The Development of the Teaching Equipment for Science Education

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SCIENCE EDUCATION AND THE TEACHING EQUIPMENT

"Development of Teaching Equipment for Science Education" (The philosophy and the nature: The educational system adopted in Japan is very unique and isolated from those of other countries; all what we have is an objective rather than philosophy and the nature.)

Due to the rapid progress in the realm of science and technology in recent years the volume of knowledge and information for the student to be imparted with has acceleratingly been increased. This means that the student is required to memorize an immense volume of knowledge which forces him out of enough time for his personal involvement in the experimental phase of science education, depriving him of his interest in science as a whole.

This research, being promoted under a grant of the Ministry of Education for it assigned research in science education, aims at the development of the teaching equipment for science education in elementary through junior college course.

A part of the results so far achieved has been summarized in a volume of book ("Tankyu-no-rika" or Exploration of Science in 158 pages published in 1974 by Meiji Tosho Publishing Company, Tokyo) and those pieces of equipment as described in this report are picked out of the book. Primary consideration is paid in designing each experimental device to eliciting and developing the interest of the student in science through his participation in an experiment.

There is a proverb in Japan "Love makes labor light."

If students are interested and their mind set to do anything, they will become skillful with little effort naturally in any line they take, not only in science but also in any other studies. We believe that a child introduced to curiosity at an early age will develop an understanding of science.

As the first step, only curiosity will do, and under a good leadership the student is made to develop his interest in search of truth. However, any important knowledge in science may drive children out of their interest in science if it is not given in a proper way.

In Japan, we have only one "Monbusho * Project", as you know. All Japanese teachers must follow the curriculums compiled and published by the Ministry of Education*(Monbusho) and must use only the text books that are approved by the Ministry of Education. Nearly all the science teacher, even with poor knowledge of science, must follow the curriculums and they are not given a free hand to teach the subjects other than those known as "Grade system". Most students are promoted to the next grade whether they are poor or excellent in their studies. One class has so many students and the average number is not less than 40, so all

teachers will try to cram the student with the minimum needs for the grade. In conclusion, when the students are promoted to the upper class, we fear that their interest in science becomes weaker to detest science under our present educational system.

The project being carried out by our research group has its own philosophy, of course, but under the current Japanese educational system which sets a rather rigid framework of curriculums we are trying to apply our own phisolophy in whatever part which allows it.

In the beginning of a science class, teachers hand materials and reference to students with no adequate guidance about the subject and have them make or construct whatever is required by the subject. It is the best way to teach science class in Japan. Every student cannot create a new good idea on the subject given by the teacher, so the teacher has to prepare fully for the subject beforehand. In the class it will not go smoothly without the teacher's guidance; when all the student fail to create good idea for the subject they will be at a loss what to do, when the teacher has to guide them in an appropriate method, giving timely suggestion for them. In order to lead the student along the well-arranged way, teachers must have a lot of knowledge and technique of fundamental science and have concepts of science education science.

Our project staff (Prof. Ryokichi Okazaki: director of our group) are trying hard mainly to create suitable experimental equipment and methods to teach with the equipment developed by us within the framework of the Monbusho curriculums and also trying to create new curriculums as far as possible. If there were enough well designed equipment and good experimental methods, even the student who are in lower grades could approach truth and discover it through the use of such equipment and would come to understand higher levels of science. For example, by using the recording air table equipped with Linear Air Track and Air Table developed by us, the student will easily be able to understand the change of velocity only by looking at it which is both interesting an beautiful in shape and color, so they will be induced to try the interesting experiment.

LIST OF EXPERIMENTAL EQUIPMENT

1. Seesaw
2. Styro-foam Cutter
3. Waterwheel & windwheel
4. Simple Stand
5. An Application of Hanger-Boards
6. Electric Circuit Experimenter
7. Floating and Sinking
8. Transmission of Sound along The String
9. Expansion of Metal Pipe
10. Expansion of Flask
11. Optic Experimenter
12. Static High Voltage Supply
13. Measurement of Joule's Constant
14. Wave Demonstrator
15. A New Idea in a Part of The SHIVE Wave Machine

16. Improved NUFFIELD Timer
17. Recording Air Table
18. GM (Geiger Müller) Counter Tube containing ultraviolet sensitive photocathode

DESCRIPTIONS AND OPERATIONAL PROCEDURES

1. Seesaw

How to lead students in handling the equipment.

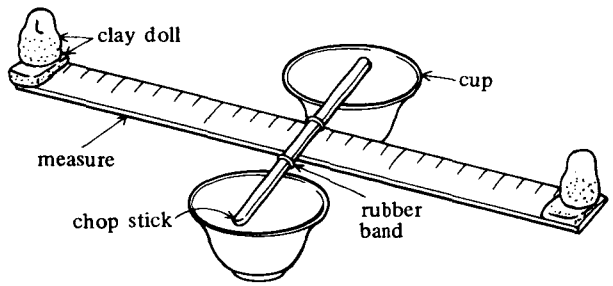


Fig. 1

(1) To do this experiment the student needs two cups, some clay, chopsticks of different diameters, a ruler and rubber bands.
(2) Give him the above materials and have him make a seesaw with no guidance.
(3) What is the best way to set up the given materials to make a well-balanced seesaw?
(4) By using different chopsticks or a ruler placed either on top or bottom of the chopsticks, try to rock the seesaw. Then make comparison.

