developed in the last part) which is adequate to rescue science from her splendid but dreary isolation of the last century. If it is still accepted that "atoms blindly run," if genetics and molecular biology have increased the inalterable aspect of our configurations, if our logic *is* that of a machine—yet even that logic remains open. Contrary to the positivists' attitude: it cannot reach out at the borderline of the known, as Goedel and Ramsey have proved, and pure mathematics will never be a closed science. And so it is—much more so—with the rest of our concepts. Bronowski has skillfully woven together the new vistas presented by the critical changes in epistemology to show how far they can lead us. "We have the luck to receive the question when for the first time it can be answered." Utterly true. But is it as unique as it is made to look? It is one of the charms of the history of science to show that real questions, new attentions, have sprung up only when the time was ripe for an answer. Even the "stodginess" of the 19th century is largely due to stodgy historians, and to stodgy pontiffs. Today's "new" lies largely in the writer's skill in presentation. It is hardly new that in watching Lady Macbeth's agony we do not simply conclude that she is headed for a breakdown, or even discover that she is not colorblind (the answer remaining: so what?) but are really led to feel, like her physician, "God, God forgive us all"—and yet, put in its proper place, this understanding reminds us that all of real knowledge is imaginative, that the artistic element in science, rediscovered, might pull current philosophy out of the horse latitudes. Science becomes again natural philosophy, as it was in the times of Galileo, Newton, and Kant, and the future is open. Bronowski's book is really a matter of persuasion and good sense rather than of flashing intuitions. A kind of Aristotelian serenity hovers over his prose. Is that quiet persuasion enough for all, as it would have been for a Stoic public, when "physics" was already paramount? There are still some true scientific minds lying in wait for the profound that may come. As Heraclitus says: "If you do not await the unexpected, you will not find what is true." Bronowski prefers to keep to one aspect of Parmenides: "This too thou shalt learn, how what appears can render a proper account of itself as it goes through all things as a whole." But this is not said in the Way of Truth: it comes from the Way of Opinion.

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The Flying Machine

Charles H. Gibbs-Smith, of London's famed Victoria and Albert Museum, has for many years made very detailed studies of the origins of the airplane. In much thinner form much of his information has been made available in (London) Science Museum publications, which culminated in his book *The Aeroplane: An Historical Survey of Its Origins and Development* (1960). Now, in **The Invention of the Aeroplane (1799–1909)** (Taplinger, New York, 1966. 384 pp., illus. $14.95), Gibbs-Smith has pulled together his very considerable knowledge of the beginnings of aviation to discuss the development of the flying machine as a study in the history of science. He takes the view that there were two vital decades, exactly 100 years apart, in which the important developments took place. The first of these was from 1799 to 1809, when Sir George Cayley made his remarkable studies, treated in full detail in J. Laurence Pritchard's biography of Cayley (Horizon, 1960), and the second from 1899 to 1909, when the Wright brothers dominated. The difference between the two periods, Gibbs-Smith stresses, was due to the fact that the Wrights envisioned the airplane as a unique problem and not merely as a surface vehicle propelled through the air. Although it is true that the Wrights were able through the invention of the gasoline engine to achieve powered flight, what they really contributed was pilotage, the ability to control an airplane in flight. They learned this from their gliders and they built their airplanes to be inherently unstable.

Once the Wrights had demonstrated their machines in Europe, Europeans took up their work and improved upon it, as did Glenn Curtiss in the United States, to such an extent that by 1909 the Wrights were beginning to lose their lead, and by 1914 had lost it altogether. That this was so may be explained by the facts that in Europe the early development of the airplane was taken up by monied young men of better education and that, owing to the international rivalries of the day, public support was available, not to mention the interest of governments. The latter began to take an active interest by 1909 when the British established the Advisory Committee for Aeronautics.

Gibbs-Smith's work is superbly illustrated—many of the photographs in the latter part reminding one of the recent movie *Those Magnificent Men in Their Flying Machines*—and includes sketches of how the controls were worked. From a scholarly standpoint there are one or two minor irritations. The index is not comprehensive (for instance, C. S. Rolls is mentioned on page 190, but not in the index). References are either in the text or in notes at the back of the book, but citations from newspapers sometimes only give the month and year. But these are minor faults. The book itself enables the reader to see how the airplane became a practical machine.

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Recent Research on Rare Earths

In a short time, almost unnoticed by many, knowledge about the "rare earths" has grown from little more than a mere list of oddly named elements, exceedingly difficult to separate from each other because of a supposedly striking similarity of behavior, to a full subfield of chemistry, actively diversifying into several branches and affecting the neighboring sciences, such as metallurgy and nucleonics.

Although a comparatively well-developed amount of knowledge had, in fact, been accumulating over more than a century, this knowledge was rather restricted to a few specialists. The "scarcity" and the difficulty of individual isolation of these elements kept them "rare," and their detailed study was hindered for a long time, until the sudden interest in uranium- and thorium-bearing minerals, with which rare-earth compounds are frequently associated, brought them to the practical attention of modern chemistry. In the last few decades a number of separation procedures have been developed, many properties of the pure rare-earth metals and their compounds deter-