Curriculum revision in the high schools of Springfield, Massachusetts.

Ulmont Cleal Cowing

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CURRICULUM REVISION IN THE HIGH SCHOOLS OF SPRINGFIELD MASSACHUSETTS

COWING - 1939
CURRICULUM REVISION IN THE HIGH SCHOOLS OF SPRINGFIELD, MASSACHUSETTS

By

Ulmont Cleal Cowing

A Thesis Submitted in Partial Fulfillment of the Requirements for the Master of Science Degree.

Massachusetts State College

1939
<table>
<thead>
<tr>
<th></th>
<th>TABLE OF CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction</td>
</tr>
<tr>
<td>II</td>
<td>Organization of the Committee</td>
</tr>
<tr>
<td>III</td>
<td>Preliminary Work of the Committee</td>
</tr>
<tr>
<td>IV</td>
<td>Criteria Governing Choice of Subject Matter</td>
</tr>
<tr>
<td>V</td>
<td>Form of Presentation</td>
</tr>
<tr>
<td>VI</td>
<td>Content of the Outline</td>
</tr>
<tr>
<td>VII</td>
<td>Preliminary Report</td>
</tr>
<tr>
<td>VIII</td>
<td>Revision of the List of Science Subjects</td>
</tr>
<tr>
<td>IX</td>
<td>Summary of the Results of the Discussion of the Science Program</td>
</tr>
<tr>
<td>X</td>
<td>The Second Preliminary Report</td>
</tr>
<tr>
<td>XI</td>
<td>Writing the Outline</td>
</tr>
<tr>
<td>XII</td>
<td>Critical Evaluation</td>
</tr>
<tr>
<td>XIII</td>
<td>Limitations</td>
</tr>
<tr>
<td>XIV</td>
<td>Conclusions</td>
</tr>
<tr>
<td>XV</td>
<td>Acknowledgement</td>
</tr>
</tbody>
</table>
FOREWORD

In working out any thesis problem it is pertinent that an evaluation be included.

It is my purpose to evaluate the following curriculum study in the light of "Criteria For Evaluating Course-Of-Study Materials" by Herbert B. Bruner, Teachers College Columbia University.*

These criteria present opportunities for evaluating in terms of:

I Philosophy
   A. Educational
   B. Principles of Learning

II Content
   A. Authenticity
   B. Utility, Adequacy and Significance
   C. Organization

III Activities
   A. Pupil Purposing
   B. Interests and Needs
   C. Social Values
   D. Reality
   E. Variety
   F. Approach
   G. Culminating Activity

IV Evaluation of Pupil's Work
   A. Purpose
   B. Variety
   C. Validity

* Teachers College Record, November 1937.
IV Evaluation of Pupil's Work (cont'd.)

D. Areas of Growth
E. Interpretation

In using the above outline I hope to obtain a measure of the soundness of the work of the revision committee.
INTRODUCTION

Two outstanding problems face the teacher of today. Every thinking educator must ask himself two questions, not only once but many times. What shall I teach and how shall I teach it?

It is no news that teachers today are facing a serious situation, however perhaps, no more serious than teachers have always faced. Nevertheless, today more children from a larger number of walks of life are going to school and are staying in school longer. It is also generally admitted that of the heterogeneous group in the public schools today a larger and larger proportion are appearing who are incapable of mastering school subjects as they have been taught in the past.

Pupils not in the college preparatory group are becoming less certain as to their future and are resisting more and more the attempts to find their interests and bring out their skills and aptitudes. "Let George do it", is becoming the byword. This all seems to be a reflection of the attitude of a large group of our older citizens of today.

With rapidly sinking budgets the schools of today cannot afford to keep the ranks filled with retarded pupils. Every retarded pupil is an additional expense, which is not sound school economy. Whether we agree or not, we are being forced to accept the axiom that everybody shall pass. No failures will be the rule of the future.
As a result of the present trend it is patent that our public school curriculums be scrutinized and our teaching methods analyzed in order to fit the type of pupil who makes up a large part of the enrollment in the public school today.

At this point our critic, in an argumentative mood, may present the question of guidance. "Why worry about the curriculum," he says, "proper guidance will weed out the less capable pupils." My answer is, that there are many pupils less capable academically, who are not fitted for other fields of effort. It may be better to keep them in the general high school rather than cluttering up an occupational course or trade school. We have many misfits in the trade schools today. The general high school can at least give this group a general cultural training and try to develop an appreciation of one's obligation to society. I am not arguing that we are succeeding.

There are two further reasons why I believe that a changing curriculum is necessary in the school today.

First, any course of study, no matter for what group, needs to be set up so that it can be continually revised from time to time without wasting time and effort in tearing down the basic structure. In our changing world a course of study soon becomes outmoded except for basic material. Also the knowledge that
changes can be easily made becomes a stimulation to teachers. They become more enthusiastic and willing to assist in keeping a course of study up to date.

Second, we are continually in a state of revision of current textbooks and the appearance of new books. These revisions and new books often make it impossible to secure new copies of books in use which ordinary wear and tear necessitate. Why not make the course of study adaptable to such changes in books without having to change it in its entirety?

It is not the purpose of this thesis to present and evaluate any special course of study, but rather to discuss and evaluate the work of a committee of teachers in the Springfield Public Schools in revising the course of study in science to better fit the present day general student. I believe that a presentation of the problems faced by this committee and methods used to solve them may prove to be an aid to other teachers who may face similar problems.

The present program of curriculum revision has been in progress since 1930. The work in the senior high schools was begun in 1934.

Being a member of the science committee and as the work of the several committees is closely correlated, I am taking the work of the science committee as a basis for this paper.
ORGANIZATION OF THE COMMITTEE
The curriculum revision program in the Springfield Public Schools was in charge of Mr. Harry B. Marsh, Assistant Superintendent of Schools. In 1930 Mr. Marsh appointed committee chairmen for each grade in the Junior High Schools. In turn, each chairman was given power, with consent of the assistant superintendent, to choose a committee of five members to work with him in revising the curriculum for that particular grade or subject. Not only were these committees to work on their own particular problem but it was necessary to hold frequent meetings with committees of other grades and subjects in order to keep the work correlated.

It was necessary for the work in the senior high schools to wait for the revision in the junior high schools to progress to the point where the work could be correlated, so that there would be no gap for the boy or girl in going from junior to senior high school and also to eliminate repetition in the senior high revision.

In the same manner, committee chairmen in each subject were appointed by Mr. Marsh and likewise these chairmen formed their own committees. The senior high school science committee was composed of Mr. J. Hawley Aiken, head of the science department of the Technical High School, as chairman, Miss Eileen M. Fitzgerald and Mr. Lyman B. Phelps of the science department of
Classical High School and Mr. Howard C. Kelly, head of the science department of the High School of Commerce, and Mr. M. Edmund Maynard and Mr. U. Cleal Cowing of the Technical High School. Mrs. Dorothea Clark, supervisor of science in the junior high schools, acted as adviser to the committee in its correlation with the junior high school work.

The first meeting of the science committee was held in October, 1934. It was decided to hold weekly meetings on a specified day and at a specified time and discuss various problems which must be settled before actual revision work could be undertaken. After the actual revision work was underway it was found that weekly meetings were too frequent and it was decided to limit the meetings to one each month, the day and hour being prearranged. Better progress was made by dividing the group into sub-committees, each sub-committee taking a single subject in the actual work of revision. Messrs. Kelly and Maynard collaborated in physics, Mr. Aiken in physiography, Miss Fitzgerald in biology, Mr. Aiken and Miss Fitzgerald in physiology, Mr. Phelps in astronomy and Mr. Cowing in Chemistry. At these meetings progress was reported to the whole committee and corrections and suggestions made by the whole group.
PRELIMINARY WORK OF THE COMMITTEE.
The first few meetings in 1934 were held with Mr. Marsh in attendance for the purpose of advising the committee and presenting certain requests from the point of view of administration. First, the committee was urged to correlate and similarize the courses of study in the three high schools. Second, the curriculum was to be correlated with the work in the junior high schools. I have referred to this in a previous section. Third, the completed curricula should serve as a useful reference to administrators in Springfield and administrators in other school systems who might be seeking information. The selection of courses, material and form of the presentation was left entirely to the committee. Suggestion was made in an early meeting that all of the present science courses, i.e., chemistry, physics, biology, botany, physiography and astronomy, be incorporated into a single two year course called science. The suggestion was made on the grounds that the fewer the courses, the less the cost, because the number of classes can be reduced. The committee was not in favor of the move because the flexibility of our present curriculum would be lost. Due to the number of electives in science, students have the opportunity of spending more than two years in study and the committee felt that the discontinuance of these electives would be a detriment to many pupils who are interested in more than the required work in
some particular field. Incorporation of all subjects into a single course would eliminate all but basic fundamentals in any one field and would obviously eliminate some elective sciences.

After taking into consideration the recommendations of the assistant superintendent, it was necessary for the committee to agree on the type and purpose of the course of study. First, should the course outlines be brief or detailed. It was pointed out that too brief an outline accomplishes little and is too true to type, while a too detailed outline is apt to become so involved as to defeat its own purpose. A happy medium must be met somewhere. After several group discussions, the following arguments were advanced for a reasonable amount of detail.

1. **TO THE SCHOOL DEPARTMENT.** By means of outlines, the Superintendent, the School Committee and others directly interested, may obtain a comprehensive view of the work planned for the several subjects. By this means also, a desirable degree of uniformity between schools and classes may be obtained.

2. **THE SCHOOLS.** All departments of a school should know something of the work of the other departments. This may be accomplished by outlines, provided that these are sufficiently detailed so that teachers who are not specialists in a given subject may understand the scope of the work. By this same
means as previously mentioned, a desirable uniformity of work in different classes of a given department may be maintained.

3. **NEW TEACHERS AND SUBSTITUTES.** A new teacher can orient himself more quickly if he understands in some detail what he is supposed to accomplish. The same is true of the substitute teacher. In this connection it might be mentioned that substitute teachers in senior high school science are practically non-existent in Springfield.

4. **VISITORS.** The visitor desires a comprehensive view of the work, coupled with such information as will convey an accurate impression of the method of approach and the points of emphasis. These cannot be secured from an outline confined to main headings and general topics.

5. **THE PUBLIC.** Community support determines the character of the schools, and the public has the right to information which it can understand as to the nature and scope of the work which is being done.

6. **THE PUPIL.** A rather detailed outline may be used in the teaching process, especially as a summary or review. By it the pupil may be impressed with the most important features of the work he has studied. Also, with an outline as a partial guide, the text book may be used more effectively and intelligently.
7. **OTHER SCHOOLS.** Teachers in other school systems have asked for copies of the results of our work. Unless our report is presented in considerable detail these teachers will not be able to gain the impression which we desire to make. We need to do more than present to them "just another outline."

8. **SUMMARY.** Outlines are not constructed for the experienced teacher alone. If he is of the proper caliber he may need none at all. The maker of an outline should have in mind the needs of those less familiar than himself with the problems he is attempting to solve. Some of those who examine his work may not be specialists in his particular field. The educational system in Springfield expanded most rapidly during the early part of the twentieth century which was also a period of specialization in the field of education. Consequently the three high schools were placed close together in what was at that time the center of population. The Classical High School has specialized in a liberal arts curriculum and preparation for liberal arts colleges, the Technical High School has specialized in the mechanical arts and sciences and preparation for technical colleges and the High School of Commerce has specialized in business training and preparation for business colleges. A boy or girl has always been allowed to choose his or her own school, regardless of place of residence.
We are now in a period when the comprehensive high school is evidently more desirable and cities are building their schools in separate districts and students are required to attend the school in their own district. From the point of view of economy and balancing school loads this is highly desirable.

