ANGELS AND ALNICO

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HE FAMILY stood admiringly around the gleaming white refrigerator, newly arrived from the factory. Proud of his purchase, Pop kept opening its big door, giving it a slight push, and watching it close again, smoothly and silently. No catch or lock was visible on the door, but each time it closed securely. The onlookers were mildly curious, and Junior echoed their general wonderment when he asked:

"Pop, what keeps the door shut?"

"Alnico, son," came his father's reply. "It's a new kind of metal that was developed during the war—makes a very strong magnet."

The rest of his answer was simple enough. Small but strong magnets, spaced along the frame of the door opening, attracted the iron in the door and kept it closed tightly enough to keep out the heat of the surrounding air. Thus the seeming magic of the closing refrigerator door was nothing more than another advance in engineering science. Satisfied with the family reaction, father deftly passed on to the other gadgets of the new appliance, and as he explained more and more, his stock as the local authority in matters scientific mounted rapidly.

Fortunately for Pop, however, no one thought to ask him what *made* the alnico magnets attract the iron in the refrigerator door. If they had, there probably would have been an embarrassed silence while the family expert struggled for an explanation. If he were expert enough, he might have passed it off as being too complicated for the non-scientist to understand. But if he were the average honest father, the chances are that he would finally have to admit either that he did not know, or that maybe there was a little magic involved in the refrigerator door after all.

AN AGE-OLD PROBLEM

The problem of what makes any magnet attract iron is something that has puzzled man through the ages, and strangely enough it has always been associated in one way or another with magic. As far back as the sixth century before Christ, Thales of Miletus conducted experiments with lodestones; he was so impressed with their magic

powers that he thought they had a soul. St. Augustine, Bishop of Hippo, was astounded by tricks he saw performed with magnets, and used the point well to show those who were puzzled by the supernatural how mystifying even natural things can be. In late medieval times, experimental science owes its beginnings to the fascination of men's minds with the occult powers attributed to lodestones and other minerals. Even in our own day, the continued use of the magnet by amateur magicians shows that the human mind is still intrigued by its strange powers.

If the magnet's connotation with magic persists even in our own day, one can easily understand how strong it was in the age in which St. Thomas Aquinas lived. What is not generally known, however, is that the great Christian doctor has written profoundly and well on a solution to the magnet problem that successfully dispels the aura of magic and mystery. Like many of his answers to difficulties, this solution is not contained explicitly in a special work on magnets, but rather is implied in the numerous references to lodestones scattered through his works. And though St. Thomas does not couch his reply in the language of modern science, in many respects it is more adequate than anything that is offered today as the final explanation. His answer, furthermore, is typical of the Angelic Doctor—not only because of its profundity, but because of its reference to the creatures whom he understood so well, but whom the moderns do not understand at all. We refer, of course, to the angels.

MEDIEVAL MAGIC

But before entering upon St. Thomas' strange explanation of why a magnet attracts iron—strange, that is, for twentieth century ears—a brief sketch of the scientific opinions about lodestones and minerals that were available to St. Thomas will enable us better to appreciate the brilliance of the saint's analysis. As is commonly known, Thomas had for his instructor in the Dominican Order one of the greatest natural scientists of the age, St. Albert the Great. This being so, we may reasonably expect that he received his knowledge about minerals at first hand from St. Albert. A sampling of the latter's writing will therefore give us an idea of what St. Thomas knew from medieval science.

According to Albert and his contemporaries, the magnet could not always exert its power of attracting iron, nor was it necessarily limited to this power. If a diamond was placed near it, or if the magnet was smeared with garlic, it was thought to lose its power to attract. On the other hand, some magnetic stones were thought to have

the marvelous power of producing phantasms in the human mind, especially if they were consecrated by some magical incantation. Then there were magnets that, instead of attracting iron, were drawn to that metal instead. A great variety of minerals were thought to have other magical powers; the latter ranged all the way from counteracting poisons to winning victories and conciliating human hearts. An emerald was supposed to be useful in restraining sexual passion, and St. Albert reports having himself seen a sapphire that could remove ulcers. He also knew of another stone that magicians used to excite a subject's imagination, but that would lose its power if it should touch a corpse. Finally, stones that were engraved with images could have even more prodigious and marvelous effects.

