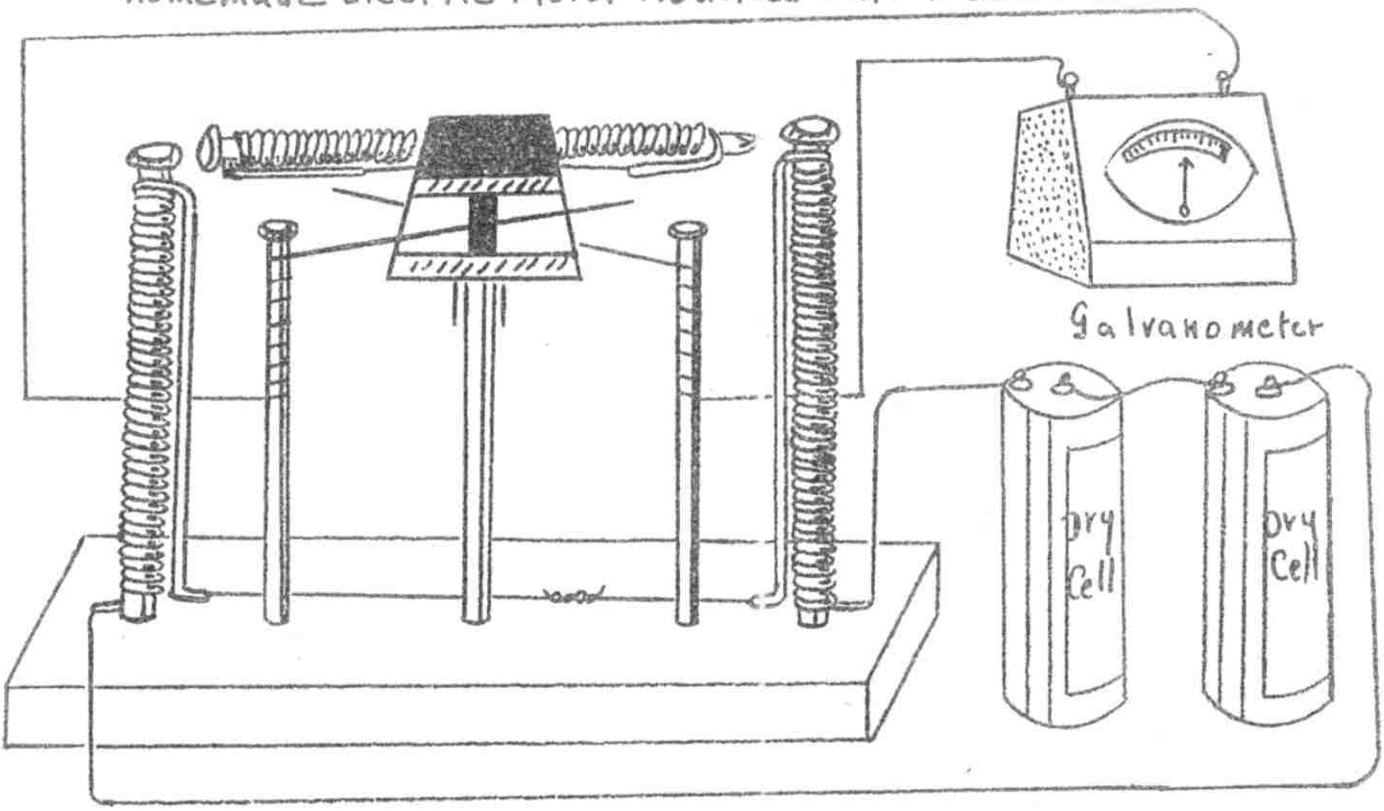

Fig. 25

A Telephone Transmitter & Receiver

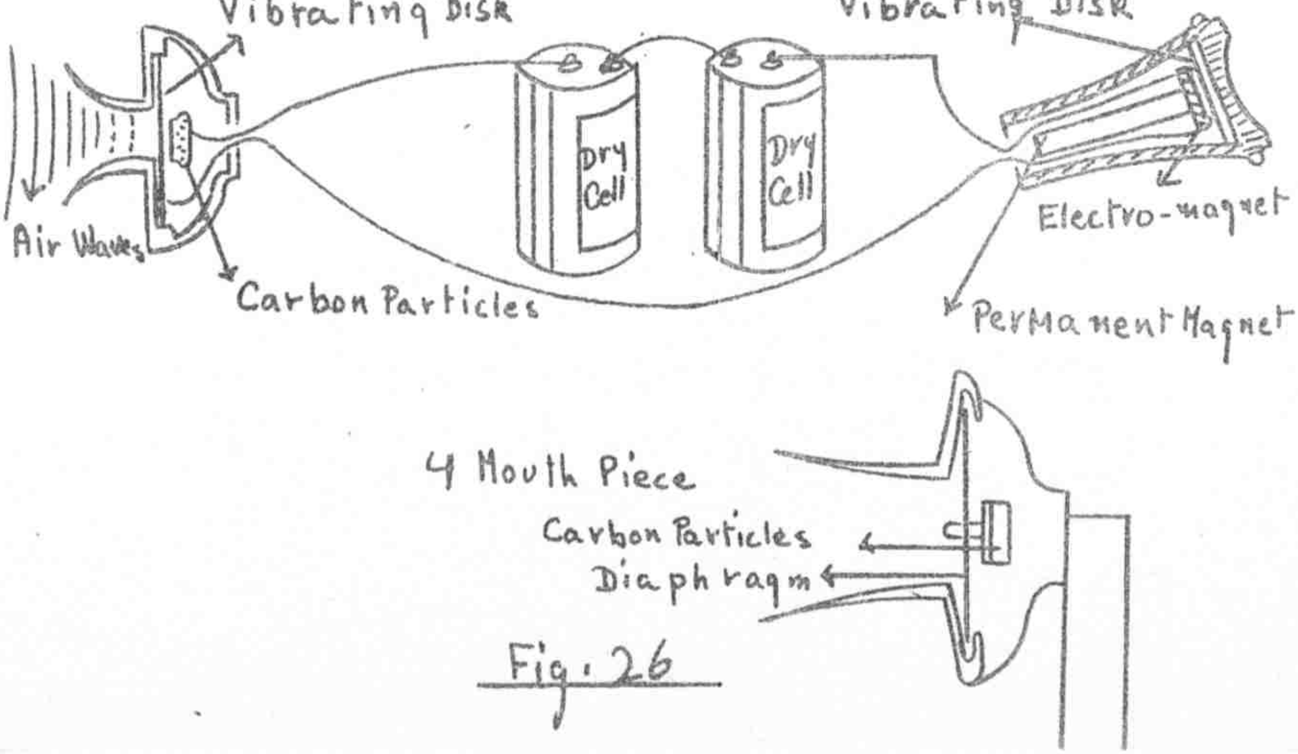

Fig. 26

needle deflects. Such a generator produces "direct current."

5c) How does an alternating current generator differ from a direct current generator?

6) How is electricity used for communication?

Let students draw diagrams and charts of the different parts of the telephone -- speaker and receiver and study the functions of each part as a part of their projects. An example of such a diagram is figure 26.

Sample test prepared to examine the students in comprehension and application of the facts and principles in the unit on electricity and magnetism.

1) When sheets of paper are run through a printing press in winter, it might soon become difficult to make a sheet lie on top of the pile. Why does this happen?

2) Why does hair bristle and produce a crackling sound when a comb is run through it in winter?

3) If all materials contain positive and negative charges of electricity, why do they not always show an electrical charge?

4) Comment on the following statement:

   When a fuse blows in your house all you have to do is to put a small coin behind the used fuse to repair the circuit.

5) Why do automobile batteries need occassional recharging?

6) Can a permanent magnet instead of an electro-magnet be used in the construction of an electric bell? Give reasons for your answer.

7) Why is it necessary that the wires in the lamp bulb be made very thin and of special metal?

CHAPTER V

A SAMPLING OF POSSIBLE ACTIVITIES WITHIN A UNIT ON SOUND

Even a hurried examination of the prescribed curriculum shows that the unit on sound has been dealt with very poorly. Poor not only in connection with the materials to be covered but also as concerns the choice and arrangement of the areas. The areas chosen to be studied appear to reflect random, thoughtless selection without their worth being judged against any suitable criteria.

First of all, the syllabus does not prescribe any study of sound for classes VI, VII and IX. The syllabus of classes VIII and X devotes three lines of instructions to the study of sound. Class VIII covers "Sound waves" and class X "Propagation of Sound waves". The instructions in both cases are not only scanty and insufficient but even fail to point out the specific ground to be covered. Clearly, the study of sound needs to be given more thorough and serious consideration. The following unit would give an over-all treatment to the study of sound by filling in the obvious gaps in the syllabus, establishing meaningful connections between topics and giving sufficient and clear instructions to teachers for carrying on the work as an integrated unit.

UNIT

HOW DOES THE PHENOMENON OF SOUND AFFECT LIFE?

The phenomenon of sound is very much interwoven with our everyday life. Scientists have always been interested in the study of sound not only for the pure sake of understanding this phenomenon but also to make use of it in the advancement in life. We have come a long way since the early times when man sent messages from place to place by means of drum beats.

Scientific observation shows that for a body to produce sound it has to be in a state of vibration. This vibration has then to be transferred to the surrounding medium which in turn delivers it to our ears. The science of sound must therefore concern itself with

a) Vibrating bodies.

b) The production and propagation of a wave motion in the air (or other medium), which waves are termed sound waves.

c) The sensation of sound.

One appropriate way to proceed in the study of sound is in the above-mentioned order.

A. <u>Subunit</u>

<u>Sound Is Produced By Vibration.</u>

Experiments-

1) Place a drum (Dholak) on the floor or on a table with one end upward. Let the students strike the skin. Then let them quickly put the tips of their fingers on the skin to feel the vibration. Let them strike it again and this time quickly sprinkle talcum powder or sand on the skin. The fine particles start a merry dance.

2) Clamp one end of a thin strip of steel in a vise (a thin saw blade will do) as shown in figure 1. Pull the end from the stationary position 'a' to position 'b' and then release it. It flies back through the position 'a' to the position 'c', and then back again through 'a' towards 'b', and so continues to vibrate backwards and forwards. The extent of the swings on each side of 'a' getting less and less until finally the strip comes to rest again at its initial position 'a'. Shorten the rod if necessary until a continuous sound is heard. Continue to shorten the rod step by step, and note the effect on the sound which it gives out. The long rod produces a low note and the shorter rod the higher note.

Note-

A meterstick, yardstick, ruler or other plastic wooden plank can be used to perform the above experiment.

3) Use the tuning fork to show that the source of sound is a vibrating body by dipping the vibrating prongs into a vessel of water, thus producing a spray.

4) Lynde gives the following simple experiment for sound production by vibration:

Vibrating Steel Strip Produces Sound

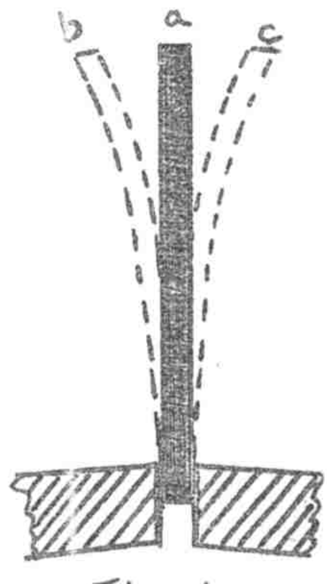

Fig. 1

Vibrating Spoon Produces Chimes

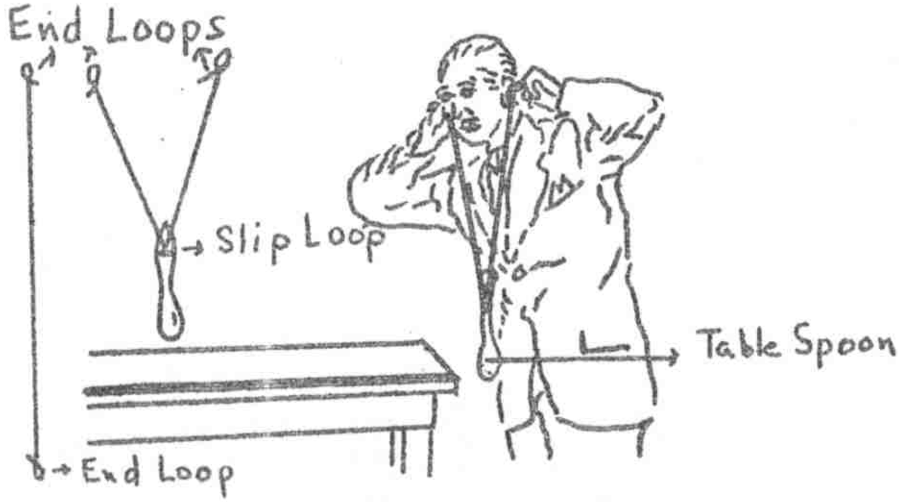

Fig. 2

Take a light string about 3 feet long and tie a loop at each end. Attach a table spoon at the exact middle by means of a slip loop as shown in figure 2. Put a forefinger in each loop and put the end of a forefinger in each ear. Lean forward and let the spoon strike the edge of a table.[19]

5) Fasten a stiff bristle or paper triangle about one inch long to the end of one prong of a tuning fork with a drop of wax. Smoke a piece of window pane with an oil lamp or candle flame until one side is entirely black. Lay it down with the smoked side up. Strike the tuning fork and draw the tip of the bristle or paper triangle across the glass as shown in figure 3. The wavy line indicates the character of the vibration.

6) How do the vocal cards produce sound?

To understand how the vocal cords produce sound, a simple experiment can be done.

Stretch a wide rubber band rather tightly so that the two edges of it are close together. Blow between the edges. If this is done right, a sound will be produced by the vibrating rubber. This is the way vocal cords work.

How do lips, teeth, tongue and mouth cavity help the vocal cords in the production of sound?

B. <u>Subunit</u>

<u>What Are The Few Essential Facts Connected With Vibratory Motions?</u>

1) Vibration - A complete to and fro movement of the disturbed

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[19]Lynde, <u>Science Experience with Ten-cent store Equipment</u>, 1950, p. 1.

The Character Of The Vibration Of A Tuning Fork

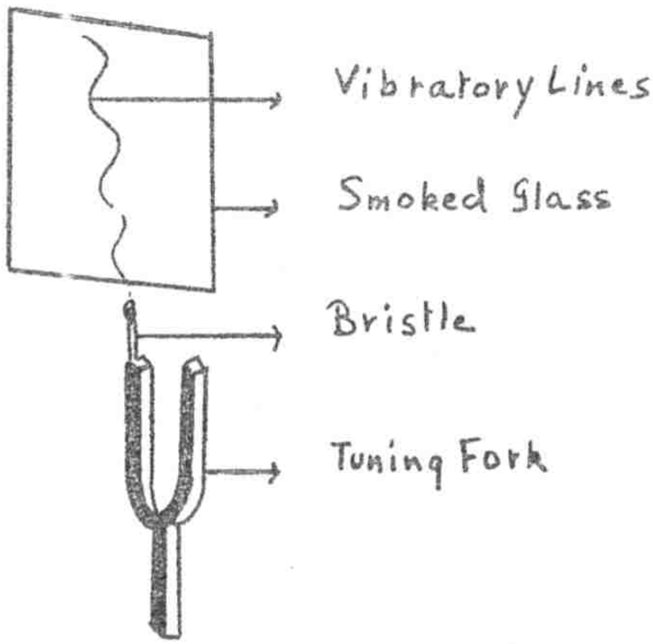

Fig. 3

Density Of Medium Affects Intensity Of Sound

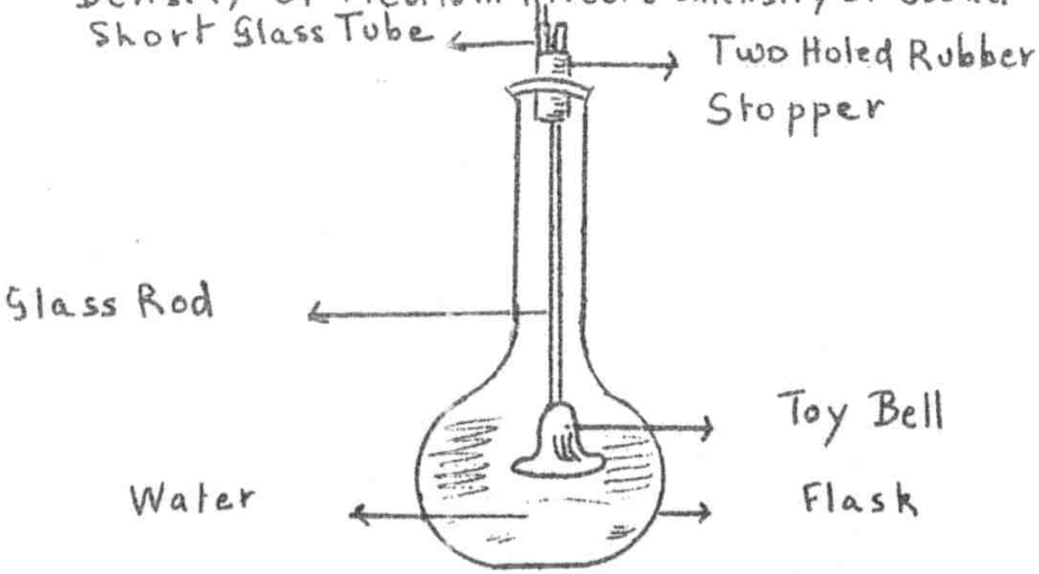

Fig. 4

particles of a medium is called a vibration.

2) Frequency - The number of vibrations of the particles per second is called the frequency.

3) Amplitude - The greatest distance that a vibrating particle move from the centre of its path is the amplitude of its motion. Sounds are louder when the amplitude of the vibrating particles is greater.

4) The loudness of sound depends upon the amplitude of vibration.

If we tap a tuning fork lightly on the table a feeble note is heard and as we are aware, the amplitude of the swing of the prong is small. A sharp blow produces a loud note, the prongs swinging through a much wider arc. In the same way, a stretched string lightly touched gives forth a feeble sound, while a much louder sound is obtained by forcibly plucking the string. Thus the loudness depends on the amplitude of the vibrations, and it can be shown that the loudness is proportional to the square of the amplitude.

4a) The loudness also depends on the distance from the source - Law of inverse squares.

C. Subunit

The Propagation Of Sound.

1) What are sound waves?

1a) Lynde gives the following experiment to show sound vibrations in air.

