Title: Apparatus of Joseph Priestley

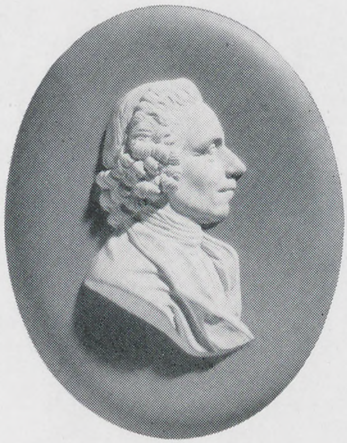
Date: 1952

Location: Priestley Collection

Apparatus of

JOSEPH PRIESTLEY

The Discoverer of Oxygen
Preserved in the Collections of
Dickinson College



PRIESTLEY MEDALLION, BY WEDGWOOD

DICKINSON COLLEGE
Carlisle, Pennsylvania

JOSEPH PRIESTLEY

Replica of the Priestley statue at Birmingham, England, dedicated August 1, 1874, to commemorate the 100th anniversary of the discovery of oxygen.

INTRODUCTORY

SOME OF THE FINEST and historically most interesting of the pieces of apparatus once owned and used by the distinguished scientific investigator and philosopher—the Discoverer of Oxygen—Doctor Joseph Priestley, have been in the possession of Dickinson College for nearly a hundred and fifty years.

There can be no doubt of their authenticity, as they came directly from his laboratory at Northumberland, Pennsylvania, shortly after his death, selected for the College, as will appear, by his life-long friend and associate, the noted Thomas Cooper, newly-appointed Professor of Chemistry and Natural Philosophy. This was in 1811.

In 1874, when some of the Priestley equipment was still in active use in the College laboratory, a number of the leading chemists of America met near his grave at Northumberland to do honor to the man who had discovered oxygen a century before. From this meeting, and the observance of this anniversary, emerged the American Chemical Society.

The occasion was one of international interest, for a part of the proceedings at Northumberland, embracing historical addresses by distinguished scientific men, was an exchange of greetings by cable with the English chemists gathered at Birmingham, England, where a statue of Priestley was being unveiled to commemorate his great discovery.

I. THE BURNING-GLASS

The large compound burning-glass has been the least used but the most revered of the Priestley apparatus at Dickinson College—revered not only as a relic of a great man and a great discovery, but as a symbol, for the College, of its own unending search for truth. It is composed of two lenses, respectively 16 inches and 7 inches in diameter, set in a wooden frame with centers 16 inches apart. Frame and lenses are supported on a three-legged base such as that of an old-fashioned candle-stand, and arranged to permit both horizontal motion and the adjustment of its angle to the altitude of the sun. *(See Page 12.)*

THE BURNING-GLASS

It was through this glass, or one like it, on August 1, 1774, that Priestley focused the sun's rays upon a tube containing *"mercurius calcinatus per se"* (Hg0) and thus obtained a new gas "in which a candle burned with a remarkably vigorous flame." Having answered his first question about this new gas, its relation to combustion, his next was: How does it affect life? A mouse immersed in it seemed to live faster. He tested it then upon himself. In 1775, Priestley told of his discovery in these words: "The feeling of it to my lungs was not sensibly different from that of common air; but I fancied that my breast felt peculiarly light and easy for some time afterwards. Who can tell but that, in time, this pure air may become a fashionable article of luxury? Hitherto, only two mice and myself have had the privilege of breathing it."

Priestley called his new gas "dephlogisticated air." Some years later the French chemist, Lavoisier, named it oxygen.

But Priestley had not merely discovered a new gas. He had opened up entirely new lines of thought and investigation, and these in a short time led to new theoretical views. No single discovery in science, in any branch, marks more sharply the separation of the new from the old. The discovery of oxygen marks the beginning of the new epoch of Modern Chemistry.

Priestley's burning-glass represents not only a new discovery, but the subversion of a theory that had hitherto controlled and directed the investigations of scientific men. Whatever its sentimental interest, the double lens must seem to us inadequate, trifling and inconvenient as a source of heat. So it is—although in good sunlight strips of sheet zinc volatilize when drawn through its focus. But to Priestley it was much more than a source of heat. Its employment in some investigations was based on a dominant theoretical conception of that day that may seem almost fanciful to us. All chemical science of the period turned around the explanation of the mysterious phenomenon of combustion, no less mysterious today than it was then, though our explanation may be more in accordance with facts.