2. Styro-foam Cutter

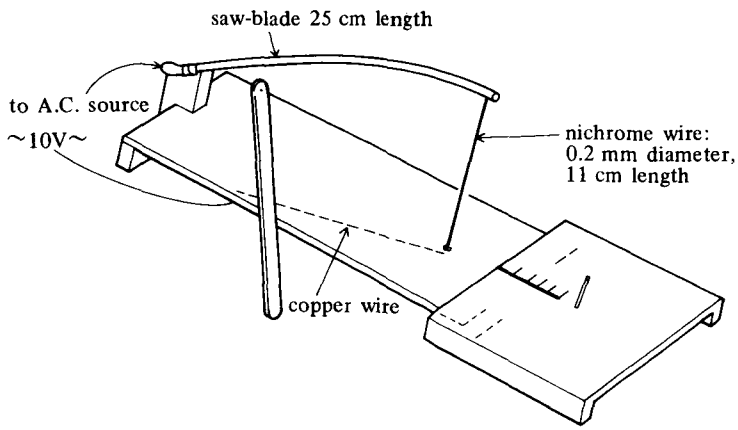


Fig. 2

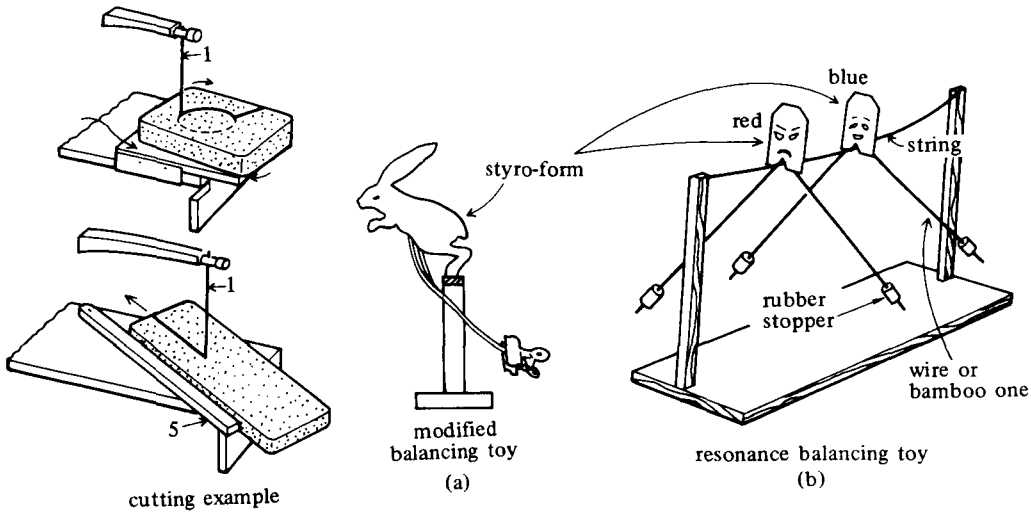


Fig. 3 Application (a) & (b)

3. Waterwheel & Windwheel

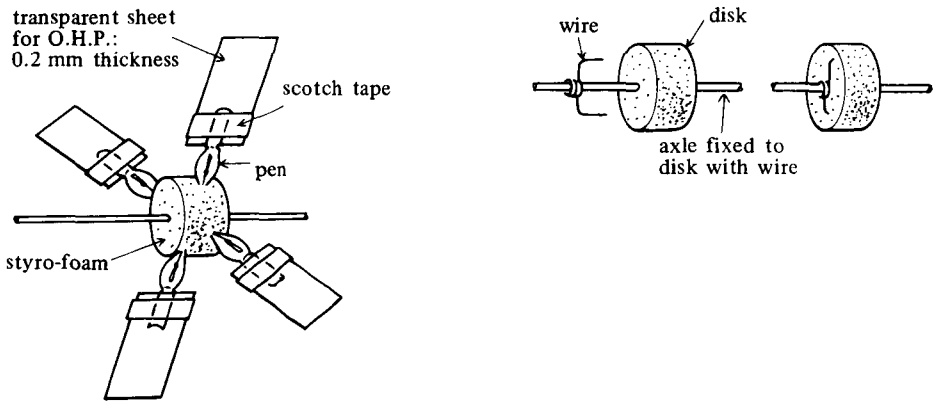


Fig. 4

(1) By changing the direction of the blades, you can make either a waterwheel or a windwheel.
(2) You can substitute a nib for tin plate.

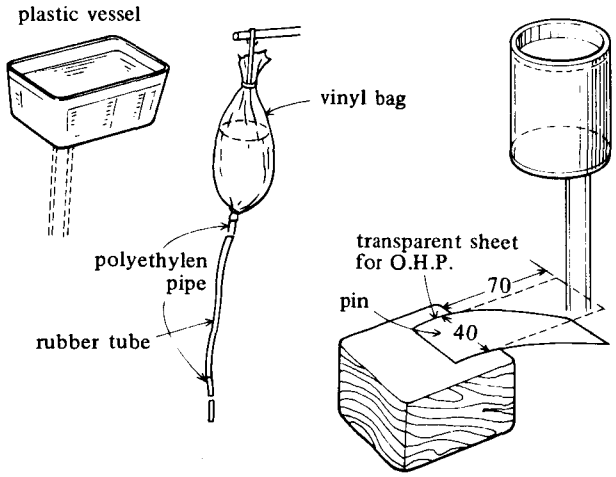


Fig. 5 A method of investigating stream velocity by the use of a waterwheel.