Cut both ends out of a small tin can, stretch the bottom half of a toy balloon over one end, and fasten the rubber with a stretched rubber band. Break off a ¼" x ¼" piece from a small mirror. Glue the piece to the bottom rubber at one-third of the

Sound Vibrations In Air

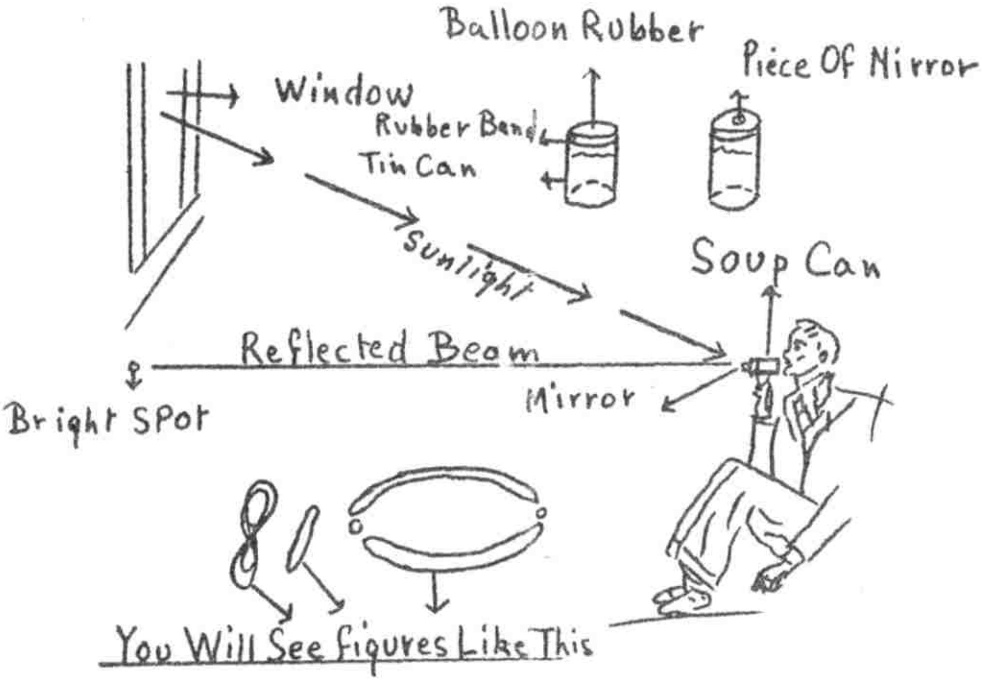

Fig 5

Character Of Water Waves

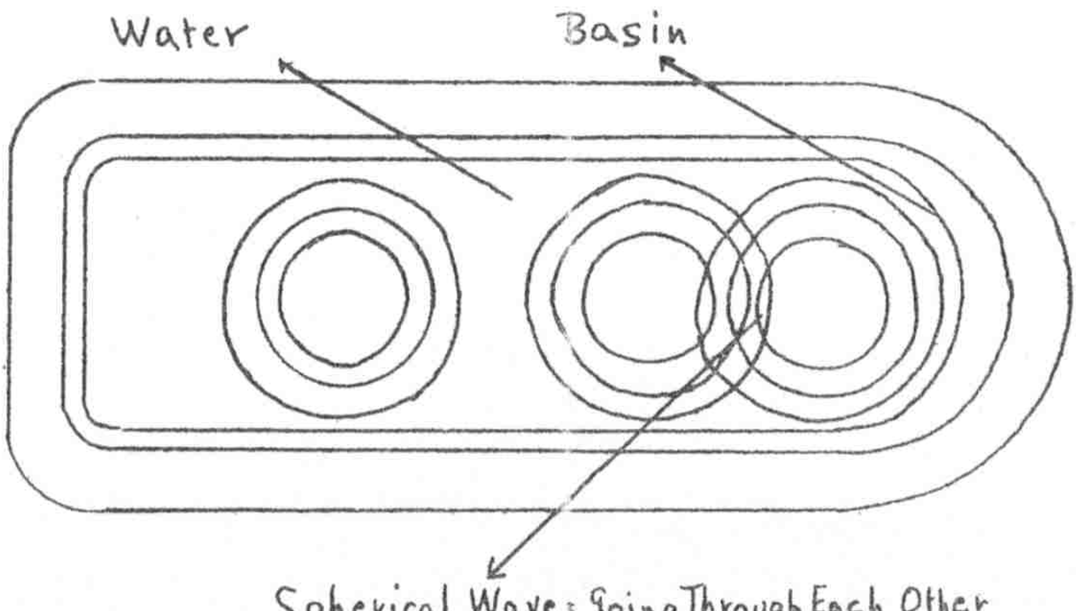

Fig. 6

diameter from one edge. Now seat yourself in the strong sunlight and reflect a beam of sunlight so that it makes a spot on the ceiling or wall as shown in figure 5. Press the open end of the can against your mouth and sing different notes into the can. You will see the spot of light vibrate in different ways.[20]

1b) Experiment with water waves.

Put some water in a fairly large basin as shown in figure 6. Let the surface become still, and then dip a finger in and out. You will see a series of waves spread out rapidly in perfect circles. Dip two fingers in and out, about one foot apart. You will see two series of waves go through each other. Each will spread out in perfect circles as though the other were not there.

Similarly, sound waves spread out in air, but as perfect spheres, and thousands of sound waves can move through one another in the same air at the same time. Each will spread out as a perfect sphere, as though the others were not there.

1c) How do Sound waves move?

Beauchamp, Mayfield and West demonstrate the movement in the following way.

Get a spring out of an old spring balance or any other source as shown in figure 7. Fasten one end of it to a support. Fasten a weight to the other end of the spring. Near the lower end press together several coils of the spring, then let go of them quickly. Watch what happens along the entire spring. Repeat the experiment

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[20] Ibid., p. 11.

Coil Of Spring Showing Compression And Rarefaction In Sound Waves

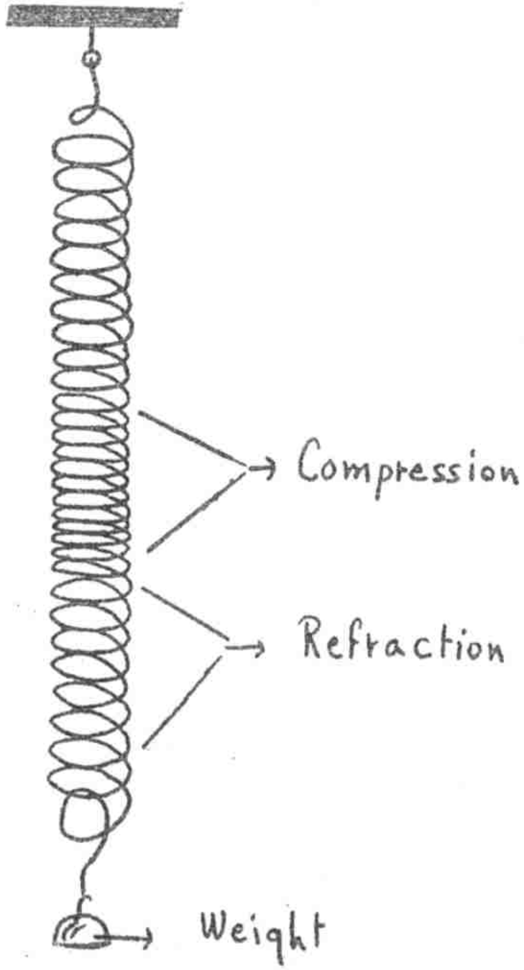

Fig. 7

Transverse Waves In Water Ripples

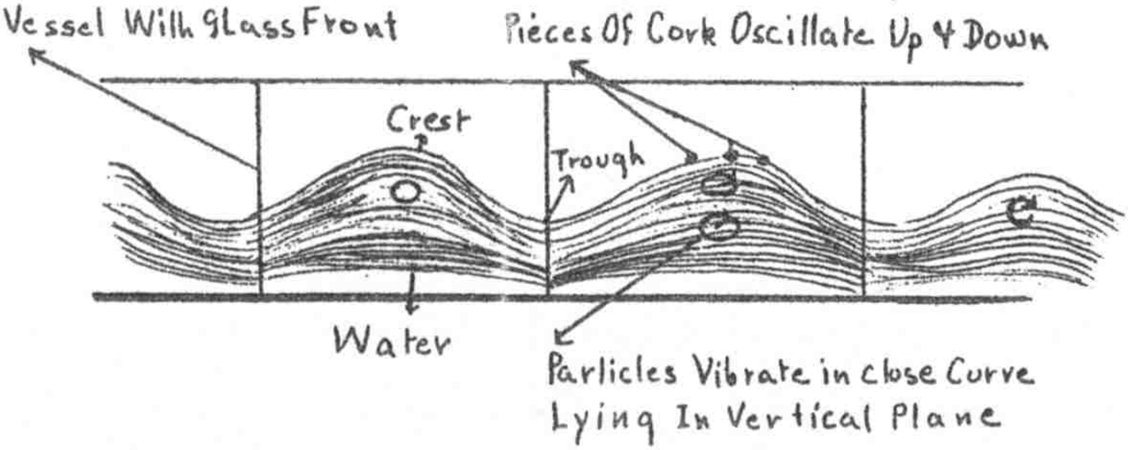

Fig. 8

several times and try to explain what happens. The compression and rarefaction that appears in the spring constitutes a complete wave. The sound waves produced in air by a vibrating body are of a similar nature.[21]

Note-

A similar experiment can be performed by making a spiral coil round a tube with copper wire. Remove the tube and use the coil to demonstrate compression and rarefaction. When the end of the spiral is first pushed in and then immediately pulled out, a complete wave is transmitted.

2) Sound propagation requires an effective medium.

2a) To demonstrate that sound is not transmitted through a vacuum conduct the following experiment.

Place an electric bell, in a glass jar and connect it with a vacuum pump. The joint between the jar and the vacuum pump must be made airtight by means of soft wax. The alarm clock is placed under the jar on a thick pad of cotton, as shown in figure 9, and is set so that it will "go off" in a minute or two. When it rings, it can be heard plainly. Then the clock is set to "go off" in five minutes, the jar is placed over it and it is sealed up again. Now as much air as possible is pumped from the bell jar and when the clock rings, you can see the vibrating but cannot hear as a sound or may hear a faint sound because the vacuum is not complete.

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[21] Beauchamp, Mayfield and West, Everyday Problem in Science, 1946, p. 586.

A Vacuum Does Not Transmit Sound

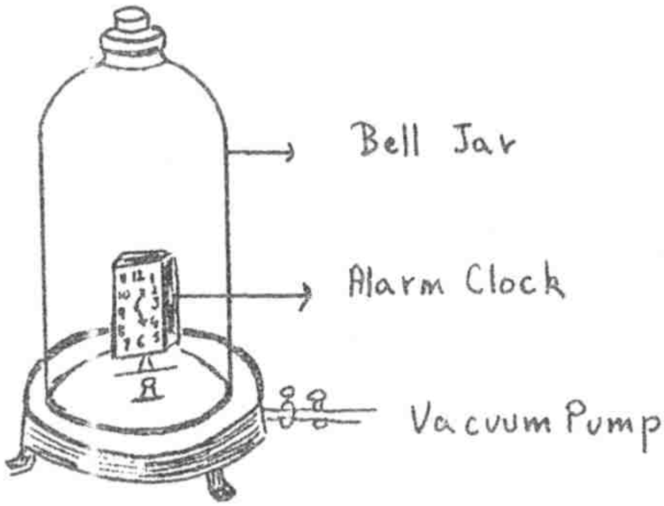

Fig. 9

Sound Conductivity Through Solids

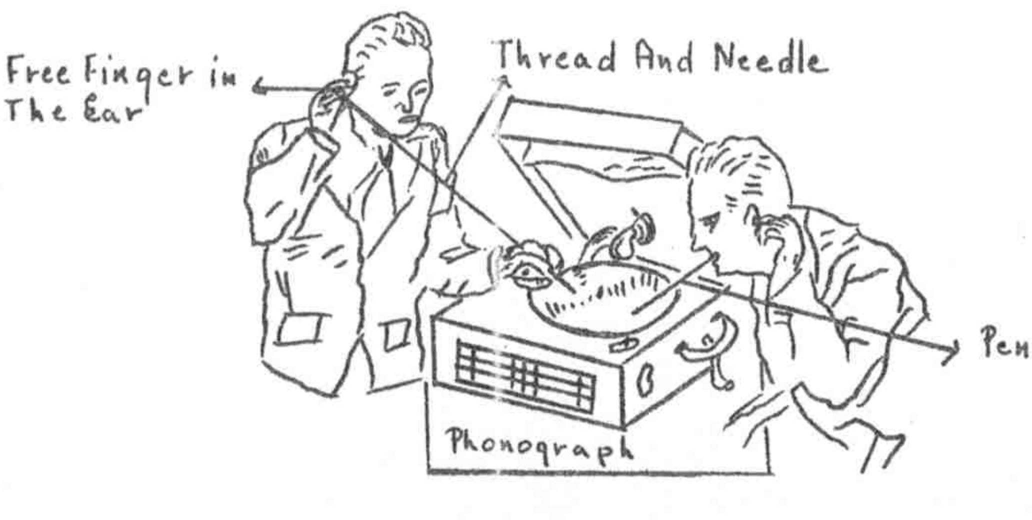

Fig. 10

2b) To demonstrate that effective propagation of sound requires continuity of structure in a medium. Stewart gives the following experiment.

Enclose a clock in a small box and pack this box into another box with sawdust. If the inner box is completely surrounded by sawdust it will be found that the ticking cannot be heard. Take a piece of wood and push it through the sawdust so as to connect the inner and outer boxes: The ticking can now be heard plainly.[22]

2c) Sound also does not readily pass from one medium to another of different density - e.g. Sound made by the wheels of a train is not audible in the air even quite close to the rails but is transmitted to great distances along the rails which can be heard by directly applying the ear to the rails. To demostrate this fact the floor of the class-room can be used. A tapping sound made on one corner of the floor may not be heard on the other corner but is distinctly heard if ear is applied to the floor in that corner.

3) Velocity of the propagation of sound depends on:

a) Distance from the source of the sound to the hearer.

b) Density of the medium through which the sound is propagating.

c) Conductivity of the medium.

d) Temperature of the medium.

e) The velocity of the wind affect the velocity of the propagation of the sound waves.

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[22] Stewart, R.W., New Matriculation Sound, 1947, p. 44.

f) Wind direction also affect velocity of sound propagation. All these above points should be explained with examples and illustrations.

D. Subunit

Sound Conductivity.

1) Sound travels through solids.

1a) Place your ear against one edge of a table and let someone scratch the opposite edge lightly. You will hear the sound distinctly. Hold one end of a pencil in your teeth while you scratch the other end lightly. You will hear the sound distinctly.

1b) Lynde gives the following experiment to demonstrate sound conductivity through solids.

Insert a heavy thread into one eye of a needle and tie it in a loop. Hold the needle in a groove of a revolving phonograph record, stretch the loop over a forefinger and hold the finger in your ear as shown in figure 10. The thread must be stretched. You will hear the music distinctly. Now crip a penholder in your teeth and hold the pen point in the groove of a revolving record. Close both ears with your fingers and you will hear the music distinctly.[23]

2) To test the sound conductivity of different substances Yates gives the following experiment.

Cut 3" by 3" squares from pieces of thick paper, card-board, plywood, glass, and metal, the being either brass, copper or sheet iron. Place these pieces, one at a time over your ear, and start

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[23] Lynde, Carleton John, Science Experience with ten cent Store Equipment, 1950, p. 8.

a large fork (table fork or tuning fork) to vibrating by striking and bring the end of the handle into contact with the square. Vigilant observation will reveal a considerable difference in the intensity of the different sounds as they reach the ear. It shall be noted that the paper is the poorest conductor of them all and that denser materials are better conductors of sound that less dense ones. Glass is a very good conductor, metal is also good but plywood is quite poor.[24]

3) Richardson and Cahoon give the following experiment to demonstrate sound conductivity through liquids.

Observe the conductivity of water by floating a block of wood in a vessel of water and touching the end of the handle of a vibrating tuning fork or a table fork to the block as shown in figure 11. The increase in the volume of sound is noted. The effect may be compared with that secured by resting the block on soft fabric and touching it with a vibrating fork.[25]

E. Subunit

Reflection Of Sound Waves.

When sound waves traveling in any medium meet the surface of another medium, the wave motion is in general partly turned back or reflected at the surface, and part is transmitted on in the second medium.

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[24] Yates F. Raymond, Science With Simple Things, 1940, p. 122.

[25] Richardson and Cahoon, Methods and Materials For Teaching General and Physical Sciences, 1951, p. 213.

A Sounding Board

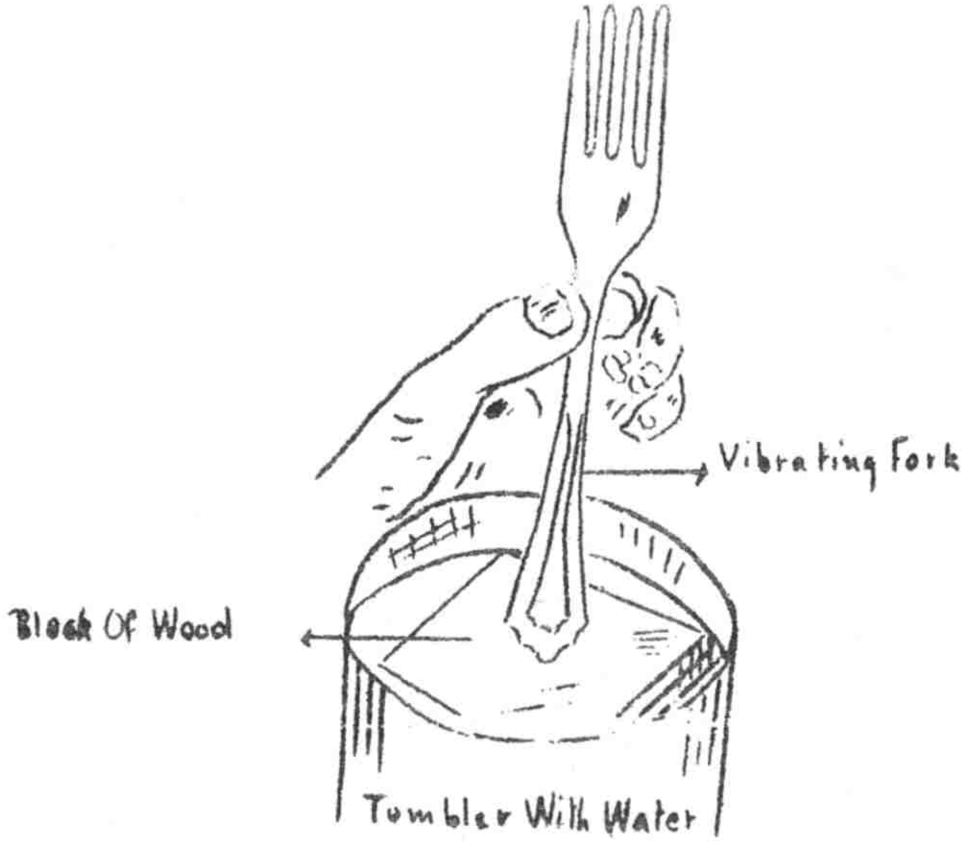

Fig. 11

A Cylindrical Tube Amplifies Sound By Reflection

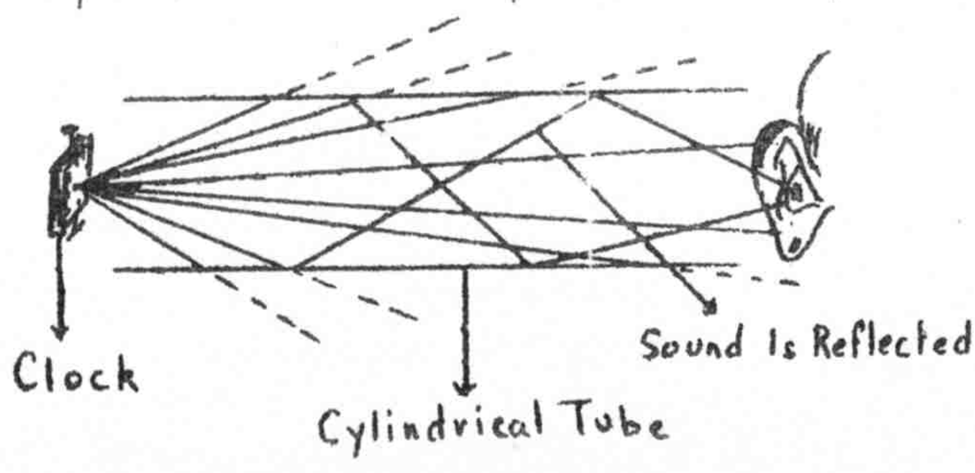

Fig. 12

1) The focal point of reflection can be determined by the following experiment given by Stewart, if one or two large concave mirrors are available.

Set up a large concave mirror and place a watch on the axis of the mirror at a point between the focus and the centre of curvature of the mirror. Attach a length of rubber tubing to the stem of a small funnel, and using the funnel as a sound collector, find the point on the axis of the mirror at which the refelection of the ticking of the watch is most clearly heard. This is the point at which the sound of the ticking is brought to a focus after reflection at the surface of the mirror. This experiment may be modified by using two large mirrors facing each other, the watch being placed at the principal focus of one mirror and the funnel at the principal focus of the other. The ticking of the watch at the focus of one mirror is reflected from this mirror to the second one, and there again reflected to the focus of the second mirror, where it can be distinctly heard by means of the funnel and the tube collector.[26]

Note-

Any shiny curved receptacle with a light-reflecting surface can do the work of the mirror e.g. chromium plated bowls etc.

2) The action of the speaking tube is a good illustration of the reflection of sound. The wave energy which without the action of tube, would spread out into a rapidly increasing volume of air, is

[26] Stewart, New Matriculation Sound, 1947, p. 117.

directed along the tube, and by repeated reflection from the inner surface, confined to the air in the tube. Pupils may experiment by making speaking tubes from poster paper or other thick paper. They will find out that their voices are much louder when they speak through the cylindrical tube than otherwise. To further illustrate the action of a tube let a watch be hung at such a distance from the ear as to be inaudible. On interposing a smooth straight tube as shown in figure 12 between the watch and the ear, the ticking can be plainly heard.

3) The ear trumpets used by deaf persons also furnish illustration of the reflection of sound. The wave energy which enters the wide end is directed by repeated reflections through the trumpet to the ear, and as the volume of the air by which the energy is carried decreases as the ear is approached, the intensity of the wave motion is increased and the sound is more easily heard.

<u>Note-</u>

This type of trumpet is not widely used nowadays because of the modern hearing aids.

4) Whispering galleries are built to reflect sound.

5) Echoes. The reflection of sound depends on the following factors.

   a) Reflecting surface e.g. a cliff, hillside, the walls of a building, clouds, etc.

   b) Sufficient distance between reflecting surface and the hearer. (56 feet minimum).

   c) Climatic conditions which affect sound velocity.

Production of multiple echoes depends on the presence and arrangements of more than one specific reflecting surface e.g. a number of cliffs.