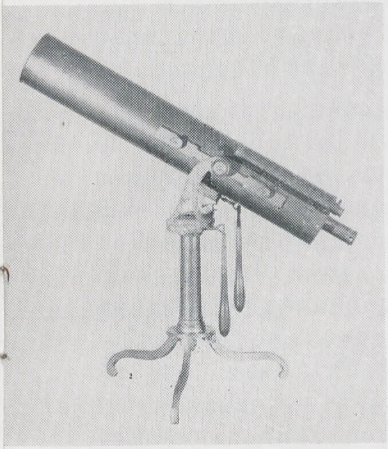
Why does charcoal, or wood, or anything burn? What is taking place to produce the light and heat? The chemists of that day said: When charcoal burns something is escaping from it and that escape, somehow, occasions the heat and light. That something which escapes they called "Phlogiston." The more rapid the escape of phlogiston, the more vigorous the combustion; the richer a substance was in phlogiston, the more combustible it was. They recognized, too, a similarity in the change that some metals experienced in the air, especially when heated; and they called what resulted the calx of the metal. So the rusting of iron was due to the escape of phlogiston, and by restoring the phlogiston they could recover the iron from the rust. But phlogiston was a purely hypothetical substance. It had never been isolated. But in all their investigations it must nonetheless be reckoned with and carefully watched. As charcoal, their chief source of heat, was very rich in phlogiston, they could not tell what part this escaping phlogiston might play in their experiments and how it might interfere with their results. Not knowing the source of the heat of the sun, they assumed that sunlight was, or at least might be, free from phlogiston. So they made large burning-glasses, and mirrors-of-force, to avail themselves of the heat of the sun. Thus Priestley, in a letter to Franklin from Birmingham, wrote: "Having at length got sunshine I am busy in prosecuting the experiments about which I wrote you."

In his record of his discovery of oxygen he tells how he produced his heat by a burning-lens "of considerable force." This lens may have been destroyed in the burning of his laboratory in 1791, but it is possible that it was brought to America with him, and is the one used by him at Northumberland, now in the possession of the College.

He was already expert in experimenting with gases and collecting them. He placed a compound of mercury in the focus of the lens, and noticed that a gas was released. The test of the flame with his new gas convinced him that this new air had less phlogiston mixed with it than atmospheric air. So it was greedy for phlogiston and took it more rapidly out of combustibles. To Priestley the remarkable thing was that he had discovered what he had believed impossible—an air having less phlogiston than the atmosphere. And he named it "Dephlogisticated Air."

This was the Phlogiston period. No one questioned its existence. It could be made to explain almost anything. But someone with a broader curiosity weighed a piece of iron, and then the rust resulting from it, and found that the rust weighed more than the iron, in spite of the escape of phlogiston. This was a troublesome fact, but the theory was easily made equal to its explanation. Phlogiston was a purely hypothetical something, not exactly substance, and could have any property imputed to it that might be necessary. So, said the chemists, phlogiston is specifically light. It has negative weight. It may be attracted more by the heavenly bodies than by the earth, so that when it leaves a body what is left will be heavier. But this explanation became more and more unsatisfactory as experiments went on. A new school of chemists led by Lavoisier explained combustion as combination, not separation—and the Quantitative period of Chemistry was ushered in. Priestley's burning-glass stands between these eras—both relic and symbol of the passing of the old, and the key which unlocked the doorway for the new.

II. THE REFLECTING TELESCOPE



THE REFLECTING TELESCOPE

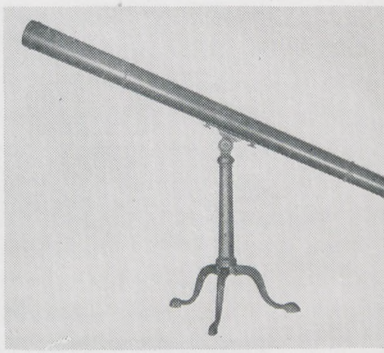
Priestley's reflecting telescope, of the Gregorian type, is a handsome piece of apparatus, and still in excellent condition. The main mirror, 5 inches in diameter, is mounted in a substantial brass tube of the same diameter, 2½ feet long. It is supplied with all the necessary accessories and adjustments, and the whole is firmly mounted on a brass tripod. The makers' name, "W. & S. Jones, 135 Holborn, London," is conspicuously engraved on it.

III. THE REFRACTING TELESCOPE

An achromatic refracting telescope, believed to have been Priestley's, is probably one of the first achromatic telescopes made. John Dollond, its maker, was the first to achieve that which from the time of Newton was regarded as impossible in optics, the production of an achromatic lens. The telescope is four feet long, and mounted also upon a brass tripod.