Although it will always be that the Springfield schools will always specialize in certain subjects i.e., Commerce in business and Technical in technical subjects, it is desirable to make certain subjects, which are taught in each school uniform. Such subjects are science, mathematics, English, history and modern languages. One of the major problems facing the science committee was the correlation of the science courses in the three high schools as recommended by the assistant superintendent. As I have pointed out, the science departments of the three high schools were represented in the committee. Some very valid objections to this step in uniformity were made by the committee members. It was not too difficult to reach an agreement on the type of courses for Classical and Technical, but it was difficult to see how to fit in the High School of Commerce. The academic work in the first two schools has always been basically the same but not so at the third. Mr. Kelly was quite logical in his objections to complying with a curriculum which might be suitable for schools of a more academic nature than Commerce.
In the first place, the High School of Commerce attracts a definitely different type of student than the other two schools. This commercial student has very little mathematical and scientific background and therefore is entirely unsuited for science work which is theoretical or mathematical in nature. On the basis of these objections, the committee agreed to formulate a basic course of study which would contain a minimum of theory and mathematics. Then in addition to the basic course would be included optional work of a nature to fit a more scientifically minded group. This optional work would be used at the discretion of the teacher. Thus the committee felt that difficulties caused by different types of students in the different schools would be overcome.
CRITERIA GOVERNING CHOICE OF SUBJECT MATTER.
It is understood and agreed that the material selected for science in the general course should guide the pupil to an understanding and appreciation of some of the important principles of science and should lead him to make personal use of the principles in his present and future activities.

It is also understood that there is much valuable factual material which does not of itself lead to generalizations, but which should be included for its cultural and utilitarian values. This material is likewise a necessary aid in the development of the facts which lead to the statement of the generalization.

The selection of subject matter should not be made in any haphazard fashion, nor should any item be included or excluded to suit the prejudices of any individual or group. Rather, definite principles of selection should be adopted and all suggested material subjected to the test of these principles. Nothing should be included which will not withstand criticism on this basis.

The following suggestions are made for the purpose of presenting something definite for discussion. No claim of originality is made. They are largely a compilation from the oral and written statements of well known and respected educators.

1. Is the material within the reach of the pupil's capacity? Is there gradation in difficulty?
Is provision made for the pupil who makes rapid progress?

2. Does the material selected relate to the environment? Is there sufficient contact with the pupil's previous experience?

3. Are problems presented whose solution appeals to the pupil as worth while? Do many of them have intrinsic value for him? Are they capable of arousing immediate interest? Will the interest be sustained?

4. Is it possible to present the material to the class in effective fashion? Is it adapted to the needs and limitations of our school system?

5. Have the interests of the individual members of the class received adequate consideration?

6. Are the activities selected such as will probably influence the pupil's response to the physical phenomena with which he comes in contact?

7. Will the material selected and the activities connected with it contribute directly to the achievement of our aims?

The details of presentation may better be left to the skill and good judgment of the teacher, taking into consideration the group ability of the pupils and the difference in laboratory equipment available in each school. But the pupil in every case should get the large concepts (Law of Conservation, molecular theory of matter, changes which matter undergoes, etc.), together with enough common practical applications to
make them real to him and meaningful in his daily life. In general, subject matter should be presented in the form of problems, but not mathematical, when it can be presented satisfactorily otherwise. Laboratory work should be such as to appear worthwhile to the average pupil — his time and attention should not be frittered away in "proving" or "checking" laws and measurements already well established.
FORM OF PRESENTATION.
The form in which the course outlines were to be presented was somewhat of a problem. One form considered consisted of an outline of each unit presented in columnar style. A sample of a unit on static electricity is submitted on page 16.

It is to be admitted that the column brief preceding each unit is of value in obtaining a view of the unit as a whole. However it would be of little value to a person untrained in science. It is but a slight variation of a topical outline which the committee wished to avoid.

The essay type of course of study was finally adopted because it conformed with the Junior High School work and could also easily be bound into book form. Thus the courses of study throughout the whole school system would be in the same style.
## PHYSICS (2)

### OBJECTIVES

| Acquaintance with the work of those who were pioneers in this field. |
| Appreciation of the fact that the action of electricity is governed by definite laws. |
| Knowledge of some of the useful outcomes of the work of the early investigators. |

### CONTENT

**Discovery:**
- Thales of Miletus
- Dr. Gilbert
- Robert Boyle

**Electrical Attraction:**
- Pith ball electroscope
- Law of attraction
- Kinds of electricity

**Detecting Electricity:**
- The first electrical machine
- Electrosopes
- Method of detection

**Storing Electricity:**
- Discovery of the condenser
- The Leyden jar
- Definition of condenser
- Different kinds of condensers

**Induction:**
- The electrophorus
- Law of induced charges

**Effects of Discharge**
- Mechanical
- Heating
- Lighting

### ACTIVITIES

**Demonstration:**
- Electrifying amber

**Lantern Slides:**
- Dr. Gilbert
- Page from *De Magnete*

**Demonstrations:**
- Rubber and pith ball
- Glass and pith ball
- Hard rubber vs. glass

**Discussion of the kite experiment of Franklin, with slides.**

**Demonstrations:**
- Hard rubber and gold leaf electrosopes
- Testing amber

**Lantern slides:**
- Page from *De Magnete*
- Other electrosopes
- Old electrical machines (several)

**Demonstrations:**
- Construction and discharge from Leyden jar

**Demonstration:**
- The electrophorus

**Demonstrations:**
- Puncturing paper
- Lighting gas
- Electric stars
<table>
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<tr>
<th>REFERENCES</th>
<th>OPTIONAL WORK</th>
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<tbody>
<tr>
<td>Standard text books</td>
<td>Electrical Recreations:</td>
</tr>
<tr>
<td>Hopkins: Experimental Science</td>
<td>Electric shocks</td>
</tr>
<tr>
<td>Franklin: Autobiography</td>
<td>Static machine</td>
</tr>
<tr>
<td>Book of Popular Science</td>
<td>Insulating stool</td>
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<tr>
<td>Compton's Pictured Encyclopedia</td>
<td>Electroscope</td>
</tr>
<tr>
<td>Special newspaper and magazine articles as they appear from time to time.</td>
<td>Camel's hair brush</td>
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<tr>
<td></td>
<td>Feather duster</td>
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<tr>
<td></td>
<td>Rubber band</td>
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<td></td>
<td>Attraction and repulsion</td>
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<td></td>
<td>Dancing pith balls</td>
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<td></td>
<td>Electric chimes</td>
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<td></td>
<td>Electrical seesaw</td>
</tr>
<tr>
<td></td>
<td>Diverging threads</td>
</tr>
<tr>
<td></td>
<td>Electrical pail</td>
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Many of the above experiments require apparatus which might be made by interested or particularly skillful pupils, and then demonstrated to the class.
CONTENT OF THE OUTLINE.
It was agreed that the outline of material as presented for consideration by the science committee should include the following:

1. A general outline showing the specific material to be included under a given heading.
2. List of subjects for class demonstration and discussion.
3. List of laboratory experiments.
4. Statement of expected outcomes.
5. Text-book references.
6. Vocabulary of important words.
7. List of visual aids.
8. Provision for the "rapid" student.
PRELIMINARY REPORT.
In the spring of 1935 the first preliminary report was forwarded to the assistant superintendent. This report consisted of a presentation in brief of the work of the science committee so far. It contained a list of general considerations in connection with the organization of the course of study, a list of science objectives as well as a number of rules which the committee had formulated for use as guides in writing the course of study. Following is a copy of the report which was approved by the assistant superintendent.
This preliminary report is presented to the Science committee for final discussion and revision. When agreement is reached, the secretary is directed to put the material into a form suitable for presentation to the Assistant Superintendent.
GENERAL CONSIDERATIONS:

It is agreed that the science of the senior high school should recognize and build upon all the past science experiences of the pupil. It should amplify, but not duplicate, the work done in the grades and in the junior high school.

It is also agreed that just as there comes a time in the life of the pupil when it is desirable to bring about a change from a comparatively unorganized to a more orderly arrangement of his science knowledge, so at the beginning of the senior high school work a convenient and desirable time arrives for introducing the pupil to science as organized in special branches.

This arrangement is desirable because
(1) at about the senior high school age the pupils seem to develop specialized interests and aptitudes;
(2) the limited time at our disposal would seem to make it impossible to give the pupil even a glimpse of the entire field;
(3) many, if not most, of the science problems which we encounter deal mainly with one particular field, and
(4) the method of "the world's most intelligent workers" is to limit their activities to one field at a time, so far as is possible.

In stating these considerations there is no intention of trying to place the various branches of science in water tight compartments. It is fully recognized that the fields overlap in many places.

COLLEGE PREPARATORY SCIENCE:

The special objective of college preparatory work is to enable the pupil to meet the requirements of the college entrance examination. This requires a special technique and methods which have this specific object in view.

The field which may be covered in this work is limited by the college entrance requirements. Some variation is permitted, but the major part of the
content is rather definitely prescribed.

Therefore, in the opinion of the committee, this phase of senior high school science should be treated in a separate report, entirely distinct from that which considers the needs and the possibilities of the "general" student.

SCIENCE FOR THE GENERAL STUDENT:

The chief objective, in this case, is to provide the pupil with science knowledge of "most worth" to him, and in a form which will permit him to assimilate and make use of it. Consequently, the work will differ materially from that offered to the college preparatory pupil. There will be more immediate and fewer deferred values.

It is understood, also, that "general" pupils are not entirely similar in each of the senior high schools. There is a distinct difference in their preparation, especially in mathematics and this fact must be taken into consideration in attempting to unify the work of the three schools.

SCIENCE OBJECTIVES:

CULTURAL
(a) Appreciation of our great debt to the scientists of past and present.
(b) Some understanding of the broad scope of science and of our dependence upon simple yet definite laws.
(c) Glimpses of the wonderful development and future possibilities in this field.

UTILITARIAN
(a) Definite information which will be of advantage in present day daily living.
(b) The cultivation of judgment by providing pupils with a background sufficiently scientific to enable them to discriminate between scientific and pseudo-scientific data.
(c) Training which will lead pupils to make accurate observations and to draw correct conclusions from what they observe.
(d) Information and experience which may connect directly with some vocations.
(e) Development of the disposition to use scientific information for the benefit of the community and the state.
RECREATIONAL
(a) The development of interests and skills which, as hobbies, will promote a more worthwhile use of leisure time.

GENERAL NATURE OF THE WORK:

The difference between objectives is so distinct that obviously the nature of the work provided for the general student should differ from that needed for college preparation. For the general student we suggest the following considerations.

(1) The work should be mainly qualitative in nature.
(2) The emphasis should be on the practical rather than the theoretical, the point of view of the consumer taking precedence over that of the producer.
(3) There should be a minimum amount of theory, and all discussion of theory should be left until the pupil has in mind a sufficient number of facts to enable him to understand the reasons for the theoretical conclusions.
(4) As far as possible, the material should be presented to the pupil in the form of questions and problems which will challenge his attention and stimulate his interest. They should appeal to the pupil as worthwhile. Many of them should have intrinsic value for him.
(5) The wording of questions and problems should be popular rather than technical, especially at the beginning of the work.
(6) Laboratory experiments should, in many instances, differ in form and content from those used in the college preparatory work. They should be truly "questions asked of nature", the answers to which will appeal to the pupil as of value. The apparatus should be, as far as possible, of the commercial type.
(7) Provision should be made for the superior pupil, and opportunity should be given him to do more than the minimum amount of work.
(8) Discussions and experiments should be planned to lead to the statement of general conclusions in every case where our present knowledge will permit.
REVISION OF THE LIST OF SCIENCE SUBJECTS.
In the fall of 1935 the science committee set itself to the task of studying and revising the list of science subjects taught in the senior high schools. It also decided to formulate a series of objectives for each course to be taught. This section of the work was to be completed by the end of the school year, June 1936, as part of a second report to the assistant superintendent.