F. Subunit

How Can One Sounding Body Produce Sound In Another Body - Resonance, Musical Sounds.

1) Sympathetic vibrations.

1a) As Yates points out that if one table fork is set to vibrating by striking a time against some solid object, the vibration created can be communicated to a second fork by holding the handles together as shown in figure 13. If you then hold the second fork close to your ear, you will hear it singing its own song. If the two forks are of the same size and made of the same material the frequency of vibrations will be the same in both. To be really successful this experiment must be conducted in great haste.[27]

1b) Experimenting with a coffee can resonator is another activity given by Yates. If a table fork is set to vibrating, the sound it produces will be greatly amplified if the handle of the fork is pressed against the bottom of an empty coffee can as shown in figure 14. The can functions as a resonator.[28]

1c) Lynde uses a revolving phonograph record as shown in figure 11, experiment 1b of Subunit 'D' to illustrate the same principle.

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[27] Yates F. Raymond, Science With Simple Things, 1940, p. 121.

[28] Ibid., p. 120.

Similar Objects Vibrate Sympathetically To Produce Similar Sounds

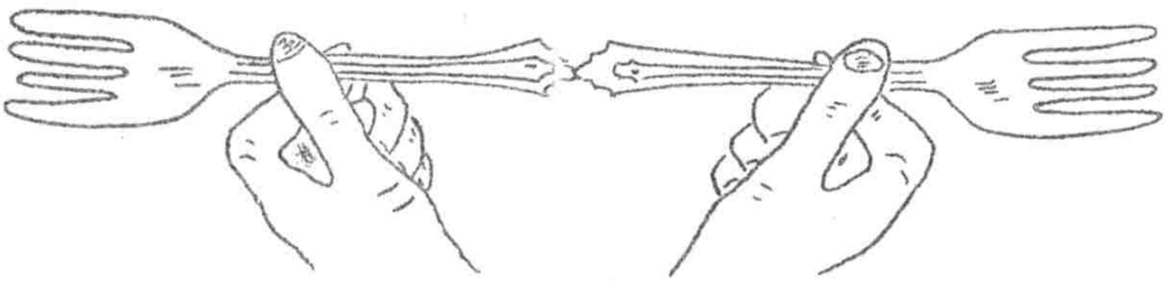

Fig. 13

A Coffee Can Resonator

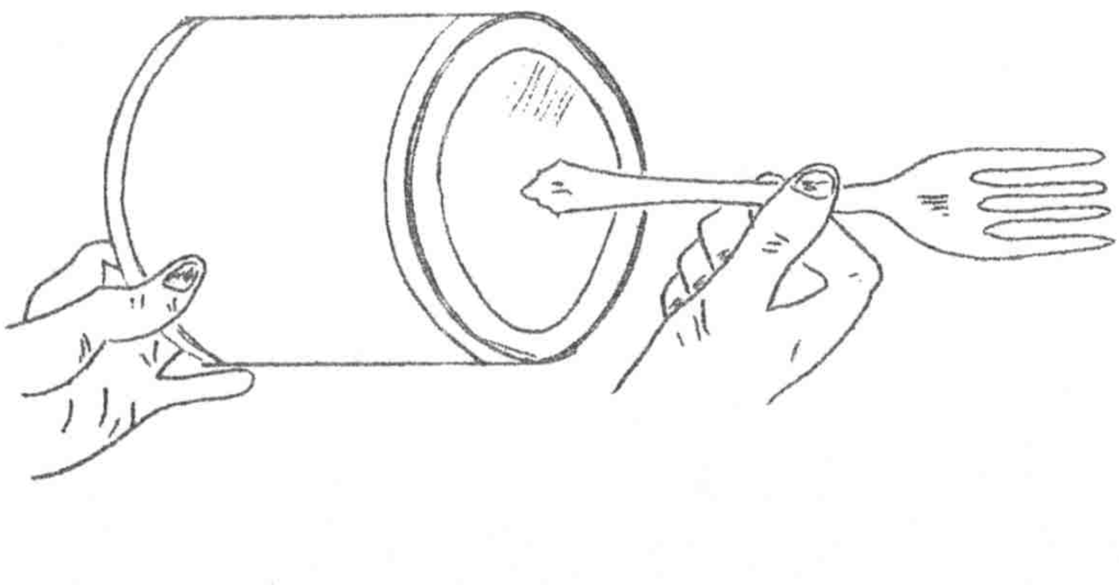

Fig. 14

Hold a needle in the groove of a revolving phonograph record and you will hear a slight sound. Fasten the needle securely near one corner of a large piece of cardboard and repeat. You will hear louder sounds. Hold your ear against the cardboard. You will hear much louder sounds. The needle has a small area and gives out little sound. The cardboard is set in vibrating by the needle and since it has a much larger area than the needle, it produces a much louder sound.[29]

1d) Yates gives the following experiment on sympathetic vibrations.

Fill two glasses with water to the same level. Thus they are in tune with each other and once glass will vibrate when the other is set in motion by stroking it with a violin bow. The wire laid across the lips of the second glass as shown in figure 15 will dance merrily. However, when half the water is poured out of the second glass, it will fall out of tune and the wire will barely dance at all.[30]

2) Pitch.

The pitch of a note depends on the number of vibrations per second. The greater the number the higher the Pitch, and the reverse.

2a) Lynde gives the following experiment to illustrate Pitch.

Sound of the sea -- Close one ear and hold an empty medium sized milk bottle near the other. You will appear to hear "sounds of the sea". See figure 16. Repeat with a tumbler and you will appear to

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[29] Lynde Carleton John, Science Experience With Ten-Cent Store Equipment, 1950, p. 18.

[30] Yates F. Raymond, op. cit., p. 120.

Dancing Wire Illustrating Sympathetic Vibration

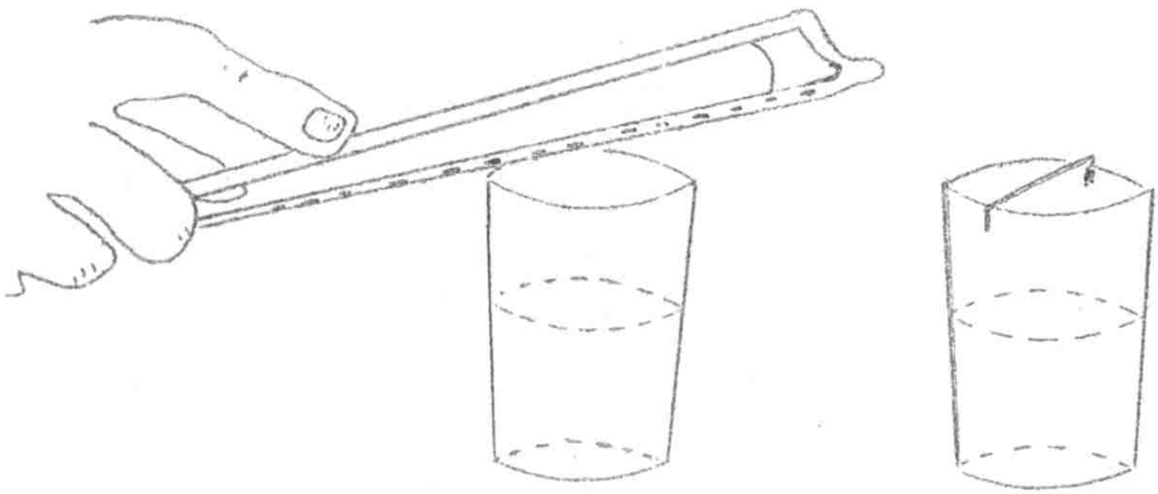

Fig. 15

Experiences With Pitch

Fig. 16

hear "sounds of the sea" of slightly higher pitch. Repeat with a large pitcher, large coffee pot, and with any other deep vessel which has not too large a mouth. The deeper the vessel the lower will be the pitch of the "sounds of the sea".

Every air column has its own note to which it vibrates symathetically, and the pitch of this note depends upon the volume and shape of the air column, and the area of its mouth. The air around us is at all times filled with sounds of such low intensity that our ears cannot detect them. The air column in a vessel, however, resounds sympathetically to its own note in these sounds and thereby produces a sound loud enough for our ears to detect. This is resonance.[31]

2b) What determines the pitch of a string of a musical instruement? Get some rubber bands of various lengths and thicknesses. Stretch a short band tightly and pluch it. Notice the sound it makes. Stretch a long band of the same size as tightly as you did before. Pluch it and notice the sound it makes. How does it compare with the sound made by the short band?

Select another band and hold it loosely. Pluck it and note its sound now. Stretch the band as tightly as you can without breaking it. Pluck it and note its sound. How are the sounds different? Select a thick band and a thin band of the same lengths. Stretch them both equally tight and note the sounds they produce. Are they alike?

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[31] Lynde, op. cit., p. 29.

Get a mandoline, guitar, violin or sitar or other string instrment.. Pluck the smallest string and note the sound it gives. Hold the string down on the sounding board so that the vibrating part will be shorter. Pluck it and compare its sound with that of the full length string. Begin plucking a string and tighten it each time you pluck. How is the sound different? Pluck one of the thin strings and one thick strings. Compare their sounds.

Conclusions -

The pitch of a sound depends upon how fast its source is vibrating.

The frequency of a vibrating string depends on:

1) The length of the string.

2) The weight of the string.

Beauchamp, Mayfield and West point out the facts that people who play or manufacture musical instruements use these above mentioned principles. For example people who make pianos must know what kinds of strings to use, and a piano-tuner must know how tight to make the strings. Scientists have agreed that the key called middle 'C' on a piano must vibrate 256 times per second if the piano is in time according to the scale known as standard pitch. The highest piano note is 3500 vibrations per second.[32]

3) Musical instruements, both string instruments and wind instruments work and produce musical notes on the principles of resonance and

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[32]Beauchamp, Mayfield and West, Everyday Problems in Science, 1946, pp. 591-592.

sympathetic vibrations. Study of a few examples of musical instruments of different kinds - saxophone, guitar and piano.

E. Subunit

The Sensation of Hearing.

a) How does the ear work?

1) Structure of the ear.

2) The functions of each part.

3) The propagation of sound sensation by the ear is due to sympathetic vibrations.

b) How do modern hearing aids, consisting of a microphone, 'radio set', and a loud speaker or receiver work?

As Beauchamp, Mayfield and West explain, one kind of hearing aid is so fixed that the receiver can be placed in the opening of the outer ear to strengthen, or amplify, the vibrations that are received. Another kind is made so that the receiver is clamped just back of the ear. The vibrations that are received by this instrument are transmitted through the bones of the head to the liquid of the inner ear. This can be illustrated by the following experiment.

Plug both ears tightly with your fingers or cottonwool and hold a watch between your teeth. You can hear the watch quite plainly. Its vibrations are transmitted through your teeth to the bones of your head and then to the liquid of the inner ear. There the auditory nerves carries the message to the brain.[33]

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[33] Ibid., p. 597.

CHAPTER VI

A SAMPLING OF POSSIBLE ACTIVITIES WITHIN A UNIT ON PLANT LIFE

Before students start studying about specific living things like "plant life", they need to know the common characteristics of living things and what "being alive" means. Thus the first part of the unit will deal with the characteristics of all living things and the basic unit of living matter - the living cell, and the rest of the unit will deal with the specific section on plant life. The whole unit is recommended to be taught in one class (either VIII or IX) instead of spreading it thinly over classes VI, VII, VIII, XI and X, which is almost certain to destroy the unity by breaking the essential connections. This unit can be taught best by allowing the students carry out numerous experiments. Most of the experiments on "Plant life" require more than the time allotted for the regular class periods. For this reason the student body should be organised to carry out group or individual projects under the teacher's guidance. It is desirable for ease of working as well as for keeping up the interest of the class to carry out the experiments in the school. That will mean that arrangements should be made with the administrative and other school staff to secure facilities for growing of plants, daily observations and so on. A teacher may get the students so interested in such projects that they ask to work on them even after school. This type of work requires the whole-hearted cooperation of administrators. Besides experiments, audio-visual materials should be very frequently used (like charts and pictures) while teaching parts of the plant or different stages of their growth. Charts are especially helpful when the students do not have access to microscopes to study microscopic details like the cross-sections of the stem, leaf and so on. Charts can be made by the students in their projects and kept permanently for the school laboratory.

A. Subunit

What Does "Being Alive" Mean?

1) Characteristics of living things.

Each specific characteristic of living should be explained and illustrated with examples taken from both Plant and animal life. The students should be encouraged to participate in discussing these topics, of course, rather than the teacher supplying all of the information in a lecture. This also applies to the other units of study.

1a) Food-taking as a vital function of living. Give examples to show how plants and higher animals differ in the way they perform this function.

1b) Respiration is necessary for living. The taking in of oxygen and giving out of carbon dioxide. Establish the similarity between the way lower animals like worms, and plants carry out their respiratory functions.

1c) Excretion as a living function. Both plants and animals give out waste products of metabolism as well as any excess food.

1d) Irritability or response to stimulus as a characteristic of a living thing. Irritability is more noticeable in animals than in plants. Some plants are sensitive enough to show responses to stimuli, but the time required is usually greater.

1e) Growth - All living things grow from birth to adulthood and then die. Life cycles of a plant or an animal.

1f) Reproduction as the essential characteristic for preserving the species.

1g) Motility is an important characteristic of animals but is also noticeable in some plant life. e.g. the movement of the Sun flower.

2) The living cell of which all living bodies are made.

One of the best ways to study living cells is to examine such things as amoebae, onion skin stained with iodine, etc. under a microscope. But if no microscope is available, explanations of the parts of the cell should be done with the help of charts and pictures of cell. Mere verbal explanations about cells fall far short of giving the students a clear idea about their real form or nature.

2a) Parts of the cell:

i) Protoplasm, its function and nature.

ii) The Nucleus, its function and nature.

This sections of living cells of plants can easily and clearly be seen under the microscope.

2b) Each cell of the body has the same living functions as the entire living organism.

B. <u>Subunit</u>

<u>The Plant As A Living Organism</u>

1) Plants need to take in food in order to live. In food taking and food assimillation, different parts of the plant - root, stem and leaves, perform various functions.

Functions of the root.

1a) Roots take in moisture.

Experiment -

Through a hole in a cork pass a bean seedling so that its roots dip into water coloured with red ink - in a test-tube as shown in figure 1. Mark the level of the liquid with a strip of paper and stand the tube in the sunlight. After a few days notice the lower level of the liquid. Cut across the root of the seedling. Squeeze the end gently and notice that the red liquid comes out of the cut surface.

1b) What are root hairs and what are their functions?

Experiment -

Root hairs can easily be examined on young bean roots grown in a damp atmosphere. Clean some jam-jars and line them with a single layer of clean blotting paper. Not more than two soaked Broad Beans should be slipped between the dry blotting-paper and

Appratus For Demonstrating That Roots Take In Water

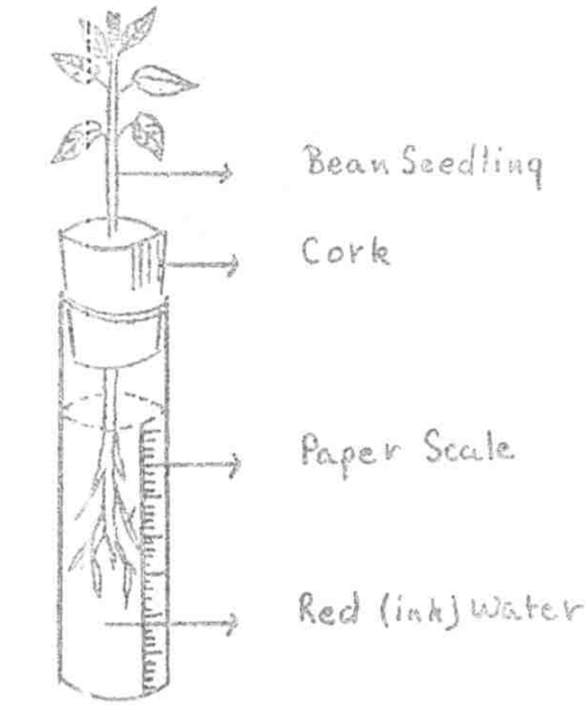

Fig. 1

Response Of Roots To Water Stimulus

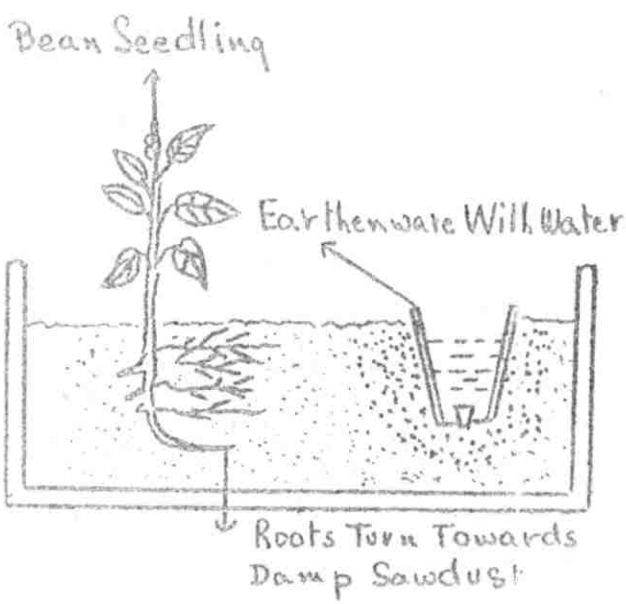

Fig. 3

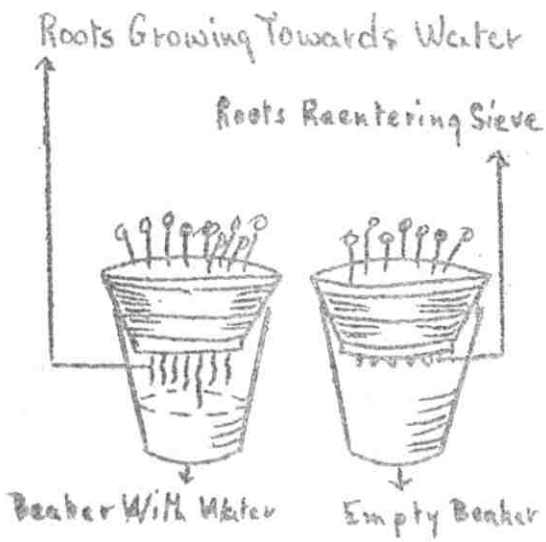

Fig. 2

the glass in each jar, one on either side. It is neater to arrange the seed so that the black mark or hilum, of the coat is downwards. Water, not more than an inch or two in depth, should then be put into the jar. When the seed germinates, its root is in a damp atmosphere, and this is exactly the right environment to induce the growth of root-hairs, which will appear as a white fuzz on the roots.
1c) How do roots respond to water? Phillip and Cox give the following experiment. Germinate some seeds (mustard or radish) in gravy strainers whose base is a fairly coarse sieve. The seeds are sprinkled on a think layer of sawdust or coconut fibre which is kept uniformly damp. Each sieve is then placed over a beaker containing water as shown in figure 2. In three or four days the seeds will push through the holes in the sieve and grow vertically downwards. If one sieve is now removed and put upon an empty beaker, the roots turn upwards and actually reenter the holes of the sieve, responding to the attraction of the wet sawdust or fibre. The roots of the other set of seedlings continue their downward growth towards the water in the beaker. This is a striking experiment to show the attraction that water has for roots and their response to this particular stimulus. [34]

Lambert gives another experiment to show that roots turn towards water.
Take a wooden box and fill it with sawdust. Put an earthenware pot

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[34] Phillips and Cox, Elementary Biology, 1948, p. 241.

with a hole at the bottom, on one side and put some water in it, as shown in figure 3. The water will seep out and dampen the sawdust around the pot on one side. Plant some seedlings in the dry section and observe their behaviour. After a time the seedlings turn their roots towards the damp sawdust.[35]

1d) How do roots respond to gravity?

The following experiment given in the General Science Handbook, illustrates the response of roots to gravity.

Between two rectangular pieces of glass place several blotters or a layer of absorbent cotton. Drop several radish seeds on the blotters or cotton and space them an inch or more apart. Fasten the "sandwich" together with a rubber band and set it an edge in a shallow pan of water as shown in figure 4. Hold it in a position with a string or a second rubber band. As soon as the seeds germinate and produce roots give the sandwich a quarter turn and note the change in the direction of root growth. After two or three days change it back to its original position and watch what the roots do.[36]

1e) How does gravity affect the entire plant?

Experiment -

Fix the root of a straightly growing bean seedling in the smallest possible hole in the cork that fits tightly into a test-tube

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[35] Lambert, M.R., Biology, 1954, p. 72.

[36] The General Science Handbook, Part I, New York State Education department, 1951, pp. 169-170.