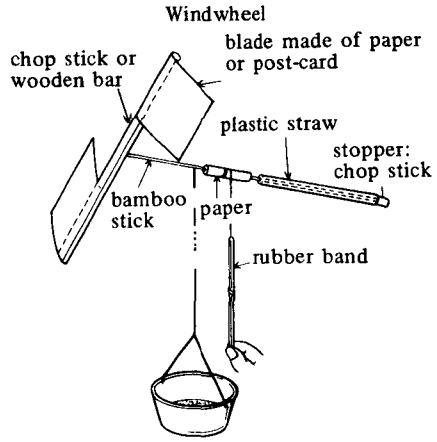


Fig. 6

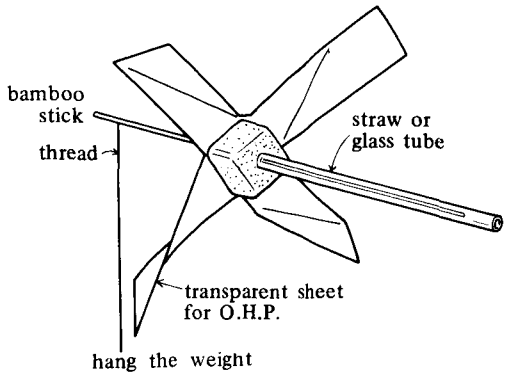


Fig. 7

(1) Study relations between wind-velocity and the weight to be lifted. And check whether the length of rubber band corresponds to the weight or not.
(2) Study each result by using axles of different diameters.

4. Simple Stand

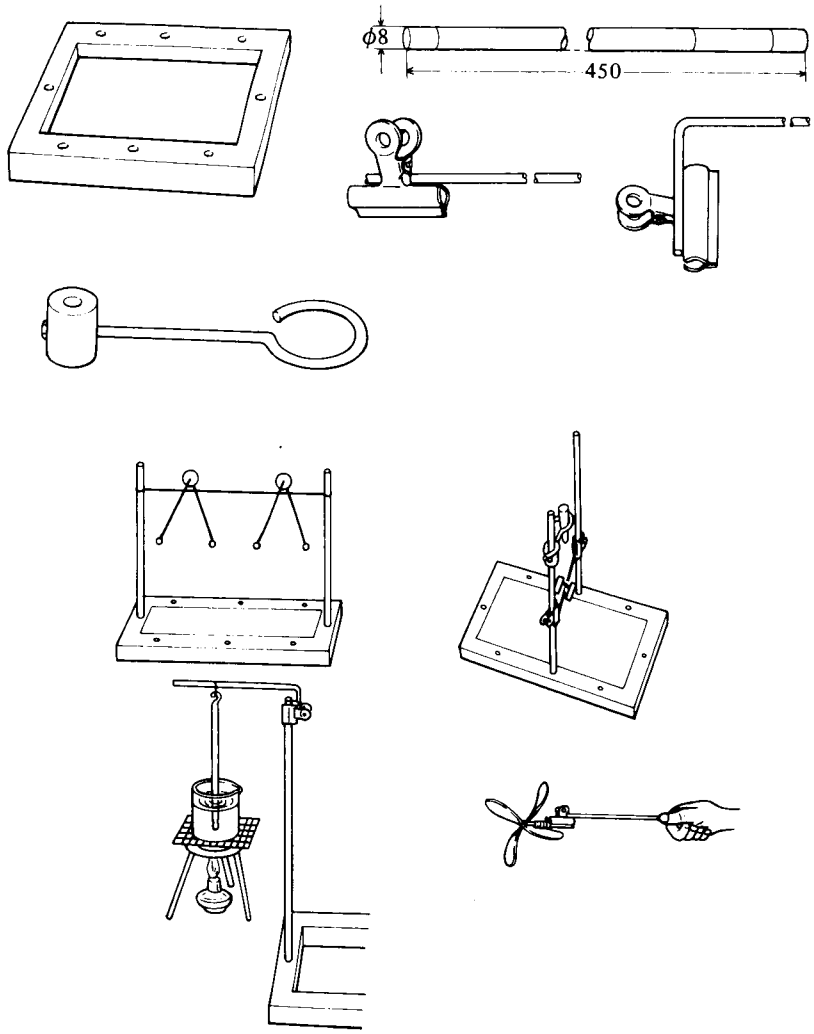


Fig. 8

Simple Stand: It is necessary for students in elementary and junior high schools to make waterwheels, windwheels and resonance balancing toys for themselves. But is it difficult for them to make their experimental stands and it will be better for them to prepare simple stands as illustrated above.