On page 26 is a chart showing the present courses taught in the senior high schools. The inference might be drawn that there is, at present, a fair degree of uniformity. However, Physics at the Technical High School covers mechanics of liquids and solids and heat; at Classical, mechanics and electricity and at Commerce, merely heat. At Commerce, Physics 2, 3 and 4, each represents a separate division, i.e., mechanics, light and sound and electricity, while at Technical and Classical, Physics 2, covers the material not considered in Physics 1. Physics 3, at Technical is a course in advanced electricity.

The chart gives the impression that more physics is taught at Commerce than at the other schools, but this is erroneous.

It will also be noted that apparently the curriculum at Commerce includes as much Chemistry as at Technical and Classical. However, Chemistry 1 and 2, at the latter schools includes the same material as
1, 2 and 3 at Commerce. Chemistry 3, at Technical is a course in qualitative analysis.

Again it appears that more science courses are offered at Classical than at Technical. Biology, astronomy and a full year of physiology are offered at the former school, while the latter offers no astronomy and only one-half year of physiology.

All of the science courses at Classical and Commerce are elective. At Technical, all boys are required to take Physics 1 and 2 and Chemistry 1 and 2. All girls are required to take one-half year of botany and one-half year of household physics and one year of chemistry. All other courses are elective.

From the above analysis, it is plain to see that very little uniformity exists among the science courses in the three schools.
SCIENCE OFFERINGS

CLASSICAL

All electives

10B.
Physics (1)
Biology (1)

10A.
Physics (2)
Biology (2)

11B.
Chemistry (1)
Physiology
Physiography
Astronomy
Biology (Reg.)
Physiology (Girls)

11A.
Chemistry (2)
Biology (Reg.)
Physiology (2 Girls)

12 B.

12A.
All previous electives.

TECHNICAL

10B.
Physics (1)
Botany (Girls)
½ yr. of Household Physics (Girls)

10A.
Physics (2)
Botany (Girls) or Household Physics (Girls)

11B.
Chemistry (1)
Physiology

11A.
Chemistry (2)

12B.
Chemistry (3)
Physics (3)

12A.
All previous electives

COMMERCE

10B.
Physics (1)
Home Science

10A.
Physics (2, or 4)

11B.
Chemistry (2)

11A.
Physics (2, 3, or 4)

12B.
Chemistry (3)

12A.
All previous electives

1933

26
The choice of science courses which would be suitable to present in each of the three high schools, proved to be a real and even a serious problem. Here the differences in viewpoint of the committee members representing the different schools, began to assert themselves. To express it more bluntly, the group became divided into factions. One faction was strongly opposed to adhering to standard courses of a theoretical nature, on the basis that the pupil of today is not capable of this type of work and quickly loses interest. Only courses of a practical nature should be selected. The other faction maintained that, perhaps contrary to some modern educational theories, courses of a theoretical nature were necessary if we were really expecting to teach fundamental science. That science is meaningless without a sound theoretical basis. Moreover, this type of science could be taught if skillfully done. Practical applications were not objectionable, but this faction did object strenously to the present tendency to lower educational standards by diluting and sugar coating courses of study.

In the hope of reaching a compromise in the above situation, the committee made a study of the special and common problems in the three high schools. Following are the results of that study.
SENIOR HIGH SCHOOL PROBLEMS:— The three senior high schools of Springfield have one large problem in common. Each school has, in addition, one or more special problems which must be solved with little, if any, reference to the work of the other two schools.

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<th>SCHOOL</th>
<th>SPECIAL PROBLEM</th>
<th>COMMON PROBLEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical</td>
<td>Preparation for college, especially for the college of liberal arts.</td>
<td>Provision for those general students who on account of ability, inclination or both, are not able to profit by the work which represents the major purposes of the school.</td>
</tr>
<tr>
<td></td>
<td>Preparation for normal schools and colleges.</td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td>Preparation for college, especially institutes of technology.</td>
<td>Such students are present in each school and cannot be eliminated. So far, no concerted effort has been made to solve their problem.</td>
</tr>
<tr>
<td>Commerce</td>
<td>Business preparation, including secretarial, accounting, retail selling, etc.</td>
<td>In this group will be found most of the low ranking students and the failures. They are not likely to succeed in the work in which the school specializes.</td>
</tr>
</tbody>
</table>

SPECIAL PROBLEMS:— The special problems of each school must be met according to the type of work for which preparation is being made. College entrance requirements make it reasonably certain that there will be sufficient similarity.

The strictly business courses are definitely vocational. They are in a class by themselves and must have individual treatment. The science committee might, however, suggest electives to be offered in connection with these courses.
THE COMMON PROBLEM:— The general pupils must be considered as a group by themselves, and work offered which they can overtake as well as pursue.

They must not be subject to the same regulations as other groups in regard to subjects required for graduation. The number of required subjects should be smaller and very carefully chosen. The electives might well be more diversified. These changes would not affect the number of credits which each pupil would be supposed to earn in order to receive a diploma.

The diploma for a general student should state that he is a graduate of the general course, or should, in some way, be differentiated from the diploma given to a student in another group.

Under present conditions it would be difficult, if not impossible, to provide uniform work for a general group in each of the three senior high schools on account of varying election possibilities. In each school, electives would have to be chosen from the subjects offered in that school. A Commerce student could not well elect a foreign language, nor could a Classical student easily be placed in a shop class.

The offerings in some individual subjects may be made reasonably uniform. This may be accomplished in science—provided opportunity is afforded, to offer similar subjects in each school. The science offerings for a general group might be:

APPLIED PHYSICS,   PRACTICAL CHEMISTRY,
GENERAL BIOLOGY,   POPULAR ASTRONOMY,
HOME SCIENCE.

These sciences should be elective, but at least one year of some science should be required of each general pupil.

If the problem of the general pupil in the senior high school is to be considered intelligently

(1) the science committee should have complete knowledge of the work accomplished by the science committee of the elementary and junior high schools, in order to avoid duplication and radical differences in general principles;

(2) the science committee should recommend a science program for the general group of each senior high school;

(3) each senior high school should determine, in at least a tentative way, its whole program of studies in order that we may know definitely whether the subjects suggested meet with the approval and will be included in
the work of the school, and

(4) then the science committee can proceed to consider content, organization and method of presentation.
SUMMARY OF THE RESULTS OF THE DISCUSSION OF THE
SCIENCE PROGRAM
The new program of courses for the three high schools represents a compromise between the theoretically and practically minded members of the committee.

The first two semesters of any one course, i.e., physics 1 and 2, were to be identical in each school and represent the basic work. The advanced courses, i.e., physics 3, and 4, were to be arranged to fit the particular needs of each school. At Technical, physics 3 and 4 would be courses in advanced electricity, while at Commerce, physics 3, and 4, might be connected up with salesmanship and office work. Courses worked out in this way, were to be left to the discretion of the individual schools concerned.

Thus it will be seen that it was at least possible to correlate the basic science courses in the three schools. The elective offerings at Classical and Technical which are not basic, were made more numerous because of the greater demand for science courses at those schools.

Note that biology is now included in all three curricula. It seemed impossible to present the courses in the same order in each school, due to differences in pupil demand, but this seemed of little consequence to the committee, as long as the courses were offered sometime during the three years. The demand for physics and chemistry is greater at Technical during the first two years than at the other two schools, so the other science electives were placed in the twelfth year because the demand for additional science work is greatest at that time.

* See page 33.
At Classical and Commerce, the demand for additional electives comes earlier, so optional courses are included during the first two years.
### RECOMMENDED SUBJECTS

<table>
<thead>
<tr>
<th>CLASSICAL</th>
<th>TECHNICAL</th>
<th>COMMERCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics 1</td>
<td>Physics 1</td>
<td>Physics 1</td>
</tr>
<tr>
<td>Physics 2</td>
<td>Physics 2</td>
<td>Physics 2</td>
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<tr>
<td></td>
<td>Physics 3</td>
<td>*Physics 3</td>
</tr>
<tr>
<td></td>
<td>Physics 4</td>
<td>Electricity (Boys unprepared)</td>
</tr>
<tr>
<td>Chemistry 1</td>
<td>Chemistry 1</td>
<td>Chemistry 1</td>
</tr>
<tr>
<td>Chemistry 2</td>
<td>Chemistry 2</td>
<td>Chemistry 2</td>
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<tr>
<td></td>
<td>Chemistry 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemistry 4</td>
<td></td>
</tr>
<tr>
<td>Biology 1</td>
<td>Biology 1</td>
<td>Biology 1</td>
</tr>
<tr>
<td>Biology 2</td>
<td>Biology 2</td>
<td>Biology 2</td>
</tr>
<tr>
<td>Physiology (Boys)</td>
<td>Physiology</td>
<td></td>
</tr>
<tr>
<td>Physiology 1 (Girls)</td>
<td>Hygiene (Girls)</td>
<td></td>
</tr>
<tr>
<td>Physiology 2 (Girls)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiography</td>
<td>Physiography</td>
<td>Home Science 1 (Girls)</td>
</tr>
<tr>
<td>Astronomy</td>
<td>Applied Physics (Girls)</td>
<td>*Home Science 2 (Girls)</td>
</tr>
<tr>
<td></td>
<td>Household Chemistry (Girls)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biology (Girls)</td>
<td></td>
</tr>
</tbody>
</table>

DIVISION INTO "ELECTIVE" AND "REQUIRED" AND PLACEMENT IN THE GENERAL PROGRAM TO BE LEFT TO THE INDIVIDUAL SCHOOLS.

* Not in present program.

NOTE: Astronomy also considered desirable though not recommended at present.
THE SECOND PRELIMINARY REPORT
In its second report, the committee desired to include a list of objectives for each course along with a topical outline of each course. For this work, the committee divided itself into sub-committees as previously mentioned and each sub-committee was to be responsible for its own particular course.

The topical outlines were intended to show the content of the subject in a general way only, and in the opinion of the committee, represent as much uniformity as is practical. Certain pupil differences in ability, aptitude, interest and preparation are hereby recognized. There are also large differences in the teaching equipment of the three senior high schools and these cannot be made uniform.

Following to serve as an example is the list of objectives and topical outlines for chemistry. All other courses were handled in the same way.
GENERAL CHEMISTRY TOPICAL OUTLINE

Objectives

1. To point out some of the practical applications of chemistry which are likely to affect the life of the student.

2. To teach the vital contributions of chemistry to the maintenance of the health of the individual and the community.

3. To provide a scientific background for reading and growth which may make leisure hours a source of pleasure and profit.

4. To encourage the formation of habits of inductive and deductive reasoning by confronting him with numerous situations and requiring him to think out the correct procedure.