In earlier telescopes the images were blurred, due to the fact that a simple lens deviates the light of different wave-lengths by different amounts. Because of this the image is fringed with color, a defect known as chromatic aberration which Newton was unable to overcome.

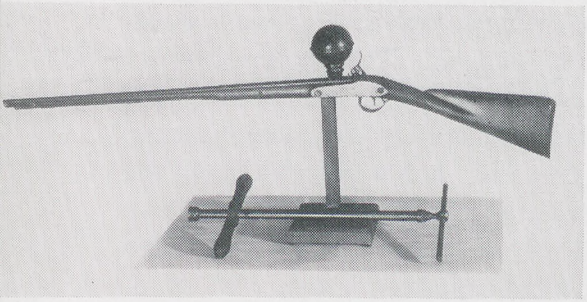
In 1758 John Dollond, by combining into one lens two lenses made of different kinds of glass, made the first achromatic lens, and thus achieved the first image free of color-fringe. All good microscopes and refracting telescopes are now so equipped.



THE REFRACTING TELESCOPE

IV. THE AIR GUN

The air gun, modelled after a fine rifle of that day, was possibly designed by Priestley to exhibit in a very practical way the mechanical efficiency of compressed air. It discharges a lead bullet weighing 45 grains. The air magazine is a wrought-iron globe 3½ inches in external diameter. This screws over the lock, communicating with the barrel. It is opened only for an instant by a small rod actuated by a spring released by the trigger, and its valve is closed by a spiral spring, assisted by the pressure of the air when charged. It closes instantly, reserving the unspent air for about a dozen shots.



THE AIR GUN

The magazine is charged by screwing it to the top of a wrought iron pump, with handles on the top and at its base a strong iron cross bar on which the feet can be placed. A hole near the bottom admits the air, which is forced upward by a piston on a stout iron rod about the length of the barrel.

According to tradition, Priestley shot at deer from his porch at Northumberland with this weapon. For many years, it is said that the Senior Class at Dickinson College held an annual target shoot with it. This event has been long since discontinued, but the air gun remains in good working order.

V. THE ORRERY

A mechanical wonder of its day, the orrery, or planetarium, exhibited on a diminutive scale the motions of the stars and planets. Priestley's was not in working condition when obtained by the College. Fragments of it remained in the 1850's, but with the years every vestige has disappeared.

VI. GLASSWARE

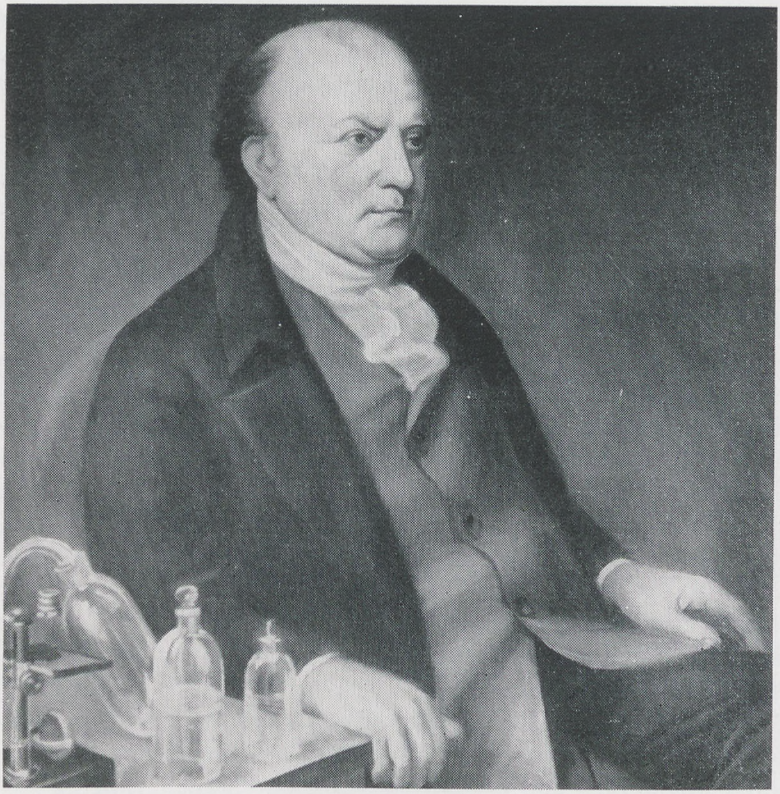
Included in the purchase from Priestley's laboratory were flasks with heavy ground necks, and heavy curved glass tubes with ground stoppers on the end to fit into the flasks. Of these, which figure in Priestley's own account of making and collecting gases, one set survives. This set is shown in the portrait of Thomas Cooper, printed for Dickinson College by Jane Hayes Jones, after the original by Charles Willson Peale.