5. An Application of Hanger-Boards

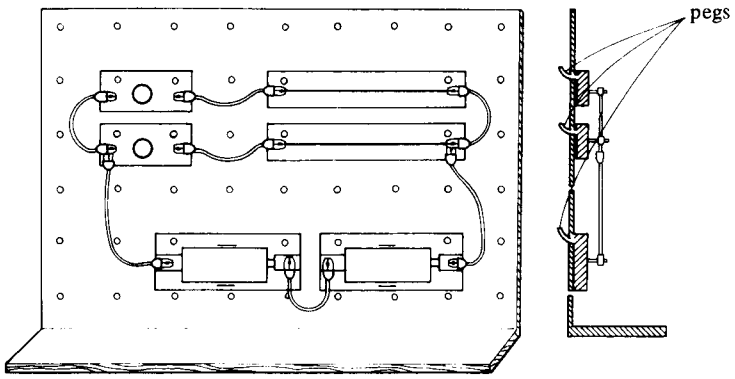


Fig. 9

(1) It is easy to hang in and take off pegs; and the pegs are not easily detached from the board when being shaken, if you make the pegs curved as illustrated.
(2) Let the student set them up.
(3) The hanger-board is useful as a demonstration for many students to see.

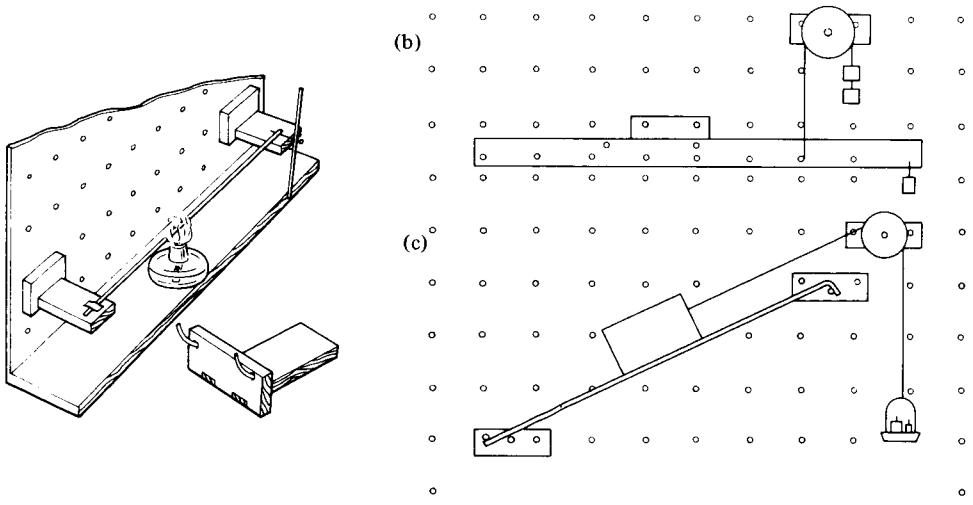


Fig. 10 (a) Expansion of Metal Bar
(b) Balance of Lever
(c) Inclined Plane

6. Electric Circuit Experimenter

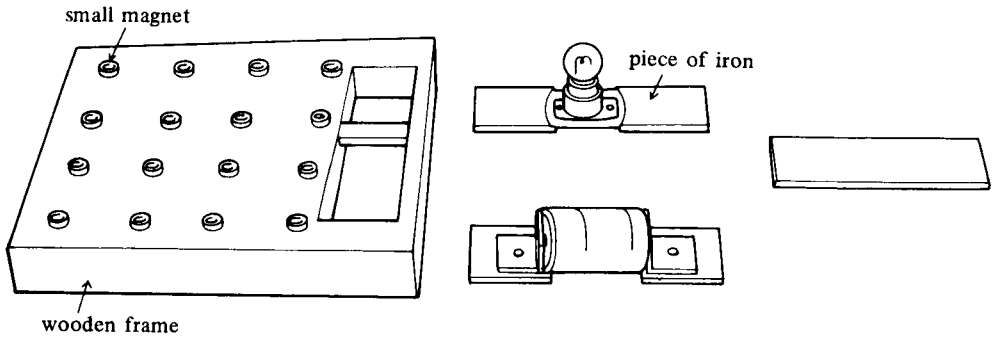


Fig. 11

Electric Circuit Experimenter: By utilizing the magnetic attraction between a piece of iron and a small magnet, you can make the wiring of electric circuit with ease. In this case if you make the surface of contact smooth, there is no worry about the electric contact resistance between the pieces of iron and the contacts.

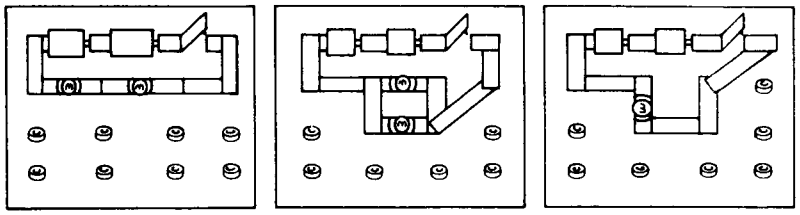


Fig. 12

7. Floating and Sinking

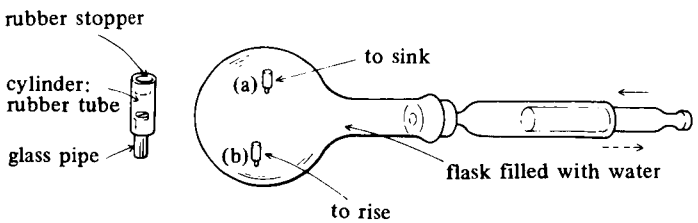


Fig. 13

(1) At normal pressure, (a) is adjusted to rise a little and (b) is also adjusted to sink a little. Both are adjusted by the glass pipes for rising or sinking.

