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Science Equipment and Materials: SCIENCE KITS

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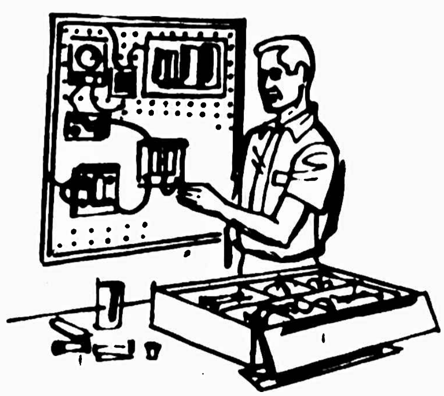

U.S. DEPARTMENT OF
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Foreword

Today, as never before, there is a national concern to discover and develop abilities in science. In the elementary and secondary schools, there is a movement toward a sequential instructional program which would involve the offering of a laboratory science each year from kindergarten to high school graduation. But in some schools teachers are still handicapped by restricted space, inadequate facilities and equipment, short class periods, and heavy workloads. Many have turned to science kits as a partial solution of their problems and are using them for such diverse purposes as demonstration, loans to pupils for home experimentation, aids to TV teaching, or for special projects such as science fairs and clubs. For some small schools, the science kit *is* the laboratory.

A wide variety of kits for most science subjects at every grade level is available from commercial suppliers. The selection of kits presents special problems to teachers and school administrators who must judge their suitability for the school program. The purpose of this bulletin is to clarify issues concerning the instructional value of science kits and to suggest criteria for their classification and evaluation.

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Introduction

Science kits are sometimes regarded as remedies for problems of school science equipment. These packaged collections of items for use in experiments or demonstrations in teaching the physical or biological sciences are currently available for every grade level and for most science subjects. Hundreds of them may be obtained commercially, and schools may assemble their own according to any specifications and purposes they choose. Some utility and other companies lend kits to schools for demonstrations of such things as radar, lighting, sound apparatus, or oil deposits.

Certainly, where school laboratory facilities are limited, kits can make possible greater student participation in laboratory type activities. They can make needed materials available in conveniently packaged form for teachers who have little time or training to prepare science demonstrations. Where storage space is at a premium, their compactness is an asset. They are sometimes an economical source of supplementary science materials and may provide matched equipment and materials at less cost than the same items purchased separately. In addition, use of a variety of kits can help meet the differing needs of pupils in the same class; out of class, they can be used for data collecting at home during weekends and holidays. Interest in science and experimentation may be stimulated by their use. The poorly motivated student may become interested in theory through achievement of the hand skill used in their assembly or, at a less ambitious level, may acquire an interest in science-related hobbies.

But this favorable view of science kits is by no means unanimous—nor unchallenged. To almost every argument advanced in their favor, a counterargument can be heard. Kits, say their critics, may be of limited use, or unsuited to the school science program. Their names can be misleading. They may consist of mere collections of unrelated scientific novelties which contribute little to the understanding of basic concepts, and the instruction manuals which accompany them may encourage "cookbook science" rather than any interest in discovery. Sometimes the cost of a kit is higher than the total cost of the individual component items; replacement of parts may be a recurring problem, since some kits are useless if key pieces are lost or broken; the quality of their construction may not measure up to standards for science equipment; and teacher and class may waste valuable time in the routine re-sorting of kit items after use. Even their portability is attacked, on the grounds that it may increase the problem of having equipment available in the laboratory when needed.

This wide divergence of opinion as to the value of science kits as teaching aids is the direct result of the differences to be found among the kits themselves. For they vary widely in the range of their contents and in their quality, value, aim, and degree of sophistication and adaptation to the rapidly changing demands of the science curriculum. The original selection of the kits and the manner in which they are used are therefore all-important.

Use of Kits in Science Learning Activities

Science kits are of two main types: general purpose and special purpose. General-purpose kits are chiefly used in elementary schools, which often lack science facilities and science equipment. These kits, as their name implies, are versatile in that the same items can be used in a number of different areas of science. A general-purpose kit, for example, may provide all the useful materials for individuals or small groups for experimenting in a number of subject areas, such as air pressure, heat, mechanics, electricity, or optics. Or, for an activity in the area of electricity, items such as a dry cell, wire, a doorbell, and a pushbutton switch can be selected from a general-purpose kit to form a special kit dealing with circuitry.