Stones were also thought to be subject to animals and in turn to have curious effects upon them. For example, the blood of a goat was commonly regarded as a solvent for diamond, and therefore goat's blood was a beneficial remedy for stone in the bladder. St. Thomas himself alludes to two other strange properties, namely, that the sapphire stops bleeding and that gold gladdens the human heart. But by far the most remarkable account of a strange power is one that is recorded in the writings of St. Albert. Here is the description in the saint's own words: "An emerald was recently seen among us, small in size but marvelous in beauty. When its virtue was to be tested, someone stepped forth and said that, if a circle was made about a toad with the emerald, and the stone was set before the toad's eyes, one of two things would happen. Either the stone, if of weak virtue, would be broken by the gaze of the toad; or the toad would burst, if the stone was possessed of full natural vigor. Without delay, things were arranged as he bade; and after a short lapse of time, during which the toad kept its eye unswervingly upon the gem, the latter began to crack like a nut and a portion of it flew from the ring. Then the toad, which had stood immovable hitherto, withdrew as if it had been freed from the influence of the gem."

If such events were not uncommon in medieval times—and we have the testimony of reliable witnesses that they did occur — the problem facing St. Thomas was one of considerable proportions. But being the intellectual giant that he was, he did not hesitate to seek a technical explanation for these phenomena, bringing to the task a scientific insight that would flatter many thinkers of our own day.

THOMAS' REPLY

In brief, Thomas' answer was this. If the powers described by the scientists of his day were actually possessed by stones and other

objects, they must either come from the intrinsic nature of the things themselves, or they must come from a higher cause. Ruling out the first possibility on the basis of his own experimental knowledge, he shows that the higher causes that may be involved again can be twofold and act in different ways. Either they may be heavenly bodies that implant some intrinsic permanent principle of action in the inferior body, which then gives it a natural power, or they may be angels—good or bad—that use the inferior body as an instrument. If the power is from a form impressed through the mediation of heavenly bodies, it will always operate in the same way. Furthermore, since heavenly bodies only act insofar as they are moved by spiritual substances, such operation is ultimately traceable to the activity of good angels. On the other hand, if the effects are not constant but are intermittent and limited to particular cases, the higher cause must be a good or bad angel that uses the inferior body as an instrument. Finally, if such effects are found to be evil in one way or another, they must be produced by bad angels, or demons.

Into this general framework, St. Thomas places the power of the magnet to attract iron as an instance of a natural power, produced by the angels through the mediation of the heavenly bodies. Practically all of the other strange powers he considers as examples of black magic, and he therefore assigns them to the intervention of demons. For our purposes, however, we are only interested in why the magnet attracts iron, so we shall pass over what may seem to be more intriguing examples of occult power to consider the lodestone in more detail.

In further analyzing the magnet's causality, St. Thomas makes a distinction that is somewhat remarkable, considering how remote he was from the modern physical scene. He states, in equivalent terms, of course, that magnetic attraction is quite a different thing from gravitational attraction. The reasons he adduces are sound enough: he observes, first of all, that a magnet will not attract iron from any or all distances, but only when fairly close to it, whereas the earth attracts all massive objects to its center. Then he notices that the magnet must be lined up with the iron being attracted. From this he concludes that the iron actually receives some influx from the magnet. He does not mention the term "magnetic induction," naturally enough, but he does state that the magnet produces some kind of change, some alteration in the iron, which is equivalent to the communication of motive power to it.

As to the precise manner in which the heavenly bodies influence the magnet's power to produce such a change, St. Thomas does not

venture much of an explanation. All that he says is that the power any particular magnet receives will be more or less intense according to the diverse distribution of matter in it and the different configuration of the heavenly bodies at the time of its coming into being. What these distributions or configurations were he evidently does not feel competent to say. However, it should be well understood that practically all medieval scientists based their explanations of natural phenomena on theories regarding the heavenly bodies. These bodies included stars as well as planets, and they were believed to be made out of a type of matter different from anything on earth or known directly to experience. They were thought never to undergo any qualitative changes, but only to move from one place to another in circular motion; this motion was then regarded as the source of all motion and change in inferior bodies on earth. Apart from these details, there was little quantitative development in the sense of our modern physical theories, so it is not surprising that St. Thomas did not go into particulars.