Roots Respond To Gravity

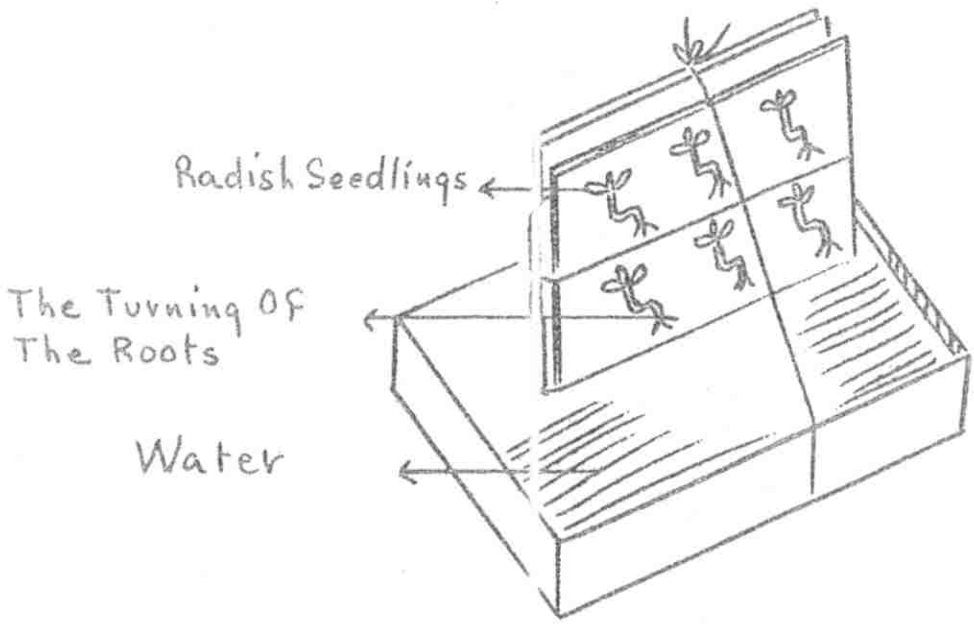

Fig. 4

Affect Of Gravity On Plants

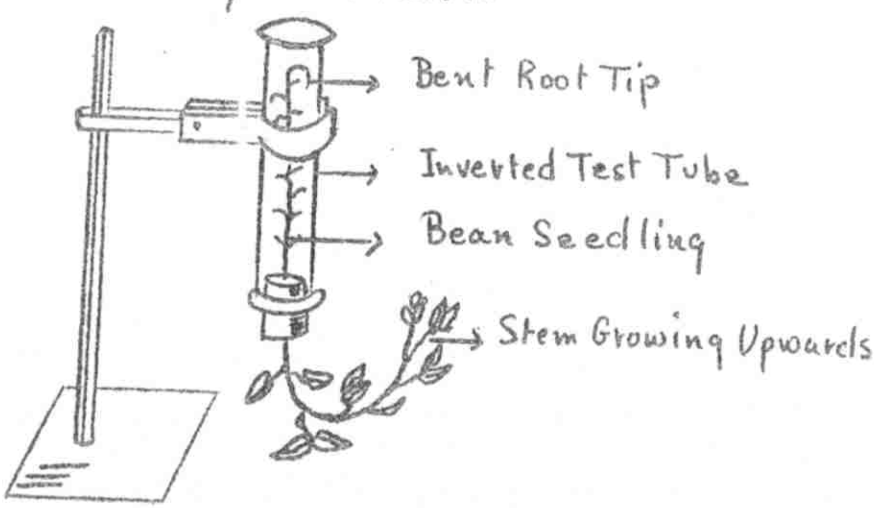

Fig. 5

or a glass cylinder full of water. For the success and continuation of the experiment all connections, between root and cork, and between cork and glass, must be made absolutely water-tight by using paraffin (sealing) wax. When the plant has grown in a normal position for two or three days the jar should be turned upside down being held by a clamp or an iron ring as shown in figure 5. If the apparatus is water-tight there will be no drip and the plant may be left in this position for some weeks. Inside the cylinder the main root bends, in the growing region, to grow vertically downwards. The stem makes a definite bend also in the growing region and grows vertically upwards.

1g) What are the types of roots and their various functions in plant life?

The root types can be well studied by allowing the students to formülate a chart of the types of roots with examples and illustrations.

2) Functions and structures of stems.

2a) How do stem conduct food materials for the plant? The following experiments with carnations and celery found in the General Science Handbook demonstrate the way stem conduct raw materials for the plant.

Cut off the ends of the flower stalks of some white carnations. Place these carnations in solutions of different colours of food dyes or ink. Split the stalk of one carnation for a distance of three or four inches, then stand the carnation up with one part of the stalk in a vessel of one dye and the other part in vessel of another dye as shown in figure 6.

Freshen stalks of bleached celery by cutting half an inch off the bottom of each and setting them in cold water for about an hour. Then put the stalks in red ink and set them in a light place in the room. After a few hours the ink can be seen as a delicate tracery in the leaves. Cut the stalks into short lengths as shown in figure 6, and note the regions into which the ink has ascended. Break some of these pieces apart along the zones in which the ink rose. The dyed "strings" or vascular bundles, can be pulled out. These bundles carry the soil water from the roots to the leaves.[37]

2b) How do the vascular bundles look under the microscope? Microscope slides can easily be prepared by the teacher or students and examined both by microscope or hand lens. If microscopes are not available, charts and diagrams should be prepared by the teacher and the students illustrating the structure of the vascular bundles and other parts of the stem - the pith, the cortex and epidermis.

2c) How does the stem grow? - Monocolyledonous, Dicotyledonous stem.

Note.

Additional teaching materials like charts etc. (which can be duplicated or copied) can be found in public libraries like USIS, British Council, etc.

3) Activities of plant cells in food diffusion. What is meant by the process of osmosis?

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[37] The General Science Handbook, Part 2, New York State Education Department, 1952, p. 99.

Stems Conduct Rawmaterials To The Parts Of The Plants

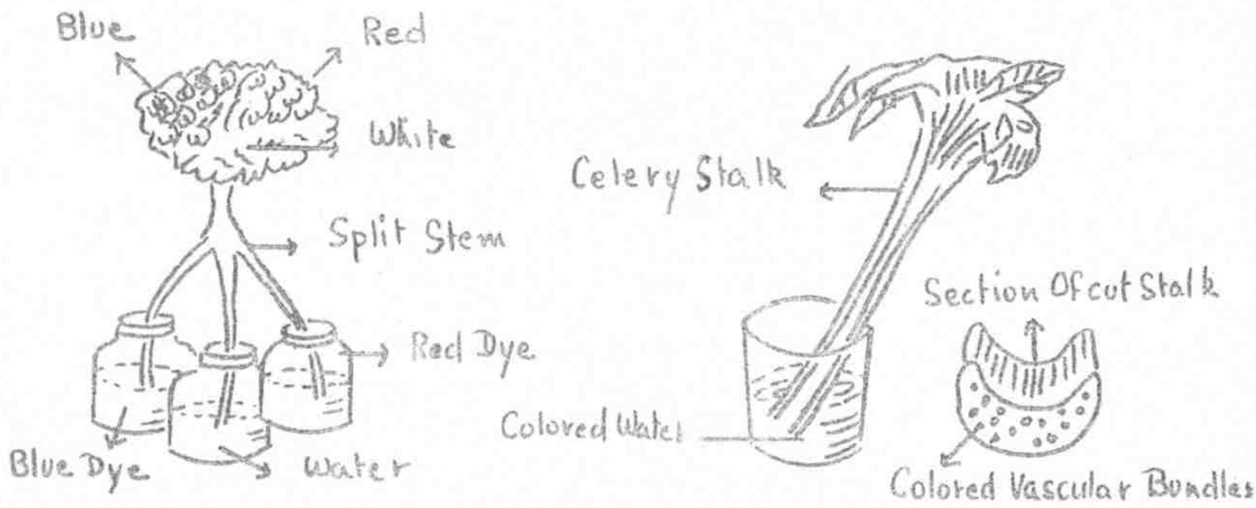

Fig. 6

The Process Of Osmosis

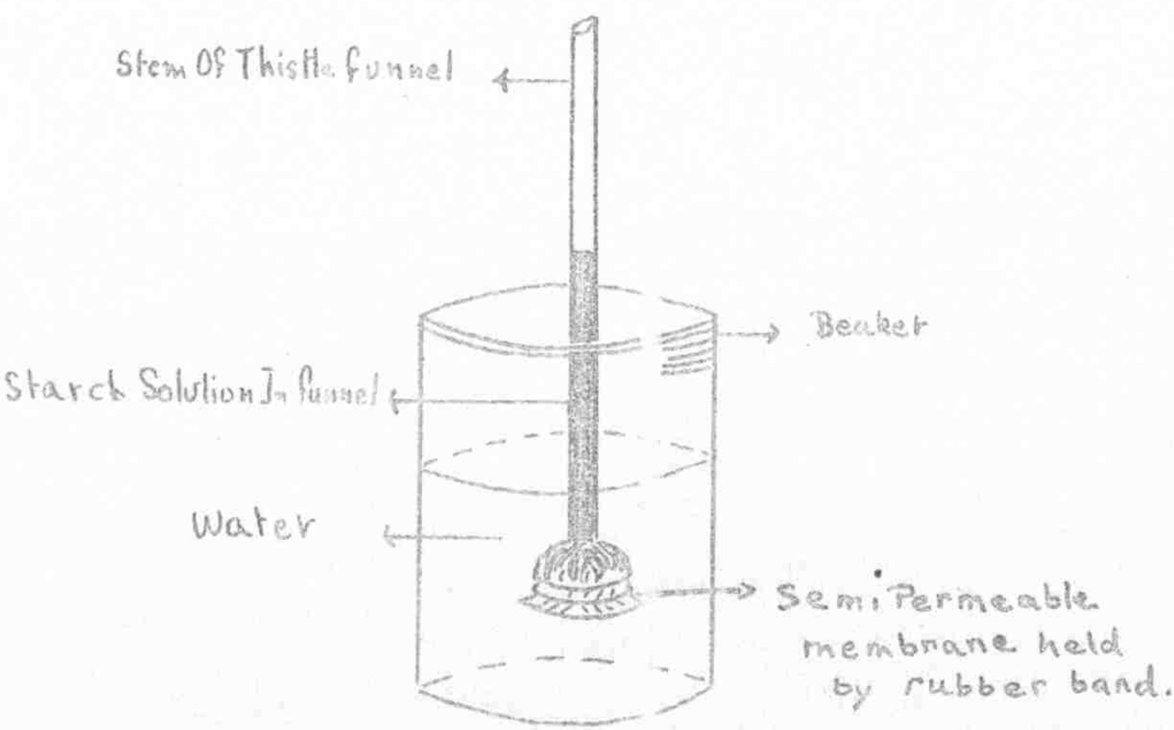

Fig. 7

Experiment -

Cut a piece of sheep's bladder from one which has been inflated and dried. Soak it in water to soften it, then bind it over the end of a thistle funnel with rubber bands. Place some sugar or glucose solution stained red with ink, in the bulb of the tube and then suspend it in a beaker filled with water as shown in figure 7. After a few hours the level of the solution in the tube rises because some of the water has passed through the membrane.

Note.

Osmotic cells can be made with any other semi-permeable membranes e.g. sausage skin, some types of cellophane wrapping materials or parchment.

4) Structure and functions of leaves.

4a) How do leaves receive food materials from the soil?

Experiment 2a with celery shows how the leaf veins conduct food particles from the soil to various parts of the leaf.

4b) How do plants get air?

When possible the leaf structure should be examined under the microscope. Lambert gives the following way to prepare a microscope slide.

Rub a leaf of a tender-leaved plant between the fingers so as to loosen the tissues. Peel off a thin piece of epidermis from the bottom of the leaf. Place this bit carefully on a microscope slide with a drop of water and a cover glass. The little mouth-shaped structures are openings which admit air to the leaf.[38]

[38]Lambert, op. cit., p. 98.

To demonstrate the presence of the structures which admit air in a leaf, (without seeing them) a simple experiment can be conducted.

Boil some water in a beaker until all air-bubbles have escaped, then drop a fresh leaf into the water. The air inside the leaf becomes hot and expands so much that it escapes in tiny bubbles, more particularly from the lower surface of the leaf where the veins are most prominent. This demonstrates not only that gaps must be present in the epidermis to make possible this escape, but that they are evidently much more numerous on the under than on the upper surface.

4c) How do the leaves help in the manufacture of food materials for the plant?

Experiment, to show the presence of starch in the leaves. The presence of starch in a leaf cannot be proved by dipping the leaf into iodine, because the strong green colour of chlorophyll masks the reaction. It is necessary, first, to get rid of the chlorophyll. As this is soluble in alcohol it can be removed by boiling the leaf in water, and then in methylated spirit over a small flame. It is well to wash the colourless leaf in water to remove its brittleness. When it is put into a dilute solution of tincture of iodine in water, a brownish blue colouration unmistakably proves the presence of starch.

5) Phillips and Cox gives the following experiment to show that light is needed for starch manufacture:-

Take a young plant with firm green leaves. Take two pieces of silver paper or other opaque paper and cut a design in them in the middle. Now pin them on one of the leaves as shown in figure 8. This way the leaf is blocked from getting sunlight except for the part exposed by the cut design. Leave the whole plant in the light for 3 or 4 days. Test the covered leaf for the presence of starch as in the above experiment (4c). On decolourizing and testing with iodine, the cut pattern is seen sharply printed in dark blue against a light background.[39]

6) Light is needed for the manufacture of chlorophyll and chlorophyll is needed for the manufacture of starch.

Stand a green growing plant in a dark room for a few days, and let another one grow naturally in sunlight. The leaves of the plant in the dark room will have a sickly yellow colour while the ones in light will be green. When both are tested for starch, the plant kept in the dark with little chlorophyll shows no starch while the other leaves full of chlorophyll will show the presence of starch.

7) To show that leaves turn towards light, the General Science Handbook gives the following experiment.

Select two flower pots that contain young seedlings of similar size. Wrap a desk blotter or piece of black poster board around one of the pots and fasten it with rubber bands or cord to form a

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[39]Phillips and Cox, op. cit., p. 307.

Light Is Needed For Starch Manufacture

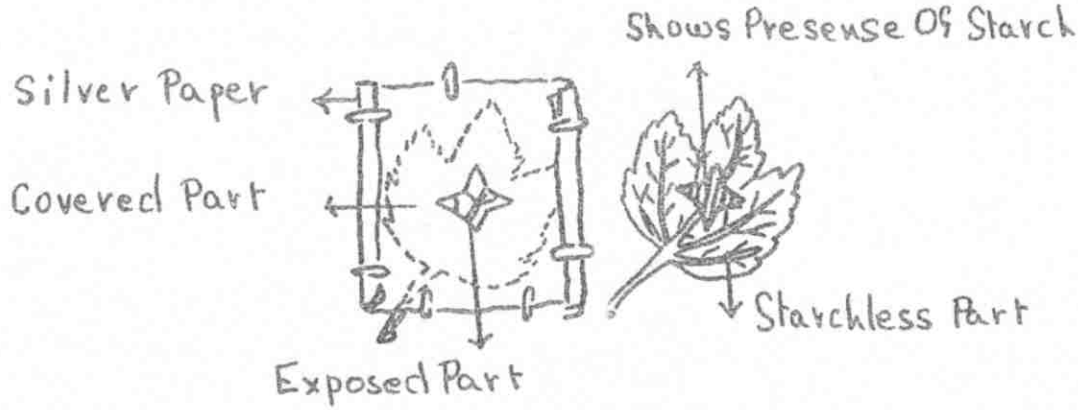

Fig. 8

Leaves Turn Towards The Light

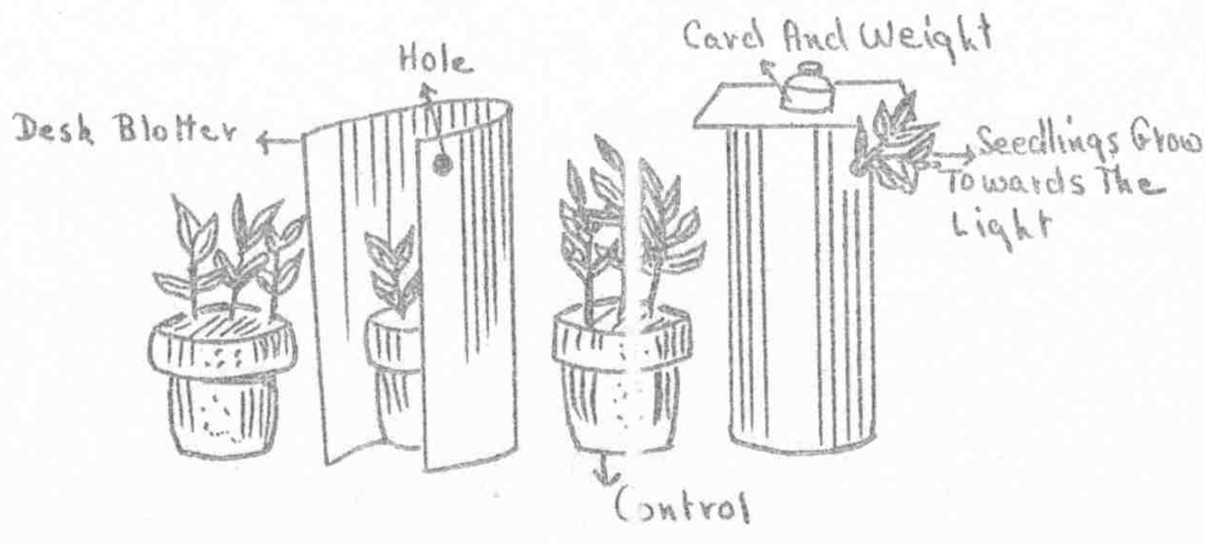

Fig. 9

cylinder which shuts out the light. Cut a hole near the top of the cylinder and shut out the light from the top by means of a piece of cardboard held down by weight as shown in figure 9. The tips of the seedlings should grow toward the hole that admits the light. Remove the cylinder after a week and compare the two lots of seedlings.[40]

8) To show that carbon dioxide is necessary for making starch, Lambert gives the following experiment.

Cover with a bell-jar a growing plant in a pot together with a test-tube containing caustic soda solution. Through the cork connect a U-tube containing soda lime as shown in figure 10. Stand the whole apparatus in the sunlight. Caustic soda is a substance which is capable of absorbing carbon dioxide. The solution in the tube, therefore, will absorb the carbon dioxide in the jar. The soda lime in the U-tube prevents more of this gas from coming into the jar. Thus the carbon dioxide supply is cut off from the plant. After a few days test the leaves of the plant with iodine for the presence of starch. There will be no starch present in the leaves though the leaves appear healthy and green.[41]

9) Experiment to show that plants give off oxygen in Photosynthesis.

Bits of plant (acquatic plants are best for this, decorative water plants grown at home are excellent) are put into a beaker of

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[40] The General Science Handbook, Part 1, New York State Education Department, 1951, p. 170.

[41] Lambert, op. cit., pp. 38-39/

Carbondioxide Is Necessary For Starch Manufacture In Plants

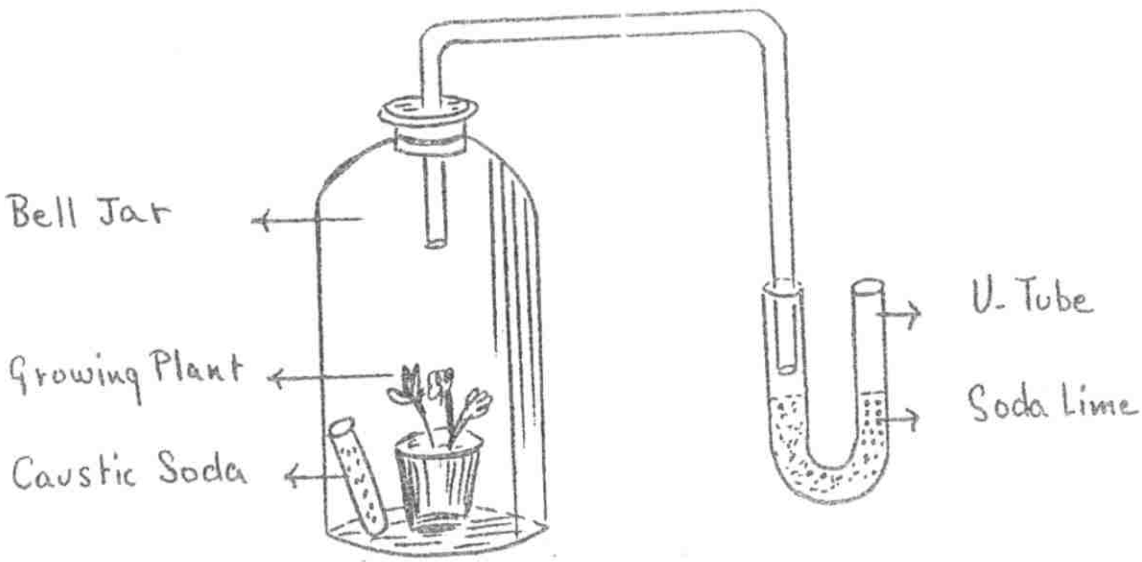

Fig. 10

Plants Give Off Oxygen

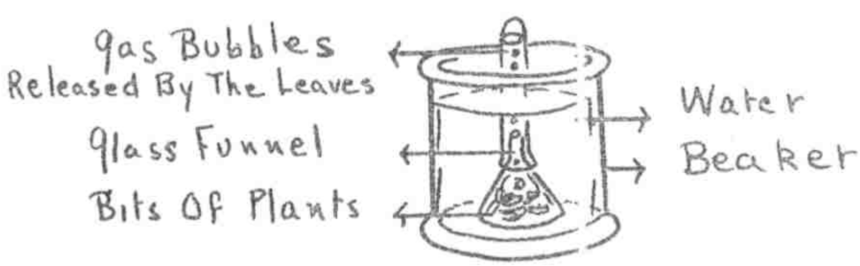

Fig. 11

water, and a glass funnel is put over them as shown in figure 11. Invert a test-tube filled with water over the funnel. Care should be taken to keep the water in so the thumb should be placed over the mouth and not removed until it is below the water in the beaker. Then the whole apparatus is put near the sunniest window of the room. Bubbles of gas are seen to be given off from the leaves. They rise up the water in the stem of the funnel and passing into the test-tube, displace a small volume of water. When the test-tube is quite full of gas a glowing splinter introduced into it bursts into flame. This demonstrates that the gas is oxygen.