Special-purpose kits, on the other hand, are designed for the study of concepts in one area only; for example, the night sky, light, heat, sound, energy, weather, the earth, plants, or animals. These kits are available for a wide range of subjects, but are often very limited in use. For the elementary school, they are obtainable in great variety. A model weather station, for example, may be employed in the follow-up of a trip to a weather station to give students an opportunity to use some of the instruments which they may have observed in forecasting activities. The human body model kit enables students to see the relationship of the various structures of the human anatomy and to make a detailed study of each part of a system. The disassembled parts may be reassembled at any time for this purpose. A bird feeder, however, when once built, is not taken apart again and serves only for observation of the feeding habits of birds. Its use can be broadened by the addition of recorded bird calls, of descriptions or color reproductions of common songbirds. Mechanics kits contain items which are useful in learning about the six simple machines. These kits are generally designed for use by an individual or by a small group, and serve to introduce students to problems involving both mathematics and mechanics, as in finding the mechanical advantage of an inclined plane or the ratio of resistance to force.

For the high school, the range of subjects, prices, and degrees of complexity of special-purpose kits is even wider. Two examples, picked almost at random, follow. Inexpensive plastic kits for embryology contain the necessary chemicals, stains, and plastic to embed chick embryos and allow students to learn the basic technique of plastic embedding. Electricity kits prepared in a series ranging from "easy," to "harder," to "difficult" not only save the time which would be required for cutting and stripping wires, soldering, or bolting down on breadboards, but permit different rates and levels of exploration by students with differing degrees of comprehension.

The decisions a teacher makes regarding the use of kits or any other items of equipment in science learning are directly related to the type and purpose of the activity involved. If a class is going on a field trip to learn about insects firsthand, each student might make his own kit, which would include a net, a killing and collecting jar, a mounting board, and sample specimens; or each might be given a commercial kit containing these items. Both the improvised and the commercial kit would serve equally well to provide the desired direct experience. So in making a choice, the teacher needs to consider not only the comparative cost and the time involved, but also how much learning is to be derived from making or assembling the items. Frequently the major learnings result from the collection of specimens, the classification, notetaking, discussion, and reading, rather than from the assembly of the pieces of equipment.

On the other hand, the student who has little or no original motivation to study science may be stimulated to an interest in theory by the development of the manual skill required for the assembly of a kit. For example, by assembling a receiver or transmitter kit, which initially requires only the ability to read technical directions and perform certain operations in wiring, the student may be led to further reading and understanding of basic concepts. In the meantime, the instrument he has assembled is a permanently useful laboratory tool.

Kits may be used to extend a 45-minute class period, within the framework of the school science fair, science club, afterschool laboratory sessions, gifted group projects, or similar group activities. Also, students may borrow kits for work at home and thus gain more time, space, and opportunity for their science learning activities. For instance, if weather instruments are kept in the classroom, the daily collection of data over an extended period of time presents a problem. But this problem disappears if all class members are given weather kits for use at home and thus enabled to read instruments and record data individually, independently, and regularly. Then too, kits can be used by individuals with special research problems while the majority of the class is occupied with another assignment. Because of their portability, they can be used in a section of the classroom, in the teacher's laboratory space, in the project room, or wherever most convenient.

Perhaps the greatest benefit to be derived from the use of kits is that it enables the busy teacher in the laboratory to allow for differences in students, to adjust the work to the individual, and to meet the challenge of a class with a wide range of interests, knowledge, experience, and learning capacity. Academically talented students can be provided with kits for more advanced study, while other students may be using kits of a different type to meet their individual variations in rate or level of learning. Thus, electronic training kits permit each student to have his own packaged laboratory so that he can work at a pace consistent with his ability and experience. A class studying electricity might use 10 different electrical kits, with one kit for each laboratory space. For example, at desks 1 through 10, respectively, might be placed kits on (1) magnetism, (2) static electricity, (3) direct current, (4) alternating current, (5) inductance, (6) resistance, (7) rectifiers, (8) capacitors, (9) receivers, and (10) transmitters. Small groups or individuals could collect data at each station and rotate through the series to study the particular principle or concept illustrated. Every science student needs to develop skill in making observations and in noting significant data for statistical handling later.

The time factor is another important consideration. The hours a busy science teacher with no laboratory aides may be compelled to spend in preparation for class laboratory work may virtually double his workload. Equipment may have to be brought from several storage areas and made ready for use, and much tedious weighing or measuring of chemicals into precise amounts may have to be done. The use of kits, carefully selected for specific experiments and demonstrations, may save hours of precious time which would otherwise have been spent in routine preparation of this kind and thus may result in better planned laboratory and demonstration programs. For example, testing kits containing special indicators or chemicals in premeasured amounts permit the quick preparation of exact concentrations used in volumetric analysis, in water analysis, in testing the pH of soils, and in similar analytic techniques. Or experimentation with hydroponics can proceed with a minimum of routine if the necessary chemicals in measured amounts are readily available.

The foregoing examples illustrate some of the ways in which science kits may with advantage be used as teaching aids. The right kit in the hands of an imaginative teacher, or of a teacher who uses it to stimulate class interest or to provide for differences among class members, can be as valuable as a film, a television lesson, a field trip, an overhead projection, or a library search. But the teacher's concept of the needs of his class and of the best techniques for meeting them is paramount. Kits, if used, should always be keyed to the course of study designed to achieve the unique goals of the class.