AUTHENTICATION

The Priestley equipment has had a varied and adventurous history through which, for a wonder, not only most of the instruments, but the record of them, have been preserved intact. Joseph Priestley, born in 1733 in Yorkshire, England, was a clergyman with an interest in science. His scientific and theological views advanced together. In one field, he became the discoverer of oxygen, of carbon monoxide, nitric oxide, nitrous oxide, hydrogen chloride, ammonia and sulphur dioxide; recognized that respiration and combustion were similar processes; invented soda water, and was the first to point out the place of vegetation in the cycle which restores oxygen to the atmosphere. In the other, he progressed toward free thought and Unitarian doctrine, and became the founder of Unitarianism in Pennsylvania. He was a warm supporter of the French Revolution, to which most Englishmen were inveterately hostile. In 1791 a celebration of the second anniversary of the fall of the Bastile touched off a riot in which Priestley's home at Birmingham was looted and burned and he himself narrowly escaped violence.

In 1794, Priestley emigrated to the freer atmosphere of America, bringing with him as much of his library and laboratory equipment as had survived this calamity. With his family, he settled at Northumberland, Pennsylvania, building a fine mansion that is still preserved as a memorial to him. With him came Thomas Cooper, who had made a previous visit to the United States. The two had been intimately associated in England, sharing the same interests, the same zeal for widening horizons of thought and knowledge. They had both been made citizens of France by the Revolutionary government. Cooper, however, had broken with Robespierre, and in the year after Priestley's narrow escape at Birmingham, had as narrowly eluded the vengeance of the tribunal at Paris.

Cooper was an Oxford graduate, trained in law at the Temple, a man of inexhaustible curiosity and intellect. Jefferson



THOMAS COOPER

This portrait, by Jane Hays Jones, was presented to the College in 1938 by Boyd Lee Spahr. The original by Charles Willson Peale is at the College of Physicians in Philadelphia, Pa.

called him "the greatest man in America in the powers of his mind and acquired information and that without a single exception." He lived and worked at Northumberland until Priestley's death in 1804. In 1804 he became a judge in Luzerne County and served until 1811. In the same year, after being impeached and removed from the Pennsylvania bench, because of the freedom and force of his opinions, he became Professor of Chemistry and Natural Philosophy at

Dickinson College. The scientific department of the College at once assumed national prominence, attracting students of a new type. Among these was Alfred Victor duPont, later president of the firm founded by his father, E. I. duPont de Nemours.

Shortly after assuming his new duties, Cooper arranged the purchase of the Priestley equipment from the son and namesake of his friend. It is first recorded in the minutes of the Board of Trustees of Dickinson College, December 17, 1811. "Resolved—that the Trustees will accept on the terms proposed by Mr. Priestley—a three foot reflecting telescope—five inch reflector—mounted in the best manner—$220.00—a lens $250.00—an air gun $60.00—& that the amt. be paid out of the Apparatus Fund—and that Mr. Cooper is requested to inform Mr. Priestley of this Resolution & that his Draft will be duly honored."

Writing to Cooper from Philadelphia, December 25, 1811, Joseph Priestley, Jr., accepted the Trustees' terms and told where burning-glass and telescope were to be found in the Northumberland house. They must have been brought to the College by Cooper, whose own library and laboratory equipment were still there. The Board of Trustees specifically purchased only the reflecting telescope, the burning-glass and air gun. The younger Priestley's letter to Cooper mentions also the orrery—"There are two, neither of them so good as the Trustees may imagine." From this we may infer that still other objects were included by verbal agreement in the transfer—particularly the refracting telescope and the glassware. These were identified as Priestley's by Professor Charles Francis Himes, who came to the College as a student in 1851, and who had them in his charge through later years.