(2) In these cases, if you push the piston (a) will start to sink and if you pull the piston (b) will rise.

8. Transmission of Sound along The String

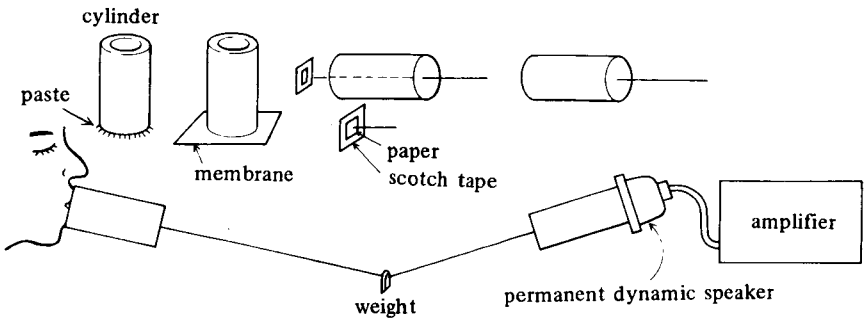


Fig. 14

(1) Paste a kind of membrane on one end of each cylinder and connect a piece of string between the centers of the membranes.
(2) Put your mouth to the cylinder closely and make a big voice into the cylinder.
(3) The connected string between the two membranes has a constant tension by the pulling of the weight, as illustrated.

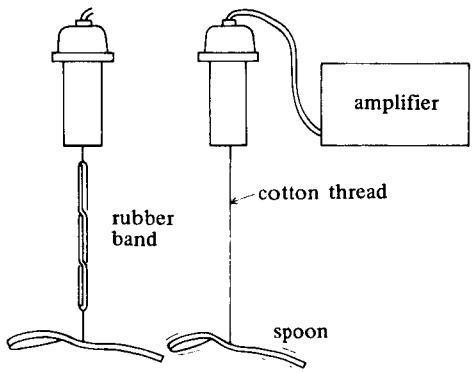


Fig. 15

(1) Compare the sound of a kitchen-spoon with the propagated sound of the kitchen-spoon connected with a cotton thread to the amplifier.
(2) By using some other kinds of materials as membranes, membranes of different tensions, various kinds of strings of various tensions between the spoon and the amplifier experiments make comparative.

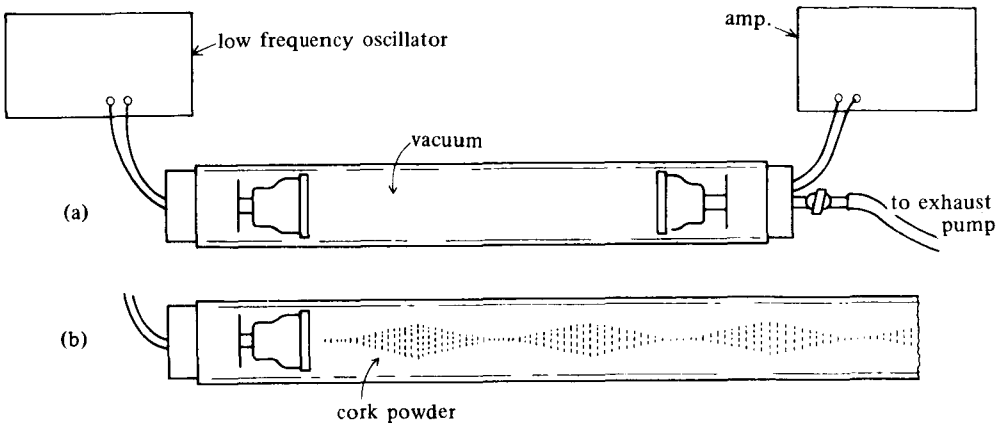


Fig. 16

(a) The demonstrational Experiment: Sound can not travel into vacuum.
(b) The same Experiment: Cork power shows stationary waves.

9. Expansion of Metal Pipe

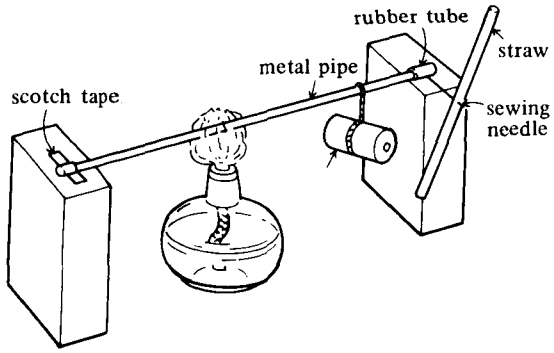


Fig. 17

(1) Cover the end of the metal pipe with a rubber tube.
(2) When the metal pipe is expanded in length, the sewing needle rotates smoothly.