The educator's main concern about the use of kits is their possible misuse—the danger that dependence on kits may limit the science program or unduly influence its direction, or that it may stifle creativeness on the part of teachers and students alike. There is danger, especially in schools lacking the basic science equipment needed for a sound program of instruction in science, that the kit may determine the science program.

Newer Trends in Design

In spite of the abundance of kits, it is frequently difficult to find those that are geared to the instructional program. In a survey of 52 elementary school systems in 36 States, answers to the question "What additional facilities and equipment would you like to have?" indicated that one need was "science kits of equipment keyed to curriculum." (John Sternig, "Purposeful Science for Elementary Grades," listed under "Selected References," p. 26.)

Kits are now being produced in even greater variety than before, and many manufacturers, aware of the objectives of the school science program and of the problems of facilities, space, budget, time, and teacher preparation, are seriously attempting to coordinate their materials with sound teaching practices and the newer approaches to science learning.

Examination of a sampling of commercial kits from 50 or more sources revealed that although many are based upon stereotyped ideas of science, the newer trend in the development of kits is to draw upon the knowledge and skills of men of science. Some kits do now reflect the creativity and accuracy of scholarly contributions, and scale miniatures of industrial apparatus are frequently made according to specifications provided by engineers.

There is also a trend toward better manuals as an aid to fuller utilization of the kit material. More manuals are being written by specialists, contain accurate information, set forth examples of problems to be solved, and require that accurate data be obtained and recorded. The trend is away from the "recipe" type of manual which does nothing to explain the underlying purpose of an activity or its relation to scientific principles. One company, for example, includes with a new kit a correlation chart showing the relationship of the content of the instructional manual to concepts found in the commonly used science textbooks. A schematic representation of such a chart is given on page 8. Teachers can use a similar device to relate the kit manual to the course of study developed by their school system.

An indication of the way in which another company has utilized professional judgment in developing a suitable product is contained in the following excerpt from an unpublished address by Hy Ruchlis,

Kit X: Correlation With Science Textbooks

(Sample Form)

Lab concepts in kit manual	Science textbooks in common use							
	A	B	C	D	E	F	G	H
1. Magnets attract objects made of iron and steel	p. 89	p. 12	p. 30	p. 46	p. 91	p. 65	p. 73	p. 25
2. Like poles of magnets repel each other	p. 93	p. 15	p. 34	p. 50	p. 96	p. 69	p. 78	p. 30

vice president of the Science Materials Center, given at the Elementary Science Conference held in New York City on December 16, 1961:

> After questioning hundreds of elementary teachers during the research preceding the development of this kit, it was found that most teachers are faced with a common problem, fear—fear of the seemingly complex subject and the unfamiliar materials and techniques used in the direct problem-solving approach. Because of lack of formal training in subject matters, teachers feel inadequate using only the text and the all-too-meager personal knowledge they bring to the situation. Kits have been specifically designed to provide both the direction and method that will enable teachers to direct science learning that emphasizes and adheres to the scientific process in every problem-solving activity.

Manufacturers are also trying to serve teachers' needs in the design of demonstration kits containing packaged chemicals and supplies in the exact amounts needed for the quick and accurate preparation of solutions and reagents. Packaging, too, is being improved in order to minimize the need for long inventories and time-consuming sorting and filing when kits are used by large groups. Package construction is being varied in quality to allow for a range of prices without altering the quality of the contents.

Some companies, aware that elementary science activity should engage the interest and participation of all the pupils in the classroom, are designing kits for class use as well as for use by small groups and by individuals. One company enlisted the cooperation of researchers at Harvard University to try out two new kits for use by entire classes in grades 1 to 8. Fifteen teachers and 400 pupils in 4 schools were involved in the project. Each kit contained enough scientific apparatus and materials to enable all the pupils in the elementary grades to work simultaneously in groups of four. Conclusions concerning class use of the kits were favorable, since the materials encouraged pupils to participate actively in the scientific process of learning by direct observation. As a result of the trial use, recommendations were made concerning improvements needed in packaging, organization, teachers' materials, and supplementary aids. (See "New Line of Classroom Kits to Aid Teachers Without Science Training," listed under "Selected References," p. 26.)

Some of the newer kits illustrate a trend in the direction of providing for individual differences among students. One set of kits contains materials for the same grade at five levels of reading difficulty. This enables the pupil with high interest but low reading ability to progress in science, and also permits the pupil of high interest and high reading ability to forge ahead.

Another trend is toward a change in terminology. Such new titles as "basic lab," "curriculum-coordinated lab," "portable lab," and "discovery lab" are indicative. In order to connote a closer tie-in with the program, it appears likely that the term "lab" may replace "kit" in much the same way that "kit" replaced "set." A prominent educator has made the following recommendation to a manufacturer: "Avoid the word 'kit.' Kits have been misrepresented and misused. As I visit with science educators I have discovered many who resist the word. Perhaps a more sophisticated title would be better." (Excerpt from address by Joseph Zafferoni, associate professor of education, Pennsylvania State University, given at the Elementary Science Conference held in New York City on December 16, 1961.)