10) Sum up the photosynthetic process of the plants for the manufacture of food from the above activities and experiments.

C. Subunit.

Plants Carry on the Usual Living Process Of Respiration.

1) To prove that in respiration a green plant gives out carbon dioxide, it must be kept in the dark. If it remains in the light the leaves take back the carbon dioxide that is exhaled and use it in their assimilatory process.

1a) To illustrate respiration in plants Miller and Blades give the following experiment.

Germinate some wheat or corn grains in a wide-mouthed bottle. When the seedlings are growing rapidly stopper the bottle and set it in the dark for 6 to 10 hours. Replace the stopper quickly with one which has a funnel and bent glass tubing inserted as shown in figure 12. Immerse the outlet end of the tube in a test-tube containing lime-water. Flood the seedlings by pouring water through the funnel until the bottle is nearly filled. This forces gases that have accumulated around the seedlings through the outlet tube into the limewater. If carbon dioxide is present the lime-water soon becomes milky.[42]

1b) Germinating seeds give off carbon dioxide, and use up oxygen.

Place enough germinating seeds (corn beans etc.) in a jar to fill it about one-third full. Close tightly and allow it to stand for several hours or overnight. Light a long slender stick, remove stopper and quickly thurst a flaming splint or straw into the jar. The flame is extinguished, showing the lack of oxygen. Repeat the test with another simillar jar that has been sealed at the same time as the one with the germinating seeds but which had nothing in it except normal air. Compare the results and account for the difference. This idea of a control experiment should be impressed upon the students.

1c) The intake of oxygen by the plants can be proved indirectly in the following experiment given by Phillips and Cox, by bringing about the death of a plant kept in an oxygen-free atmosphere.

Take two healthy growing plants. Put them both under bell-jars. Under one of the bell jars however put also a beaker of pyrogallic acid which has a strong affinity for oxygen. But at

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[42] Miller and Blades, <u>Methods And Materials For Teaching Biological Sciences</u>, 1938, p. 347.

Plants Give Off Carbondioxide In Respiration

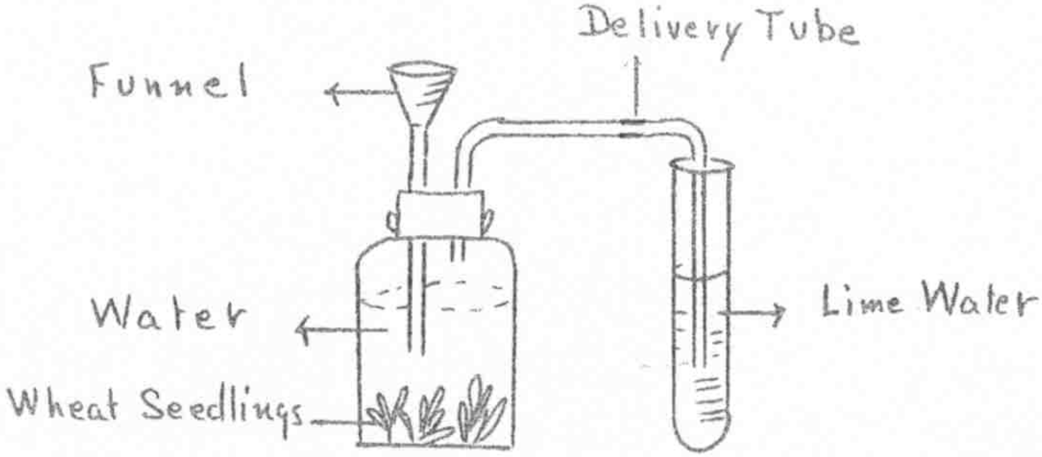

Fig. 12

Leaves Give Off Water

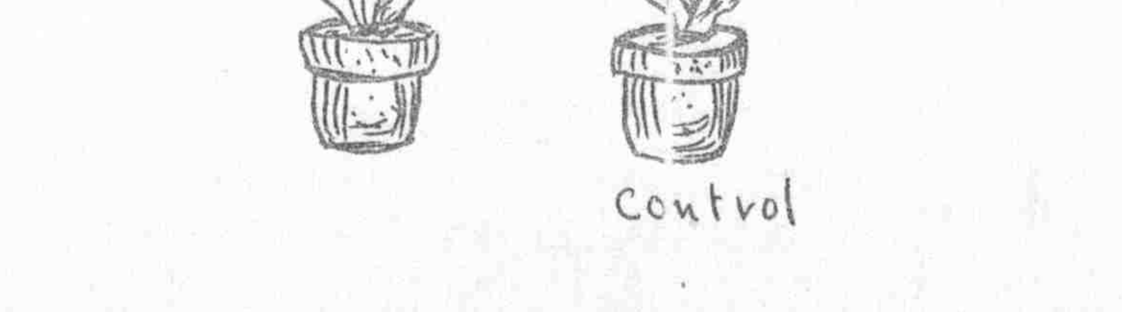

Fig. 13

first the plant carries on the work of photosynthesis. The oxygen it gives out in the process, as well as that originally within the jar however is absorbed by the pyrogallic. There is therefore no available oxygen for use in breathing. After some time the plant dies of actual suffocation while in the control experiment the plant grows healthily.[43]

1d) The same experiment can be done with germinating seeds. Seeds without oxygen will not germinate while those with oxygen germinate normally.

2) Leaves give off an excess of water to the atmosphere, (water not needed in food assimilation).

2a) Place a plastic or cellophane bag, such as is used for food storage, over a house plant. Tie the mouth of the bag tightly around the stem of the plant as shown in figure 13. As a control put another bag of the same kind over a dead branch set in a similar flower pot. Set both in sunlight and note which bag collects the more water. The escape of water from the leaves is called transpiration. Some of this excess water given off may already have served a useful purpose in carrying dissolved minerals into the plant. Plants also need a continuous supply of water coming from the roots to keep them from drying out.

2b) Dry air causes rapid transpiration: -

Put two similar plants under separate bell-jars whose vaselined

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[43] Phillips and Cox, op. cit., p. 313.

rims rest on glass plates, so that no air enters from without. In one case a basin of dry calcium chloride accompanies the plant. The effect of calcium chloride is to remove every trace of moisture from the limited supply of air. In this dry atmosphere the leaves gradually give off all the moisture they contain. They are so dry that they can be crumbled to a fine powder. The leaves under the other bell jar are still fresh and green. They have given off water vapour until the air has become saturated with moisture. This point reached, they could give off no more. In the damp atmosphere, therefore, transpiration has been brought to a dead stop.

2c) Excess water is given off through the stomata. Take two fresh living plants and smear the under surface of the leaves of one plant with vaseline. Then cover both plants with plastic bags as in experiment C. Only very little mist appears on the plastic the plant treated with vaseline, while the control becomes full of water vapour. The stomata have been blocked with vaseline, and moisture cannot get out.

3) Study of the different types of leaves - Simple and compound, illustrated with examples. Each pupil can be asked to bring several samples of each kind to class.

D. <u>Subunit</u>.

<u>The Flower and Pollination</u>.

To understand pollination, students should have a good idea about the main parts of the flower and the functions of each part.

1) Examine specimen of large simple flowers such as lillies, lubiscus flowers etc. Count the stamens and note how they are arranged about the central pistil. Draw large blackboard diagrams of the essential organs and label the parts of the pistil (stigma, style and ovary) and the parts of the stamens (filament and anther). Point out the sepals and the corolla.

1a) The General Science Handbook gives the following way in which flower parts (use large flowers) can be studied and dissected by students, even at ordinary desks.

Label each of five cards or pieces of paper with one of the following words: Stamens, pistil, petals, sepals, receptacle. Disect a flower carefully and place the parts neatly on the appropriate cards. Some flowers can be pulled apart quite easily, but a knife or scissors may be needed for others. If a sufficient number of flowers are available this exercise is most valuable as an individual pupil activity. Simple flowers with a single row of petals should be selected.

Pick up one of the stamens and rub the anther lightly across a piece of black paper. Traces of pollen will usually be seen. Rub a stamen across a pistil held upside down and note how the sticky surface holds the pollen.

Cut the ovary crosswise with a sharp knife and count the ovules or "seed pockets". Look for traces of incipient seeds in the ovules.[44]

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[44] The General Science Handbook, Part I, New York Education Department, 1951, p. 174.

Note -

In the study of the flower point out with appropriate illustrations and examples that all the parts of the flower are not always present together in all flowers e.g. some flowers have no pistil and others may have no stamen.

2) How do pollination, fertilization and seed development occur?

2a) Why is pollination necessary for reproduction?

i) What is pollination and how does it help fertilization?

ii) Kinds of pollination - self and cross pollination.

iii) Agents of pollination - Insects and wind.

iv) What factors determine insect visits? - Food, shelter and egg laying.

All these above aspects of pollination should be studied with examples and illustrations.

2b) The role of the reproductive organs of the flower in fertilization (stigma, stamen, pollen grain, ovary, style etc.). For clarity, the various stages of fertilization in the flower should be diagramatically shown to the pupils.

2c) How does fertilization cause fruit formation?

i) Kinds of fruits - simple fruits, aggregate fruits, composite fruits.

ii) Further classification - One seeded fruits, many seeded fruits, dry fruits and juicy fruits.

2d) How does seed dispersal take place?

i) Dispersal by wind - winged seeds, hairy seeds.

ii) Censer mechanism - Seed drops in a limited area - light seeds.

iii) Dispersal by water.

iv) Dispersal by animals.

v) Explosive mechanism.

vi) Controlled planting by man.

The study of each one of these kinds of seed dispersal should be accompanied by examples and illustrations.

E. Subunit.

Seeds And Germination.

1) Parts of the seed and their functional role in germination should be studied with illustrative diagrams and drawings. For effective studying, a broad bean which has been soaked in water for some time should be broken apart and its parts studied. This way pupils should be able to recognise the parts - testa, hilum, cotyledons, micropyle and the embryo in a germinating seed. Pupils can make charts of the parts of a seed which can be kept permanently in the school laboratory. Pupils can be shown that the embryonic peanut plant is visible adhering to one of the split halves of a peanut (even a roasted salted peanut). A hand lens or a very sharp eye can locate leaf veins in the peanut embryo.

2) The seeds contain stored food materials needed by the germinating plant.

Experiment -

Testing with iodine shows the cotyledons contain large quantities of starch. In this test it is interesting to scrape one cotyledon and leave the other intact, inorder to see the resistance provided by the protective epidermis.

3) What are some of the changes that take place when seeds germinate?

To observe the changes seeds should be planted in flower pots kept in the classroom and kept under observation. The recording of observation of growing plants form an excellent method of study. Tumbler gardens can be prepared by individual pupils for the study of germination.

To make a tumbler garden, cut a rectangular piece of blotter and slip it inside a drinking glass. Fill the centre of the glass with moss, cotton, sawdust or some similar material. Push a few seeds between the outside of the glass and the blotter. Keep a little water in the bottom of the glass.

4) Certain environmental conditions are essential for the seeds to germinate.

Seeds will not germinate unless they are provided with air, moisture and sufficiently high temperature. It is easy to prove that this is really so by depriving seeds in turn of these conditions and noting the results. Barley mustard seeds etc. may all be experimented with in this way.

The following experiments given by Phillips and Cox demonstrate the above:

Place a layer of cotton-wool at the bottom of each of four jam-jars.

In one dry seeds are sprinkled on the dry cotton-wool and the jar is kept in an ordinary warm place. The seeds have plenty of air, a moderate temperature but no moisture. The result is that germination does not take place. In the remaining jam-jars soaked seeds lie upon the damp cotton-wool.

Water that has been boiled to expel air, and then allowed to cool is added to one set of seeds, until the jar is little less than half full. A layer of oil on the top prevents air from coming into contact with the water from without. In this case the seeds have plenty of water, but no air. Again they do not germinate.

The third jar stands in a pneumatic trough, packed around with ice. Air and moisture are both available but cold prevents germination. This experiment is often better as a home project for those students who have refrigerators in their homes. As a control of this experiment some seeds are placed in a jar which is kept in a dark box. This also shows that light is not needed for germination.

The fourth jar stands on a bench in the classroom and the seeds germinate. They are provided with air moisture and are at ordinary room temperature.[45]

5) Germinating seeds respire.

The fact that germinating seeds give off carbon dioxide can

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[45] Phillips and Cox, op. cit., pp. 390-391.

be easily proved by putting a test tube of lime water in a jar in which seeds are germinating. The lime water turns milky after it has been in the jar overnight.

The fact that oxygen is used up by the germinating seeds can be shown by introducing a lighted splinter inside the jar. As soon as the taper is introduced it is extinguished showing the absence of oxygen in the jar.

6) Seeds do not germinate without oxygen:-

The following experiment is given by Millar and Blades.

Take some freshly soaked seeds (wheat or other grains) and divide them in two lots equally. Bag each group of seeds in a piece of mosquito netting as shown in figure 14. Tie each bag securely with string leaving one end of the string long. Moisten each bag of seeds with water. Suspend a bag of seeds in each bottle from the bottom of the cork. A pin will attach the string to the cork. Prepare a fresh solution of Potassium pyrogallate (equal volume of pyrogallic acid solution and potassium hydroxide solution) and pour it into one bottle and stopper immediately. Pour an equal quantity of water into the other bottle and stopper with the bag of seeds suspended above the liquid. Allow the two bottles to stand for a few days and observe the grains. The bottle with the potassium pyrogallate soon becomes oxygen-free since this substance has a strong effinity for free oxygen. The other bottle still contains free oxygen since the water will dissolve but a small portion. The seeds germinate

Oxygen Is Necessary For Germination

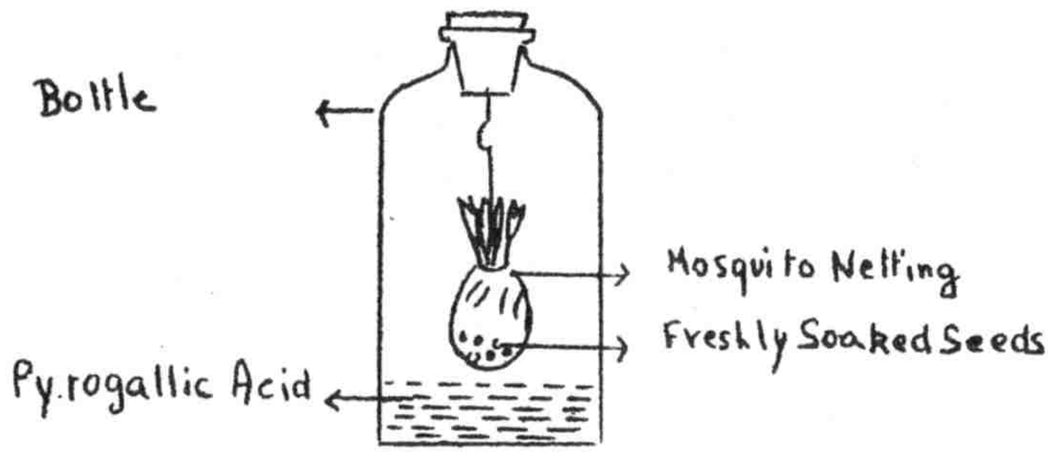

Fig. 14

in the atmosphere containing oxygen, those in the oxygen-deficient atmosphere do not.

Note -

Ordinary garden peas should not be used for this demonstration. They may be used to show a seed type which does not require free oxygen for germination. Soak and suspend these over the potassium pyrogallate as in the experiment above. This type of respiration is known as intra molecular or anaerobic respiration.[46]

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[46]Miller and Blades, op. cit., p. 345.

CHAPTER VII

A SAMPLING OF POSSIBLE ACTIVITIES WITHIN A UNIT ON HEAT

The secondary school syllabus distributes the study of Heat over four years (classes VI, VII, VIII and X with the exclusion of only class IX). No mention is made in the syllabus as to any specific reasons or criteria which might have prompted the choice of the materials or topics which appear to have been arbitrarily set down to be studied in each year. Furthermore, the study of the syllabus shows that no attempt has been made to give any unity to the whole study. The requirement is only to cover a certain number of facts and terminologies which have been thinly spread over the five years in question without any apparent unity or cohesion, either logical or psychological. Not only are the meaningful connections missing within the study prescribed for one specific class, but there is also no apparent connection between what is to be studied in one class and the next. The absence of any smooth transition from one part of the study to another, makes the whole syllabus appear to be no more than a sparse group of disorganised facts, accidentally jostled into a five-year sequence, one year of which is devoid of them entirely.

In the sample unit on Heat an attempt has been made to develop a unified picture by providing the missing connections, discarding the unnecessary repetitions, and bringing the entire topic into a reasonable time-span. It is recommended that instead of distributing the study over four years, the whole unit be studied in one year. Class VIII would probably be the best for the study of the Unit on Heat.

It is further recommended to conduct the study on the Unit on Heat along the lines of the following general objectives:[46a]

1) To unfold and interrelate in the minds of the children, the facts about the great forces and power of heat that abound in nature and which form an integral part of our lives.
2) To impress the students with the vast and important role of heat in our daily lives. The subject of heat extends far beyond the kitchen stove. We live and move, eat and sleep, in a boundless, pulsating sea of heat, and there are few things that we can do that are not in some way affected by heat.
3) To impress the students "with the power that heat embodies," and at the same time reveal to them that humanity to a certain extent has learned to control somewhat the manifestations of its power and to use it for beneficial purposes.
4) To trace step by step, historically, the scientific work that has been done on heat and the facts and knowledge that are now available about heat because of the work of scientists through the ages.

[46a]These are sample objectives that can be drawn up by individual teachers for different units of study.

UNIT

WONDERS WITH HEAT

A. Subunit

Measurement of Heat.

1) Why is it necessary to measure temperature by scientific instruments?

1a) Show that temperature sensation is not reliable. Three vessels contain water; one cold, another lukewarm, the third hot. One hand is placed in cold water and one in hot water. After one minute, both are placed in the lukewarm water and the sensations noted. This clearly demonstrates that "hot" and "cold" are relative terms, and established the need for non-subjective measurement of heat.

The following two samples of questions exploring the historical aspects of heat measurement are offered:

1b) How did Gabriel Daniel Fahrenheit try to measure heat?

i) Did he have modern equipment available at that time?

ii) Could he control weather conditions in order to secure accurate findings?

iii) Inspite of limitations hampering his experiment what did he discover about heat measurements?

iv) How did his findings help contemporary and future generation and how did they further scientific discoveries in heat.

1c) What did Galileo discover before Fahrenheit and what were its limitations?

1d) What other standards for measuring heat were established later, which are now used in most scientific work?

1e) What is the relationship between a Fahrenheit and a centigrade thermometer and what are their uses?

Activities -

Let students examine and handle both a Fahrenheit and a centigrade thermometer and point out the fact that the difference is only in the numerical grading.

Place enlarged drawings of Fahrenheit and centigrade thermometers either on the blackboard or bulletin board (students should help draw) Side by side and work out the relationship between the two types of markings.

Obtain a cheap outdoor thermometer (those fixed on a wooden base) and remove the scale by sandpapering. Let the students experiment by placing the bulb in ice water and in their mouths. Let them mark the fluid column level each time on the wooden base. After the freezing and the body-temperature points are found, the whole column should be graded in both Fahrenheit and Centigrade scale. This will clarify exactly how thermometers are marked, if it is explained that the mouth is here being used only as a substitute for a heated place of known temperature, or for boiling water, which would destroy a cheap outdoor thermometer.