5. To show that chemistry has vocational possibilities.
SEMMETER I

I. Introductory lessons
   A. Matter and energy
      1. States and properties and forms of energy
   B. Changes in matter
      1. Composition
      2. Kinetic and electron theories
      3. Physical and chemical changes
         a. Aids to chemical changes
         b. Energy changes
      4. Types of chemical changes
   C. Elements
      1. Number, occurrence, classification, names and symbols
   D. Compounds and mixtures
      1. Variable and fixed proportions
      2. Chemical union
   E. Conservation of matter and energy and definite composition

II. Oxygen
   A. Preparation
      1. From mercury oxide, potassium chlorate, water, air, peroxide
   B. Properties
      1. Physical
      2. Chemical conduct
      3. Relation to life
      4. Uses
   C. Ozone
      1. Preparation, nature and properties and uses

III. Hydrogen
   A. Preparation
      1. Water, acids
   B. Properties
      1. Physical
      2. Chemical
   C. Uses

IV. Water and hydrogen peroxide
   A. Abundance
   B. Properties
      1. Physical
      2. Chemical
   C. Water as a standard for specific gravity and heat measurements
   D. Impurities and purification
      1. Methods
   E. Hydrogen peroxide
      1. Preparation
      2. Properties
      3. Uses
   F. Law of multiple proportions

V. Solutions
V. Solutions (cont'd)
   A. Definitions of terms used
   B. Characteristics of solution
   C. Kinds of solutions
      1. Dilute, saturated, concentrated, supersaturated
   D. Factors affecting solubility
   E. Suspensions and emulsions
   F. Colloidal suspensions
   G. Crystallization
      1. Growth, water of hydration, efflorescence, deliquescence
      2. Crystalline and amorphous forms

VI. Atmosphere
   A. Composition—mixture not a compound
   B. Liquid air
   C. Nitrogen
      1. Preparation
      2. Physical and chemical properties
      3. Uses
      4. Nitrogen cycle
   D. Ventilation
   E. Rare gases

VII. Ammonia
   A. Preparation
      1. Ammonium chloride and calcium hydroxide, soft coal, Haber process, cyanamide process, decay
   B. Properties
      1. Physical
      2. Chemical
         a. Compounds formed with water
   C. Uses
      1. Refrigeration, ammonia water, nitric acid

VIII. Chemical theory
   A. Atoms and molecules
   B. Atomic and molecular weights
   C. Symbols and formulas
   D. Electron theory
   E. Valence
   F. Percentage composition from the formula
   G. Derivation of formula from percentage composition

IX. Acids, bases, and salts
   A. General properties of acids
   B. Naming of acids
   C. General properties of bases
   D. Naming of bases
   E. Salts—products of neutralization
   F. Naming of salts

X. Ionization
   A. Classification of solutions according to conductivity
X. Ionization (cont'd.)
   B. Definitions
   C. Ionization
   D. Electrolysis and neutralization
   E. Degree of ionization
   F. Hydrolysis
SEMESTER II

I. Nitric acid and oxides of nitrogen
   A. Preparation: sodium nitrate and sulfuric acid
   B. Properties
      1. Physical: color, specific gravity, boiling point
      2. Chemical
         a. Action as acid
         b. Oxidizing agent
   C. Oxides of nitrogen
      1. Preparation, properties, and uses

II. Chemical equations
   A. Rules for writing equations
   B. Balancing equations

III. Chemical calculations
   A. Problems relating to equations
      1. Weights given and weights required
      2. Weights given and volumes required
      3. Volumes given and volumes required

IV. Carbon, its oxides
   A. Carbon: occurrence—nature, combined
      1. Allotropic forms
         a. Crystalline
         b. Amorphous
      2. Physical and chemical properties
      3. Uses: fuels, reducing, tires, paints, inks, sugar, gas masks
   B. Carbon dioxide
      1. Preparation—carbon, carbonates fermentation
      2. Physical properties—density, solubility, liquefaction
      3. Chemical conduct: stability
      4. Uses
      5. Test for carbon dioxide
   C. Carbon Monoxide
      1. Preparation: burning carbon, reducing carbon dioxide, reducing steam, formic and sulfuric acids
      2. Properties
         a. Physical
         b. Chemical
      3. Uses

V. Fuels
   A. Solids: wood, coal, coke
   B. Liquids: oil, gasoline, alcohol
   C. Gases: natural gas, artificial gases
   D. Gas burners
   E. Coal and oil burners
   F. Smoke prevention
VI. Sulfur and its compounds
   A. Sulfur
      1. Occurrence
      2. Mining and extraction
      3. Properties
         a. Physical
         b. Chemical conduct
      4. Uses
   B. Hydrogen sulfide
      1. Preparation
      2. Properties
         a. Physical
         b. Chemical
   C. Sulfur dioxide
      1. Preparation—burning sulfur, roasting metallic sulfides, acids on sulfites
      2. Properties
         a. Physical
         b. Chemical
      3. Uses
   D. Sulfuric Acid
      1. Manufacture—contact process
      2. Properties
         a. Physical
         b. Chemical conduct
      3. Uses
      4. Test for sulfate ion

VII. Halogens
   A. Fluorine
      1. Preparation
      2. Uses
   B. Chlorine
      1. Preparation—electrolysis, manganese dioxide and hydrochloric acid
      2. Properties
         a. Physical
         b. Chemical conduct
      3. Hydrochloric acid
      4. Bleaching compounds
      5. Uses
   C. Bromine and iodine
      1. Uses

VIII. Sodium and potassium
   A. Metals—preparation, properties, and uses
   B. Important compounds—comparison
      1. Uses
   C. Solvay process
   D. Flame tests

IX. Calcium
   A. Metal—preparation and properties
   B. Compounds—Carbinate, oxide, sulfate, chloride, carbide, cyanamide, bleaching powder
   C. Hard water—permanent and temporary
C. Hard water (cont'd.)
1. Methods of softening
2. Boiler scale
3. Action of soap

X. Aluminum
A. Historical
B. Occurrence: corundum, emery, bauxite, cryolite, clays
C. Preparation
   1. Hall process
D. Properties
   1. Physical
   2. Chemical conduct
E. Uses
F. Compounds--oxide, hydroxide, sulfate, alum, artificial gems

XI. Phosphorous
A. Matches--manufacture
B. Fertilizers--manufacture

XII. Selected topics--optional
A. Organic compounds
   1. Methane series
      a. Alcohols
      b. Acids
   2. Carbohydrates
      a. Foods
B. Metallurgy
   1. Iron and steel
   2. Copper, silver and gold
C. Alloys
D. Paints and Lacquers
E. Inks
F. Photography
G. Explosives
The second report consisted of the present list of science subjects, new recommended list of subjects, together with course objectives and topical outlines for each course.

In the fall of 1936, the assistant superintendent returned favorably on the second report. Exceptions were, that it was impossible at the present time, to institute new courses, i.e., advanced physics and chemistry, because economy made impossible the obtaining of additional teacher time and equipment. The courses recommended were in favor but the committee was advised that attention be fixed on the revision of the courses now being taught.
WRITING THE OUTLINE
The committee planned to have the finished outlines in the hands of the assistant superintendent by June, 1937. During the first few months in the fall of 1936, the committee worked as a whole, on a complete unit on heat. The purpose was to acquaint each member with the style of procedure, in order to attain a degree of uniformity in all the course outlines. This completed unit was to serve as a sample and guide for all the other work.

On pages 44 and 45, are parts of a unit used in the junior high schools. Examination would show that the senior high school unit need not use too much time and space on such topics as, sources of heat, or simple heat expansion, as the pupil has already been made acquainted with these concepts. However, the committee did not feel that it ought to avoid these concepts in its course of study. They should be mentioned in the senior high school work as a matter of review. This policy of examining the junior high school work was followed throughout the preparation of the senior high school course of study.
PUBLIC SCHOOLS, SPRINGFIELD, MASSACHUSETTS.
Elementary and General Science

GRADE 7, UNIT II

HEAT

PREVIEW FOR PUPILS

I. WHAT IS HEAT?
Underline the word you think best expresses what heat is:
A gas - a solid - a force - a liquid - an invisible object

II. SOURCE OF HEAT
Complete the following sentences:
Heat comes from ______________________
The most common way of producing heat is by ________
Other ways of producing heat are, ________, _______.

III. USING HEAT
Select the correct word to complete the following statements:
furnace - stove - steam heat - hot air - hot water
1. We use _________ to heat our house.
2. The school building is heated by means of_______

IV. FUELS FOR PRODUCING HEAT
1. We use _________ for cooking.
2. We use __________ for heating water for dishes, baths, etc.
3. We use __________ for heating the house in which we live.

V. HOW MANY CAN YOU ANSWER?
1. Why do some cooking utensils have wooden handles?
2. Why are wheels of wagons or autos greased?
3. What makes a stove or fire smoke occasionally?
4. What causes a wind to blow?
5. How is a thermos bottle constructed so as to keep food either hot or cold?
6. Is it warmer near the ceiling or near the floor of a room? Why?
PROBLEM I - HOW DOES HEAT AFFECT A SOLID?

Exercise 1, Part I. Try to pass the ball through the ring.

a. Result
b. Check ( ) the diagram that illustrates the result.

Diagram A

Diagram B.

Part 2. Heat the ball. Then try to pass it through the ring.

a. Result
b. Check the diagram that illustrates the result.

Diagram A

Diagram B.

Answer the problem

Exercise 2. How does the loss of heat affect a solid?

Let the ball cool. Try to pass it through the ring.

a. Result
b. Check the diagram that illustrates the result.

Diagram A

Diagram B.

Answer the exercise

Find the meanings of the words EXPAND and CONTRACT, using the dictionary.

Use these two underlined words in the following blanks.

a. Heat makes solids ____________________.

b. The loss of heat makes solids ____________________.
On the following pages are two examples of earlier attempts to write the unit. Unit number one was immediately discarded. It was obviously too much of a topical outline and of little value to an experienced teacher and at the same time, too brief and meaningless to be of value to a new teacher, or a person not versed in science. This outline also contained too many meaningless formulae, the theory of which, it was hoped to avoid. These formula can be found in any textbook, if they are desired and do not need to be reproduced in an outline.

Unit number two was still not satisfactory to the committee, although it was an improvement over the first. Much of the theory and formula were omitted, but still it was considered to be too much of a topical outline, and hence was open to the same criticism as outline number one.
ENERGY THE SOLE CONCEPT OF PHYSICS
Simple energy changes
Heat to electricity
Heat to sound
Heat to mechanical energy
Heat to chemical

THE SUN, THE EARTH'S CHIEF SOURCE OF ENERGY
Sun's mass being changed over into energy
Every square yard of the earth's surface absorbs
1/2 H.P.
Less than 1/2,000,000,000 of the sun's energy being absorbed by earth

RADIATION OR SENSELESS HEAT
Its speed
Its mode of transmission
Travels in straight lines in a given medium
Absorption and reflection
Radiometer
Differences in radiant energy in colors of sun's spectrum
Demonstration: prism, thermopile, mirror galvanometer, (greatest deflection in red).

THE HEAT OF A BODY IS THE AVERAGE OF THE MOLECULAR K. E.
Absorption of heat by a body means an increase in the K. E. of the molecules.
Liberation of heat by a body means a decrease in the K. E. of the molecules.

SENSIBLE HEAT
Convection — actual movement of heated mass
In gases — winds
In liquids — ocean currents
Conduction — transference from molecule to molecule
In solids — conductometer
In liquids and gases

EXPANSION IS A PHENOMENON OF INCREASED MOLECULAR K. E.
Of solids.
Application in structural design
\[ e = kl (t' - t) \]
"K" defined — problems
Class experiment on coefficient of expansion of metals, of liquids
Thermometers
Critical points
\[ C = \frac{5}{9}(F - 32) \]
\[ F = \frac{9}{5}C + 32 \]
Class experiment on critical points of thermometers and the effect of increased and decreased pressure on the boiling points
Of gases

Absolute zero and absolute temperature
\[ \frac{P}{T} = \frac{P'}{T'} \]
\[ \frac{PV}{T} = \frac{P'V'}{T'} \]

Heat Units

B. T. U.
Calorie

Specific Heat

Class experiment on specific heat of metals
\[ H = W(t' - t) \text{sp. ht.} \]
Heat mixture problems

Change of State

Heat of fusion (solid to liquid)
Class experiment on latent heat of fusion of ice
Energy increased, so heat is absorbed
30 cal. per gm. of ice at 0 degrees C.
144 B.T.U. per lb. of ice at 32 degrees F.