10. Exapnsion of Flask

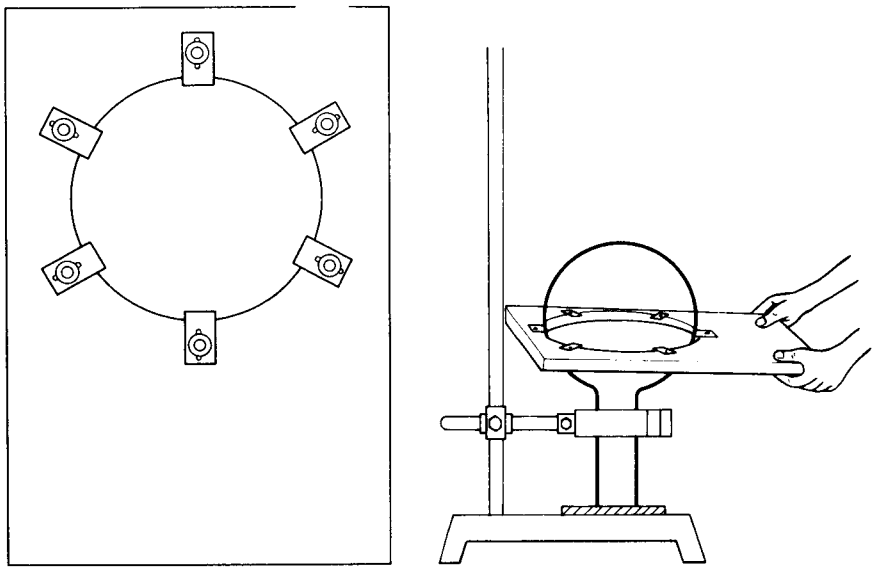


Fig. 18

(1) First, fill the flask with cold water and check whether the flask can pass through the hole or not.
(2) Next, fill it with hot water and try again. Then make comparison.

11. Optic Experimenter

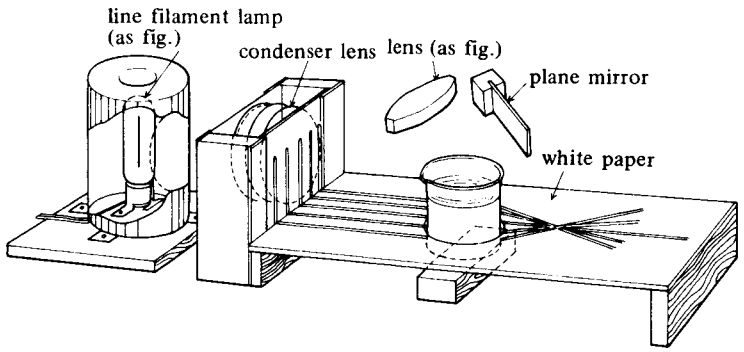


Fig. 19

Optic Experimenter: With the above-experimenter, we can show the traces of light to the student located in a not so dark room. It is applicable to a group experiment in class.

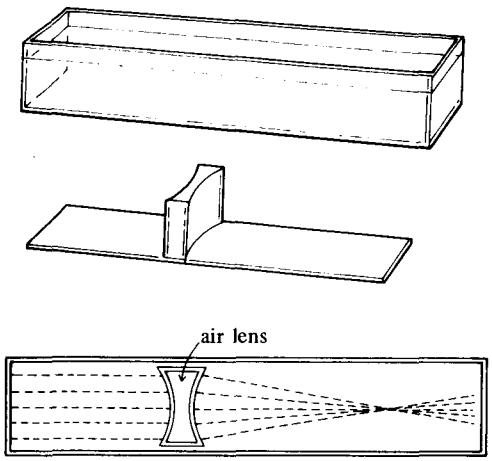


Fig. 20

(1) The vessel is made with transparent boards.

(2) In case of the vessel filled with water, a concave lens works as a convex lens in water

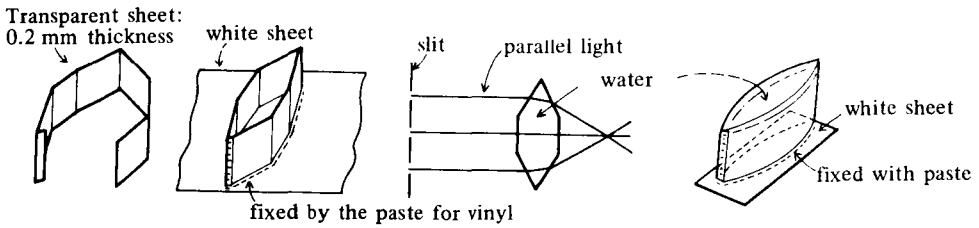


Fig. 21

12. Static High Voltage Supply

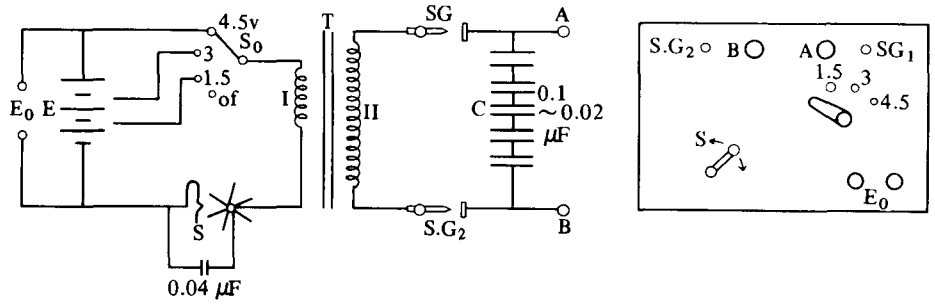


Fig. 22

E_0 :	Terminal from outer source	T :	Step-up transformer (1:30)
E :	Dry cell	SG :	Spark gap
S_0 :	Main switch	C :	Condenser
S :	Rotary switch	A.B. :	High voltage terminal