On May 21, 1814, Cooper and one of his students, James Hamilton, Jr., of the Class of 1812, made a brief catalogue of the Dickinson apparatus, including the burning-glass, the two telescopes and the air gun. And we may assume that Hamilton, afterward a lawyer, author and trustee of the College, was "the youth" who, over the signature "H," published a particular account both of the glass and Cooper's use of it in the leading American literary magazine of the period. *The Port Folio* of September, 1815, promised its readers a scientific tidbit:

TO READERS AND CORRESPONDENTS

The account of certain experiments made in Carlisle with a burning glass belonging to Dickinson College, is a curious and interesting morsel of science, and shall not fail to appear in our Journal. The youth who communicated it merits our thanks, and will have still higher claims on them by a continuance of his favours.

The "morsel of science," our most intimate view of Cooper's experiments, appeared in the December issue:

EXPERIMENTS MADE WITH THE LARGE BURNING-GLASS OF DICKINSON COLLEGE, UNDER THE DIRECTION OF PROFESSOR COOPER.

This lens was purchased by the trustees of Dickinson college from the son of the late Dr. Priestley. It was made by the same Mr. Samuel Parker of London, who constructed the celebrated burning-glass sent, among other presents, to the emperor of China, and which was esteemed the most powerful ingenuity and perseverance had produced. The burning-glass of Dickinson college may be considered as one of the best in the United States. It is made of flint glass, and compounded of two lenses, both double convex, of solid glass.

The diameter of the large lens is
in the frame 16 1/4 inches.
surface exposed 15 1/2
Its thickness at the centre, 1 6/10 inches
at the edge, 4/10ths of an inch.
Its focal distance, 2 feet 11 3/10ths inches.
The diameter of the small lens is 6 1/4 inches.
Its focal distance, 1 foot 5 1/2 inches.

Both glasses are fixed in a wooden frame, which turns on a pivot and slides on a brass bow, and can be moved with ease horizontally or perpendicularly. The smaller lens is placed at such a distance from the large one as that the diameter of a cone of rays falling on the small lens is equal to the diameter of the small lens.

Substances fused, with their weight and time of fusion.

Farenheit's thermometer at eighty-six degrees in the sun, and seventy-four degrees in the shade.

Silver—7 gr. melted in two seconds.
Copper—22gr. melted in thirty seconds.
Bar iron—18 gr. partly melted in five minutes.
Antimony—25 gr. melted instantaneously.
Flint glass—5 gr. Melted in forty seconds.
Green glass—6 gr. melted in thirty-five seconds.

Farenheit's thermometer at one hundred and one degrees in the sun, eighty-six in the shade.

Crystal of limestone—in four minutes partly reduced to lime.

Glass coloured by gold—in thirty seconds ran into a beautiful globule of variegated colours.

Blue clay from Jersey—6 gr. in one minute melted and ran into a globule.

Asbestos—became instantaneously red hot, but not otherwise affected.

Clay and Lime—in equal proportions instantaneously melted into a glass globule.

Lime and quartz—3 gr. each, melted in thirty seconds.

Clay, quartz, and lime—3 gr. each, in thirty-five seconds melted into a glass.

Mica—in ten seconds partly melted.

Precious serpentine—in two minutes changed in colour and reduced in weight.

Platina in grains—in five minutes aglutinated into a mass.

Iron filings—in three seconds partly melted.

Red lead and charcoal—in ten seconds the lead reduced to its metalic state.

Pyrites or sulphate of iron—the sulphur driven off and the iron reduced to the metalic state, which was proved by the magnet attracting it.

Porcelain clay from Armstrong county, Penn. in five minutes partly changed its colour.

A cork, suspended in a decanter of water, was slightly chared.

All the above substances were placed on charcoal when exposed to the lens.

H.

Carlisle, September 20, 1815.

It is an interesting sidelight on this account that Lord Macartney, appointed British ambassador to China in 1792, brought with him on his mission not only a similar burning-glass made by Parker of London, but two air guns, probably identical with those at Dickinson College. Sir George Leonard Staunton, who accompanied the embassy and published an account of it in 1797, tells briefly of the Emperor's appreciation of the scientific instruments presented to him. "Distant objects were observed through the telescope; and metals melted in the focus of Parker's great lens."

Priestley's orrery had already been found unworthy of inclusion in the list of 1814. But the other equipment reappears in John Paxton's catalogue of 1833, including the "Large Burning Lens for the vitrification of incombustible substances." Telescopes, air gun and burning-glass were still in active use late in that century and early in our own, when Charles Francis Himes and John Frederick Mohler were carrying into new frontiers the tradition of study and experiment founded at Dickinson College by Thomas Cooper.

[The text of this booklet is largely a reprint of a pamphlet prepared by the late Dr. Charles F. Himes, a member of the faculty at Dickinson College from 1865 to 1896.]