Name: Harry H. Wyrick Date of Degree: May 25, 1958

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Title of Study: A SERIES OF DEMONSTRATIONS SUITABLE FOR A SCIENCE PROGRAM

Pages of Study: 40 Candidate for Degree of Master of Science

Major Field: Natural Science

Scope of Study: Over the past decade it has become increasingly apparent that the United States needs to increase the number of engineers and scientists graduating each year. Investigation of the causes for high school pupils failing to continue their education revealed that lack of funds was the reason in only one half of the cases. Lack of interest accounted for the other half. It is thereby evident that scholarships sponsored by industry and government will be only partially successful in bringing these pupils into college. The causes or "roots" of disinterest were found to lie with the parents and classmates as well as with the pupils themselves. With this lack of interest in both adults and pupils as a point of attack, a series of startling demonstrations was assembled. These demonstrations are designed to arouse their interest by focusing the attention of the public on science. Such programs have been used by both industry and government in the past, however the method and purpose here differs in that this series of experiments were designed to be a nucleus or model for the individual science teacher who has had little training or experience in the techniques of large audience demonstrations.

Findings and Conclusions: Since the purpose of the demonstrations is to stimulate interest, the criteria for their selection was necessarily their spectacular nature rather than the illustration of specific scientific principles. The selected demonstrations were also designed to be easily observed by a large audience as well as small groups. Thirty-two demonstrations were organized into the following groups: Explosions and Incendiaries, Colors, Mechanical Devices and a group titled Miscellaneous.

ADVISOR'S APPROVAL ____________________

A SERIES OF DEMONSTRATIONS
SUITABLE FOR A SCIENCE PROGRAM

by

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Bachelor of Science

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1940

Submitted to the faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
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A SERIES OF DEMONSTRATIONS

SUITABLE FOR A SCIENCE PROGRAM

Thesis Approved:

Thesis Adviser

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CHAPTER I

INTRODUCTION

The purpose of this paper is to propose a partial solution to the problem of increasing the number of graduating engineers and scientists. The immediate problem considered is that of motivating capable high school graduates to enroll in college, particularly in the fields of science and engineering. The method developed here for achieving this goal is to stimulate the scientific interest of these young people at both the elementary and the high school level. Pupil interest can be effectively captured by the use of startling demonstrations of scientific principles designed to be entertaining as well as educational and the bulk of the paper is devoted to a series of demonstrations designed to carry out the objectives cited above.

The need for more mathematicians, engineers, and scientists of all types has been cited by many more qualified than the author, such as the National Manpower Council,[1] which says:

> Some visualize the United States as losing out in the race for highly trained personnel because about twice as many new engineers are currently being graduated in Russia as in the United States.

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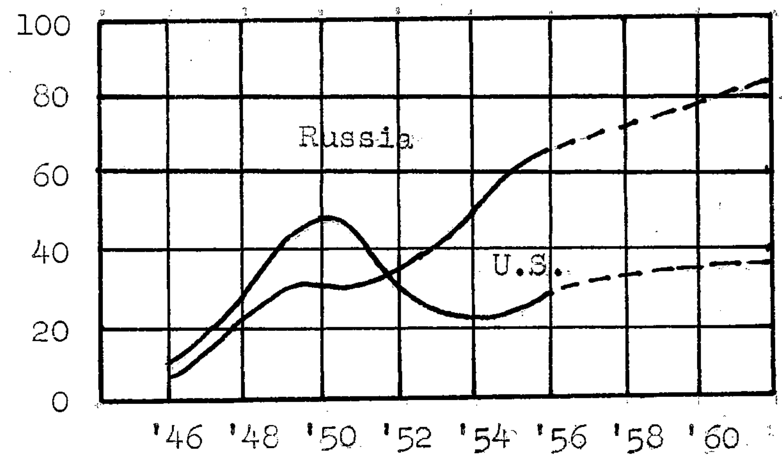
[1]National Manpower Council, Womanpower, New York, Columbia University Press, 1957, p. 262.

Another estimate of the situation comes from an editorial in Chemical Week[2] with its' accompanying graph:

Thousands — Engineering Graduates in the United States and Russia--1946-1960



Source: Nicholas Dewitt, Soviet Professional Manpower, U.S. Office of Education McGraw Hill, Department of Economics.

> Over the last five years we have turned out only 142,000 engineers compared to an estimated 216,000 in Russia. In 1955 our output was around 23,000 compared to their 63,000. Over the next five years our projected output is 153,000 against at least 400,000 in Russia. There will be an additional 150,000 or more graduates in the satellites and Red China.

The causes for the relatively low number of graduates in the scientific fields as manifested by that of the engineers shown above are twofold and are summarized in a study by Charles C. Cole[3] in cooperation with the National Science foundation:

> ...the United States is wasting its intellectual re-

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[2]Editorial, "The Shortage of Scientists and Engineers: Are We Losing the Race With Russia"; Chemical Week, Vol. 78, June 1956, pp. 71-72.

[3]Charles C. Cole, Encouraging Scientific Talent, New York, College Entrance Examining Board, 1956, p. 196-7.

> sources at the rate of approximately 200,000 18-year olds a year. These are young people with college ability who terminate their education upon graduation from high school. Apparently between 60,000 and 100,000 highly able high school graduates with aptitude and interest for college fail to continue their education for financial reasons. Another group of approximately 100,000 with similar ability lack the interest or motivation for college.

It is to this latter group that this paper is directed. The federal government with its' schlorship program directed specifically at the first group undoubtedly will do much toward alleviating the situation of lagging college enrollment in the sciences specifically. Therefore, it would seem that the burden of recruiting the latter group falls directly upon their high school teachers and parents.

The importance of the parents' role insofar as their children continuing their education is considered by the Educational Policies Commission[4] as follows:

> The child tends to accept the values that predominate among his family and playmates. Children in a cultured home are more likely than others to develop a taste for music, art, and books, and are more likely to want to go to college. Such children are not necessarily superior in ability, but they are more likely to develop whatever abilities they have....The high school youth who develops a strong desire for attending college in the face of the opposition or apathy of his parents is the exception rather than the rule.