Let students measure each other's temperatures by placing a clinical thermometer in the mouth.

i) What are the advantages in the use of a clinical thermometer in measuring body temperature?

ii) How is it specially made so that mercury column will remain stationary once it has expanded?

Let students examine an alcohol and a mercury thermometer side by side. Point out the advantages and disadvantages of the use of mercury in thermometers.

i) Shining surface easily visible.

ii) Does not wet the sides of the tube.

iii) Uniform and quick in expansion and cooling.

iv) Can be heated to high temperature without vaporizing.

v) Freezes too easily for outdoor use in cold climates.

vi) Is poisonous if it enters body via a cut or scratch.

Mention the advantages of alcohol thermometers in measuring extremely low temperature without freezing, and in being relatively non-toxic.

B. <u>Subunit</u>.

<u>Where Does This Heat Come From, Which We Have Been Measuring</u>?

1) What is the present theory about the nature of heat?

1a) How is heat explained or kinetic energy?

1b) How can we illustrate that heat makes molecules of a substance move faster? That when any body has heat its molecules are moving?

1c) Agitation of molecules produces heat. Yates gives the following experiment.

Materials -

A thermometer. A hammer. A small piece of metal.

Lay the thermometer face down on the metal in such a way as to insure the bulb of the instrument coming in direct contact with the metal as shown in figure 2. After leaving the instrument there for a period of at least five minutes, we note the level of the alcohol or mercury. This is the ordinary temperature of this metal. Now proceed to strike the metal hard and repeatedly with a hammer. If we have done a good job of pounding, we shall have raised the temperature of the piece of metal to a point where the difference may be noted even with a crude thermometer. Lay the thermometer once again face down as near as possible to the point where the hammering was concentrated. This point, obviously, will have a temperature in excess of the remaining portion because the heat will not yet have had the opportunity of "soaking" through the whole mass.[47]

1d) Friction can produce heat also in liquids and gases.

Ask children to experiment this by using a kitchen egg beater. The temperature of the water or any other fluid is noted before and after being violently agitated. The thermometer will show a rise in temperature after the fluid has been agitated by the

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[47] Yates F. Raymond, <u>Science with Simple Things</u>, 1940, pp. 67-68.

A Skiing Tumbler

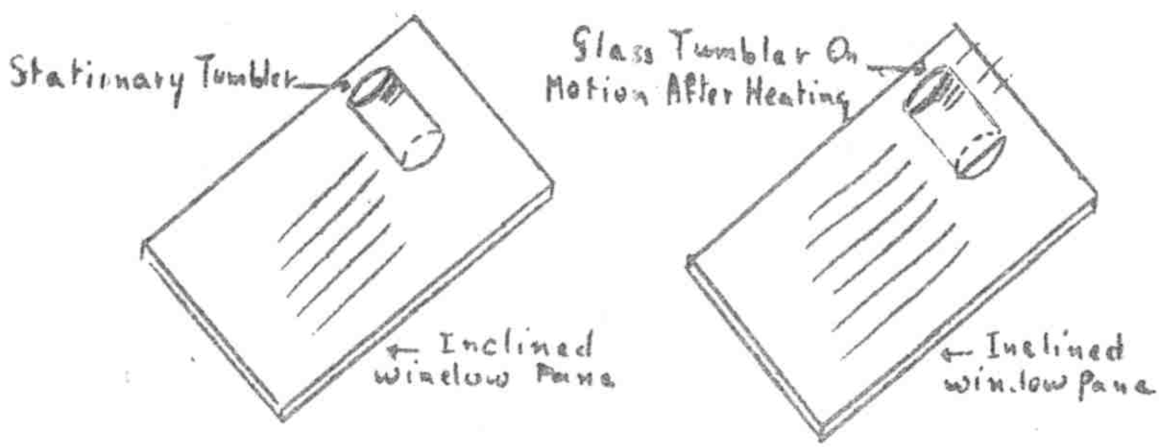

Fig. 1

Agitation Of Molecules Produces Heat

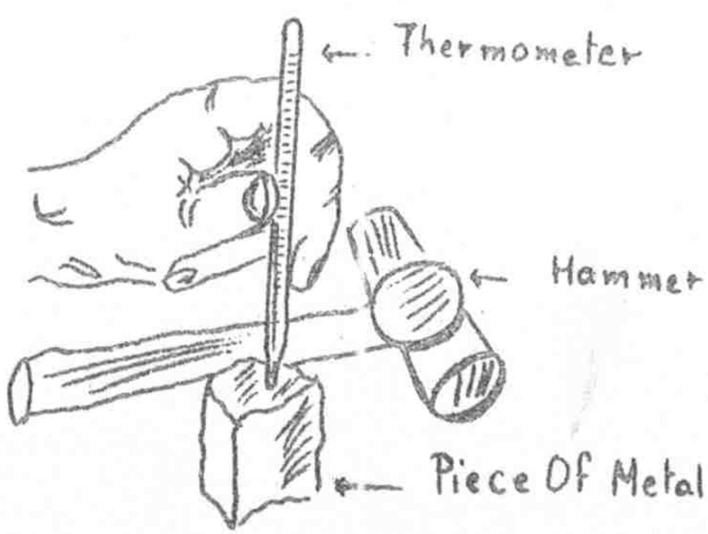

Fig. 2

the egg beater. The experiment has to be conducted quickly otherwise the heat produced by agitation is quickly lost, mostly by convection to the surrounding air.

1e) Explain how scientists have been successful in freezing even a rubber ball so that it can be shattered to pieces like glass.

1f) What is absolute zero and its relation to molecular movement? Can things be found naturally on earth which are at absolute zero? (459.4^{o}F below zero).

2) What is the principal source of heat of the earth?

2a) Does the earth absorb all the heat that the sun sends down daily?

2b) How is radiant heat lost by reflection?

2c) How does the earth's surface absorb radiant heat?

2d) How do the things that are the storehouses of absorbed radiant energy serve us in a supplying heat or other energies?

2e) Explain how everything that burns, giving heat (wood coal etc.) owes its stored heat to the energy of the sun.

2f) Explain the fact that the various waves (light and heat) that the sun sends out are of the same nature. The difference is only in the wave length and not in their essential nature - heat waves are infra-red rays and they belong to that part of the spectrum which is longer than red rays and shorter than radio waves.

The following activities will help establish the relationship between heat and light waves.

Concentrate the waves of sunlight by means of a magnifying glass on a piece of paper. The paper catches fire.

Photographs of heated iron can be taken on a specially treated "infra-red-ray film" in a perfectly dark room. The picture shows a perfect picture of the electric iron.

C. Subunit

What Effect Does Heat Have When It Passes Through Various Bodies?

1) What happens when solids are heated?

1a) Attach a piece of copper or iron wire about 2 feet long to two iron stands or any other supports. Hang a small weight from the centre and stretch the wire as tightly as possible as shown in figure 3. Carefully mark the distance of the weight above the table. Now heat the wire along its whole length with a candle or alcohol lamp. Again notice the height of the weight. Does the height change? How does the length of the hot wire compare with the length of the cold wire? Now allow the wire to cool. What happens? - the wire expands when heated and contracts when cooled.

1b) The seesaw gadget given by leeming provides a striking method of demonstrating that heat expands metals.

Take a brass curtain rod or a piece of stiff copper wire and pass it through the centre of a large flat cork as shown in figure 4. (Do not use a steel wire because steel is a slow conductor of heat). Push two long nails into the sides of the cork so that it will pivot on them. At each end of the rod push on a cork and insert pins or

Solids Expands When Heated

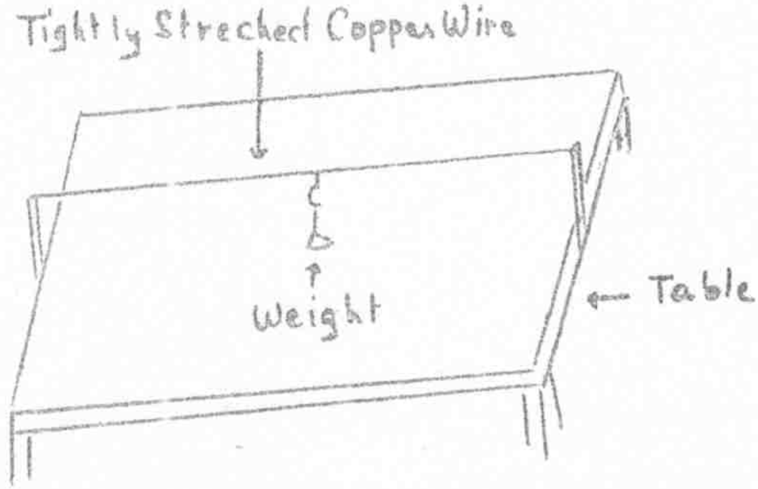

Fig. 3

Metal Expands When Heated

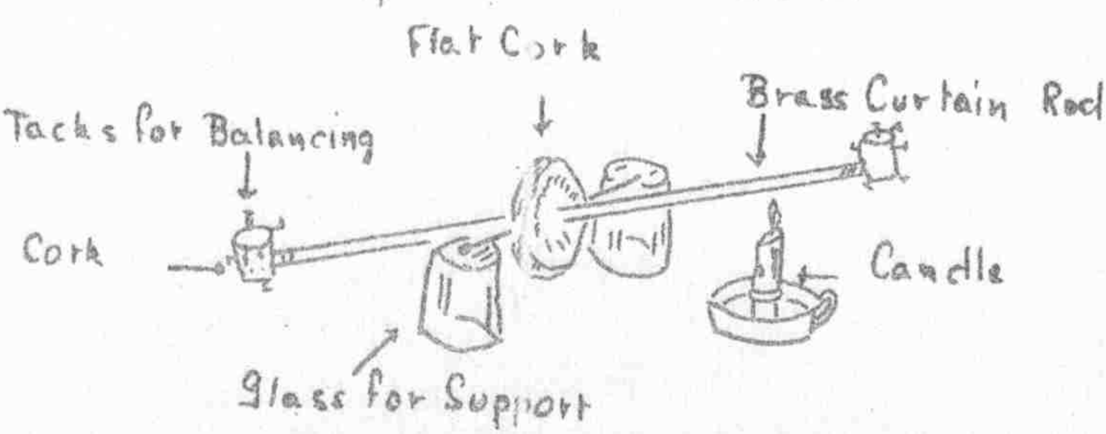

Fig. 4

tacks in them until the seesaw balances exactly. Set the seesaw on the bottoms of two glasses, and light a candle under one end of the rod. The heat will soon make the rod expand, and this will upset the seesaw's balance. The heated end will slowly fall. If you remove the candle, the rod will cool, contract, and balance. By moving the candle from one end of the seesaw to the other, you can keep the seesaw in almost constant motion.[48]

1c) Why does a glass tumbler crack if hot water is poured in it suddenly?

1d) To cut off the bottom of a bottle.

Use cotton cord between 1/16" to 1/8" in diameter not twine. Wrap the cord three around the bottle, leave enough to tie and cut it. Soak the cord in kerosene. Wrap the kerosene soaked cord around about 1 1/2" to 2" above the bottom of the bottle with loops close together and tie it. Cut off the knot ends. Hold the bottle nearly horizontal but with the bottom about 2 inches above the top (tilted), light the kerosene and turn the bottle over and over until the flame dies down. Dip the bottom into cold water and hold it there until it is cool. Tap the bottle with a file just below the cord and the bottom will separate.The edge will be irregular because most bottles vary in thickness and are imperfectly annealed. Why did the bottom separate?

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[48] Leeming Joseph, Science Experiments, 1954, p. 69.

1e) Do all metals expand the same amount when heated?

Yates give the following experiment.

Take two thin metal strips, one of brass and one of steel, rivet them together and heat them in a flame, you shall see that the combination will bend in a slight arc as shown in figure 5. If the strips are then suddenly cooled, they will bend slightly in the opposite direction.[49]

1f) Experiments can be done with rods of various metals (copper, iron, steel, silver, etc.) by measuring them carefully before and after heating. The total expansion is very slight, and requires the use of accurate measuring instruments.

2) How does heat effect liquids and gas?

2a) Fit a flask with a cork through which a long tube is passed. Fill the flask to the brim with water coloured with ink as shown in figure 6. When the cork is replaced some of the water will be forced up the tube. Slip a paper scale on the tube to assist observations of movements of the surface of the water. Heat the flask by means of a spirit lamp. At first the water will fall a little in the tube for the flask gets hot and expands, making more room for the water, before the heat reaches the liquid. Soon the liquid will be seen to rise in the tube showing that it does expand when it gets hot, and it will rise beyond the mark from which it first fell. This shows that the expansion of the water is greater

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[49]Yates F. Raymond, <u>op</u>. <u>cit</u>., p. 50.

Metals Expand At Different Rates

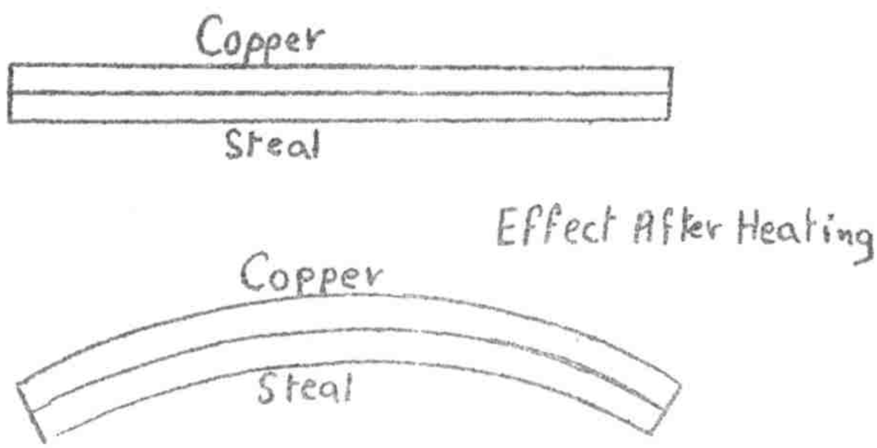

Fig. 5

Liquids Expand When Heated

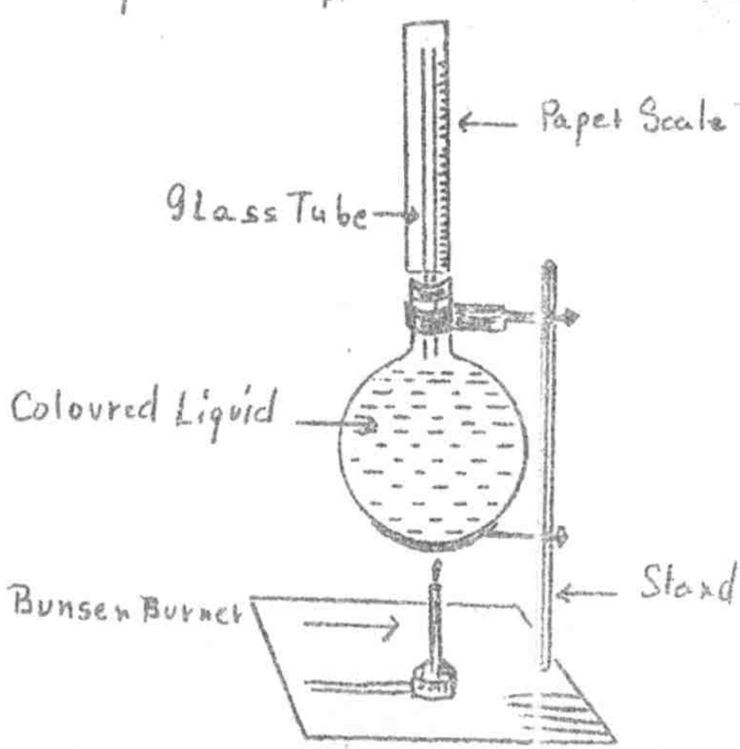

Fig. 6

than that of the flask. If the flame is removed the liquid will continue to risk for a time. The flask cools more quickly than the liquid, and its contraction squeezes more liquid into the tube. Eventually the liquid will fall again, showing that it does contract as it cools. Like solids different liquids expand unequally when equally heated. This can be illustrated by heating water and methylated spirit or another such liquid in similar flask and in similar volume. Alcohol (spirit) expands more than water.

2b) Get a rubber baloon or a India rubber bladder of a football. Fill it with air and then hold it over a hot stove. The baloon gets larger. If it becomes hot enough it might burst.

D. <u>Subunit</u>

<u>How Does Heat Pass Through Different Bodies</u>.

1) Heat travels by conduction, and the conductivity of different materials varies.

1a) Take a copper and an iron wire of the same length (about 2 inches) and diameter. Place them side by side on the table and place on one end of each and dab of pareffin or wax. Strike a match and hold the flame under the free ends of the wires. After a few moments it will be noticed that the wax in the vicinity of the end of the copper wire slowly melts and only later that the wax near the end of the iron wire melts. What does this signify?

1b) What are good and bad conductors of heat?

1c) Yates give the following experiment:

Wrap dry paper around a small piece of brass tubing. Secure it with a rubber band very tightly so as to leave no air space in between the tube and the paper. Hold a lighted candle under the wrapped tubing as shown in figure 7. The paper might get scorched but does not catch fire. Repeat the same experiment but this time with a piece of wood inside instead of a metal tubing. The paper will catch fire. Metals are good conductors of heat, while wood is a poor conductor.[50]

1d) Turn up the sides and ends of a calling card so as to make a little tray with raised edges. (If readymade paper food trays are available, they will do). Fill the tray about half full of water. Then hold the tray just above the flame of a spirit lamp. The heat will make the water boil, but the card will not burn as long as water remains in it. The water cools the card by absorbing the heat and keeps the card from getting hot enough to burn. More than 212°F of heat (the boiling point of water) would be needed to set the card on fire. The temperature of the water never gets higher than 212°F because once water reaches its boiling point it stays there. Any further heat applied to it is used to change the water into steam, and the steam carries off the extra heat.

1e) Water is a poor conductor of heat.

Leeming gives the following experiment.

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[50] Ibid., p. 51.

Metals Are Good Conductors Of Heat

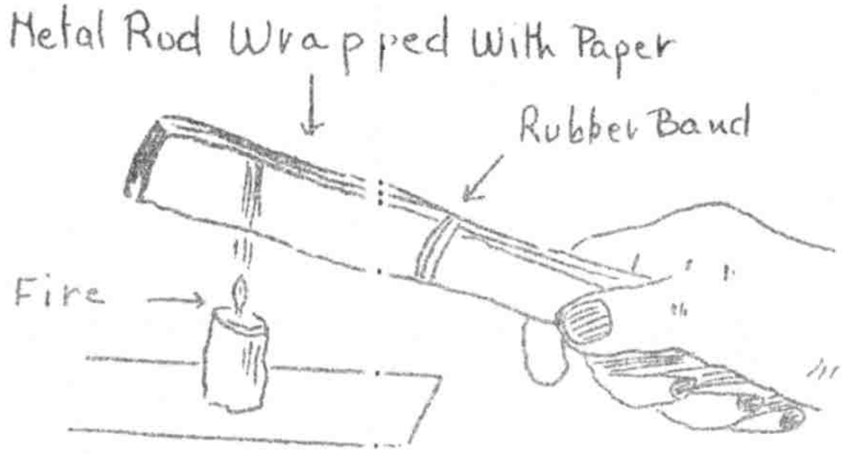

Fig. 7

Water Is A Bad Conductor Of Heat

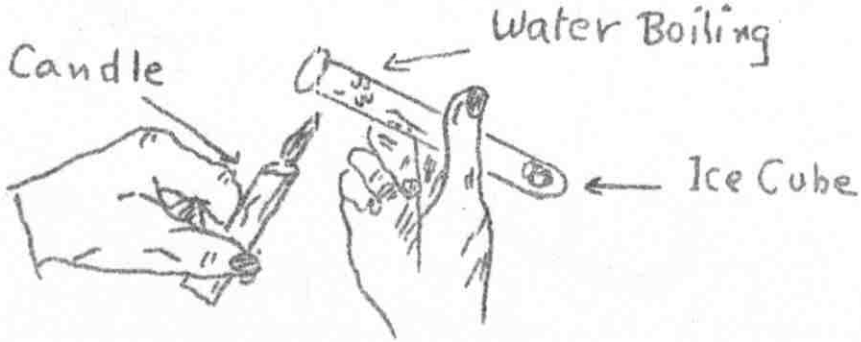

Fig. 8

Metals Are Good Conductors Of Heat

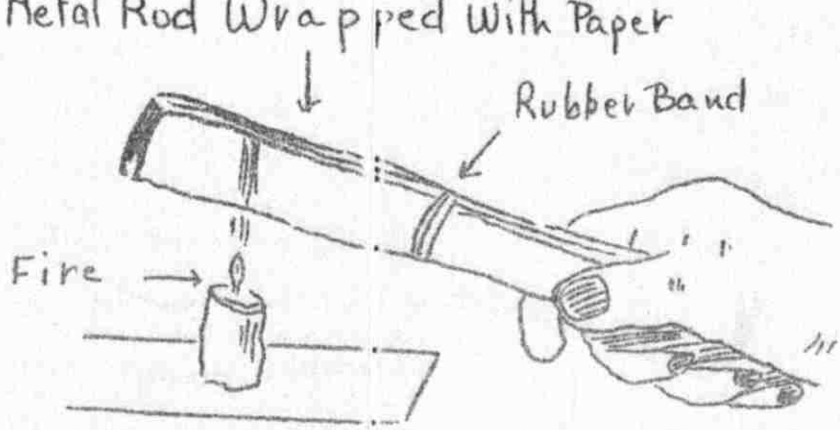

Fig. 7

Water Is A Bad Conductor Of Heat

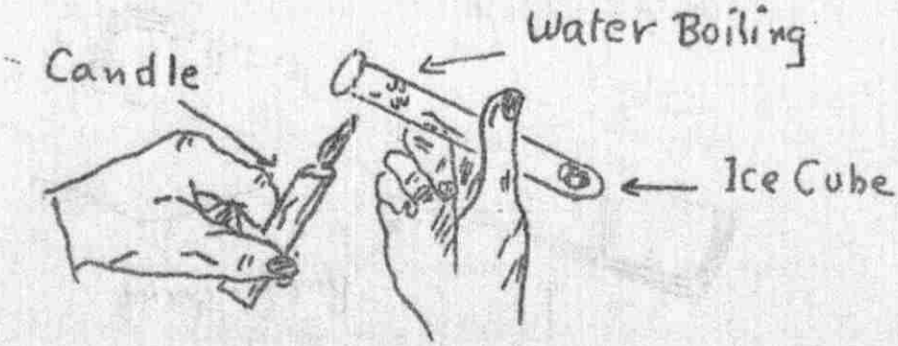

Fig. 8

Put a small lump of ice in the bottom of a test tube and fill the tube with water. Then tilt it and hold a candle under its upper end as shown in figure 8. In a few minutes the water at the heated end will boil, but the ice at the bottom will remain unmelted. This is because water is a poor conductor of heat.[51]

1f) How can heat conduction be defined?

