had independently recognized the practical and scientific importance of magnetic data—not only of declination but of intensity. In the United States the Department of Terrestrial Magnetism was set up; several magnetic observatories were established, and non-magnetic ships sailed the seas gathering data. A journal published by this agency is devoted entirely to the subject of terrestrial magnetism, which now includes studies in the outer spheres of the earth's atmosphere, cosmic rays and nuclear physics. Two hundred and seventy years after Swedenborg's birth the collection of data and the increase in knowledge has been considerable. Yet from the perspective of history he was a pioneer in this field.

SWEDENBORG THE MATHEMATICIAN

MARGARET JACKSON *

It is not my aim to introduce you to the technicalities of mathematics, nor to indicate, except in a very general way, in which of these technicalities Swedenborg was versed; but rather to tell you something of the effects which I believe the study of the discipline of mathematics had on Swedenborg—how it may have influenced his thought, his philosophy and his style.

There is plenty of evidence that Swedenborg had made a fairly wide study of the mathematics of his day, that he felt himself to be at home in this field of inquiry, and that he enjoyed the pursuit of mathematics; furthermore, that he realized the uses which mathematics can serve. In the *Diary Minimus* he describes mathematics as "one of the useful sciences, by which as means each one can become rational"; and in the *Spiritual Diary* he describes mathematics as "a means for acquiring understanding."

The mathematics of Swedenborg's day was considerably less in content than is present day mathematics, although it had recently been considerably swollen by the work of such mathematical giants as Leibnitz and Newton. In reading Swedenborg's *Algebra and Geometry*—something of a misnomer, for the book includes work

* The substance of an extemporaneous address by Dr. Margaret Jackson, M.Sc., Ph.D., at the Swedenborg Birthday Meeting of the Swedenborg Society, London, 1958.

which belongs strictly to the fields of Calculus and Mechanics—I form the impression that Swedenborg's mathematical erudition was comparable to that of the first year "honours mathematics" student in a British University of today.

The *Algebra and Geometry* to which I have referred was published in 1720 in Latin. It was not Swedenborg's first publication on mathematics, as, in 1718, he had written an Algebra and had it published in Swedish. This Algebra was divided into ten books, and a handwritten English translation of the first seven books, by J. N. Cosham of Bristol, is in the archives of this Society. In the front of the translation there is a letter written by the Rev. J. R. Rendell in which he says that he has found the translation of considerable interest, but is of the opinion that its publication would add nothing to Swedenborg's reputation. I, too, have found this translation of considerable interest and, I might add, a source of great amusement; not because it is in any way incorrect or frivolous, but because the style and the subject matter are so different from what one finds in a modern work on Algebra. This Algebra was intended, in the words of its author, to introduce the reader, who had not previously wrestled with the subject, to the "incredible excellency of Algebra." He wished it to be an intelligent guide for such students, and to show them how Algebra could be applied in various fields of inquiry. Again, I regard the title as something of a misnomer; for in the book arithmetic, algebra, geometry, mechanics and physics are all defined, and work from each of these fields is included. Probably today the book would be entitled "An introduction to mathematics—being a book suitable for use by boys in the lower forms of Grammar Schools." I say, "by boys," because some of the ideas in the book are not calculated to stimulate the feminine mind. Take, for example, this one: "Gunpowder, and a ball of equal weight, will produce the same force at the touchhole."

There can be no doubt, however, that Swedenborg achieved his purpose in writing this book; and it would, I am sure, be intelligible to every member of my audience. To give you some indication of the leisurely progress made in the book, let me say that, at the end of Book I, we find ourselves "seeking a number, which, when joined to 2, will make 7." Admittedly, some clarity has perhaps been achieved, at the expense of over-simplification, or of verbosity; but in defense it may be said that truth must be accommodated to the minds of its hearers. The more mathematically minded of you can no doubt share my joy in the following definitions: "an ellipse is 'a circle made more long than high'"; "an hyperbola is a curve which casts itself upwards"; and can also appreciate the following graphic, if verbose, statement of the commutative law of Algebra: "Letters may, when multiplied together, be arranged in that order which seems most suitable."

I shall say no more about the contents of this book, nor about those of Swedenborg's more learned mathematical works, the *Algebra and Geometry* to which I have already referred and a "Mathematics and Physics" written in 1741.

Before I can tell you something of the effects which I believe his study of mathematics had on Swedenborg, it is desirable that I should tell you a little about mathematics and about what a mathematician does. It is important to realize that mathematics is both an art and a science; indeed Krönecker refers to music "as the finest of the fine arts with the possible exception of mathematics." Since mathematics is an art, there is good, bad and indifferent mathematics: good mathematics is beautiful and aesthetically compelling; bad mathematics—which must, of course, be distinguished from incorrect mathematics—is that which, in the words of Poincare, "merely commands assent." Mathematics is a science, for mathematical truths are irrefutable; opinion has little place in mathematics. The methods of mathematics are essentially scientific, but the way in which these methods are applied can be, and should be, an art. A mathematician states a set of basic axioms, which are usually independent, and certainly non-contradictory, and from these axioms he proves theorems. These theorems constitute "pure mathematics"; they deal only with whatever entities are involved in the axioms. These entities, however, often prove to be models of quantities, or objects, in the physical world, and if we apply our theorems to these naturally occurring phenomena we have produced a piece of "applied mathematics."