Cole[5] continues with the following statement:

> Parental influence is so potent a factor because of opinions expressed in the family toward elementary education, homework, and planning for one's career can

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[4]Educational Policies Commission, <u>Education of the Gifted</u>, Washington D.C., The Commission, 1950, p. 26.

[5]Charles C. Cole, p. 88.

> mean the difference between success and failure in school, between full utilization of a child's talents or waste of them. Achievement in school or the lack of it has been frequently traced to parental influences or to some aspect of the home situation.

It is clear then that in any attempt to increase the scientific interest of these 100,000 18-year-olds, their parents must also be considered. For this reason, the demonstrations described in this paper are designed to be suitable for presentation before an adult as well as a juvenile audience. The purpose here is to gain the parents support by capturing their interest. Therefore, the program should be presented before such groups as the P.T.A.. and the Lions Club or wherever suitable opportunity for publicizing and stimulating public interest in science presents itself.

The above statements about presentation before adult groups is not meant to exclude high school, junior high, and even elementary school assembly programs. Wherever possible the members of the chemistry class, science club, or some similar group should do the demonstrations rather than the instructor. This is advisable for a variety of reasons, most important of which are, the demonstrations should have more appeal if performed by the pupils and the students doing the demonstrations will receive excellent training thereby.

In answer to the question: "What has been done previously of a similar nature?", the Oak Ridge Institute of Nuclear Studies as well as many corporations have adopted this plan of creating public interest. This has been done largely at the high school level by putting skilled demonstrators on the road who visit selected high schools over the nation. It is difficult to measure, but it is quite definite that their efforts have resulted in increased science enrollments from these schools. However, because they reach a limited number of schools, it is the authors' contention that their efforts should be supplemented by the individual science teacher through the use of similar demonstrations.

The balance of this report is devoted to a description of these demonstrations. Some of them were selected from the authors' own experience, but credit for authorship being given wherever possible. In addition, the literature was searched and experiments were selected with which, for the most part, the author was familiar. For this reason, the demonstrations described herein are practically "fool-proof". Familiarity with the experiments has made possible more detailed explanation of the precautions to be taken and explanation of the theory involved in each experiment. Demonstrations which might be dangerous to either the experimenter or the audience have been omitted.

CHAPTER II

INCENDIARIES AND EXPLOSIONS

2.1 EXPLODING BUBBLES

Procedure:

The person performing this demonstration comes on stage with a large beach ball or balloon (already inflated), a beaker or other container at least one liter in size containing water, a bottle of liquid shampoo or liquid soap, and a "presto-lite" torch (if a bunsen burner and gas source are not available). While he is adding some of the soap solution to the water, lighting the torch and preparing the equipment he explains to the audience that today he is going to make a few bubbles for their entertainment and invites someone from the audience to help him with the demonstration. As soon as the volunteer is on stage the demonstrator does everything possible to allay his suspicions and natural fear of being hurt or embarassed by suitable comments about the phlogiston theory, the elements of the alchemist being earth, fire, and water, two of which they have here--fire and water. The harmless nature of the flame is demonstrated by passing one's hand through the flame while it is wet. Fear of the flame on the part of the volunteer must be overcome, if necessary by even having the demonstrator guide his hand through the flame. The entire success of the demonstration depends on this one detail. When this detail has been perfected the stopcock on the beachball is released and with the nozzle or mouth of the tube of the ball below the surface of the soap solution, the gas is allowed to escape which results in great quantities of bubbles (to the extent that they boil over onto the table--if possible) being formed. Then as quickly as possible, the guest is told to pick up a large handfull of the bubbles and hold them over the fire. The result should be a gigantic explosion which is completely harmless to the individual.

Preparation:

The balloon is filled with hydrogen and oxygen in a ratio of 2:1.

Explanation:

The explosion is completely harmless because, unlike most explosions which result in an increase in volume of the reacting gases, this one actually results in a decrease in volume according to the equation:

$$2\ H_2 + O_2 \longrightarrow 2\ H_2O$$

$$\text{or } 2 \text{ vol's} + 1 \text{ vol.} \longrightarrow 2 \text{ vol's}$$

upon explanation of these equations, it becomes apparent to almost everyone why the reaction is harmless. Actually the water vapor shown on the right side is converted to liquid water which results in a further decrease in volume. If the two volumes of water vapor were converted completely to liquid, the resultant decrease in volume would be in the order of 2000:1!

Precautions or suggestions for setting up the experiment are concerned with the preparation of the balloon. A beach ball is more suitable than a balloon (the bladder from a basket ball also has been used), as the small hydrogen molecules will leak through a rubber balloon. If pressureized bottles of hydrogen are not available for filling the beach ball, a conventional hydrogen generator may be used; however the hydrogen should be added first as it will be more convenient to add the oxygen against pressure from a bottled source, such as an oxy-acetylene torch.

2.2 BURNING ICE

Procedure:

This demonstration may be introduced by using a hypothetical situation of being stranded on an iceberg slowly freezing to death. The problem was solved by pouring together two beakers of water into a third large test tube or beaker, shaking out the resulting ice cube or block of ice discover that upon touching a match to it discover that it burns vigorously.

Preparation:

The combustible solid results from pouring together a saturated (water) solution of calcium acetate and ethyl alcohol in a ratio of 1:10. The relative proportions may be varied if the solid is too "stiff" to be shaken out of the container easily, as it is supposed to resemble a block of ice or icicle, depending upon the preliminary remarks.