Heat of vaporization (liquid to gas)
Class experiment on latent heat of steam
Energy increased, so heat is absorbed
536 cal. per gm. of water to steam at 100 degrees C.
965 B.T.U. per lb. of water to steam at 212 degrees F.

Evaporation

Of liquids
Cooling effect
Compare with boiling

Condensation

Dew and frost
Dew point
Fog and clouds
Precipitation
Rain and snow

Humidity
Practical value

Distillation

Heating and ventilating homes
Hot air, steam, hot water
Methods of heat transference
Comparison of systems

Refrigeration

Compression cycle
Motor-driven compressor type
Review heat changes and latent heat
Absorption cycle
Gas refrigerator (Electrolux)

Joule's experiment
Mechanical energy to heat energy
778 ft. lbs. = 1 B.T.U.

Heat engines
Historical
Hero's reaction type
Branca's apparatus
Huygen's gunpowder engine
Newcomen's atmospheric engine
Watt - the modern steam engine
Superheated steam.
   Demonstration: superheat steam in copper tube with Bunsen burner.
   Steam lights match, chars paper.
Types of modern heat engines
Slide valve
Corliss
Turbine
Power plants
Stationary and mobile
Internal combustion engines
4-cycle gas engine
   Automobile
3-cycle engine
Diesel
   Wide usage on land and sea
II

GENERAL PHYSICS

OUTLINE OF SUBJECT MATTER

HEAT

OUR DEPENDENCE ON HEAT:
Heat and life
Differences of temperature necessary
Necessity for the control of heat
Advances made because of controlled heat
Some unsolved problems of heat control

SOURCES OF HEAT:
Natural
The sun
Hot springs
An unusual house heating system
Volcanoes, etc.
Fuels
Coal and its story
Wood and forest conservation
Gas, natural and manufactured
Coke—a by-product
Fuel oils
Mechanical
Friction
Percussion
Compression

HEAT AND TEMPERATURE:
Temperature vs. quantity of heat.
Measurement of temperature
Thermometers
Galileo’s thermometer
Mercury, alcohol, air, and metal thermometers
Special values and uses of each
Thermometer scales
Fahrenheit and his scale
The centigrade scale.
Other scales
Relation between F and C. scales.
The fixed points
How determined
Tests
Measurement of quantity of heat
Units
Calorie
B. T. U.
Simple method
Calorimeters
Specific heat
II (cont'd.)

SOME COMMON EFFECTS OF HEAT:
Expansion of solids
Familiar illustrations (bridges, tracks, etc.)
Unequal rates
Coefficient of linear expansion
Practical applications
Balance wheel of watch,
Metallic thermometer,
Thermostat - controlling temperature

Expansion of liquids
Cubical expansion
Peculiar action of water
Applications
Thermometers
Thermostats - mercury
Compensating pendulum

Expansion of gases
Coefficient of expansion
Absolute zero
Fusion and solidification
No temperature change
Heat of fusion
Heat absorbed when a solid melts
Measurement
Applications
Heat liberated during solidification

Expansion of water during solidification

Vaporization
Effect of pressure on the boiling point
Effect of dissolved solids
Effect of dissolved gases
Heat of vaporization

Evaporation
Cooling effect
The electric refrigerator
The gas refrigerator
Other common applications

Water vapor in the air
Meaning of humidity
Relative humidity
Humidity and health
The "comfort zone"
Measurement of relative humidity
Sling psychrometer
Hair hydrometer
Chemical hygrometer

Condensation
Condensed water vapor
Dew, frost, clouds, fog, rain, snow, and hail.

Distillation
MOVEMENT OF HEAT:
Conduction
Conductivity of common solids
Application to household devices, etc.
Conductivity of liquids and gases
Heat insulators and their uses
Houses
Fireless cookers
Automobile bodies
Vacuum bottles
Clothes

Convection
Currents of gas or liquid
Ventilation
House heating systems
Comparison
Kitchen hot water tank

Radiation
Meaning of the term
Good and poor radiators
Applications

HEAT AND WORK:
Hero's steam engine
Other early attempts
Modern heat engines
Watt's engine
Improvements on the steam engine
Gas engines
Oil engines
"Sun engines"

WHAT IS HEAT?
The molecular theory
Heat a mode of motion
Reasons for our belief

CLASS DISCUSSIONS WITH DEMONSTRATIONS:
Our common fuels
Flames and burners
Electricity and gas compared
The bomb calorimeter
Transfer of heat
Comparison of house heating systems
The school heating and ventilating system
The pressure cooker
Boiling under reduced pressure
"Dry ice"
Heat from mechanical work
Humidity and its measurement
Molecules and atoms
LABORATORY EXPERIMENTS:
Testing thermometers
  Laboratory thermometers
  Household thermometers
Cost of operating a gas stove
Measurement of heat from a gas stove
Economy of high and low flames
Efficiency of a gas stove
Cost of operating an electric stove
Test of "calrod" unit
Radiator finishes
Test of heat insulators
Effect of solution and evaporation
Freezing mixtures
The dew point
Humidity tests and control
Heating effect of steam and boiling water
Cooling effect of ice and ice water
Specific heat
"Saucepan conduction"

(For the general pupil in particular, the statement of each experiment should be in the form of a question or a problem. The language should be popular rather than technical)

EXPECTED OUTCOMES:
Practical knowledge relating to common devices for the use and measurement of heat.
Understanding of the following generalizations:
(a) The sun is the source of all heat.
(b) "Uniform temperature is useless temperature".
(c) Nearly all substances expand when heated and contract when cooled.
(d) Heating and cooling consists in the transfer of heat from warmer to cooler bodies.
The beginning of an understanding of how theories originate, and the part they play in science work.

REFERENCES:
Dull - Modern Physics, Sections 212-315 incl.
Good - Laboratory Projects in Physics (See Contents)

VOCABULARY:
Bunsen burner  conduction  latent heat
Meker burner  convection  condensation
temperature  radiation  dew point
boiling point  specific heat  humidity
Centigrade  fusion  hygrometer
calorie  evaporation  combustion
B. T. U.  vaporization  explosion
Fahrenheit  steam
OPTIONAL WORK:
Set up and demonstrate Carré's ice machine.
Test of house heating system
Study of camp stoves
Construction of models:
   Steam heating system
   Hot water house heater.
   Kitchen hot water tank.
Look up and report on the refining of sugar, with particular reference to the heat principles involved.
After considerable discussion, the committee agreed that the most important function of the course of study was to aid the present teachers and new teachers. It is expected that teachers of science will have a knowledge of the subject, so the outline should not only present course content, but also methods of presentation. The procedure in teaching the unit should be quite detailed. The teacher should know what results to expect. It is also desirable to include and explain to the teacher, useful aids and experiments not generally found in available textbooks. The unit should also be written so that the layman could understand what it was trying to accomplish, although he might not understand it in detail.

With these thoughts in mind, unit number three was completed and approved by the committee and later by the assistant superintendent. The reader will note certain of its features.

1. First, a teacher with a knowledge of physics, would not need to refer to a text.

2. Complete list of references, materials, and visual aids are given for each unit.

3. The procedure is written to tell the teacher not only what to do but how to do it.

4. It is expected that the teacher is able to interpret the results of the teaching procedure.

5. The desired results of each unit are listed at the end.

6. Unusual experiments are diagrammed as well as explained. See pages 71 and 72.
7. The objective tests at the end do not have to be used and are simply inserted as examples.
Introduction

The subject of heat is usually interesting because of the great number of ways in which it touches the life of the pupil, and for the general student in particular, common knowledge should be utilized and practical values stressed on all possible occasions.

There is opportunity, at the discretion of the teacher, to include in this unit some material not usually classified as physics. However, as a means of arousing interest, of giving general information, of obtaining a right attitude, and of illustrating the interdependence of the several branches of science, this "extraneous" matter may prove to have a very special value.

The method of presentation needs serious study, and it is recommended that the teacher read again the first chapters in Tyndall's "Heat Considered as a Mode of Motion." We have learned something about heat since his day, but not so much about presenting our ideas with scientific accuracy and yet in simple, understandable language.

References

Recent Physics texts
Todd. New Astronomy
Tyndall. Heat Considered as a Mode of Motion
Young. Manual of Astronomy

Material

Thermopile
Galvanometer
Ice
Pieces of wood
Brass tube
Rotator

Vise
Lead
Hammer
Samples of fuels
Apparatus for producing coal gas
Anvil

Visual Aids

Lantern slides
a. The Sun
b. Geysers
c. Volcanoes

Procedure

A brief discussion of the nature, appearance and
characteristics of the sun, illustrated with slides, need not encroach on other work in Astronomy and gives a breadth of view much needed by the average pupil. This will include tracing the common sources of heat back to the sun.

In a similar way, though even more briefly, hot springs, geysers, and volcanoes may be considered. A demonstration of geyser action is interesting, if time permits.

Coal, wood, gas, coke, and fuel oil each has a story which may be told by the teacher, or may be assigned as a special topic to some pupil who will report his findings to the class.

In considering the mechanical sources of heat, the heating effect of friction, compression, and percussion may be demonstrated by such experiments as those used by Tyndall, but the common illustrations of rubbing the hands, pumping up an automobile tire, stamping the feet "to restore circulation," etc., should not be overlooked. Encourage the pupil to find his examples in the world in which he lives.

**Outcomes**

Some definite knowledge about the sun, the source of all heat

Understanding of the fact that differences of temperature are necessary to sustain life as we know it

Knowledge of the sources of our common fuels, and the necessity for conservation.
III (cont'd.)

ELEMENTARY PHYSICS I

Heat

Unit 2 - Heat and Temperature

Introduction

The fact that it is not always easy for the pupil to distinguish between temperature and quantity of heat, and that this difficulty persists, should be kept in mind throughout this unit. Every possible opportunity to emphasize this distinction should be sought. Too much repetition is practically impossible.

References

Encyclopedias
Standard texts

Material

Pans  Gas meter
Air thermometer  Gas burner
Comparison thermometer  Tubing
with three scales
Alcohol thermometer  Metal beakers
Metal thermometer  Bomb calorimeter
Maximum and minimum  Soapstone
thermometers
Clinical thermometers
House thermometer  Lead
Oven thermometer  Brass
Refrigerator thermometer  Iron
Candy thermometer  Aluminum
Graduate, trip scales
and weights

Visual Aids

Lantern slides
a. Old thermometers
b. Comparison of thermometer scales
c. Equivalents on C and F scales
d. Gas meter dials (for reading)

Procedure

Discuss the difference between temperature and quantity of heat. Melt ice in a small quantity of hot water and a large quantity of cool water.

By means of the experiment of the three pans of water, show the unreliability of sensation as a means of determining temperature. Test the difference between
Set up an air thermometer similar to Galileo’s and show its limitations. Discuss available materials, reaching a conclusion as to why mercury is so generally used. Why are other materials still used for certain purposes? Samples of all available types of thermometers should be shown, and their specific uses and values discussed. Suggest looking at a display of thermometers in a store, comparing the readings.

A consideration of Fahrenheit’s experiments and his scale, together with the reasons for the invention and use of the centigrade scale, should precede laboratory tests on the fixed points. Locating the fixed points on an unmarked thermometer is an interesting variation. Additional tests may well include checking of house, oven, and refrigerator thermometers, giving opportunity for devising a special method and testing its effectiveness.