Practical Considerations in Selection and Purchase

Whether to use a kit or some other type of science equipment is basically an educational decision, since the needs of the instructional program govern the choice of materials and equipment. If kits are to be used, it should be clear, before any particular selection is made, how and by whom the kit will be used in instruction and what it can contribute to the pupil's progress in science. Consideration should be given to the question of how the kit would compare with assembled apparatus or separate items in cost, quality, extent of use, ease of handling, time required for assembly, convenience in storing, and durability. It should also be determined whether many items in the kit would duplicate items already available in the classroom or laboratory.

One of the claims often made on behalf of kits is that they cost less. The price of some general-purpose science kits, however, is likely to run from 10 to 50 percent more than the total price if the individual items were purchased separately. The higher cost may be attributed in part to the storage box, arrangement system, accompanying manual, and labor required to collect the items. Certain types of specialized kits, on the other hand, may be purchased for less than the total cost of the individual items. This is especially true for assembly type kits of electronic equipment, such as amplifiers, meters, receivers, and transmitters. Instruments with identical specifications cost more if they are already wired and assembled, since the manufacturer's expense in having the parts assembled must be included in the price.

Some schools purchase kits which, when assembled, provide a good-quality instructional instrument. An oscilloscope, for example, can be purchased in kit form at a saving of up to 50 percent, and the job of assembly can in some instances be a profitable learning activity for a student interested in physics.

If a school decides to purchase kits, the following are some preliminary steps which will help insure maximum satisfaction with the kit selected:

1. Examine similar kits from a variety of sources to compare durability, quality, and cost.

2. Make sure that the items contained in the kit conform to the specifications set up in advance.

3. Find out whether it will be possible to replace items which may be damaged or consumed, if such items are essential to the kit's use.

4. Notice whether the items in the kit are packaged to facilitate easy accounting.

5. See that the kit conforms to standards of safety.

6. Determine whether the kit is suited for individual, small group, or class use. The maximum number of pupils who will be able to use the kit is an important factor in ordering.

7. Notice whether the kit manual contains adequate information regarding the contents and whether it will stimulate creative activity. The manual should (1) correspond to the level of interest and maturity of the pupils using it; and (2) be based on a thorough knowledge of the science curriculum and its objectives.

Classification and Evaluation

Although there is an abundance of information about science kits in catalogs and promotional literature, it is impossible to classify or evaluate any kit without physically examining it. In the first place, manufacturers do not standardize terms to describe science kits. In one publication, for example, kits for rockets, weather, jets, and astronomy are advertised as "science activity kits," but consist of printed matter only—a teaching guide, charts, and booklets. Another publication applies the term "science activities kits" to collections of equipment for specific areas of study, such as plant life. A third set of "science activities kits" contains a miscellany of general-purpose articles, such as a spring balance, candle, thermometer, and magnifier. A collection of minerals or a box containing permanent magnets of various shapes may be labeled a "kit." Some kits contain living material; others consist of parts for models of atomic or molecular or biological structure.

In the second place, while most elementary school kits are of two main types, special purpose and general purpose (see p. 3) manufacturers generally classify their kits for secondary school science according to the subject—general science, biology, chemistry, physics, earth science, or some subdivision of these. A sampling survey of commercial kits indicates that most junior and senior high school kits are for physical science. About half of these are designed for physics courses, a fourth for general science, and the rest for earth science and chemistry. The physics kits are most numerous and varied in the fields of electricity and electronics. There are few biology kits.

No one can know what a specific kit is or of what value it will be to him until he has examined its physical makeup and assessed its potential use in a particular frame of reference. Such an examination is needed for any piece of equipment or device for which specifications are written. But the appraisal of kits may be more difficult because of the variety of their components, the diversity of their purposes, and the range of their complexity.

School personnel concerned with instructional programs in science find it time saving to devise a chart or checklist including such items as name of kit, type, age level, individual or group use, activity for which intended, brief description of contents, adequacy of manual of instructions, source, and cost.

The main classification can be done by subject or by type, for example, assembly, model, collection, systems, demonstration, portable lab, special purpose, multipurpose, and so forth. Most types are readily identifiable, although some kits may have elements of more than one type. Kits of models with removable parts, for example, have elements of the assembly or construction type kit. The systems kit has its component parts prearranged to perform an experiment, but these can generally be rearranged for other experiments. A good example of this type is the electrical kit whose parts, when connected, form a conductor of electricity; different circuits are possible, depending upon how the components are arranged and connected.