2.3 COLD FIRE

Procedure:

This demonstration is best performed by two persons. They ask for a volunteer, who turns out to be either the principal, president of the club, or some person of similar position. While he is making his way to the stage the demonstrators decide to test their "fire water" by immersing one of their own handkerchiefs or neckties in it and on touching a match to it find, the article burns vigorously. Their flaming "mistake" is dumped into a conveniently located wastebasket. As the volunteer is now on stage, his necktie is removed by one of the demonstrators despite the protests of volunteer which serve to distract the attention of the audience from the first "scientist" who makes a switch in the containers of "fire water". When the new necktie is immersed in the new solution, it burns quite harmlessly. If it appears the tie may smolder a bit, it can be put out by stroking it quickly with the fingers and returned to the owner unharmed.

The harmless nature of the flame may be further demonstrated by pouring the solution onto the hand of one of the persons (even the volunteer) and with the stage lights extinguished give a very colorful demonstration of a flaming hand.

Preparation:

The correct solution is a 50-50 mixture of carbon disulfide and carbon tetrachloride. The proportions may be varied slightly to give the desired temperature of burning. If the solution burns a bit too "hot", more carbon tetrachloride is added. If the solution fails to burn, more carbon di-sulfide is added. The solution should not be prepared far in advance and stored; furthermore, it should be tested each time to insure against a failure due to unequal evaporation of either of the two solvents on standing.

The first solution in which the article is burned up can be alcohol, which by its' odor distinguishes it from the correct solution which will further insure against mistakes on stage.

2.4 SPONTANEOUS COMBUSTION[6]

Procedure:

A test tube which seems to be perfectly cool is unstoppered and as the contents are thrown out across the stage, they burst spontaniously into flame.

Preparation:

Six and six-tenths grams of pure lead nitrate are dissolved in fifty ml. of water and four and two-tenths grams of sodium potassium tartrate (Rochelle Salts) are dissolved in fifty ml. of water. The lead nitrate solution is added to the sodium potassium tartrate solution and the precipitated lead tartrate is filtered by suction through ordinary filter paper, dried carefully in an oven and ignited

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[6] J.O. Frank and Guy J. Barlow, Mystery Experiments and Problems, Oskosh, Wisconsin, J.O. Frank, 1945, p. 67.

in a dry hard glass test tube (about three-quarters by six inch) until all volatile matter has been driven off. While still hot, a tight fitting stopper is inserted in the tube; the stopper and the entire upper end of the tube is then dipped in molten paraffin. If the tube is air tight the contents may be kept almost indefinitely. When the stopper is removed and the contents thrown into the air, the finely divided lead takes fire spontaneously.

2.5 THE MAGIC CANDLE[7]

Procedure:

A lighted candle and two stoppered bottles are standing on the demonstration table. The operator opens one bottle which appears to be empty but on pouring "nothing at all" upon the candle, it is extinguished. The operator thereupon opens the second bottle and likewise appears to pour "nothing at all" on the candle and it is immediately relighted.

Preparation:

An ordinary candle is used. A bottle of carbon dioxide is used to extinguish the flame and a bottle of oxygen is used to relight it while the wick is still glowing. Care must be taken to use the oxygen quickly.

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[7] ibid., p. 73.

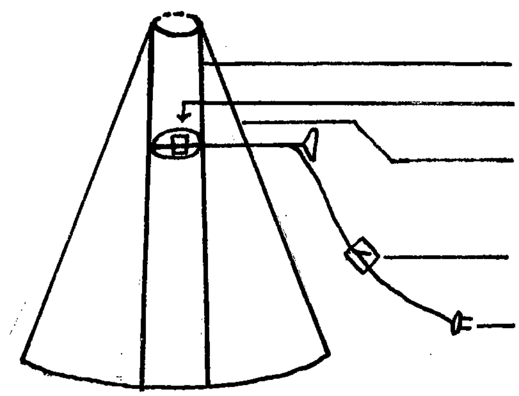
2.6 VOLCANO[8]

Procedure:

Ten grams of ammonium dichromate are poured in the top of the volcano frame (shown in the diagram below), the switch is thrown and when the resistor has had a few moments to heat, a volcanic effect results.

Preparation:

The equipment is arranged as shown in the (cut-away) diagram below:



Since this frame can be used again and again and requires no preparation other than adding the chemical and plugging in the electrical resistor, it is very useful. This equipment can be used with a variety of similar demonstrations. The frame for the volcano is a cone of metal covered with asbestos paper. Down the middle is the stove pipe, near the top of which is the iron disk (similar to the movable damper in a stovepipe) which can be rotated by turning the axle which projects outside the cone--this facilitates emptying the cylinder. On top of this metal disc

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[8]D.C. Evans, "Quickees", Conference of High School Chemistry Teachers, Uni. of Wyoming, Larmie, Wyoming, 1954.

is a 200-watt, 2500 ohm resistor with switch. When the demonstration is completed, the green powdery residue may be dumped out and the equipment is ready for reuse.

2.7 EXPLOSIVE GAS MIXTURES[9]

Procedure:

A can similar to a paint can (with a press-in lid) having a hole in the lid and another in the side near the bottom of the can is placed upright on the demonstration table. The lower hole is connected to a gas outlet by leading a rubber hose from the gas supply to the hole. After the gas has had time to fill the can, it is lit at the top. Withdraw the tube from the lower hole and turn off the gas. After a time when just the right proportion of gas and air is reached, the cover (if pressed in firmly) will be blown to the ceiling.

Preparation:

The can should not be over one quart in size and the effect is more spectacular if the hole in the top is small, about one-fourth inch in diameter.

2.8 PHOTOCHEMICAL EXPLOSION[10]

Procedure:

A piece of magnesium ribbon is ignited and held near an inflated polyethylene bag. As if by magic the bag ex-

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[9] ibid.,

[10] Hubert N. Alyea, "Tested Demonstrations in General Chemistry", Journal of Chemical Education, (August 1956)

plodes, due to exposure to the intense light of the burning magnesium ribbon.