The transfer of readings from one scale to the other should be limited to just enough practice to give familiarity with the use of the formulas, which need not be memorized. More important to retain are a few equivalents, such as 68° F and 20° C, and -40° C and F.

Before proceeding to the actual measurement of heat quantities, the value of the calorie and the B.T.U. should be understood, together with the special instances in which each is used. Their numerical relation need not be emphasized at this time.

Laboratory experiments, such as "Economy of High and Low Gas Flames" and "Practical Efficiency of a Gas Stove" may be used in such a way as to bring out the principle involved and the meaning of the units, without burdensome calculations. Disregard "water equivalent" and concentrate the pupil’s attention on the source of heat and the ultimate practical effect produced. He should understand the limitations of his work, however, and this may be brought about by exhibiting a bomb calorimeter, and describing the precautions which are necessary when exact measurements are required.

Differences in heat capacity may also be shown by semiquantitative experiments which emphasize the general principle rather than attempts at extreme accuracy. Compare the old-fashioned soapstone with a flat iron as
a foot warmer, and both with water. Allow the pupil to exercise a little ingenuity in devising methods of testing, or a method may be worked out by a general class discussion, the teacher doing the demonstrating and raising objections, if necessary.

Outcomes

The work of this unit should lead to an understanding of the principle that heating and cooling consists in the transfer of heat from warmer to cooler bodies – that calories lost equal calories gained. The effects of the high specific heat of water should also be clear.
Introduction

One of the common effects of heat which is of particular interest is change of size when heat is applied. It has many practical applications and explains many things which occur about the home.

References

- Standard texts
- Trade catalogs

Material

- Ball and ring
- Compound bar
- Radiator valves
- Thermostat
- Metal thermometer
- Multiplying device

Visual Aids

- Demonstrations of above materials

Procedure

Some idea of expansion as an effect of heat is usually present, but it will do no harm to show the ball and ring, compound bar, and similar pieces of demonstration apparatus, while collecting familiar illustrations by class discussion. If possible, some of the newer applications, such as the thermostat in the automobile cooling system, and the automatic choke, should be obtained and demonstrated. Be sure that each member of the class learns something he did not know before.

A multiplying device may be used to show differences in expansion, and the idea of coefficient of expansion should be made clear. The teacher should feel under no obligation to make an accurate determination of the coefficient of expansion of any substance, but if within the ability of the class it is an interesting demonstration.

The peculiar expansion of water should be discussed with a view to emphasizing the practical results.

The study of the expansion of gases should lead to an understanding of the reason why $-273^\circ$ C is the
absolute zero, but it should not overshadow the common examples of gas expansion and contraction.

**Testing**

*Quiz limited to applications of change of size with change of temperature*

**Outcomes**

The student should understand the thermal control of many devices such as metallic thermometers, radiator valves, and thermostats. There are many other applications of the principle which come within our daily experience.
III (cont'd.)

ELEMENTARY PHYSICS I

Heat

Unit 4 - Heat As a Quantity

Introduction

The quantity of heat given off by certain sources and the heat required to bring about certain changes is likely to be a new line of thought for many high school students and as such should bring interest to the study of this topic.

References

Black and Davis. New Practical Physics. pp. 234-362
Dull. Modern Physics. pp. 280-313
Other high school texts

Apparatus and Materials

Thermometers
Scales
Calorimeters
Various metals
Ice
Source of steam

Visual Aids

Demonstrations and pupil experiments

Procedure

Introduction

Recall the various units already used and have mentioned some article or substance that would be measured by each unit. Would any of these units be suitable to measure heat as a quantity? We need a new unit. Name two. Define calorie and B.T.U. In order to avoid confusion it is better for a while to confine the discussion to the use of one of these units, perhaps the calorie. Having defined the calorie ask what tools will be needed in order that we use the calorie as the yardstick with which to measure heat.

It is well to build up the use of the definition by a short demonstration. Take a weighed amount of water of known temperature and apply heat. After warming it a little, take the temperature again. Compute the number of calories that went into the water. Use the following:

Weight of water (times high temperature minus low temperature)
Introduce the motion of heat losses being equal to heat gains. Demonstrate. A known amount of water at or below room temperature. A known weight of water at 40 or 50 centigrade. Pour the hot water into the cold, stir, and take the temperature of the mixture. Write the heat equation. Heat losses will probably exceed the gain. Get suggestions regarding the reason. The heat absorbed by the cold dish will raise the question of specific heat which may then be discussed. As each of these demonstrations is completed it will be well to give some similar data and have the student write a similar equation of losses against heat gains.

Specific Heat

Demonstrate the usual experiment for determining the specific heat of a metal. Write the heat equation. This is a good experiment for individual or group work by the class. Use pellets or chunks of various metals such as iron, copper, aluminum, brass, and lead. Tabulate the results to show the wide range of heat necessary to warm the same weight of these metals the same number of degrees. Add such problem work as seems advisable for the particular group.

Heat of Fusion

The idea of absorption of heat without a change in temperature is rather difficult for the student to assimilate. An easy approach to the subject is to recall the difference between a solid and a liquid. Try to get over the idea of the mechanical work necessary to change the molecular nature of a rigid solid to that of the easy flowing liquid. It is easy to infer that if the change occurs, energy was needed. If the melting is brought about by the application of heat, those particular calories were used for that purpose and their energy used to produce the change of state instead of a change in temperature.

Heat absorbed when a body goes in solution will give some idea what goes on. Have on the desk a small beaker containing 40 or 50 cubic centimeters of water at room temperature, also about the same bulk of fine ammonium nitrate. Take the temperature of each. Have someone feel of the beakers to get a notion of the temperature. Pour the salt into the water, stir briskly, and note temperature. The beaker may be passed quickly around the class. Why so cold?

In contrast to this, prepare a large test tube of supersaturated solution of sodium thiosulphate. (It is well to have this ready before the class assembles.) Have the solution at room temperature. Drop in a small crystal of the salt and stir with a thermometer. Note the temperature. Pass the test tube around the class.
Why the high temperature? Discussion. Under what conditions does water freeze, and ice melt?

"Which has the greater cooling effect, ice or ice water?" A qualitative experiment to answer this question, followed by a demonstration that the application of heat to ice and water does not affect the temperature until the ice is melted, makes a suitable introduction to the discussion of the heat of fusion. What becomes of the heat applied? Why is it sometimes called "latent?"

Can we ever get it back again?

A bottle of frozen milk and a jar or beaker of melted paraffin will furnish suggestions for answering questions about changes from liquid to solid.

Why is antimony used in type metal?

Why are some patterns larger than the castings?

What is a "shrink rule?"

What would happen if water did not expand when it freezes?

Having established the fact that heat is transferred when a change of state occurs, one may settle by laboratory demonstration the number of calories required to melt one gram of ice. This is not too difficult for individual, or group work by the class. Write the heat equation.

Applications of use made of heat of fusion is suggested by the use of freezing mixtures in preparing ice cream. Discuss this process. Should the ice be coarse or fine? Should the salt be coarse or fine? Get various opinions, in defense of opinions offered. If interest is keen enough and if time permits a definite answer could be obtained by a group experiment with different pupils using fixed amounts of ice and varying amounts of salt both fine and coarse. Tabulate and work out the answer to the questions.

Heat of Vaporization

A little ether sprayed on the hand and allowed to evaporate is usually effective in leading up to the idea that heat is required to change a liquid into a vapor. The surgical use of this principle is interesting.

The change of state from a liquid to a gas with the high molecular velocity is even more striking than from a solid to a liquid. We may expect an even greater absorption of heat. How is water changed into a gas? Distinguish between vaporization, evaporation, and boiling.

The effect of pressure on the boiling point, the action of dissolved solids, etc., may be shown either by experiment or by demonstration. If by demonstration, each pupil should have at least one opportunity to take readings. Use commercial apparatus, such as a pressure cooker, rather than the laboratory equipment where possible. Discuss distillation.

The idea of heat of vaporization may be conveyed by an experiment comparing the heating effect of steam and boiling water, rather than by attempting to find
III (cont'd.)

the mathematical value exactly. Let the question be: "Which has the greater heating effect, steam or boiling water?"

Optional

Demonstration of heat of vaporization of water. Write the heat equation. Add similar problems for the students who are interested in this type of work.

Having found the large number of calories needed to vaporize water it is easy to see how low temperatures may be produced by rapid vaporization of a liquid.

If it is clear that when a liquid does evaporate it takes heat from something near at hand, the mechanical refrigerator will present no great difficulty. Carre's ice machine is another way of illustrating this effect.

Moisture in the Air

Discuss the terms of everyday use referring to this topic. The students should have well in mind exactly what is meant by humidity, relative humidity, saturation, dew point, dew, fog, clouds, mist, rain, frost, snow, and hail.

The application of humidifiers in local industries, such as textile manufacture, is a desirable subject for investigation and report by an interested pupil. Electric humidifiers for home and store may be treated in a similar way. Generally a dealer is willing to loan one for demonstration. If it seems wise, the whole question of air conditioning, with its numerous applications of heat principles, may be opened up and carried as far as the teacher elects. Caution: Be careful about making dogmatic statements or conclusions about any commercial apparatus, and do not let the pupil carry away "half-baked" ideas. Be on the safe side.

Chemical hygrometers may be made or bought for a small sum. Have one hanging in the laboratory constantly. Note its sensitiveness by comparison with the readings of the psychrometer. Househould hygrometers are becoming more common. Obtain and test one or more of these. Some of the results may be illuminating.

More time than is customary may well be spent on humidity, particularly in its relation to health and comfort, and its possibilities in the line of economy. A record of schoolroom humidity, taken if possible with a sling psychrometer, should be kept. If the record is poor, means should be devised to improve conditions. See if this improvement may not be extended to include homes. The "comfort chart" emphasizes the idea of economy as well as comfort, and should be familiar to all.

Testing

A short quiz each day, or one problem, on the work
of the day before
An essay type or newer type test on the whole unit as it is completed

Outcomes

Appreciation of the numberless ways in which the principles of heat may be applied to our advantage.
Understanding of the principles, particularly those of latent heat.
Appreciation of the value of proper relative humidity in both home and industry.
A disposition to make immediate application of the knowledge gained.
Introduction

The emphasis which is being placed on improved heating systems for homes, on insulation for stoves and houses, and on various other means for preventing as well as assisting the movement of heat, leads naturally to making the home the central theme in this unit, though not to the exclusion of available material from outside. The teacher must be up-to-date, as improvements and changes are coming rapidly.

References

Good. Laboratory Projects in Physics
Recent texts
Trade catalogs

Material

Samples of conductors and insulators, vacuum bottle, conductometer, heat sensitive paper, double walled calorimeters, thermometers, burners, radiator paints, radiometer, heat filter, and safety lamp.

Visual Aids

Models of steam and hot water heaters
Lantern slides
a. Heating systems
b. Insulating methods

Procedure

Fasten a piece of heat sensitive paper along one side of a square metal bar, and heat one end of the bar gently. The changing color of the paper shows the gradual movement of the heat along the bar.

Two similar bars of different metals, heated from the same source, will show difference in conducting ability, or a regular conductometer may be used.

Fill a large test tube three-quarters full of water. Hold it by the bottom and heat the upper part in the Bunsen flame until the water boils. Pass it around to show that the water at the bottom is still cold.

Use the demonstration with the air thermometer as shown on page 316 of Dull's Modern Physics.

As an experiment, pack the space in a double walled calorimeter with an insulator. Fill the inner calorimeter
with boiling water, and check the rate of cooling. Compare with other insulators, and with an open calorimeter. Good materials for this test are excelsior, asbestos wool, hay cotton, wool, and air. Compare with a Thermos bottle.