Application (1): Line of Electric Force

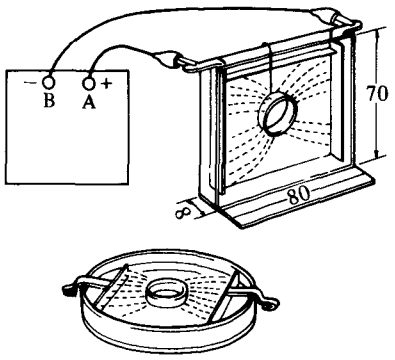


Fig. 23

(1) Put a thin glass vessel filled with so many short hog-bristles in salad-oil and stir them well.
(2) Put two metal poles in the vessel and set a metal ring in the center of the vessel.
(3) When the two poles get in contact with high voltage supply, the short hog-bristles show the force of electric line.

13. Measurement of Joule's Constant

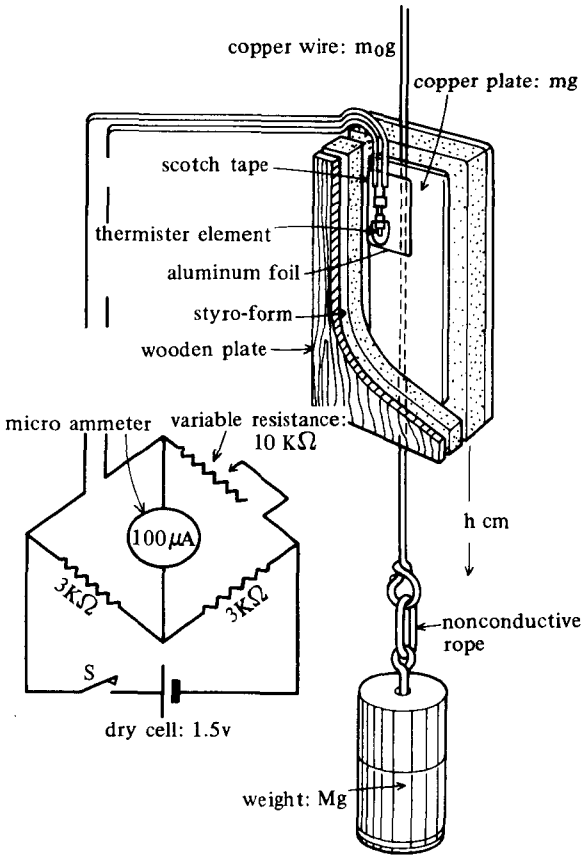


Fig. 24

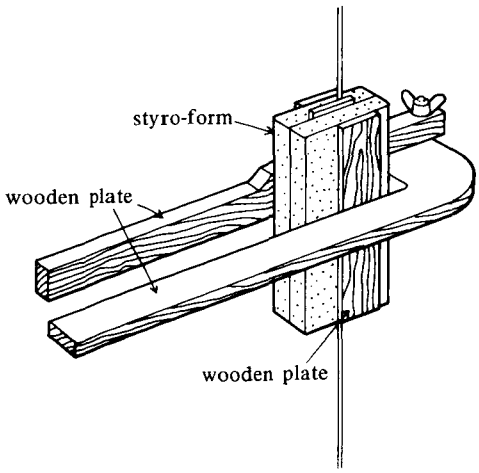


Fig. 24

When the weight (Mg) hung by a copper-wire is dropped, it works to give heat to the copper plates by friction.

The friction is generated by the dropping of the weight and the copper-wire to hang it passes down thru the sandwiched copper plates. We can measure heat with the thermister. As the result, we will find the relationship between work and heat energy.

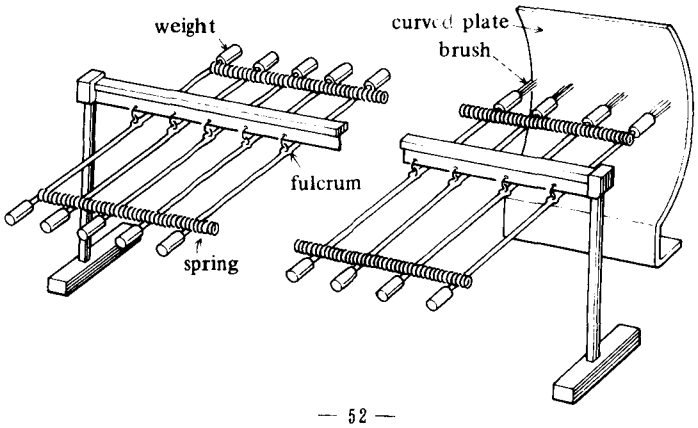
$$Mgh = JC(m + m')t$$

M: Mass of the weight h: Distance of falling of weight
m: Mass of copper-plate t: Temperature increase
m': Mass of copper-wire
g : 9.8 m/s²
C: The specific heat of copper = 0.093 Kcal/kg.deg.

According to the result of this method, we can obtain Joule's Constant

$$J = 4.0 \sim 4.4 \text{ joule/cal.}$$

14. Wave Demonstrator



(1) This device is applicable to transversal wave, logitudinal wave or trochoidal wave experiments without changing any parts.
(2) By using a curve plate (frictional plane), it can be used for a progressive wave experiment.