Preparation:

A polyethylene bag (about two by six inches, similar to those used in deep freeze storage) is filled with equal volumes of hydrogen and chlorine, the top tied off and placed on the demonstration table. The explosion which results is due to the photoreactive mixture of the two gases which is ignited by the strong light of the burning magnesium ribbon. If possible bottled sources for the two gases should be used, observing the usual laboratory precautions to prevent air from entering the mixture as oxygen present in only trace amounts will stop this reaction.

CHAPTER III

COLORS

3.1 OLD NASSAU[11]

Procedure:

This demonstration, only one of the many color change reactions, is perhaps best performed before an audience of high school pupils whose school colors are orange and black. It has even been done accompanying a cheer leader leading the student body through their "yell" concerning these two colors. The experimenter uses large cylinders (at least one liter in size) mixing equal volumes of solutions B,C,A, in this order. The colorless solution will change first to orange, which persists for only an instant then flashing to black. Proper manipulation of solutions by pouring the final black solution into combinations of two of the above will produce secondary changes.

Preparation:

Solution "A" contains fifteen grams potassium iodate (KIO_3) per liter; solution "B" contains fifteen grams of sodium bi-sulfite ($NaHSO_3$) plus two grams starch per liter; solution "C" contains three grams mercuric chloride ($HgCl_2$) per liter. The speed of this reaction is so precise that

[11]Hubert N. Alyea, NSTA meeting, Cincinnati, 1955

the time of appearance of the colors can be varied by slight changes in the volume of "C".

3.2 IODINE CLOCK[12]

Preparation:

This demonstration, similar to the preceeding one, uses the clock type--or delayed action type of color change. The color change is only to black however, and the reagents are prepared as follows: Solution "A" is identical to that used in Exp. 3.1, solution "B" is made by dissolving two grams of starch in one-half liter boiling water then add four-tenths grams of sodium bi-sulfite plus five ml. of one molar sulfuric acid and one-half liter of water to the starch solution. Mix equal quantities of solutions "A" and "B", pouring back and forth several times to mix thoroughly. The time of the color change can be varied by varying the proportions of "A" and "B".

3.3 PAINT FROM WATER[13]

Procedure:

This is another delayed action color change. When two beakers containing colorless liquids are poured together no reaction appears to take place. But, apparently at the will of the operator, the liquid suddenly changes to a deep yellow color.

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[12] ibid.

[13] J.O. Frank and Guy J. Barlow, Mystery Experiments and Problems, Oskosh, Wisconsin, J.O. Frank, 1945, p. 54.

Preparation:

The two solutions are made as follows: Dissolve ten grams of sodium arsenite in one-half liter of water. Add fifty-five ml. of glacial acetic acid and stir until thoroughly mixed. Pour two hundred ml. of this solution into two hundred ml. of a solution containing forty grams of sodium thio-sulphate (hypo). In from thirty-five to forty-five seconds the yellow color will suddenly form. The exact time depends upon the temperature when the concentration of each solution is constant.

Explanation:

The color change results from the formation of arsenic sulphide. This is due to the production of hydrogen sulphide by the action of acetic acid on sodium thio-sulphate. The hydrogen sulphide then reacts with sodium arsenite. By giving attention to the concentration and the temperature the change in color may be made to take place within a very definite number of seconds after the two liquids are mixed.

3.4 THE DEVIL'S WINE BOTTLE[14]

Procedure:

The demonstrator runs water from the tap into a bottle. Out of the same bottle the demonstrator then pours: (1) milk, (2) wine, (3) ink, (4) tea, (5) soda water, and (6) water. The liquid in the bottle is hydrochloric acid and ferric

[14] ibid., p. 62.

chloride solution. Demonstrator pours into beakers which seem to be empty since he has just taken them from a carton and removed the tissue paper in which they were wrapped.

Preparation:

Beaker No. 1 contains five ml. of concentrated silver nitrate solution; No. 2 contains concentrated potassium thiocyanate solution; and No. 3 contains five ml. of concentrated tannic acid solution. At this point the demonstrator draws more water from the tap, so that the remaining solution is now very dilute and nearly colorless. No. 4 contains one ml. potassium thiocyanate solution; No. 5 contains five ml. concentrated sodium bicarbonate solution, and No. 6 is empty.

One hundred eighty ml. beakers are used. They may be deposited in holes cut in a thick white cardboard with white paper underneath. It is explained that the white paper is to make the colors more easily observed. The cardboard will thus conceal from the audience the small amount of liquid in the beakers. For the "Devil's Bottle" any odd shaped, green, brown or otherwise opaque bottle may be used.

The hydrochloric acid and ferric chloride solution may be so concentrated as to be highly viscous. Thus the bottle may be inverted as if to empty it of all water just before it is filled the first time.

3.5 PATRIOTIC COLORS

Procedure:

When a colorless liquid is poured from a pitcher into each of three large beakers they turn respectively red, white and blue.

Preparation:

The colorless liquid is dilute ammonium hydroxide. The first beaker contains a few ml. of alcoholic phenolphthalein; the second a little concentrated lead nitrate solution and the third a few drops of concentrated copper sulphate solution.

3.7 ARTIFICIAL SUNRISE[15]

Procedure:

A two liter beaker containing solution "A" is placed on the demonstration table under a floodlight, with a white paper backing, in the path of a parallel beam of light (one-half inch in diameter) from a projector. Solution "B" is added and the resulting solution is stirred. The Tyndall cone appears in about one minute, red transmission in two minutes, and the solution becomes opaque after five minutes.

Preparation:

Solution "A" is made in the two liter beaker as follows: one hundred ml. of one molar sodium thiosulfate (hypo) is added to nine hundred ml. of distilled water. Solution "B" is made by mixing thoroughly one hundred ml. of three molar

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[15]Hubert N. Alyea, "Tested Demonstrations in General Chemistry", Journal of Chemical Education, July, 1956

hydrochloric acid plus nine hundred ml. of distilled water in a one liter beaker.