From these experiments and demonstrations the discussion should lead to insulators for houses, steam pipes, ovens, refrigerators, hot water tanks, etc.

To illustrate convection a model hot water tank, or hot water heating system as described in Laboratory Projects in Physics, is about as convincing as can be desired and is worth the effort required to set it up.

Much time can be spent on convection, and the bypaths which lead from it, and the teacher must use judgment as to what will be of greatest value to the class. It is suggested again that the latest developments offer the greatest opportunities.

"What is the most effective finish for radiators?" New paints are coming on the market, and much is claimed for them in efficiency as well as appearance. Paint several similar calorimeters with samples of these paints, fill them with equal quantities of boiling water, and note the rate of cooling. Compare this with the cooling rate of a polished calorimeter.

Demonstrate the radiometer. Show how alum solution will cut off radiant heat, while an iodine solution transmits it. Apply this idea to cold frames, etc.

Outcomes

Ability to apply the principles of conduction, convection, and radiation in explaining methods of controlling the movement of heat in the home.
III (cont'd.)

ELEMENTARY PHYSICS

Heat

Unit 6 - Heat and Work

Introduction

We have already seen that mechanical work produced heat by friction and it is fitting that we consider the production of work by heat.

References

Black and Davis. New Practical Physics, pp.233-287
Dull. Modern Physics, pp.335-355

Materials

Pasteboard tube, corks to fit
Thermometer
Models of steam and gas engines
Working models of same if possible

Visual Aids

Diagrams and charts of early engines, various types of boilers, slide valves and other controls, turbines, four cycle gas engine, and two cycle gas engine.

Procedure

An illustration that work may be converted into heat is shown by using a cardboard tube an inch and a half or so in diameter and some three feet long, fitted with cork stopper at one end and at the other a one hole stopper through which a thermometer has been thrust with the bulb just inside the tube. The tube should also contain fine lead or copper shot. Hold the tube vertically and quickly change ends, pause, and allow the shot to fall around the thermometer. Repeat several times. Note the change in temperature. How is this brought about?

Discuss the Newcomen engine. Use diagrams to show how motion was produced. What faults did this first engine have? What early corrections were made? What improvements were made by James Watt?

What uses made of steam engine today? Discuss the several types of boilers which produce steam to operate
engines. Which is more efficient as a steam producer? Why?

Show model to demonstrate the slide valve. Also model or diagram of the Corliss type.

If a working model of engine is available demonstrate by using compressed air or steam as motive force.

Show diagrams and discuss various types of turbines.

Internal combustion engines are of special interest. Try to get across the notion that any gas that will burn will explode if mixed with air. A striking demonstration of several essential points can be covered by the following:

A can about two inches in diameter and eight or ten inches long with cap, (not screw) cover fitted as follows:

Punch two or three quarter inch holes near the bottom of the can. Punch a small hole in the center of the cover or better solder a short bit of metal tube as shown in diagram. Stand the can upright on the table. By tubing inserted in a hole at the bottom fill the can with gas from the table supply. When the can is filled with the gas ignite it at the top of the tube. Withdraw the supply tube. The gas will burn with luminous flame a half inch or more high. As the rising gas burns, the pressure gradually becomes less. Finally it flickers as if it were about to go out but instead snaps back into the can where the gas-air mixture explodes blowing the cover several feet in the air.

The demonstration illustrates several points of physics and chemistry and teaches a valuable lesson regarding explosive mixtures. What about the man who used a lighted match to look into his gasolint tank?

Show models or diagrams of four stroke and two stroke engines. What is the purpose of each stroke? How fired? Mention the Diesel engine.

What advantages and disadvantages of the various types of engines? Compare the efficiency of internal combustion engines with that of steam engines.

The numerical relation between heat and work may be mentioned but problems had better be omitted.

Testing

Short oral quiz on main points
Outcomes

Some knowledge of the history of heat engines and how the heat energy is converted into mechanical action in these machines.
III (cont'd.)

ELEMENTARY PHYSICS I

Heat

If the statement is true make a plus (+) on the line preceding the question, if it is false make a minus sign (−).

1. A vigorously boiling liquid has a higher temperature than the same liquid boiling slowly.

2. The boiling point of a liquid is independent of pressure.

3. One pound of ice water will cool a refrigerator more than one pound of ice.

4. When water freezes, heat is liberated.

5. When steam condenses, it loses heat.

6. Fanning does not cool the face unless one is perspiring.

7. Steam arising from boiling water burns more severely than the boiling water because its temperature is higher.

8. Woolen clothing is warmer than linen because it is a better heat insulator.

9. Good reflectors of heat are also good radiators.

10. The coldest part of an ice refrigerator is just on top of the ice itself.

11. In washing, a clinical thermometer must not have a temperature higher than 130 degrees C.

12. One cubic foot of gas measured in a cold basement room will weigh more than one cubic foot of gas measured in a warm attic room.

13. A football inflated in a warm room will become much tighter when taken out-of-doors on a cold day.

14. A large radiator with 14 sections has a temperature just twice as great as one which has only 7 sections.

15. To make a sensitive thermometer, a tube with a large bore should be used.
Fill in all the blank spaces with the word or expression needed to complete the statement or answer the question.

1. For very cold climates, the liquid used in a thermometer is ............ (1)

2. A thermometer reads -40 degrees C. What is the corresponding Fahrenheit reading? ...................... (2)

3. Water boils at 100 degrees C. provided the pressure of the air is ... (3)

4. At what temperature does water have its greatest density? .............. (4)

5. Which is more likely to break when put in boiling water, a thin glass dish or a thick one? .................. (5)

6. The freezing point on a thermometer is the temperature of .............. (6)

7. In the Metric system, the heat unit is ...................... (7)

8. How does heat from the sun reach the earth? ......................... (8)

9. Will tea cool more quickly in a highly polished metal pot or in a tarnished one? .................. (9)

10. How can water be made to boil at a temperature lower than 100 degrees C? (10)

11. How does a thermos bottle prevent conduction, convection, and radiation?
Fill in all the blank spaces with the word or expression needed to complete the statement or answer the question.

1. Our common thermometer was invented by ________________________ (1) 

2. The word centigrade means ________________________ (2) 

3. The boiling point on the C. scale is ________________________ (3) degrees 

4. The freezing point on the F. scale is ________________________ (4) degrees 

5. The freezing point on all thermometers is the temperature of .... (5) 

6. The boiling point on all thermometers is the temperature of .... (6) 

7. 68 degrees F. is what on the C. scale? ________________________ (7) 

8. What temperature is the same on both C. and F. scales? ________________________ (8) 

9. What will the C. thermometer read if the F. thermometer stands at 98.6? ________________________ (9) 

10. At what temperature (about) does the mercury thermometer freeze? ... (10)
With type III as an example, the sub-committees were then able to start work on their particular course outlines. When each outline was completed it was presented to the whole committee for approval and then forwarded to the assistant superintendent.

In the fall of 1937, copies of the courses were distributed to the various science teachers in the three high schools for trial.
CRITICAL EVALUATION
In order to evaluate the work of the science committee it might be well to consider it in the light of the Criteria For Evaluating Course-Of-Study Materials by Herbert B. Bruner, Teachers College, Columbia University. The quotations are from the Columbia report.

"The experience in the Laboratory has been (1) that these criteria serve as an excellent instrument for rating courses of study and (2) that their greatest value consists in providing standards for the construction of courses of study and for giving course-of-study committee members and teachers better insight into the qualities a really good course should have."

PHILOSOPHY

A. Educational

1. "Is it recognized that the school should provide adequate opportunities for differentiated education to meet individual differences in attitudes, interests, understandings, abilities, needs, and skills?"

In my introduction I pointed out the need of changing the content of studies as well as method in order to meet the above mentioned differences which certainly are apparent today.

2. "Is significance attached to relationships existing between the pupil and his environment?"

3. "Is the aim of education conceived of as the development in individuals of the ability to direct intelligently their own thinking in regard to their betterment and the improvement of society?"

The philosophy embodied in the Science Objectives on page 22 is significant in connection with the above two statements.

4. "Is the course of study considered as a suggestive guide rather than a rigid outline of materials to be taught?"

*Herbert B. Bruner, Criteria for Evaluating Course-of-Study Materials, Teachers College Record, November 1937.
The outlines on pages 47-54 inclusive, were discarded because they were considered to be too much of a rigid outline. It can be plainly seen that course III is much more of a suggestive guide.

B. Principles of Learning

1. "Is self-activity considered fundamental to learning?"

Each unit in the course of study is provided with activities in order to stimulate learning. For example, the heat conductivity experiments on page 53.

2. "Is study conceived of as an attack upon the situation, 'and what is learned is learned as and because it is needed for the control of this situation?"

On page 63 it will be seen that all the learning situations converge on the large conception of the unit and must be learned to gain the principle notion of heat movement.

3. "Is the position held that the learner should experience satisfaction from engaging in activities?"

The point is brought out in various situations where it is suggested that the teacher encourage pupil ingenuity in experimenting. For example, on page 60 are suggestions for pupil participation in the measurement of the heat capacities of different materials.

4. "Is knowledge considered as a means to enable the individual to participate more effectively in life situations?"

The subject of moisture in the air on page goes a long way to enable the student to understand and appreciate the importance of moisture and the
attempts being made today to control the moisture content of the air.

5. "Is provision made for making the situations of the school real and dramatic?"

In the entire course the pupil is brought face to face with life situations and practical applications at the earliest possible moment.

CONTENT

4. Authenticity

1. "Are the materials based upon the soundest available primary and secondary source materials?"
2. "Do the reference materials include or suggest the most reliable primary and secondary sources for teacher and pupil?"

In each unit is included a list of the best available textbooks, a complete list of materials and visual aids to best stimulate the learning process.

5. Utility, Adequacy and Significance

1. "Will thorough understanding of the problems involved be crucial to most of the group using them?"
2. "Do the materials assist the pupil to develop and foster a more critical sense of discrimination?"
3. Are the data sufficient to arouse in the pupil a keen awareness of the need for problem solving?
4. "Do the materials help the pupil to see better his relations as a member of the group?"
5. "Are the materials of everyday significance to society?"
6. "Is the content included in the course selected to meet the individual and social needs of the pupils?"
7. "Are the materials sufficiently challenging to take into account the needs and desires of each individual at the age and intelligence level considered?"
8. "Are the materials such that they will arouse in the pupils a keen awareness of the need for problem solving?"
9. "Do the materials provide adequately for the total present experience of the pupil?"

10. "Does the course of study make adequate provision for the proper use of physical as well as academic materials?"

11. "Do the materials lend themselves to the securing of intangible outcomes, such as appreciations, attitudes, and certain techniques?"

The above criteria and the criteria set up by the committee, pages 12 and 13 appear to have the same significance. Although not as complete I feel that the committee criteria would give a valid measure of the utility and adequacy of a course of study.

12. "Do the materials provide for various types of learning experiences, such as building, reading, and creating?"

In glancing through the references, materials, and visual aids provided with each unit, it can be seen that the student has at hand an abundance of material to stimulate learning and to provide building, reading and creative stimuli.

C. Organization

1. "Are the materials organized around broad areas of significant human experience?"

In glancing through the study of heat it can be seen that each unit is built around a "significant human experience" as Sources of Heat, Heat and Temperature, Change of Size, Heat As A Quantity, Movement of Heat, and Heat and Work.

2. "Are the materials developed through the use of a few large and important problems?"

I should say that the titles of the several units constitute the larger problems. The introduction
to each unit consists of a more detailed statement of the large problem.

3. "Is each of the major problems developed through a series of carefully arranged consecutive minor problems?"

4. "Are the facts organized around related ideas so that they may help in developing major understandings or generalizations?"

