

A List of Demonstration Experiments in Physics Suitable for Lecture Table Use in First and Intermediate College and University Courses

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This list constitutes a resumé of demonstration experiments in physics, original, wholly or in part, with the author during his 34 years connection with the department of physics, University of Illinois. Many of the items listed have been presented down through these years before the physics sections of the Illinois State Academy of Science and also the Indiana Academy of Science. Five were exhibited, by invitation, at A Century of Progress, Chicago, 1933 and 1934. A number also have been used by the author in demonstration lectures before educational and civic organizations throughout Illinois and neighboring states, and also before the Science Exhibit section sponsored the past four years by the American Association for the Advancement of Science, notably at its New Orleans, Pittsburgh, St. Louis and Atlantic City meetings. The list of workable experiments is fairly complete and is here given for the first time.

- 1 Bicycle wheel gyroscope. This well known lecture table demonstration was first described by the writer in 1901. See *Phys. Rev.*, XIII, p. 43, Jan., 1901.
- 2 A method of maintaining intermediate temperatures. *Phys. Rev.*, XV, p. 125, Aug., 1902.
- 3 A simple cloud apparatus. A beautiful experiment to show cloud formation. Suggested by C. T. R. Wilson's cloud researches. *Science*, XXX, p. 930, Dec. 24, 1909.
- 4 An efficient and rapid mercury still. The mercury is vaporized in the electric arc. (A physics shop apparatus). *Science*, XXXIII, p. 667, Apr. 28, 1911.
- 5 Hot lime (Wehnelt) cathodes. The cathode ray beam from the hot lime shows the Crookes and Faraday dark spaces, and how these vary with the temperature and also with the voltage. The tube shows the effect of positive and negative acceleration as they affect the magnetic deflection of the beam.
- 6 The production of a helix of rays from the hot lime cathode. A long horizontal tube. Beam along the axis. The tube is surrounded by a loosely wound solenoid. The resulting helix is interesting and its deformation by compressing or extending the loosely wound solenoid is striking. *Phys. Rev.*, XXXIV, p. 58, Jan., 1912.
- 7 Hot lime cathode. To show circular path of beam in a uniform magnetic field at right angles to plane of circle.
- 8 Hot lime cathode ray beam to show the aurora borealis (northern lights). Rather complicated but very convincing.

- 9 The diffusion of gas at low pressures made visible by color effects. Science, XLII, p. 93, July 16, 1915.
- 10 Absorption of air by charcoal cooled to the temperature of liquid air. A striking lecture table demonstration. Science, XLII, p. 429, Sept. 24, 1915.
- 11 Color effects of positive and of cathode rays in residual air, hydrogen, helium, etc. (Knipp and Kunz design, was exhibited at A Century of Progress, Chicago, 1933, '34.) Science, XLII, p. 942, Des. 31, 1915; Trans. Ill. Acad. Sci., X, p. 283, 1918.
- 12 Positive and cathode rays in residual helium, hollow triangular cathode. (Kunz design, was exhibited at A Century of Progress.)
- 13 Electrical discharge between concentric cylindrical electrodes. Science, XLIII, p. 787, June 2, 1916.
- 14 Mercury vapor tube, containing pith balls. Tube is highly evacuated. Illustrates Boltzman's Law. (Was exhibited at A Century of Progress.) School Sci. and Math., XVII, p. 442, May, 1917; Trans. Ill. Acad. Sci., X, p. 284, 1918.
- 15 An improved form of high-vacuum high-speed mercury vapor pump. Trans. Ill. Acad. Sci., X, p. 286, 1918; Science, LXXVIII, p. 183, Feb. 17, 1922; Trans. Ill. Acad. Sci., XXI, p. 212, 1928.
- 16 An old form of top revived. A simple, powerful and long spinning top. School Sci. and Math., XX, p. 113, Jan., 1920.
- 17 Possible standard of sound. Phys. Rev., XV, p. 155, Feb., 1920; Ibid., XV, p. 244, Mar., 1920.
- 18 A convenient form of the new singing tube. School Sci. and Math., XX, Dec., 1920.
- 19 Production of sound by the application of heat (singing tube). Trans. Ill. Acad. Sci., XIV, p. 21, 1921; Nature, CXX, p. 362, Sept. 10, 1927.
- 20 Production of sound by cooling. The entire singing tube, except the closed *tip*, is cooled to the temperature of liquid air. A very striking experiment.
- 21 Simple form of C. T. R. Wilson's alpha-ray track apparatus (with N. E. Sowers). Trans. Ill. Acad. Sci., XVII, p. 121, 1924.
- 22 Improvement in alpha-ray track apparatus. (Was exhibited at A Century of Progress). Science, LXIV, p. 140, Aug. 6, 1926.
- 23 Electrodeless ring discharge (with L. N. Scheurman.) Trans. Ill. Acad. Sci., XXII, p. 365, 1929.
- 24 Electrodeless discharge (with J. K. Knipp.) Phys. Rev., XXXVIII, p. 948, Sept. 1, 1931.
- 25 Photoelectric cell (Kunz design and patent.)
- 26 High-speed high-vacuum air pumping outfit for lecture table demonstrations, using the writer's internal type of water cooled mercury vapor pump.
- 27 High-potential low-frequency outfit. To produce low potential A. C. discharges and operate ladder experiment.
- 28 High-potential high-frequency outfit. To operate disruptive discharges, electrodeless discharges, active nitrogen experiments, etc.
- 29 Active nitrogen experiments. Afterglow lasts 15 to 30 minutes. In one bulb, it lasted 3 hours. (Was exhibited at A Century of Progress.)
- 30 Liquid oxygen experiment. The gas oxygen under pressure is cooled to the temperature of liquid air, and liquid oxygen results. It is blue in color.