Procedure No. 2:

Another demonstration showing the effect of precipitation of colloidal sulfur as a means of filtering light is very similar to that given in No. 1, except that the time of appearance of the various effects is much longer, due to the lowered concentration of the reactants. The two liter beaker is located as above. In this procedure the solutions will be referred to as "C" and "D" to avoid confusion. To solution "C" in the two liter beaker is added solution "D". The Tyndall cone appears in four to five minutes, in about eight minutes opacity increases with the transmission being orange in fifteen minutes, red in thirty minutes, magenta in forty-five minutes, violet in fifty minutes and blue in sixty minutes.

Preparation No. 2:

Solution "C" is made by mixing exactly five ml. of one molar sodium thiosulfate with nine hundred ninety-five ml. of distilled water in the two liter beaker. Solution "D" is prepared by mixing exactly five ml. of three molar hydrochloric acid with nine hundred-ninety five ml. distilled water in a one liter beaker. Solution "D" is poured into "C" and thoroughly stirred. The time of the effects are as noted above.

Explanation:

These two demonstrations are best performed in a darkened room and because of the time involved for full production of the colors, especially of the latter demonstration, something should be planned to fill in the time with occasional observances of the colors. All glassware must be washed with chromic acid cleaning solution and rinsed thoroughly with distilled water.

3.7 COLORED CLOCK REACTIONS[16]

Procedure:

Production of delayed formation of red and white colored solutions are as follows: To one hundred fifty ml. of distilled water in a beaker add fifty ml. of solution A, one ml. of phenolphthalein indicator and then fifty ml. of solution B. The time of appearance of the red color may be varied by varying the ratio of solutions A and B (up to 1:1). If white is desired a five per-cent solution of cadmium nitrate is substituted for the distilled water.

Preparation:

The required solutions are: solution A--twenty grams of sodium metabisulfite, three grams of sodium sulfite (anhydrous), water to make one liter; solution B--ninety ml. of formalin solution (37%), diluted to one liter; Phelolphthalein indicator--ten grams phenolphthalein in five hundred ml. of ninety-five per-cent ethyl alcohol and water to make one liter; five per-cent cadmium nitrate--fifty grams

[16]E.B. Dutton and Gil Gordon, "Colored Clock Reactions", Journal of Chemical Education, Vol. 34, No. 7, (July 1957), p. A303.

cadmium nitrate in water, diluted to one liter.

Thymolphthalein or other indicators may be used for different color changes. If a universal indicator is used, a series of colors may be observed.

Explanation:

The reactions suggested are:

(1) $HCHO + HSO_3^- \longrightarrow CH_2OSO_3^-$

(2) $H_2O + HCHO + SO_3 \longrightarrow CH_2OSO_3^- + OH^-$

(3) $OH^- + HSO_3^- \longrightarrow SO_3^= + H_2O$

Reactions (1) and (2) are rate determining, but reaction (3) is virtually instanteanous. Thorough stirring is essential to obtain sharp changes. The reaction time may be shortened by raising the temperature; each 10°C rise approximately doubles the rate.

3.8 DISPLACEMENT OF HALOGEN GASES[17]

Procedure:

Place the cylinders as shown in the diagram, on a light box--or some source of light. Remove the glass plates separating the cylinders, steadying the cylinders with the hands since heat is generated and there is a temporary expansion of the gas within the cylinders. Purple iodine vapor appears immediately, accompanied by an occasional flash of light. Subsequently sparkling iodine crystals are formed and rain down through the lower cylinder. Brown liquid iodine and iodine chloride (ICl) are visible on the

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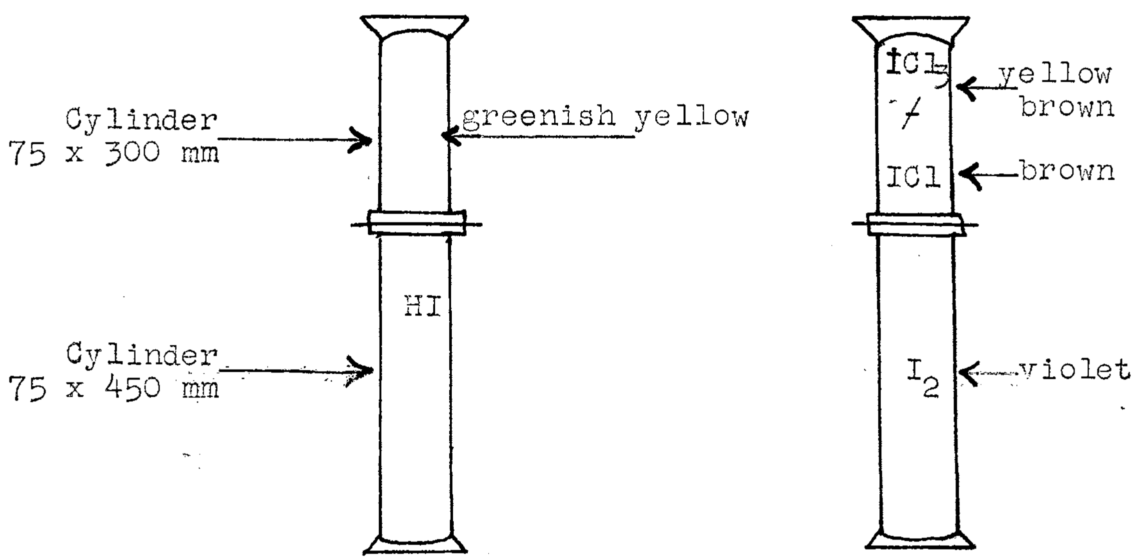
[17] Col. E.C. Gillet, Jr., "Displacement of Halogen Gases", Journal of Chemical Education, Vol. 34, No. 6 (June 1957) p. A265.

cylinder walls and iodine trichloride (ICl_3), which is yellow, may be seen at the top of the cylinder.