Now let us consider some of the ways in which the study of this art and this science may have influenced Swedenborg. When we consider Swedenborg's philosophical works, it seems to be quite clear that at least two of these, the *Principia* and the *Infinite* *and the Final Cause of Creation* would not have been written if Swedenborg had not been well grounded in mathematics. Indeed, in the *Principia,* Swedenborg describes philosophy as "the knowledge of the mechanism of our world, or whatever in the world is subject to the laws of geometry, and which it is possible to view by experience assisted by geometry and reason." He also says that "a medium leading to wisdom by which the arcana of invisible nature may be unlocked or revealed is geometry and rational philosophy, by means of which we are enabled to compare our experiments, to reduce them to rules, laws and analogies, and thence to arrive at some more remote principle or fact, which was before unknown." He announces his intention of trying to explain the secrets of elemental nature and says: "In such an ocean, I should not venture to spread my sail without having experience and geometry continually at hand to guide my hand and watch the helm. With these to assist and guide me, I may hope for a prosperous voyage over the trackless deep."

You notice the emphasis which is put on Geometry—although, as I have suggested, it may be necessary to interpret this term rather widely as it is used by Swedenborg; and in the *Principia* Swedenborg asserts that "geometry is inseparable from the world." This is an old theme, which has been retold by mathematicians throughout the ages; its rendering may be said to grow slightly more sophisticated as the years pass by. The Greek version was "The Deity ever geometrices"; a more modern version was provided by Sir James Jeans: "the great architect of the universe now begins to appear as a pure mathematician." Only last year, Professor C. A. Coulson (Rouse Ball Professor of Applied Mathematics in the University of Oxford) said: "I am impressed by the unity in the Universe and believe that mathematics really has something to say in this connection"; and he instanced the recent work of D'Arcy Thomson who has correlated botanical and biological phenomena with known mathematical results; Fibonacci numbers with fir cones and equangular spirals with spiral shells. Swedenborg, too, was impressed by the unity in the universe; and however this impression may have been formed, I cannot help feeling that it must have been strengthened and confirmed by his study of mathematics.

The style of the *Principia* is very much that of the mathematician, the premises from which we start are non-contradictory, and often independent, the deductions are logical and the methods by which these deductions are made are sometimes beautiful.

When he spoke at this meeting last year, Mr. John Chadwick said that, although he had not made a study of the problem, his impression was that Swedenborg's style did not change substantially from that in his philosophical and scientific works to that in the theological works written after his illumination. Is some of the style of the Writings the style of mathematics? I think that it is, and this opinion is strongly reinforced by Mr. Chadwick; for in speaking of Swedenborg's expository style he likened it to the theorems of Euclid, and in speaking of Swedenborg's argumentative style he used, for comparative purposes, a passage from Newton's *Principia Mathematica.* Mr. Chadwick went on to say that the expository style was not the style of great literature and that it pursued its monotonous way through most of the numbers of the *Arcana.* To me this style is not monotonous, it is a mathematician's style. I admit that repeated use is made of the theorem if $a = b$ and $c = d$, then $a + b = c + d$; but the arguments are supremely logical, the applications of the theorem are wide and varied, and the total result is non-contradictory. Some of the paragraphs may be likened to pure mathematics, in that the entities involved in them are intangible; some of them are more like applied mathematics, as they involve physical concepts; many of them stand up to the criterion of good mathematics, and as I read them I am impelled to say *"Quod est demonstrandum."*

I hope that this reference to the style of the *Arcana* as the style of good mathematics will not offend some of my hearers. If you prefer it, I will refer to the *Arcana* as containing much beautiful analytic thought; and we are told in the Writings that man could not think analytically unless the Divine from its wisdom flowed in from the spiritual world.

Were there any other ways in which Swedenborg's mathematical training influenced him after his illumination? I believe that Swedenborg's mathematical training helped him to think beyond time and space in thinking of God. Mathematicians can think apart from a three dimensional world. They also ponder the mathematically infinite; and mathematicians have used their ideas about the infinite—although it must be realized that any valid interpretations of this mathematical notion are comparatively recent—to help their fellow men to visualize the Infinite—in so far as a finite mind can. A mathematician has said of the Deity: "He is supreme or most perfect, eternal and infinite, omnipresent and omniscient, his duration reaches from eternity to eternity, his presence from infinity to infinity. He is not eternity and infinity but eternal and infinite, not duration or space but endures and is present. He endures for ever and is everywhere present and by existing always and everywhere he constitutes duration and space." These words were written by Newton, but I cannot help feeling that they might have been written by Swedenborg. We learn from the *Divine Love and Wisdom* that Newton did not have to revise these ideas about the Infinite very much in the other life; for in a conversation between Newton and the angels, which is recorded there, Newton says that "the Divine which is fills all things." Swedenborg himself tells us: "The Divine, being omnipresent, is not in space"; "The Divine apart from time, is in all time"; "The Divine fills all the spaces of the universe, apart from space."

Dr. Hilda Hudson, a British geometer, has declared: "To all of us who believe the Christian belief that God is truth, anything that is true is a fact about God and mathematics is a branch of theology." Was mathematics a branch of Swedenborg's theology? As Swedenborg used mathematical truths and ideas, and the knowledge of this world to which a study of mathematics had led him, to confirm Divinely revealed truths, I submit that mathematics was a branch of Swedenborg's theology.