In evaluation, the educational philosophy and principles, either implicit or explicit, in the makeup of the kit and manual are of primary importance. Before any purchase in quantity is made, a kit should be tried in several classes so that teachers may discuss and compare results. It is generally possible by these subjective means to find out whether a given kit contributes to the effectiveness of instruction. More objective guidance may be obtained by setting up experiments to test the comparative usefulness of different kits of the same type in a given teaching-learning situation.

The following hypothetical cases illustrate a classification and evaluation process in the selection of a kit.

Case I

The problem

A fifth-grade teacher in a self-contained classroom is faced with the problem of selecting a kit which will most nearly conform to the equipment and materials required for a unit on magnetism and electricity.

Background information

The course of study in use is the teacher's manual of a newly adopted science textbook series. Prior to the adoption of the textbook series, science had been taught in incidental fashion; there had been no articulation of units and no definite program. The materials and equipment items which the teacher had accumulated had been used mainly in demonstration, to interest pupils in reading about science. The pressure in the school program to upgrade science and to use an experience or laboratory approach in science teaching is uppermost in the thinking of the teacher as she inventories the facilities available and the equipment needs. She has decided to use a kit because of limited storage space and lack of time for ordering the items individually. The main purpose is to develop concepts of magnetism through activities involving the entire class.

Description of kits examined

The teacher examines and briefly describes the kits in terms of grade level, type, purpose, quality, price, and contents.

Kit A *Science Kit Junior*. Grades K–3. General-purpose type, for demonstration or individual use. Standard quality. $22. Contents: 4 of the 31 items applicable to the unit on magnetism. No teacher's manual. Randomly organized but compactly packaged. Size of items suitable for primary children. Cardboard case.

Kit B *Science Kit*. Grades 4–6. General-purpose type, for demonstration or small group activity. Standard quality. $38.60. Contents: 6 of the 41 items applicable to the unit on magnetism. Contains teacher's manual and star chart. Randomly arranged but compactly packaged. Wooden case.

Kit C *Basic Magnets Kit*. Grades 5–6. Special-purpose type, for demonstration. Standard quality. $20. Contents: 17 of the 27 items applicable to the unit on magnetism. Contains instructions. Sturdy package.

Kit D *Curriculum-Coordinated Magnetism Kit*. Grades 4–6. Special-purpose type, for demonstration and large group use. Superior quality. $21. Contents: All items applicable to the unit on magnetism. Company advertises replacement parts. Includes individual notebook and supplementary materials for pupils and complete instructional manual for teacher, with tests and charts. Contains eight boxes of items organized for use by groups of four pupils per box. Items fit in recessed grooves of each box. Durable construction.

Kit E *Science Kit*. Grade 5. General-purpose type, for demonstration and medium-sized group use. Excellent quality. $24. Contents: 10 of the 65 items applicable to the unit on magnetism. Company advertises replacement parts. Designed for use with a particular textbook. Organization excellent. Packaging makes for maximum convenience in use and includes arrangement key for the teacher.

The selection

Kit A is not suited to the age group. Kits B and C are not adequate for use by the entire class at the same time. Kits D and E are similar in price and each has certain advantages, but kit E is correlated with a textbook which is not available in this school. Kit D meets the requirements because it contains all the materials needed for the experiments pertaining to magnetism in the fifth grade and includes a manual, charts, tests, and notebooks to facilitate the use of the materials. It has the added feature of providing supplementary materials and suggestions for pupils with special abilities.

Case II

The situation

In a community that is fast becoming a center for electronic industries, the school's science offerings have been expanded to include the study of electronics. With the revised course of study, the ninth-grade classes in general science are expected to spend more time in a laboratory setting, although the facilities of this 4-year high school are still inadequate for general science.

After considering the advantages and disadvantages of electronic kits, it is decided to use them in order to (1) provide each student or group with a box of matched components with which to experiment, (2) aid the teacher whose general science background is weak in this area, (3) provide for a range of student abilities, (4) save time and reduce errors in ordering the necessary laboratory equipment to teach the unit, (5) permit purchase of ample equipment within a limited budget, and (6) facilitate storage.

It is recognized, however, that two factors should be kept in mind in selecting a kit: (1) Since some loss of parts is to be anticipated, kits containing fewer parts (for basic work) will give rise to fewer replacement problems; and (2) since errors by beginning students may damage components, especially resistors, capacitors, and transistors, kits with well-matched high-quality parts will in the long run be more economical.