Preparation:

For this demonstration one ungraduated glass cylinder approximately seventy-five mm. in diameter and three hundred mm. tall and a second of the same diameter but four hundred-fifty mm. tall are necessary. These are set up as shown in the diagram. Fill the small cylinder about two-thirds full of chlorine gas. This may be used directly from commercial cylinders or if generated, it must be dried in the usual fashion (by passing it through anhydrous calcium chloride). Fill the large cylinder with dry hydrogen iodide gas. Cover both cylinders with well greased glass plates. Arrange a light box to illuminate the cylinders from the bottom.



To prepare the hydrogen iodide, forty grams of iodine crystals and five grams of red phosphorus are placed in a five hundred ml. Erlenmeyer flask fitted with a small separatory funnel and a glass delivery tube leading to two U-shaped drying tubes containing red phosphorus on glass chips or wool and calcium chloride, respectively. Addition of ten drops of water from the separatory funnel will start the reaction. (Not more than twenty drops for the complete reaction). Heat gently with a Bunsen burner as required.

3.9 FLUORESCENT SOLUTION[18]

Procedure:

A fluorescent or glowing solution can be effected as follows: Darken the room completely and pour solutions A and B through a large funnel--a glowing solution will be formed which is allowed to pass into a large Erlenmeyer flask. The solution is then poured into beakers once more. As the glowing begins to fade it may be restored by adding solid crystals of potassium ferricyanide or additional aequous sodium hydroxide. The solution may also be poured into a plastic stoppered bottle and passed through the audience or poured into one limb of a U-tube. Also, a towel may be dipped in the solution and rinsed over the sink.

Preparation:

Solution "A" consists of one-tenth gram of luminol (3-amino-phthal-hydrazide) plus five ml. of five per cent sodium hydroxide plus one liter of water. Solution "B" is made of ten ml. of three per cent hydrogen per-oxide plus twenty-five hundredths gram of potassium ferricyanide plus

[18]Hubert N. Alyea, "Tested Demonstrations in General Chemistry", Journal of Chemical Education, (July, 1955).

one liter of water. Caution: Care must be exercised in this demonstration to avoid any of the solution splashing onto one's clothing as it contains sodium hydroxide.

3.10 LIGHTING A NEON TUBE WITH A MATCH

Procedure:

If a neon tube is suspended in the middle of the stage and connected to a variable power supply which is set just below the voltage required to illuminate the tube. Then, when a lighted match is held under the tube, the release of free electrons by the match will cause the tube to glow.

3.11 A FLAMING WELCOME

Procedure:

A program may be introduced by having an assistant paint with a small brush the word "Welcome" onto a piece of paper suspended from wires over the center of the stage. By the time they are finished the word bursts into flame. The paper is allowed to fall to an asbestos or metal mat on the floor, which may be covered with wet towels.

Preparation:

The solution consists of yellow phosphorus dissolved in carbon disulfide. Caution: Extreme care must be exercised in handling yellow phosphorus and the assistant must be careful to put the brush back into the solution as soon as finished. Do not allow any of the solution to get on the clothing or hands.

CHAPTER IV

MECHANICAL DEVICES

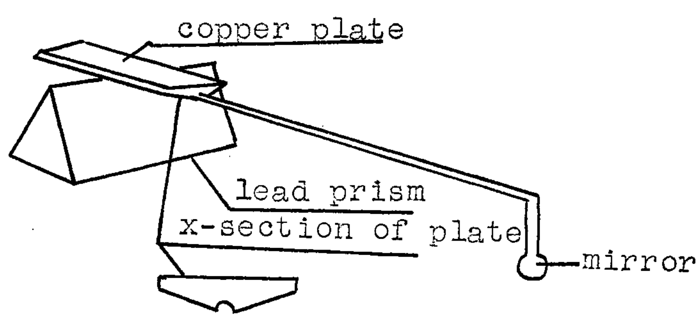
4.1 TREVELYAN ROCKER[19]

Procedure:

A prism of lead is placed on the demonstration table. A heated bar or rocker of copper or brass is laid upon the lead prism in such a way as to cross the edge at right angles. The bar of copper immediately begins to rock rapidly back and forth producing a humming sound. A small mirror may be attached to the handle of the copper bar, and a beam of light reflected on the wall making the motion apparent to a large audience.

Preparation:

The equipment is arranged as shown in the diagram below.



The lead prism is two and one-half inches long, the ends forming a one inch equilateral triangle. The sides are

[19]Richard M. Sutton, Demonstration Experiments in Physics, New York, McGraw-Hill Book Co., Inc., 1938, p. 202.

planed or filed so that the edges are very even and sharp. The bar is two and one-half inches long, one and one-half inches wide, and five-sixteenths inches in thickness at the center, tapering off toward the edges to one-eighth inch in thickness. One side is perfectly flat while the other is flat at the center through a width of three-eighths of an inch and with a groove running from one end to the other. A rod may be screwed into one end of the copper bar as shown in the diagram, in such a way as to keep it horizontal to the table and permit it to rock easily. Care must be taken to heat the copper to a temperature not much higher than the melting point of lead (327°C). It will be found that the bar will not rock at some points along the edge of the lead prism but with a little experimentation good results will be obtained and a distinct humming sound will be produced.

Explanation:

This experiment is perhaps most effective when given a straightforward explanation. The specific heat of copper is about three times that of lead, and the coefficient of expansion of lead is about one and one-half times that of copper. When the hot copper bar is resting on the lead prism it is touching it in two places. On one spot it is pressing more heavily than on the other so the heat is being transferred more rapidly. Thus the lead explands at this point, raises the bar of copper and transfers its' weight to the other point of contact. After the shift of weight the lead cools at the first point of contact and heats at the second, raising the copper bar at that point and shifting the weight again to the first point of contact. Thus the shift of weight occurs many times a second. The slight blows struck as the weight shifts from one point on the lead prism to the other is the cause of the sound given off. It should be mentioned once more that both rocker and lead block should be polished, perhaps with fine emery, at the points of contact.