As each unit is worked out, the solutions of the minor problems within the unit contribute toward the working out of the major problem.

5. "Are the materials so organized that the teacher is permitted sufficient latitude in determining the way in which the materials will be used?"

It will be seen that in each unit that the teacher is given wide range in choice and use of material.

6. "Are the materials so organized that provision is made for individual experiences which have worthwhile values apart from the group activities?"

Individual experiences apart from the group often crop out. For example, some pupils may, and often do have experiences with model engines which may be worth while to the whole group. (Page 72).

7. "Are the materials so organized that provision is made for frequent revision in the light of teacher and pupil evaluations?"

Much in the course of study is flexible and can be adapted to differences in pupil interest and ability as the teacher sees the opportunity.

ACTIVITIES

A. Pupil Purposing

1. "Do the activities provide for real purpose and planning which will stimulate in the pupil a desire to proceed on his own initiative?"
The activities in each unit point toward and assist in solving the major problem. It seems that the skill of the teacher must be relied upon to guide the pupil and stimulate him with the idea to proceed.

2. "Do the activities result from a problem-solving attitude on the part of the pupil?"

Here again it seems that the course of study can only provide the material to work with. The teacher must assist in developing the problem solving attitude.

3. "Will the activities give opportunity for the pupil to assume responsibility and to control his experiences to an increasing degree?"

With proper teacher stimulation the activities will present opportunity for the pupil to proceed on his own.

4. "Do the activities furnish adequate opportunities for practicing and developing valuable work and study habits needed in accomplishing pupil purposes?"

If the activities fulfill their purpose of creating a problem solving attitude, it seems that work and study habits will develop spontaneously. Here again I repeat, that I believe that the teacher is an important factor in creating the problem solving attitude.

B. Interests and Needs

1. "Are the activities so closely related to the pupil's present life that his own interests will become the natural driving force in initiating and carrying the activities through?"

The activities chosen in the course of study are related to the pupil's life, but I do not believe that
they become a natural driving force unless his interests, guided by the teacher, are directed to those particular activities. We have ceased to believe that all pupils can be interested in the same problems. One pupil might be keenly interested in a model steam engine, while another may take no interest in the engine but is absorbed in making an air thermometer.

2. "Will the activities, if successfully carried through, result in satisfying present interests and needs and also in creating new and still more valuable interests?"

I believe that in many cases this is so. I recall cases of boys now employed in industrial chemistry because the original interest was encouraged in the high school chemistry class. The auditorium of the Technical High School is equipped with loud speaking apparatus, constructed by a boy who, in the physics class, became interest in electricity.

C. Social Values

1. "Do the activities assist the pupil in realizing to a greater degree the problems and work of others in making life socially effective and happy?"

The course of study certainly does emphasize the debt we owe to science for its contribution to a more comfortable and healthier people with a standard of living at a high level. This point is brought out in the science objectives on page 22.

2. "Is provision made for the consideration of the opinions and suggestions of others?"

3. "Is provision made for the individual to seek assistance from the social group and for giving assistance to the social group when such help is desired or needed?"
Yes. Group demonstrations where two or more pupils perform an experiment before the rest of the class. The experiments on page 59 might be done in this manner. The onlookers have the opportunity to offer suggestions and criticism to the demonstrators. At times it may be desirable to have the group guide the experimenters step by step through the experiment.

D. Reality

1. "Do the activities arise from real life situations?"
2. "Do they produce, as far as possible, actual life situations?"
3. "Are the life situations involved in the activities the most realistic that can be chosen and do they provide the greatest promise for growth in things that matter?"
4. "Do the activities provide opportunity for the development of the willingness and ability to face life situations realistically?"

The science objectives on page 22 indicate the interest of the committee in creating life situations. In the course of study activities involving practical applications are numerous. It may be noted that unnecessary theory is carefully avoided and when theory is necessary it is not presented until enough facts have been faced to make it seem worth while. For example, on page 35 the measurement of the heat of fusion of ice is not suggested until a number of ideas have been presented to create a desire to measure the heat of fusion.

E. Variety

1. "Is there a sufficient range of activities to provide adequately for the various interests and needs of the group?"
In examining any section of the unit on heat it will be seen that as many activities as possible are provided. Somewhere in the unit there must be at least one activity which would interest each pupil.

2. "Is there sufficient variety of activities to enable pupils to face realistically the problems involved?"

As I have pointed out before, a large number of activities are constructed around each problem so that participation in the activities will lead to an intelligent appreciation of the problem and lead to a desire to solve it.

F. Approach

1. "Do the materials provide a dynamic approach which will lead to further challenging and accomplishing?"

2. "Are the suggested approaches based upon the present needs, interests, and capacities of the group of which the teacher is the guiding member?"

Material has been chosen for each unit associated as nearly as possible with living with the intention that the activities experienced in the classroom can be translated into an understanding and appreciation of these same problems as they are met in the day to day experiences of the pupil. How interested students become in the readings of the barometer once they understand the relation of air pressure to weather conditions.

G. Culminating Activity

1. "Has the culminating activity been planned by all the members of the group in the early part of the work?"
The culminating activity or purpose of each unit is mentioned in the introduction and outcomes of the same unit. This gives the teacher opportunity, as the guiding member, to formulate with the class a notion of the unit as a whole and plan a method of attack, which will eventually lead to a solution of the main problem.

2. "Does it provide for the optimum and most meaningful use of the activities and materials utilized throughout the work?"

The culminating activity cannot be reached unless the approach activities are first utilized.

3. "Has it offered optimum opportunities for a sharing of the work according to the interests, needs, and abilities of each member of the group?"

There are enough activities presented in each unit so that they must be shared by the group in order to reach the major solutions.

EVALUATION OF PUPIL'S WORK

A. Purpose

1. "Is the process of evaluation conceived of as an integral part of the learning experience?"

It must be. How else can we measure the progress of a child or gain a knowledge of his interests, appreciations, attitudes etc., unless that child returns in a material way the solutions to the problems with which he has been faced.

2. "Does it provide optimum opportunities for furthering the growth process of the individual?"

*Dr. Hugh B. Wood is chiefly responsible for the section on Evaluation.
Any valid evaluation should indicate both to teacher and pupil the best channels for future growth of that pupil.

B. Variety

1. "Does the course of study suggest methods whereby the teacher may evaluate the pupils' work in terms of the individual pupil as well as in terms of the group?"

2. "Is provision made for the individual to appraise his own progress in terms of both himself and his group?"

3. "Are various techniques, such as observation, the oral examination, and the written examination utilized in the evaluation process?"

In each unit will be found at opportune points, questions which may be asked by the teacher or pupils themselves. (Page 65). There are opportunities all the way for the teacher to make observations. At the end of the unit is a series of objective tests which may be used as the teacher desires. These tests are not standardized but being objective, they do show the individual where he stands in progress in relation to the class as a whole.

Standardized tests of achievement have not been available to the committee since its inception. I am in no position to state the reason, but it may be due to the lack of funds because of present economic conditions.

At the present time each teacher's testing program has to be worked out by him or herself which I do not believe is desirable. I have several times advocated a uniform testing and evaluation program in science but have met with little success and I do
not know why.

C. Validity

1. "Are the evaluation procedures set up in such a way that they become a natural part of an actual learning situation?"
2. "Are the evaluation procedures such that they not only permit but tend to encourage the whole-hearted co-operation of the individual in the evaluation process?"

Yes. The questions are of a practical nature intended to create the desire to investigate if the solutions are not known. See pages 65, 66, 67, 70 and 72.

3. "Do all devices and techniques of evaluation have a reasonably high reliability?"

As I have stated before the tests have not been standardized.

D. Areas of Growth

1. "Is provision made for the measurement of basic skills, techniques, and abilities, such as reading, writing, arithmetic, library skills, and expressional techniques?"

The tests on pages 74, 75, and 76 apparently bring out these abilities.

E. Interpretation

1. "Is provision made for drawing all evaluation data together into an 'integrated portrait' of the individual, rather than using separate and minute data to indicate growth?"

No provision has yet been made for this sort of an evaluation.

2. "Are all evaluation procedures, their interpretations and use, continuously appraised and revised in light not only of their own efficacy but of changing educational goals and objectives as well?"

In answer to this question may I state that the tests included in the units by the committee were
intended to be merely samples. Each teacher is expected to revise and improvise according to individual needs. The testing program must be changed according to the manner in which each teacher uses the course of study.
The question may be brought up as to why no measurement of the value of different courses was made in this work.

First may I repeat an introductory statement, that it is not the purpose of this thesis to measure the value of any course of study.

Second, I have pointed out that the courses of study are used only by the teachers and I fail to see how any measurement can be made except by pupil success or failure. Furthermore, I fail to see how pupil success or failure would be a valid measure of any outline, because the skill of the teacher is a factor which is not constant. A skillful teacher could be successful without any outline at all, while a poor teacher might fail with the best of outlines.

Accordingly, it seemed that the only way to evaluate the accomplishments of the committee, was to gather opinions, as frank as possible, from teachers using the courses of study.

These courses have, up to the present time, been in use in the senior high schools for two years. There are at present, nineteen regular teachers, one full time substitute and one part time substitute in the three science departments. All of these teachers, together with two others who were required to teach courses with which they were unfamiliar because of shifting pupil load, have been interviewed and asked to make comments on the courses of study. The greatest proportion of
comments indicate that the revised courses have been of value. A few adverse criticisms were returned.

All of the twenty-three teachers have made use of the course of study.

All of the twenty-three teachers favored the course of study, because a definite piece of work had been laid out and there resulted a notion of uniformity in all of the science taught.

Two of the teachers pointed out that pupils, in transferring from one school to another, had less difficulty in picking up and carrying on the work.

One teacher found that visitors seemed to be much more interested in the work and understood the class procedure better when guided by the course of study.

Several teachers reported that they were materially aided by experiments and teaching skills not found in current textbooks.

Two teachers who were required to teach courses in which they had had little experience reported that the course of study rendered them invaluable aid in teaching procedure. Also it proved valuable in enabling them to know what material to cover.

One day substitutes have reported that the course of study has rendered much assistance when they have been required to step in and teach one or two days assignments. They find that the day's work is thoroughly laid out.

The chief criticism of the course of study was to the effect that it had a tendency to regiment teaching and destroy initiative. The committee answered this
criticism by pointing out that the outline was flexible and covered only basic requirements. Any teacher is at liberty to add whatever he feels is suitable for the aptitudes and requirements of his classes. It is to be admitted that the teacher of experience does not have to be told what to teach, but it must also be admitted that at times, even the veteran teacher must be told what not to teach.
In conclusion, I wish to review briefly. I have traced, step by step, the actual procedure in working out a course of study.

I have shown how the science committee, after receiving instructions from the administrative office, first found it necessary to formulate a policy, by setting up ideals and standards for a course of study which they hoped would be of value and not simply to be glanced over and then filed away to be forgotten.

I have shown how material was selected to back this policy and how the administrative chairman was kept in touch with the work of the committee.

I have shown how the selected material was worked up into a completed course of study.

I have pointed out outstanding problems, which a group of educators must face in attempting such a piece of work.

I have endeavored to evaluate the work of the science committee according to the Columbia Scale without prejudice. I have found favorable and unfavorable comparisons.

The work of the committee most favorable compares with the scale in regard to selection and content of the course but is weak in methods of evaluation.

Such a task as revising a curriculum is not an easy one. There are bound to be clashes between committee members and it is not to be expected that the committee will always agree with all the policies of the administrative officers or vice versa.
I believe that the above survey of the work of the science committee will prove of value to other teachers, as well as school administrators.
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Approved by:

[Signatures]

Thesis Committee

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