- 31 A cold cathode rectifier. Trans. Ill. Acad. Sci., XXIX, p. 209, 1936.
 32 To show that electrons leave the surface normally. A simple and new experiment, of a long accepted phenomenon, strikingly shown.

Finally, a short series of experiments suitable for lecture table demonstration that might be styled, "Sleight of hand in physics" (15 to 20 min.)
 The subject is:

SINGING TUBES

- a) Long tube (about 1.5 x 70 cm.) Heat closed tip.....Result is a tone of low pitch.
- b) Two short tubes (about 2.5 x 25 cm.) Heat closed tips simultaneously. One tube has sliding trombone for tuning.....Beats, very sharply defined.
- c) Long tube (similar to *a* above.) Open end now closed. Heat closed tip.....Effect is uncanny. Heat again and place cold end firmly on a sounding board....Tube speaks out.
Repeat, with two similar tubes, and place both simultaneously on same sounding board.....Beats.
- d) Two small tubes (about 1 x 15 cm.) One end open. Heat closed tips. Sliding trombone for tuning.....Beats.
- e) One small tube. Body of tube is inserted in a special jacket and cooled to the temperature of liquid air. Tip kept at temperature of room.....Effect is surprising,—the tube sings.
- f) Two small tubes. The body of each is bent in the form of a U. Grasp tip, one in each hand, and lower into liquid air.....Tubes sing. Beats.

Results observed in each of the above cases should be explained.

LECTURE TABLE DEMONSTRATIONS

(The numbers refer to experiments in the preceding list)

3. **Cloud apparatus.**—A spherical glass bulb, with stem, to which a rubber bulb filled with water is attached, forms a convenient means of producing supersaturation by simply squeezing the bulb, then quickly releasing it. The excess moisture obtained on expansion settles on the walls of the vessel or on particles of dust that may be present, thus forming a cloud. Carbon particles from a burning match greatly facilitate cloud formation.
11. **Positive rays.**—The existence of positive and negative ions in an electric discharge through a discharge tube was firmly established about 25 years ago. We thus have cathode rays, positive rays, negative rays, etc. Cathode and positive rays may be simultaneously shown in the same tube by employing a hollow cathode due to Goldstein. By introducing helium as the residual gas, both beams stand out prominently—the cathode rays emanating from the cathode face, while the positive rays seem to pass through the hollow cathode and appear as a compact beam on the opposite side. The cathode rays are apple green in color and are deflected readily by a horseshoe magnet, while the positive rays are red and not visibly deflected. The mass of the positive ion is about 7,000 times that of the electron.
19. **Singing tubes.**—Singing tubes were exhibited by the author at Rockford sixteen years ago. To make one of these tubes sing a temperature difference between the closed tip and the body of

the tube is required. This is usually obtained by applying heat to the closed tip, making the temperature difference about 350°C . A temperature difference sufficient to cause the tube to sing may also be obtained by holding the tip in one's fingers and submerging the rest of the tube in liquid air. The temperature difference now is about 200°C ., with attendant lowered pitch.

30. **Liquid oxygen.**—Liquid oxygen may readily be produced by making use of the principle of lowering the temperature of a gas under pressure until condensation results. The bulb with its stem contains the gas oxygen at a pressure of about 2.5 atmospheres absolute. By placing the stem in liquid air the gas is condensed on the walls of the vessel and collects as a liquid at the lower end of the stem. This action continues until nearly all of the gas is liquified—until the pressure in the bulb falls to about .25 of an atmosphere. Liquid oxygen is quite blue in color.
24. **Inductive effect.**—An electrodeless discharge is always interesting. The energy in the exciting coil around the bulb induces a current in the gas within it. This induced current may in turn be used as a primary of an air transformer and induce a current in its secondary, which may well consist of a few turns of a copper wire circuit containing two or three pea flash light bulbs. This experiment gives one some idea of the energy flowing in the gaseous circuit. Ordinarily we think of the electric current in a gas as being very small.
29. **Active nitrogen.**—Some gases exhibit an afterglow of definite color when the exciting energy is applied (as in experiment 24 above) and then cut off. The gas nitrogen is unique in this quality. The applied energy causes some of the gas molecules to pass into a meta-stable state. While this is going on energy is radiated with attendant color. The electrons thus displaced within the molecules of gas require considerable time to return to their equilibrium positions. Energy is again radiated. The bright lemon color is peculiar to nitrogen. The afterglow may last for many minutes.