An interesting variation of the above experiment is achieved by substitution of a block of dry ice for the lead block. The evolution of gas from the solid carbon dioxide (due to heat absorbed from metal in contact with it) may be used to vibrate the rocker. An iron rod or a silver teaspoon may be used instead of the copper bar. Rest one end of the rocker on the piece of dry ice, the other end on the lecture table. Upon being jarred slightly there ensues a high pitched vibration.

4.2 GIANT PENDULUM

Procedure:

A simple demonstration with a great deal of audience appeal is found in this pendulum experiment. A pendulum consisting of an iron ball weighing from one to five pounds is suspended by a piano wire from the ceiling in the center of the stage. The length of the pendulum is such that the ball just touches the nose of the volunteer who is seated at one side of the stage with the back of his head resting against the wall, piano, or some similar object so that it cannot be moved backwards. The ball is drawn up to his nose and

and allowed to swing free. The ball, of course, swings to the other side of the stage and returns to within a fraction of an inch of the person's nose. Care must be taken in releasing the pendulum that it travels straight out and also that it is not given any acceleration during release!

4.3 FOUCAULT PENDULUM[20]

Procedure:

Another pendulum demonstration, perhaps which should be set up somewhere other than in the same location as the previous one (4.2) illustrates or gives proof of the rotation of the earth. This pendulum can be started at the beginning of the program and observed at the end to show the desired result.

Preparation:

A simple and effective method of supporting the pendulum so that it may be free to swing in any plane is to use piano wire clamped at the top and passed through a circular hole (of diameter slightly larger than that of the wire) in a horizontal steel plate rigidly mounted a short distance below the clamp. This eliminates the necessity of using a more complex knife edge or ball-bearing support. The ball is drawn aside by a thread, and after all motion is damped out it is set swinging by burning the thread.

Explanation:

Its' plane of oscillation may be observed to rotate

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[20] ibid. p. 90-1.

slowly with respect to the floor of the room at a rate equal to the vertical component of the earth's rotation ($15^{\circ} \sin \lambda$ per hour, where λ is the latitude) and in the opposite sense. The rotation will therefore be clockwise in the northern hemi-sphere as viewed from the point of support and counter clockwise in the southern. The magnitude of the motion is readily observable in the course of an hour in the middle latitudes, provided the initial plane is marked.

The change in plane of oscillation of the bob may be shown by shadow projection of the motion of a small bead attached to the pendulum wire. The light should be placed as far as possible from the bead. The pendulum is started in a plane parallel to the direction of the light so that the shadow of the bead moves only along a vertical line on the wall. After a few minutes, the shadow shows an appreciable lateral motion that increases in amplitude as time elapses, and the component of motion perpendicular to the original plane of oscillation increases.

4.4 JUMPING RING[21]

Procedure:

An aluminum ring placed on top of a primary coil of a transformer will be thrown into the air when the circuit is closed. Two volunteers are used, the first is handed a split ring (of which the split may be filled with putty or

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[21]ibid., p. 349.

some other non-conducting material and then painted). This dummy ring will fail to show any action. The second volunteer is asked if he can hold the ring on the coil. He is given a closed ring for this trial. The temperature built up in the ring makes this impossible.

Preparation:

The primary coil is made by wrapping two hundred turns of No. 14 wire about a cardboard core whose outside diameter is eight cm. The height of the coil is about six inches.

CHAPTER V

MISCELLANEOUS DEMONSTRATIONS

5.1 A DISAPPEARING SOLUTION[22]

Procedure:

This demonstration uses the same reagents as were required in 4.2 Burning Ice. The operator shows two aluminum beakers and two glass beakers, each being of two hundred fifty ml. capacity. The aluminum beakers are declared to be empty and may be examined by the audience. The glass beakers appear to contain colorless liquids, as shown by the fact that the liquids may be poured into the aluminum beakers and back again. When, however, the glass beakers are emptied into the aluminum beakers, and one aluminum beaker emptied into the other, all the beakers may then be placed on the desk, bottom upward and no liquid will run from the beakers.

Preparation:

One of the glass beakers contains 15 ml. of a saturated solution of calcium acetate, the other 85 ml. of absolute alcohol. When these are poured together and mixed, the solution solidifies and in a moment the beakers may be inverted without having any liquid escape.

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[22]J.O. Frank and Guy J. Barlow, Mystery Experiments and Problems, Oskosh, Wisconsin, J.O. Frank, 1945, p. 52.

5.2 MOIBUS TAPE

Procedure:

An interesting demonstration is made by fastening the ends of a strip of paper four inches wide and twenty inches long together after first making a half twist in the paper. Then the person announces he is going to cut or split his ring into as many rings as possible. By cutting down the middle of the strip he finds on completion of the initial cut he has, not two rings, but a single large one. Upon repeating this he finds the same result, i.e., one ring twice the size of the preceding one with a half twist in it. Continuation of this procedure a few times with an initial strip of the size used here will give an impressive pile of paper on the stage, still in the form of a single continuous or endless ring.

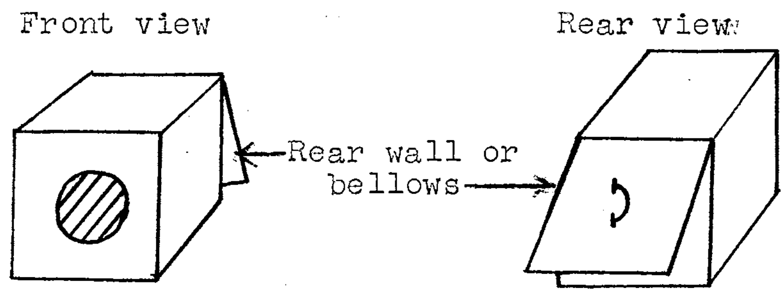
5.3 SMOKE RINGS

Procedure:

Giant smoke rings can be formed and blown to the back of a large auditorium by use of a large cardboard box at least twenty-four inches on edge. The rear wall of the box is hinged and acts as a bellows to pump or force the rings out of the box.