Examination of kits

From suppliers' catalogs, seven kits that appear to meet the particular needs of this situation are selected for examination. Sample kits are obtained and the basic features of each are set forth as follows:

Description of Kits Examined

Kit	Contents	Instructions for use	Additional tools required	Packaging: Type	Packaging: Size	Quality of materials	Cost range
A	30–40 components for 50 exercises. 2 transistors. Peg board. Powered by flashlight batteries. 17 separate devices.	Good	None	Lightweight plastic	17" L 12" W 4" H	Fair	$40–$50
B	10–20 components for 57 exercises described. 10 exercises require use of 110 v. current. Basic electricity topics. No capacitors, resistors, transistors.	Fair	Screwdriver Wrench Pliers Cutters	Plastic	15" L 11½" W 6" H	Poor	$25–$30
C	40–50 components to be mounted on a board. 19 separate circuits. Flashlight batteries.	Excellent	None	Cardboard	17" L 10" W 1½" H	Fair	$20–$25
D	Printed circuit board with basic components to be soldered in place. Headphones; battery powered. Templates (guide cards); 2 transistors. Builds 10 devices; plug-in wires only for circuit changes.	Good	Screwdriver Soldering iron Pliers Cutters	Cardboard	10" L 10" W 2" H	Fair	$15–$20

E	55–65 plug-in components mounted for use on peg board. Templates. 2–4 v. cells provide power. Experiments related to radio circuits.	Good	None	Durable plastic	12" L 9¾" W 5½" H	Good	$140–$160
F	130–150 plug-in parts for exercises in electricity, and in electronics. 9 vacuum tubes, 4 transistors; principal items mounted on plastic base for use on peg board. Flashlight batteries.	None	Wrench	Wood	18" L 12" W 5½" H	Excellent	$200–$225
G	15–25 plug-in components for 14 exercises; additional templates (guide cards) for independent work. Head set. Flashlight batteries. Student assumed to have no technical information on electricity.	Good	None	Wood	15½" L 11" W 3¼" H	Fair	$40–$50

Comparison of contents

As the items in each kit are examined, the following checklists serve to facilitate a more detailed comparison of the kits as to (1) the adequacy of the manual, (2) the special nature of the parts, (3) the range of teaching topics, and (4) the variety of instruments that can be assembled according to instructions given in the manual. The "X" indicates the presence of the desirable feature.

Comparison of Kit Manuals

Distinctive features	Kit						
	A	B	C	D	E	F[1]	G
1. Appropriate reading level		X	X	X			X
2. Clearly written	X		X	X	X		X
3. Easy-to-follow directions	X		X	X	X		X
4. Technical terms defined	X		X		X		
5. Suggested further readings listed	X		X				
6. Self-evaluation devices							
7. Wiring diagrams	X	X	X	X	X		X
8. Circuit schematics	X		X	X	X		X
9. Pictures			X				
10. Charts			X				
11. More than step-by-step direction provided.	X				X		X
12. Adequate technical information provided	X		X		X		X
13. Function of kit parts explained	X		X		X		X
14. Basic principles explained	X				X		X
15. Use of mathematics required	X						
16. Problems to be solved							X
Total	11	2	11	5	9	0	10

[1] No manual.

Comparison of Component Parts

Distinctive features of parts	Kit						
	A	B	C	D	E	F	G
1. Warranted	X	X	X	X	X	X	X
2. Can be reordered	X	X	X	X	X	X	X
3. Can be reused	X		X		X	X	X
4. Can be added							X
5. Can be easily disassembled	X		X		X	X	X
6. Can be assembled without tools			X		X		X
7. Can be connected without solder	X	X	X		X		X
8. Durable	X		X		X	X	X
9. Standard size	X		X		X	X	X
10. Color-coded wire					X		
11. Transistors	X		X	X	X	X	X
Total	8	3	9	3	10	7	10

Range of Teaching Content Areas

Content areas	Kit A	Kit B	Kit C	Kit D	Kit E	Kit F	Kit G
1. Basic electricity	X		X			X	X
2. Transistors	X						
3. Amplifiers and oscillators	X				X	X	X
4. Radio receivers	X		X	X	X		X
5. Transmitters	X		X		X	X	
6. Vacuum tubes						X	
7. Rectifiers						X	
8. Power supplies						X	
9. Phase inverters						X	
10. Transformers							X
11. Solar batteries							X
Total	5	0	4	2	4	8	5

Variety of Instruments Listed in the Manual

Instrument	Kit A	Kit B	Kit C	Kit D	Kit E	Kit F[1]	Kit G
1. Radio direction finder	X						
2. Electronic monitor	X						
3. PA system	X		X				
4. Intercom	X		X				
5. Code oscillator	X		X	X			
6. Metronome	X		X				
7. Electronic flasher	X		X	X			
8. Electronic timer	X		X	X			
9. Open circuit alarm	X			X			
10. Short circuit alarm	X			X			
11. Photocell detector	X	X	X	X			
12. Electronic organ	X						
13. Noise-activated alarm	X		X				
14. Proximity alarm	X	X					
15. Moisture detector	X	X		X			
16. Heat detector	X	X		X			
17. Rain detector	X	X		X			
18. Rheostat		X					
19. Relay		X	X	X			
20. Thermostat		X					
21. Wet cell							X
22. Galvanometer		X					X
23. Electromagnet		X		X			X
24. Radio receiver			X		X		X
25. Audio amplifier				X	X		X
26. Audio signal connector			X				
Total	17	10	11	12	2	0	5

[1] No manual.