2) Heat travel by convection.

2a) Put some litmus colouring or iodine at the bottom of a flask or a beaker of water. Heat it gently. Follow keenly the movement of water that goes on inside as the water gets heated. The circular currents of water inside the flask are easily visible.

Note -

The same experiment can be done by using small bits of light paper instead of colouring and then following the path of the bits of paper as they go up and down with the water current.

2b) How can the phenomenon of rain be explained as a result of the work of convection currents on the earth's surface and in the atmosphere?

2c) How are the creation of the regions of high and low pressure on the earth's surface attributed be convection currents in the air?

2d) How do convection currents cause land and sea breezes?

The following experiment will illustrate convection currents.

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[51] Leeming Joseph, Science Experiment, 1954, p. 661.

Take a discarded rectangular biscuit tin or a cardboard box and saw out one of its side walls and replace it with a window glass pane, so as to make the interior visible. Place the box on its lid on the table and make two round holes on its top side (ceiling) so as to fit two ordinary lantern chimneys in them as shown in figure 9. Light a candle under one of the chimney and blow some smoke (either from a cigarette or otherwise) through the other chimney. It will be observed through the window glass that the smoke goes downwards and comes out through the chimney with the candle. Now try to blow smoke through the lighted one you will be unsuccessful.

3) How is heat transferred by radiation?

3a) How does heat from the sun reach earth by radiation?

3b) How does radiation differ from both conduction and convection?

3c) How does the fact that radiant heat passes through a vacuum make it different to preserve heat?

3d) Study the construction of a vacuum flask to illustrate how heat loss through conduction, convection and radiation is prevented.

3e) How does reflection prevent transferrance of heat?

Take two pieces of paper - one white and one black. Place under each of them some wax shavings. Now place about 18" over it on a bracket an electric heater and switch it on. Notice that the wax under the black paper melts much before and much faster than that under the white.

3f) Take two tumblers and wrap one with a piece of white paper and

Apparatus To Show Convection Currents

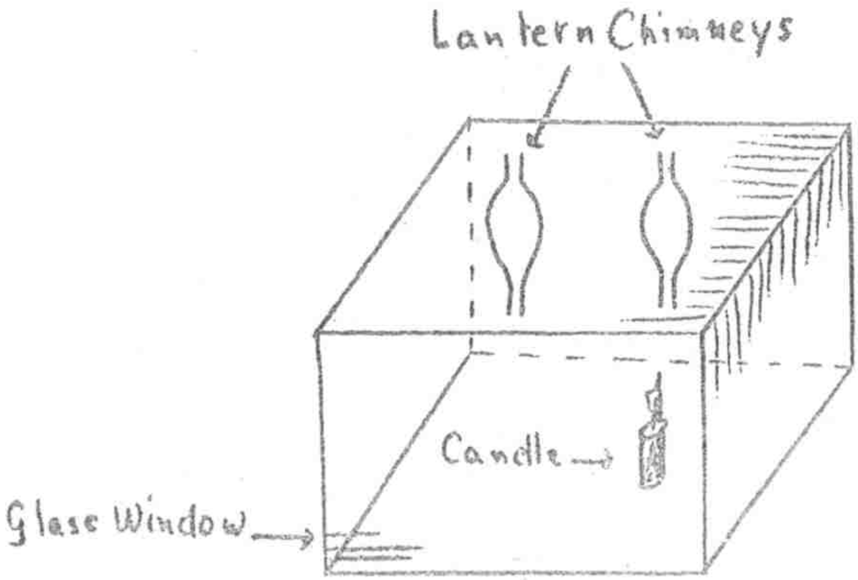

Fig. 9

Heat Causes Change Of State

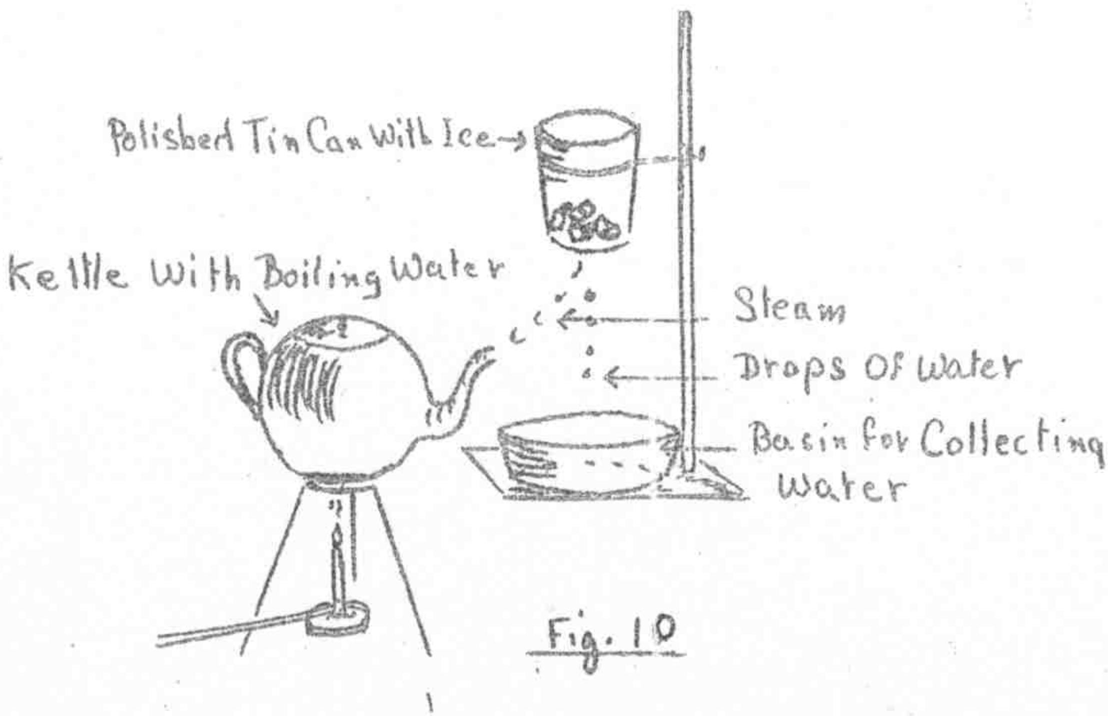

Fig. 10

the other with a piece of aluminium foil, hold them in place by rubber bands. The tumblers are filled with hot water and left aside for a few minutes. On measuring the temperature of the water in both the tumblers by a thermometer it will be found that the one with the aluminium foil around it has a much higher temperature than the other. Why?

3g) How does clothing help in conserving heat in the body?

i) Why is clothing made of cotton, linen etc. cool and hence used for summer wear and wool, silk etc warmer and used for winter wear?

ii) Why is it warmer to wear two or three lighter garments than one heavy garment?

E. Subunit

<u>Heat And Change Of State.</u>

1) How does the addition of heat change solids into liquids and liquids into gases?

1a) Fill a clean kettle 2/3 with blocks of ice from the refrigerator. Put the kettle on the fire. Place a clean polished coffee can or any other polished vessel full of cold water infront of the kettle spout in such a way that the steam coming out through the spout strikes its cold outer surface. Place a clean vessel just below the coffee can as shown in figure 10. It will be noticed that the solid ice will slowly melt into water, then the water will change into steam (gas) as more and more heat is applied to it. Later as the steam hits the cold surface of the coffee can it loses some of its heat and turns back into water drops and fall into the vessel below drop by drop. Mark the following points in the above experiment:

i) Notice that the change takes place from solid to liquid and liquid to gas as more and more heat is applied.

ii) Record the temperature with the help of a thermometer as change in each stage takes place. It will be seen that the temperature of the ice as well as the temperature of the melting point of ice is the same, i.e. the temperature of the ice remaining stationary at $32^{o}F$ or $0^{o}C$ until all the ice is melted in spite of the obvious application of additional heat necessary to melt the ice. The temperature also remains stationary at the boiling point $100^{o}C$ or $212^{0}F$ until the boiling water is converted into steam, inspite of the additional application of heat.

2) How can this additional heat which does not affect the temperature level be explained? Can latent heat be calculated?

3) What is meant by the specific heat of a substance?

4) How does the presence of a foreign substance e.g. salt, affect the temperature of any matter?

4a) Put some crushed ice cubes in a vessel and note the temperature with a thermometer. Now mix some salt with the crushed ice and after a while note the temperature of the mixture. What is the result?

4b) Take two kettles - one filled with pure water and the other with salt mixture. Bring both of them to boil and note the temperature. The thermometer does not record similar temperature in the two kettle. Why?

5) How is liquid evaporated by the application of heat?

5a) Does heat make water evaporate more quickly?

Dip one dish in cold water and another in hot water. Which one dries more quickly? Does heating speed up or slow down the evaporation of water?

5b) Does evaporation always need the obvious application of heat?

Put some water in a flat open container, and have it aside overnight. It will be found that the water has disappeared. Wet clothes dry in the shade also.

5c) The rate of evaporation is not always the same. During humid, rainy days clothes do not dry as easily as during dry sunny days.

5d) How do we know that there is water vapour in the air?

Take a glass tumbler and put some cold water or ice in it. It will be found that the glass gets smoky and on touching, the outer wall will be found to be wet with water drops. How is this explained?

6) How does evaporation help in bringing down the temperature of a body?

6a) Take a thermometer and tie a piece of cotton over its bulb. Dip the bulb in alcohol on water and wave the thermometer to and fro to help the evaporation to take place quickly. (Alcohol is somewhat better than water because of its greater ability to evaporate quickly). It will be seen that the mercury column in the thermometer falls, showing lowering of temperature. Leave a control thermometer in the covered glass from which the alcohol or water was taken. See fig 11.

6b) Take two test tubes, one narrower than the other, so that one fits into the other. Put a little water at the bottom of the larger test tube, and ether in the smaler test tube. Fit the smaller one into the larger one and blow into the ether with a blowing tube as shown in figure 11. Take out the small tube, it will be seen to be coated with ice.

6c) Put some alcohol on the back of your hand and wave it back and forth for the alcohol to evaporate. Your hand will feel cool at once.

7) What is meant by condensation?

7a) On a cold day if one blows on a cold polished window pane or any other shiny surface at once its surface gets cloudy and it feels wet to the touch. The warm air full of water-vapour coming in contact with a cold surface loses a considerable amount of its heat and its water vapour content is turned back into drops of water.

7b) How is the phenomenon of dew-formation explained by the principle of condensation?

7c) How does the formation of raindrops in the degree of condensation that has occured?

Evaporation Causes loss Of Heat

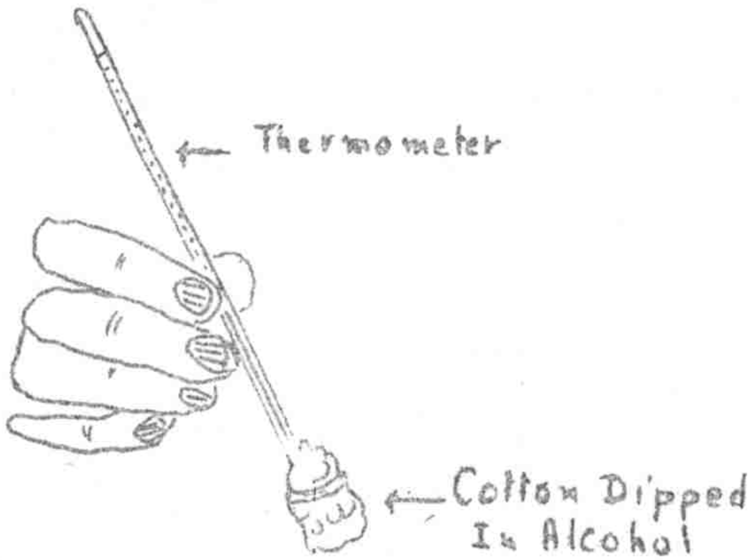

Fig. 11

Water Is A Bad Conductor Of Heat

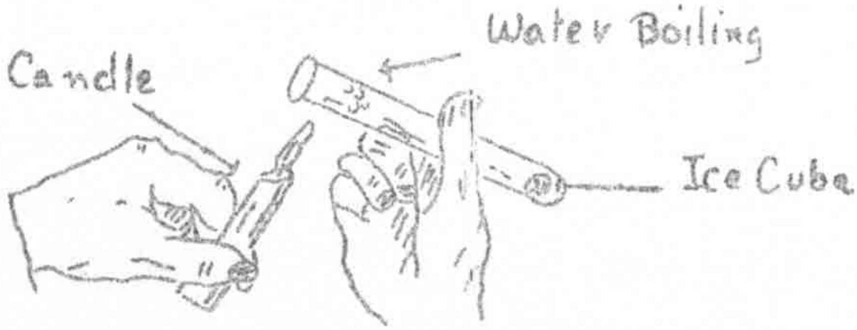

Fig. 8

Take two glass tumbler, in one put some cold water and in the other a quantity of crushed ice. Notice the exterior of both the tumblers. The exterior of No. 1 tumbler will be smoky and feel wet to the touch while little drops of water might be seen on the wall of the No. 2 tumbler and might gather together to become so big and heavy as to roll down the side of the wall of the tumbler.

7d) Put a wet blotter in a large vessel. Cover the vessel. In a few hours the humidity of the vessel will be high. Put a small can of cold water in the vessel and note the condensation. Use a similar can of cold water as a control outside the vessel.

7e) Use the smoke from a match to seed the air within a jar (Tilt the jar and place a lighted match in its mouth). Next blow into the jar several limes to raise the relative humidity by placing your mouth on the glass mouth. This together with the suspended smoke particles, create ideal conditions for condensation. Now place the mouth of the jar against the lips, blow hard and release pressure suddently. The sudden release of the pressure cools the air slightly and a thick fog forms. Blow into the jar again and the fog disappears. It reappears when the pressure is again released. Try the same experiment without seeding the air in the jar with smoke particles.

7f) Fill a milk bottle with hot water. Then pour out most of the water, leaving about an inch in the bottom. Place an ice cube on the mouth of the bottle. Set up a control using cold water instead of hot water. Ask pupils to explain why the fog forms in one bottle and not in the other.

7g) Place a piece of wet blotter in a covered wide mouthed jar for a few minutes to raise the humidity. Then set a can containing a mixture of crushed ice and salt in the jar. Cover the jar again. A thick layer of frost should form. Compare the conditions within the jar with those under which natural frost forms.

8) What is weather and how is it affected by the phenomenons of condensation and evaporation.

8a) What are some causes of local weather changes?

To show the unequal heating of land and water, place some soil in one beaker and fill the other to the same level with water. Allow the containers to remain in the shaded place until their temperatures are the same. Then set the beakers in direct sunlight. Support a thermometer in each dish with the bulb just covered. Read the thermometers every ten minutes during a class period and determin which gains heat faster. Relate the results to the development of land and sea breezes.

8b) Ask the pupils to bring daily newspaper cuttings of weather charts and help them to read them.

8c) Similar weather charts can be drawn out in class by following any typical weather condtition in the style of the newspaper weather charts.

8d) Paint out, why weather charts have to be drawn up daily and are not for showing permanent conditions.

Problematic Questions Prepared to Test the Student's Ability to Apply Facts Learnt to Daily Situations.

Answer each one of these problems and give reasons for your answer.

1) Why do concrete roads sometime bend and crack?

2) Why do car tires burst more often in the hot season? What can be done to prevent bursting?

3) Why are spoons with metal handles not so good for stirring hot food on a stove as sppons with wooden handles?

4) Why do you think it is not wise to pour very hot drinks into a glass tumbler, and why is it better if you put a metal spoon in the glass before pouring?

5) Why do the birds fluff up their feathers in winter?

6) Which do you think will cuase more of a severe burn:

   i) The steam when a steaming pot is suddenly uncovered?

   ii) Boiling water from a kettle?

7) Why is it that in the warm countries, water is kept much cooler in an earthenware vessel than in a metallic one?

8) Why is it that on a very humid day, though the thermometer records 90°F you are drenched in sweat, while on a dry day even when the temperature is above 100°F, you do not seem to perspire much?

9) Why is more dew formed on nights when the sky is clear than when the sky is clouded?

10) It is said that clothes worn in hot countries have to be made of materials which can endure the wear and tear of frequent

laundering and hence cotton has always been popular in the tropics. Now after the discovery of nylon which is definitely stronger than cotton, why is cotton as popular as ever?

11) Why are white clothes more popular in the tropics than clothes of darker colours?

12) Karachites are frustrated to find out that the local cheaply made air conditioning device (parts - fan, moist earth and pail of water) which work so well at Lahore and other towns of the interior is a failure for Karachi's climate. Why is this so?

13) Why is a good deal of salt put in the ice used for the ice cream churner?

CONCLUDING STATEMENT

In conclusion the writer wishes to state her hopes concerning the possible adoption of the proposals of this study by both the secondary board of education and the individual schools of Pakistan. It is ardently hoped that a fair trial may be given to the proposals so that they may be judged in the actual teaching situation.

The first task would be to make the existence of this study known to the educationists in Pakistan. My hope is that either the International Cooperation Administration of United States in Pakistan (The sponsors of the writer's education at A.U.B.) or the Ministry of Education in Pakistan will assist me in this task. To my knowledge this is the first such study of practical proposals to be completed. Unless this study is made available to as many science teachers and other educationists as possible, the likelihood of its helping to bring about the needed improvement in General Science Teaching is very meager. If this thesis can be reproduced and distributed even in a modest way, it is the writer's firm belief that some Pakistani pupils, who might otherwise never have discovered their leanings will become some of the nation's leading scientific thinkers.

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APENDIX A

October, 1960

QUESTIONNAIRE ON SCIENCE EDUCATION IN WEST PAKISTAN

1. How many years of secondary science courses did you take? ______years.
2. Did your secondary science teacher/teachers seem to you to have had special training for teaching Science? ____ Yes ____ No
3. Did you use a separate laboratory for practical work in your school? ____ Yes ____ No
4. About how often were you asked to do practical work with your own hands in connection with science courses? (Please check one)
   ____ Never
   ____ About once a year
   ____ About once a month
   ____ About once a week
   ____ More than once a week
5. Check those of the following statements which characterized your practical work:
   ____ No practical work
   ____ Followed experiments in the text books
   ____ Followed teacher-planned experiments apart from the books
   ____ Followed pupil-planned experiments guided by teacher
   ____ Students were enthusiastic about doing practical work
   ____ Students were unenthusiastic about doing practical work

   Please write here what do you think were the reasons for enthusiasm or lack of enthusiasm:

6. In about what percentage of your assignments did your teacher provide you with or urge you to use science reference materials outside of the text books? ___________%.
7. Give the approximate percentage of the science periods which you think your science teacher/teachers gave to each of the following activities:
   Percentage of time:
   _________% He delivered lectures.
   _________% He used materials to demonstrate the lesson to the class.
   _________% He conducted field trips.
   _________% He asked you to observe, experiment with your own hands and draw inferences.
   _________% He organized group activities.
   _________% He checked whether the pupils were able to repeat the statements of the text book.
   _________% Other activities (Please state them here):

8. Which of the following statements is closest to the impression that you had of your science teacher: (Please check one or more)
   ____ He behaved as though he knew everything.
   ____ As a science teacher he could not make any mistakes and pupils had to accept anything told them as the absolute truth.
   ____ He let it be known that pupils need to study additional reference materials to supplement what they study in class.
   ____ He made clear to us that no teacher's education can ever be complete; that a teacher needs to study all the time to keep up to date.
   ____ He taught in a way that said "a teacher should always have an open mind susceptible to new ideas and suggestions, and pay them due credit".
   ____ He taught in a way that said "a teacher should always be willing to try out new methods and procedures, and should encourage experimentation and questioning attitude in pupils".