Preparation:

A six inch circular hole is cut in the front wall of the box. The box is then sealed and the side opposite the hole is cut open on three sides, leaving the top edge intact,



as shown in the accompanying diagrams. This hinged rear wall performs the function of a bellows. A handle may be attached to facilitate moving this hinged back at will. The box is placed on stage with a beaker or large evaporating dish containing fifty ml. of concentrated ammonium hydroxide. The operator then places a second beaker or large evaporating dish containing fifty ml. of concentrated hydrochloric acid into the box and he then begins to operate the hinged back with short regularly spaced strokes which result in large regular "smoke rings" of ammonium chloride which will remain intact and attain a diameter of as much as three feet. Caution: Care should be taken to keep the hydrochloric acid out of the box until one is ready to start the experiment to prevent premature production of "smoke".

5.4 TOUGH SOAP FILMS AND BUBBLES[23]

Preparation:

Many experiments which require soap bubbles (2.1 Exploding Bubbles) are more successful if the film is stronger than those usually formed with soap or detergent alone.

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[23] Hubert N. Alyea, "Demonstration Abstracts", Journal of Chemical Education, Vol. 34, No. 3, (March 1957) p. A138.

Therefore, it is thought advisable to include some of the more simple methods of preparing them.

(a) Prepare a stock solution of two grams of waxy solid Aerosol O.T. (100%) plus ninety-eight grams of distilled water; shake occasionally for twenty-four hours (the solution will still be cloudy). For solid bubbles; mix twelve grams sucrose plus twenty-five ml. stock solution. For elastic films for bubbles; mix twenty grams sucrose or dextrose plus thirteen and one-half ml. glycerol plus twenty-five ml. stock solution, warm gently to hasten dissolving.

(b) Stir triethanol-amine with a little less than twice its weight of oleic acid; age in a stoppered bottle for twenty-four hours; mix thirty ml. of this with a liter of distilled water; let stand for twenty-four hours, siphon off the lower, light-grey layer and mix with three-tenths its volume of glycerine; age twenty-four hours and store in a well stoppered bottle in the dark.

(c) Use ten grams Aerosol O.T. aequous 10% (American Cyanamid and Chemical Co.,) plus two grams Tensol (Synthetic Chemicals, Inc.,) plus ten grams glycerine plus eighty ml. of water.

(d) Dreft solutions are sometimes adequate, being more satisfactory than soap solutions, especially in hard water.

5.5 LOW TEMPERATURE EXPERIMENTS

Procedure:

A rubber ball placed in a low temperature medium for three minutes will explode when dropped onto the floor. A coil of fuse wire immersed in liquid air (or other low temperature medium) becomes elastic, with all the action of a coiled spring when removed. An iron ball attached by a wire to an insulated handle when removed from the liquid air and held in a Bunsen flame attains a coating of frost. Liquid air may be used to charge a test tube, which when held in the hand will shoot corks out at the audience almost as rapidly as they are placed over the mouth of the test tube.

Preparation:

If liquid air is unavailable, a mixture of acetone into which lumps of dry ice are placed may be used as the cooling medium. Liquid air is of course more versatile and should, if possible, be used.

5.6 DISAPPEARING SPOON

Procedure:

A member of the audience is invited to the platform to assist in the experiment.. As the experiment is not quite ready he is asked to sit down and have a cup of coffee while waiting. He, therefore, is handed a beaker or cup of hot water, a jar of instant coffee and a spoon. He will very shortly become aware as he stirs the coffee that the spoon is getting shorter. When he finally pulls it out of the coffee he discovers he has only the handle--or part of it!

Preparation:

The spoon is specially prepared from either Wood's or

Rose metal (low melting alloys). The formulae of either of these alloys may be found in any handbook. The mold in which the spoon is cast is made of plaster of paris.

5.7 FOCUSING BY RADIATION[24]

Procedure:

Many laboratories are equipped with a pair of large parabolic reflectors for use in heat, sound, and light experiments. The two reflectors may be so arranged as to reflect the radiation of a red-hot iron ball. The reflected heat may be used to light matches, warm a thermostat hooked in series with a dry cell to ring a bell or turn on a light, or even explode a small balloon filled with hydrogen and oxygen.

Preparation:

The two reflectors are arranged several meters apart so that when the hot iron ball is placed at the focus A of one reflector, the radiation comes to a focus at point B after reflection from the second mirror. Point B may be located by observing the visual image of the red-hot object. The objects used to show the effect of focusing the heat waves are located at point B.

Screens of glass or other absorbent material may be interposed between the two mirrors. A sheet of black cell ophane transmits the infrared but cuts out practically all the visible radiation.

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[24]Richard M. Sutton, Demonstration Experiments in Physics, New York, McGraw-Hill Book Co., Inc., 1938, p. 238.

5.8 FOCUSING OF INFRARED RADIATION[25]

Procedure:

Place a two hundred-fifty ml. spherical flask full of an opaque solution of iodine in carbon di-sulfide immediately in front of the projection lens of an arc lantern. The flask serves as a crude lens that focuses the infrared from the arc but cuts off all visible radiation. It is very easy to locate the focus of the system by moving the hand about in the region in front of the flask (it should be very hot, if not, get a hotter arc). A piece of black paper held at the focus will glow and catch fire; blackened safety matches will be ignited at the same spot. By contrast, a water filled flask passes visible radiation but absorbs the infrared. Its' focus is not as hot as that of the former.

5.9 PERSISTENCE OF VISION

Procedure:

The program may well be ended by having a lantern slide projector equipped with a slide with the words "The End" cut in fairly large letters. This may be just thrown out over the heads of the audience and not focused on anything in particular. When a person waves a white wand in front of the projection, the words appear as if by magic on the wand due to the persistence of the image by the eye.

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[25] ibid., p. 238.

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