After analysis of the kits by science teachers and pilot use with selected students, the basic advantages and disadvantages of each kit for the particular purpose of the 9th-grade general science classes are listed as follows:

Suitability for General Science, Grade 9

Kit	Advantages	Disadvantages
A	Wide range of topics presented. Some thinking required on part of students. Basic definitions and principles clearly stated in manual.	Unsuited for average or below average student at this level.
B	Operating circuits to be built may arouse the interest of apathetic students.	Emphasizes assembly skills rather than understanding. Parts lack durability. Manual primarily concerned with giving directions; no provision for independent investigation. Unsafe. Use of line voltage (110) required for power relay experiments.
C	Reasonable cost. Good quality. Directions for assembly easy to follow. No tools or extra equipment required. Function of basic parts described in manual. Easily adapted to most 9th-grade science textbooks.	Manual stresses skill in assembling parts more than concepts to be learned.
D	Low cost. Operating circuits to be built may arouse the interest of apathetic students.	Manual mainly stresses skill in assembling parts; too little science included in manual. Excellent soldering skill required. Not easily disassembled. Printed circuit easily damaged.
E	Good quality equipment. Well-packaged.	Comparatively expensive. Treatment of topics in manual too advanced for 9th grade. Subject matter limited to treatment in depth of semiconductors and radio circuitry. Use of templates, although reducing error and damage to parts, deters learning by discovery. Kit requires use of expensive external equipment (oscilloscope, signal generator).

Kit	Advantages	Disadvantages
F	Excellent quality construction. Represents wide range of topics. Use of kit can be correlated with textbooks on the subject.	No kit manual available. Most costly of kits considered. Not suited to 9th grade—more useful for physics and senior electronics classes.
G	Excellent instructions. Requires no prior technical background. Suitable for beginners. Suitable for grade level 9.	Conclusions are stated in manual, forestalling discovery by students. Requires use of extra equipment (voltmeter and milliammeter). Many items in kit not clearly related to manual and the few items that are related could be purchased separately at reduced cost.

The selection

An analysis of the seven kits represented reveals that in general all require that certain components be mounted and connected on a circuit board according to written directions, wiring guides and diagrams, or templates (guide cards).

The kits vary in: (1) cost, (2) quality and number of basic components, (3) variety of devices to be assembled, (4) techniques used to assemble the circuit board, (5) scope of the subject matter, and (6) nature of the accompanying manuals which range from giving instructions only to explaining the basic principles of the field and leading the student toward independent investigation.

Of all the kits analyzed, kit C offers more advantages for the hypothetical class situation than any of the others. It is selected to provide equipment for beginning laboratory work in electricity and electronics for 9th-grade science classes. Its comparatively low cost of $20 will permit purchase for almost every student in a class. For maximum effectiveness, the kit manual should be used as supplementary text or reference material. The manual accompanying kit C offers the clearest set of directions for building the base assembly used to wire the circuits of the operating electronic devices. In addition, kit C can be used at home as well as in a classroom without the usual science laboratory equipment, furniture, and outlets. A 9th-grade science textbook which develops the principles of magnetism and electricity can be used as a basis for the laboratory "try and see."

Kits B, D, E, and F appear to have disadvantages of such proportions as to preclude them from further consideration. Kit B lacks safety features; kit D contains components easily damaged; kits E and F are expensive and complex, and require laboratory facilities not currently available.

The A kit manual contains updated information presented in an interesting and stimulating style. Diagrams and drawings are used to aid the student in the initial exercises. To solve major problems in circuitry, the student must know how to read the technical schematics, since for these later problems wiring diagrams are not provided. The purchase of several A kits is recommended for use by gifted students, for special project work, or for students who have an understanding of magnetism, basic electricity, and electronics.

The manual accompanying kit G is the best of the manuals examined for use in the school situation described, since it deals with basic understanding of the subject. It can be read and understood by 9th-grade students of normal achievement. It assumes no prior knowledge of electronics on the part of the student. It does state the conclusions of the experiments, but the teacher can blank out these pages so that students can discover and draw conclusions of their own. Kit G would have received first consideration if the price had been $25 or less instead of the $40 listed. By comparison with the others, this kit appears to be overpriced.

The foregoing examples illustrate the processes and forms that may be adapted by teachers, supervisors, and procurement officers if kits are being considered for the school science program.

Some Commercial Suppliers of Science Kits

The following list gives a representative sampling of commercial sources for science kits. The listing of products and manufacturers does not imply endorsement by the U.S. Office of Education. The list is provided in order to give the purchaser a start in locating the various kinds of kits available for use in science instruction. Many department stores also sell these kits.

Allied Radio Corp.
833 North Jefferson Boulevard
Chicago 7, Ill.