15. A New Idea in a Part of the SHIVE Wave Machine

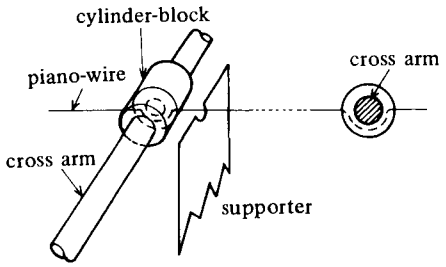


Fig. 26

We had a new idea of a joint which uses a cross-arm and a piano-wire.
(1) It allows the using of the various lengths of arms: The arms and the piano-wire are fixed.

16. Improved NUFFIED Timer

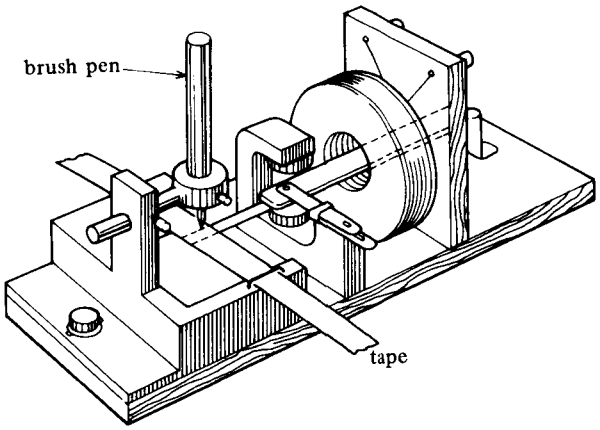
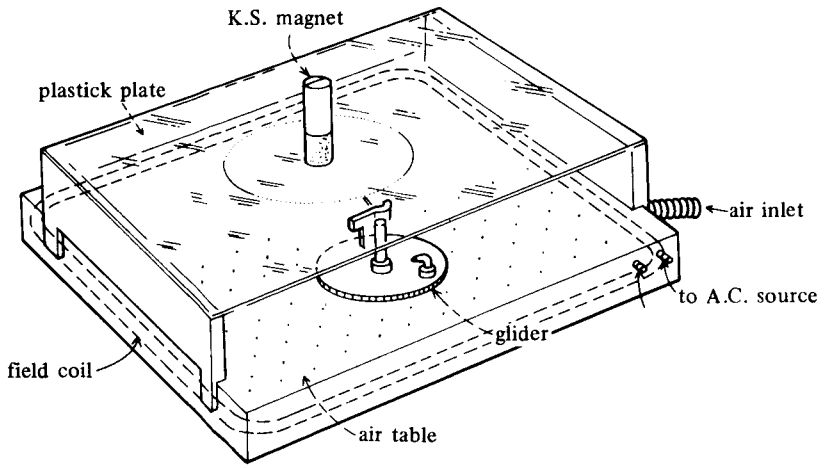


Fig. 27

It is not necessary to replace carbon paper.

17. Recording Air Table



field coil: 1 mm diameter, 100 turns, A.C. 3~5 ampere

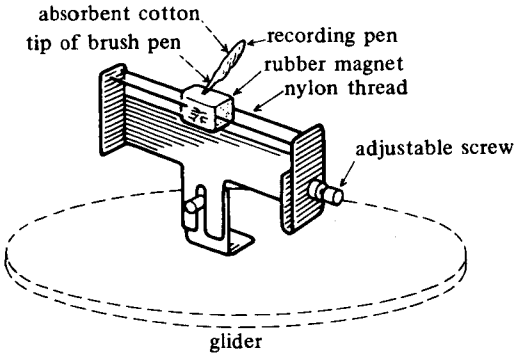


Fig. 28

Set the glider, with a recording pen on top, in magnetic field produced by A.C. field coil.

If the tension of the thread is adjusted, the rubber magnet starts resonating in the field current and on the other hand the recording pen placed on the rubber magnet starts vibration. It is employed for the recording of linear or curved motion.

Application: the model of Kepler's Law

18. GM (Geiger Müller) Counter Tube containing Ultraviolet Sensitive Photocathode

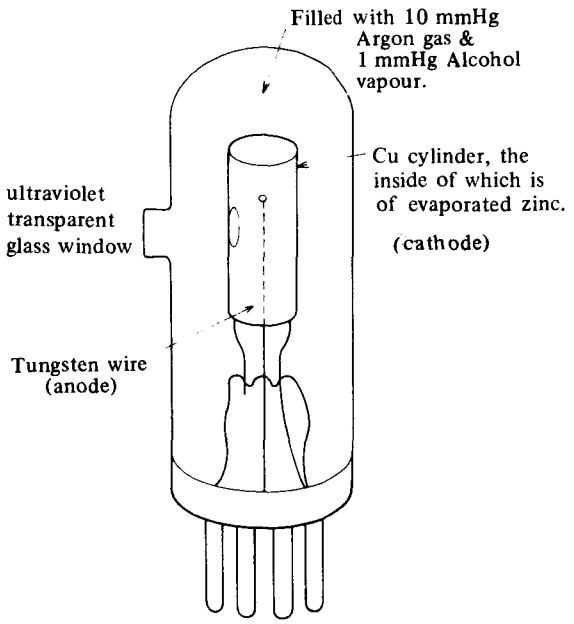


Fig. 29

It is convnient to measure the intensity of feeble ultraviolet ray.