9. About what percent of your science learnings were presented in each of the following ways:
   Percentage of time:
   ________% Facts and statements to be learned by heart without attention to understanding.
   ________% Materials to be learned with emphasis on comprehension rather than memorization.
   ____
   Total 100%

10. Estimate about what percentage of the materials in all your secondary science courses you really understood in school. ________%.

11. About how often did the classroom activities motivate you to carry out further individual work outside the school without any suggestion from the teacher?
   ____ Never
   ____ About once a year
   ____ About once a month
   ____ About once a week
   ____ More than once a week

Name ____________________

Sex ____________________

Age ____________________

Location of School(s) in which you took secondary science courses:

____

____

____

APPENDIX B

DIRECTORATE OF EDUCATION

BOULTAN MARKET, KARACHI

****

No.DE/G-V/53268-70 /60.

KARACHI, the 4th October,1960.

To

Miss Khalida Pathan,
American University of Beirut,
P.O.Box No. 1087,
Beirut, Libanon.

Dear Miss Khalida Pathan,

With reference to your letter dated 4-9-1960 regarding Science labortries and their equipment, it is stated that no statistical data is available for being transmitted to you, but the information in General terms inrespect of the conditions prevailing in the schools of Karachi are laid down below in the hope that they will meet your requirements.

There are 90 schools in Karachi recognised by the Board of Secondary Schools. Of these 35 are Government Schools and 55 managed by private bodies and often aided through Government grant-in-Aid.

In all the Government schools, the Science Labortries exist and are well equipped to carry on practical work by students and demostrations by Science Teachers.

But in most of the Non-Government Schools the science labortries are no better than store rooms and are moreover badly equipped with science apparatices. Demonstration by teachers may be carried on by make shift arrangement but practical work by students is out of question in these schools.

Reference books and magazines etc. are present in school liberaries specially in Government schools, but they are not generally consulted by students and very rarely by the teachers.

Some of the more energetic science teachers both in Government and Non-Government schools prepare charts, models and sometime even undertake to prepare simple scientific instruments like the electric bell, voltaic cell, periscope etc. but the vast majority depend upon manufactured apparatus supplied by the different Scientic Stores and firms.

Yours faithfully,

(signed)

(S. ASIF HUSSAIN)
for Director of Education, Karachi.

APPENDIX C

FIGURE CREDITS

The following figures were constructed in part by direct tracing from the published materials which are reffered to in that part of the text which deals with those figures:

CHAPTER IV

Figure 14

Figure 16

Figure 17

Figure 24

Figure 25

Figure 26

CHAPTER V

Figure 2

Figure 5

Figure 7

Figure 9

Figure 10

Figure 11

Figure 13

Figure 14

Figure 15

Figure 16

CHAPTER VI

Figure 2

Figure 3

Figure 4

Figure 6

Figure 8

Figure 9

Figure 10

Figure 12

Figure 14

CHAPTER VII

Figure 2

Figure 4

Figure 5

Figure 7

Figure 8

APPENDIX D

THE GENERAL SCIENCE CURRICULUM AND SYLLABI FOR SECONDARY SCHOOLS OF KARACHI*

Class VI

Volume:- Determination of volume of solids. Use of Graduated cylinder, overflow vessel, measuring out quantites of water with the help of burette and pipette.

Some Effects of Heat:- Expansion of solids, liquids and gasses-examples and applications-bridges, concrete roads etc. Land and Sea breeze. Change of state-melting, boiling, evaporation, freezing, condensation. Clouds and rain, rain gauge.

Electricity:- Frictional, attractive and repulsive power of charged bodies. The spark and sound produced by combing dry hair. Electricity in clouds.

Magnetism:- Artificial and natural magnets. Polarity. Compass-determination of direction.

Soluble and Insoluble Substances:- Making solutions. Soluble and insoluble part of soil. Filteration. Cultured solution from manure. Making solution of shellac in spirit-its use. Making salt from sea-water.

Plant Life:- Revision of the course covered in primary class V. Study of Leaf-its parts. Arrangement of leaves on plants. Work of leaves. Respiration, transpiration, oxygen cycle in nature.

*Source: _Prospectus, Curriculum And Syllabi For Secondary Schools of Karachi_, 1956.

Demonstration by production of carbon dioxide by breathing and burning candle or wood and production of oxygen by water plant.

Health Science:- The human body as a factory. Outer protective wall-the skin. For support and giving shape - skeleton. The machinery - the internal organs. Watch-men - the sense organs. Care of skin, hair, teeth, nose, throat, ears, eyes. Necessity of wearing clean clothes.

Observational Study on the Seashore:- Waves, tides, Jelly fish, shore crab, lobster, shell houses, birds at the sea shore. The sand at the beach.

Soil:- Its composition, effect of water, plants, insects, and worms on the formation of soil. Absorptive power of soil.

Class VII

Gravitation:- Why things fall? Sir Issac Newton - the Force of Gravity. Weight. The Spring Balance. Why do we not fall off the earth? The plumb line. Centre of gravity - stability of objects. Importance of correct postures.

Physical balance:- Its use. Determination of the density of a solid and a liquid.

Some Effects of Heat:- Temperature and its measurement. Thermometers - Mercury and Alcohol - Clinical, Maximum and Minimum. Temperature chart.

Machines:- What a Machine is? Levers of different kinds.

Burning and Rusting:- Making fire - air necessary. Composition of air. No loss of weight in burning. Oxygen and its properties. Uses of Oxygen. Rusting - Oxidation. Breathing - air necessary for breathing. Oxidation in body - Carbon dioxide - heat produced by breathing. Breathing in fishes. Methods of breathing - insects, animals, plants. Lungs - nose breathing.

Acids, Bases and Salts:- General properties of acids. Presence of acids in fruits. How the presence of acids in the stomach helps digestion. Properties of Lime-water and Caustic Soda.

Flowers:- Flower- its parts. Pollination, Fertilization. Formation of seed. Brief account of dispersal of seeds. Germination of seed. (Been seed.)

Health Science:- The body as a factory. Working of the internal organs and their functions (very elementary idea). Air - respiratory system. Food - Digestive system. Drainage - Excretory system. Circulatory system and Nervous System. Food - Balanced diet.

Microbe Friend and Foes:- Soil bacteria. Harmful bacteria. Common infectious dieases - modes of infection and prevention. Disinfectants and their proper use.

Class VIII

Our Water Supply:- Sources, filteration and purification. Water seeks its own level. Spring. Supply of water pressure. Dams.

How Heat Travels:- Conduction, Convection, Radiation. Good and bad conductors. Good and bad reflectors. Absorption of heat. Thermos-flask, Ice-box. Clothing and body covering. Ventilation.

Pressure of Air:- Air has weight. Barometer. Pressure at high altitudes. Taking readings on Aneroid barometer, Altitude meters. Uses of air pressure - syphon, syringe, lift and force pumps, cycle pump, foot pump, sucking through straw.

Current Electricity:- Simple Voltaic cell, Leclanche cell (dry and wet). Good and bad conductors, simple effects of the current, electric bulb, bell, iron and stove.

All kinds of Waves:- Waves in water - how a wave travels - reflection of waves. Sound waves in air. How do we hear? Noises, musical sounds.

Diamond and Soot:- Graphite and charcoal. Coal. Carbon dioxide and its properties. Soda water, baking powder. Carbon cycle in nature. Fire extinguisher.

Health Science:- Simple rules of health. Diet, exercise, rest, postures. Maintenance of weight quotient chart.

First Aid:- Meaning and principle. Bleeding - how to stop it. Simple and compound fractures, dislocation, sprain, shock, artificial respiration. Snake, wasp, scorpion bite and their treatment. Burns by - fire, acids and alkalies. Use of stretcher. Care of patients. Principles of nursing. The patients' room. Cleanliness of home and surroundings.

The teaching of the subject in classes IX and X will be treated as one unit and will cover (I) Biology, (II) Physics, (III) Chemistry, and (IV) Practical work. The scope of the subject will be as under:-

Class IX

I. Biology:

The general elementary structure and physiology of a mamal as illustrated by the following scheme. (While rabbit or rat is being used for demonstration and dissection, a reference should be made to man). Miscroscopic details excluded.

Animal Life:- Rabbit or Rat:- External features in relation to habits and environment, skeleton functions of bones. Muscles-kind and functions. Alimentary Canal - food and digestion (excluding enzymes). Essential constituents of diets of man. Balanced diet.

Circulatory system:- Simple treatment of structures and functions of heart, arteries and veins. Work of blood and need for circulation. The pressure points in man. Recording of pulse.

Respiratory system:- The respiratory organs and their mechanism. Role of Oxygen in the release of energy. Recording of respiration per minute. Excretion; kidneys, sweat glands, lungs. (No structural details, only functions) Maintenance of body temperature.

Plant Life:- Examination of beans or a mustard plant. Various types of plants - trees - herbs, shrubs, climbing plants, twiners, trailors. Parts of plants and their work. The root - collection of water and salts from the soil, holding the plant in position. Storage of food. Stem - carrying water and food. Leaves - their functions. Manufacture of food and loss of water.

Physics:- The principle of Archimedes, and its application, excluding inverse numerical questions. Floatation (ships, Air-ships), specific gravity of bodies by Principle of Archimedes. The Diver's Dress. Water tanks in submarines. Aeroplanes (Simple and easy treatment)

Light:- Rectilinear propagation of light. Reflection of light. Plane mirrors - Applications. Refraction. Dispersion of white light by prism. Primary rain - bow colour, concave and convex lenses and mirrors. Their uses (No formulae and mathematical question) Graphical representation of images. Combination of two lenses to form telescope and Microscope. Camera and human eye.

Electrification:- Conductors and insulators. Electroscope, Lightning and thunder.

Magnets:- Polarity, Earth's magnet, compass needle, Mariner's compass.

Chemistry:-

Elements:- Compound and Mixtures. Atoms and Molecules. Study of atmosphere. Preparation and properties of Oxygen. Uses of Oxygen, Acidic, Basic and natural oxides. Water. Action of sodium and iron on water. Water as a solvent of gases and solids. Evaporation. Distillation, Crystallisation, filtration. Uses of solvents for fats, oil paints Cleansing agents.

Hydrogen:- Preparation and properties. Acids, bases, and salts. Acids in every day use (acetic, citric, tartaric, baking powders) Carbon - allotropic forms. Preparation and properties and uses of carbon dioxide.

Nitrogen:- Its preparation and properties. Nitrogen cycles. Ammonia-preparation, properties and uses. Important ammonium salts, their importance and uses.

PRACTICAL WORK:-

Biology:- (In General Science Course)

Observation of the living rabbit or rat. Habits and mode of life. Demonstration of the important parts of the alimentary canal and the circulatory system. External features of the bean and mustard plant. Collecting and studying of various types of plants.

To study the respiratory and excretary organs from dissected rabbit or rat.

Simple experiments mainly (demonstration) to show that food (starch) accumulates in leaves exposed to sunlight, that water is lost through leaves, that plants require a continuous supply of water, that water rises through the stem, that carbon dioxide is given off through respiration that plants grown in darkness are not green but become green when exposed to light.

Physics (In General Science (Course)

To determine the relative density of a solid by the principle of Archimedes. To show that the weight of the floating body is equal to the weight of the liquid displaced (using a loaded test tube in a graduated jar with different liquids).

To verify the laws of reflection in a plane mirror. To trace the path of rays passing through glass. To draw the image of an object (Point) as seen through glass-slab. To draw the path of rays in prism. To determine the focal length of a concave mirror by the parallel ray method. To charge a gold-leaf electroscope.

Chemistry:- (In General Science Course)

To determine the change in weight due to oxidation when a substance is sufficiently heated in air.

To find the proportion of Oxygen and Nitrogen in air (groups of 4)

To prepare Hydrogen from Zinc and Sulphuric Acid and to study its properties.

To prepare Carbon dioxide from marble and Hydrochloric Acid and to study its properties.

To study the action of heat on: Potassium Nitrate, Calcium Carbonate, Copper Sulphate, Sulphur, Camphor.

To prepare Ammonium Chloride and Quick lime and to study its properties.

Class X

Biology:-

Animal Life:- Nervous system - External structure and functions of sensory and motor nerves. Voluntary and involuntary action, position and functions of sense organs (simple treatment and functions of sensory organs.

Animals and plants that are harmful to man. Methods of preventing and destroying them - (1) Ticks lice, fleas, bed-bugs mosquitoes. (II) malarial parasite, Bactaria. Cholera, Smallpox, Tuberculosis, rabbies.

Insects:- Outline of the life history of house - fly, their destruction and checking of growth.

Plant Life:- Flower-pollination, fertilization without reference to microscopic detail other than growth of pollentube and fusion of gametes.

Fruits - Typical method of fruit and seed dispersal. Germination of seed illustrated with the help of one example (Bean or Pea).

Physics:-

Sound:- Production and propagation of sound in various media. Vibration Transverse and longitudinal waves. Frequency and pitch, Amplitude and intensity. Velocity of sound in open air echoes.

Current electricity-simple and leclanche cell (wet and dry) E.M.F. and P.D. of cell-comparison with level and pressure of water-battery, Electro-magnet and its use in Electrical-bell, Telegraph and Telephone.

Heating effect of current:- Electric-lamp, stone, iron switches and fuses-chemical effects of current. Electrolysis of water-Electroplating. Electrical power and energy. Definition of watt-Kilowatt-volt ampere only. Simple study of Electromagnetic induction to explain the action of a dynamo and Transformer (very simple treatment).

Heat:- Unit of heat. Specific heat. Latent heat. (No calculation) cold on evaporation-freezing mixtures. Effects of heat. Thermometer and different scales. Maximum and Minimum and clinical Thermometers. Transmission of heat and its application in every day life:- Water vapour and the different forms it takes. Weather chart.

Chemistry:-

Preparation of nitric acid. Chlorine-preparation and properties. Bleaching powder-its use. Preparation and properties of Hydro-chloric acid. Sulphur-Preparation and properties of Sulphur Dioxide-its use as a bleaching agent.

Calcium and its compound-calcium carbonate-its various forms and uses. White washing mortar and cement - their uses. Concrete. Plaster of Paris and its uses. Calcium carbite and its uses, welding. Calcium Phosphate and its uses.

PRACTICAL WORK

Biology:- Process of germination-study and sketches (Bean and Maize).

Physics:- To study the relation between object and images produced by convex lense. To study the magnetic effect of a current. To shows that the loss of heat of a body is equal to the gain of heat in another.

To compare heat required to melt ice and to boil water.

Chemistry:- To prepare sulphur-from copper and sulphuric acid and study its properties. To prepare chlorine from Manganese Dioxide and Hydro chloride acid and to study its properties.

APPENDIX E

A PROPOSED SET OF UNITS

It was indicated in the first chapter of the thesis, that the study of General Science can be concentrated within a period of two years instead of spreading it over a span of four years. Every item in the official syllabus (plus many others) can be found to fit one of the categories in the following proposed set of units. Topics marked with * have been added for the purpose of making the unit complete. The following syllabus is suggested to indicate how this can be achieved. Two units of study - heat and plant life - have also been prepared in detail. These follow the brief syllabi of Classes VIII and IX.

I. PROPOSED SYLLABUS OF GENERAL SCIENCE FOR CLASS VIII.

Biology:-

Unit on animal life and the human body.

Physics:- Unit on measurement of length, volume, capacity. Unit on density and relative density. Unit on Archemedes Principle and its simple applications. Unit on gravity, weight and measurement of weight. Unit on nature and Laws of gases - Boyle's Law. Unit on simple machines. Unit on heat. Unit on natural phenomena like tides, weather etc.

Chemistry:- Unit on Elements, compounds, mixtures, acids, bases and salts, solutions and soluble substances. Unit on water. Unit on air.

Health Sciences:- Unit on the study of pests and insects e.g. House fly - life cycle and checking their growth.

II. PROPOSED SYLLABUS OF GENERAL SCIENCE FOR CLASS IX.

Biology:- Unit on plant life, cultivation and conservation of soil.
Unit on animal life - simple and higher forms.

Chemistry:- Unit on preparation of gases and their properties. Unit on combustion.

Health Science:- Unit on the study of common diseases in the area e.g. cholera, Typhoid, T.B. etc. Unit on simple rules of hygeine and first aid. Unit on bacteria - friends and enemies.

Physics:- Unit on sound. Unit on electricity and magnetism. Unit on light.

III. DETAILS OF A UNIT ON HEAT RECOMMENDED TO BE STUDIED IN CLASS VIII.

Wonders With Heat

A. Subunit:- Measurement of Heat.

1. Necessity of measuring Temperature by scientific instruments. Temperature sensation is not reliable,* difference between heat and temperature.* Historical development of instruments for measuring temperature.* Farenheit and centigrade seales, clinical thermometer. Maximum and Minimum thermometers. Mercury and alcohol thermometers, their advantages and disadvantages.* Temperature charts.

B. Subunit:- What is Heat?*

1. Present theory of the nature of heat.*
   Heat as kinetic energy of molecules.* Relation of Friction to heat.* Absolute zero and its relation to molecular movement.*
2. The sun as a principal source of heat.* Absorption of radiant heat by earth.* Heat waves and light waves have similar nature.*

C. Subunit:- Effects of Heat on Various Bodies.

1. Expansion of solids, liquids and gases by heat. Different degrees of expansion.

D. Subunit:- Transmission of Heat. Conduction, convection and radiation. Good and bad conductors. Convection currents in wind and water.* Land and sea breezes, ventilation. Good and bad reflectors. Absorption of heat by different bodies. Preservation of heat.* Thermos flasks, ice boxes and clothing.

E. Subunit:- Heat and Change of State.

1. Melting, boiling, evaporation, freezing, condensation. The unit of heat. Specific heat. Latent heat. Boiling and freezing point of mixtures.* Effect of heat on evaporation.* Evaporation and condensation - their effect on weather conditions, clouds, rain snow,* hails* etc. Rain gauge. Weather charts.
2. Evaporation - a heat absorbing process.*
3. Formation of dew, fog and mist.*

IV. DETAILS OF A UNIT ON PLANT LIFE RECOMMENDED TO BE TAUGHT IN CLASS IX.

A. Subunit:- Characteristic of Living Things.*

Growth, reproduction, food taking, excretion, respiration and motility.* Study of the fundamental cell and its parts and functions in living things.*

B. Subunit:- Plant As A Living Organism.

Parts of the plant and the functions of each in the life process.

1. Parts and functions of roots - intake of moisture, minerals, holding the plant in position, storage of food. Response of roots to water stimulus and gravity.*
2. Parts and functions of the stem. Stem carrying food and water. Storage of food. Study of the vascular bundles.*
3. Activity of the plant cells in food diffusion.* The process of osmosis.*
4. The structure and function of the leaf. Arrangement of leaves in plants. The work of the leaves: Respiratory and transperatory functions of the leaf. Study of the stomata openings.* Response of leaves towards light.*
5. Functions of the parts of the plant in food manufacturing.* Cholorophyl, sunlight, and carbon dioxide are needed for starch manufacturing. Study of the photosynthetic process in plants.* Plants give off oxygen in the photosynthetic process.

C. Subunit:- Plants carry on the usual process of Respiration.

Oxygen and the carbon dioxide cycle in life.*

D. Subunit:- Various types of plants. Trees, herbs, shrubs , climbing plants, twiners, trailors.

E. Subunit:- The Flower And Pollination.

1. Parts of the flower and their function in reproduction.

Agents of Pollination and kinds of Pollination.* Pollination in reference to fertilization.

2. Fertilization and formation of seeds and fruits. Dispersal of seeds, agents of seed dispersal.* Kinds of seeds.* Kinds of fruits.*

F. Subunit:- Seeds And Germination.

1. Parts of the seeds and their function in germination and plant growth.* Changes take place in germinating* seeds. Environmental conditions necessary for seed germination - air, moisture, adequate temperature.* Germinating seeds breathe.*