American Basic Science Club, Inc.
501 East Crockett Street
San Antonio 5, Tex.

Atomic Accessories, Inc.
811 West Merrick Road
Valley Stream, N.Y.

Atomic Corp. of America
14725 Arminta Street
Panorama City, Calif.

Baird-Atomic, Inc.
33 University Road
Cambridge 38, Mass.

Barnett Instrument Co.
Kraft Street
Clarksville, Tenn.

Bell Telephone System
195 Broadway
New York 7, N.Y.

Broadhead & Garrett Co.
4560 East 71st Street
Cleveland 5, Ohio

Cambosco Scientific Co.
37 Antwerp Street
Boston 35, Mass.

Carolina Biological Supply Co.
Burlington, N.C.

Central Scientific Co.
1700 Irving Park Road
Chicago 13, Ill.

Clay-Adams, Inc.
141 East 25th Street
New York 10, N.Y.

Clinton Misco Corp.
6780 Jackson Road
Ann Arbor, Mich.

Creative Playthings, Inc.
Post Office Box 1100
Princeton, N.J.

W. H. Curtin & Co.
Box 14
New Orleans, La.

Denoyer-Geppert Co.
5235–5259 Ravenswood Avenue
Chicago 40, Ill.

Dumville Manufacturing Co.
Box 5595
Friendship Heights
Washington, D.C.

The Ealing Corp.
33 University Road
Cambridge 38, Mass.

Eckert Mineral Research, Inc.
110 East Main Street
Florence, Colo.

Edmund Scientific Corp.
101 East Gloucester Pike
Barrington, N.J.

Fisher Scientific Co.
620 Fisher Building
Pittsburgh 19, Pa.

General Biological Supply House
8200 South Hoyne Avenue
Chicago 20, Ill.

General Electric Co.
1001 Broad Street
Utica, N.Y.

A. C. Gilbert Co.
Erector Square
New Haven, Conn.

Harvard Apparatus Co.
Dover, Mass.

D. C. Heath & Co.
285 Columbus Avenue
Boston 16, Mass.

Heath Co.
Benton Harbor, Mich.

Irving Science Laboratories
2052 Hillside Avenue
New Hyde Park, N.Y.

J. Klinger Scientific Apparatus
82–87 160th Street
Jamaica 32, N.Y.

Laboratory Furniture Co.
Old Country Road
Mineola, N.Y.

Labosco, Inc.
Lombard, Ill.

Lafayette Radio
165–08 Liberty Avenue
Jamaica 33, N.Y.

Arthur S. LaPine & Co.
6001 South Knox Avenue
Chicago 29, Ill.

Lionel Corp.
15 East 26th Street
New York 10, N.Y.

Living Science Laboratories
1605 Jericho Turnpike
New Hyde Park, N.Y.

Macalaster Scientific Corp.
253 Norfolk Street
Cambridge 39, Mass.

Models of Industry, Inc.
2100 Fifth Street
Berkeley 10, Calif.

National Scientific Co.
13 South Park Avenue
Lombard, Ill.

New York Scientific Supply Co., Inc.
28 West 30th Street
New York, N.Y.

Nucleonic Corp. of America
196 Degrow Street
Brooklyn 31, N.Y.

O.K. Distributors, Publishers
Post Office Box 74, Outremont
Montreal, Canada

Oregon Metallurgical Corp.
Post Office Box 484
Albany, Oreg.

F. A. Owen Publishing Co.
Dansville, N.Y.

Paco Electronic Co.
70–31 84th Street
Glendale 27, N.Y.

Philco TechRep Division
Post Office Box 4730
Philadelphia, Pa.

Product Design Co.
2796 Middlefield Road
Redwood City, Calif.

Research Scientific Supplies, Inc.
Department ST8
126 West 23d Street
New York 11, N.Y.

Science Associates
Box 216
Nassau Street
Princeton, N.J.

Science Education Products
2796 Middlefield Road
Redwood City, Calif.

Science Electronics, Inc.
195 Massachusetts Avenue
Cambridge 29, Mass.

Science Kit, Inc.
2299 Military Road
Tonawanda, N.Y.

Science Materials Center
A Subsidiary of Allis-Chalmers
220 East 23d Street
New York 10, N.Y.

Science Research Associates, Inc.
259 Erie Street
Chicago 11, Ill.

Science Service
1719 U Street NW.
Washington 6, D.C.

Sesco, Inc.
1312 South 13th Street
Vincennes, Ind.

Stansi Scientific Co.
1231 North Honore Street
Chicago 22, Ill.

The Torsion Balance Co.
Educational Aids Division
Clifton, N.J.

Ward's Natural Science
Establishment, Inc.
3000 East Ridge Road
Rochester 9, N.Y.

W. M. Welch Scientific Co.
1515 Sedgwick Street
Chicago 10, Ill.

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