A superficial glance at St. Thomas' explanation of the magnet, with its references to angels and celestial bodies, would incline the modern physicist to reject it immediately as a bit of medieval nonsense. Actually, however, there is a profound resemblance between it and modern theories of magnetism, as will become evident from a brief consideration of the latter.

THE MODERN ANSWER

Before the advent of the present era in physics, the classical theories of electricity and magnetism attempted to explain magnetic phenomena simply in terms of the rotation of electrons about the nuclei of the atoms making up the magnet. This concept, in spite of its simplicity, never could be tied in with an accurate quantitative theory, and it has been superseded by more complex concepts that defy simple explanation or pictorial representation. These concepts are studied in the branch of modern physics known as quantum mechanics. According to the latter, the presently accepted explanation of permanent magnetism is sought in the particular energy states of some atoms that make up the magnet. Sparing ourselves the mathematical details, we can say that these states occur when there is an alignment of the "spins" of the electrons that lie in a "shell" close to the nuclei of these atoms. Elementary college textbooks on physics generally avoid the the problem, or like Hausmann and Slack, say simply: "There is no commonly accepted theory which gives a satisfying explanation of the observed facts of magnetism." Writing for students at the graduate

level, Richtmyer and Kennard make the more mystifying statement: "The explanation of ferromagnetism on the basis of wave mechanics is intricate; that it occurs at all is rather of the nature of an accident."

Whatever may be the shortcomings of the quantum explanation, however, considering it from the plane at which St. Thomas attacked the problem of a magnet's causality, it is easy to see that the modern picture is not much different from the medieval one. Naturally enough, with the passing of time and the accumulation of experimental data, the theory of heavenly bodies has been discarded, and has been replaced by a theory involving energy shells and electron configurations that predicts results more in accord with observed facts. So, instead of saying simply that a lodestone has the quality of magnetism, modern physics makes the more involved statement that the electrons in its atoms are in certain particular energy states, and that within restricted domains of the magnet that are free of impurities, the atoms are aligned in such a way as to produce a resultant magnetic field. The cumulative effect of several such domains produces a phenomenon in the body known as magnetism. But then the question St. Thomas was trying to answer becomes, in the language of modern physics: what made the component electrons and atoms of the magnet become aligned in such a peculiar way?

Pushing the problem back this far makes things a little uncomfortable for the modern physicist, mainly because the "scientific method" has not produced much successful speculation in this field. The only phenomenological basis for an answer is a recently proposed theory on the origin of the elements, and this is as yet in a quite undeveloped state. In its fundamental viewpoint, however, it is an evolutionary theory which assumes considerable purposeful activity on the part of inanimate objects. To the philosopher, this is the same as signaling the presence of intellectual substances directing such objects towards particular ends. Or, in other words, a complete answer to St. Thomas' question, even considered in the light of modern theories, brings us back to his reply—these phenomena are due, in some way, to the intervention of intellectual substances, or angels.

ROOM FOR ANGELS?

We can now return to our question about what makes the alnico magnet attract the iron in the refrigerator door. First of all, we would make clear that an alnico magnet is quite different from a lodestone. The lodestone occurs in nature—it is a mineral evolved in the bowels of the earth over a period of millions of years, and as such it would be difficult to explain how it got its very special magnetic properties

without some type of angelic activity. But alnico is an alloy made from aluminum, nickel, and cobalt (whence it gets its name, "al-ni-co") by artificial chemical processes. It is true that the latter elements occur in nature, and have some magnetic properties, but the precise question is one of how the magnetic power is increased. The reason a strong magnet can be made from them, say the moderns, is that their ferromagnetic domains can be aligned into stable configurations that produce a strong magnetic field. But again, in what does this alignment consist? If it consists in certain relations between energy states, how are these ultimately determined? The usual answer would be: by the motion of electrons. Very well, then—what moves the electrons in such a way? Once again we are in a region of embarrassed silence. Barring the favorite dodge of the logical positivists—that we have asked a "meaningless question" — there is no answer forthcoming from the moderns.

As a matter of fact, there is ultimately little difference between saying a thing is caused by the motion of heavenly bodies, or by the motion of electrons, when you do not know what is the cause of the motion of either one or the other. And the entire modern explanation of magnetism, permanent or any other kind, rests sooner or later on the motion of electrons, about which there is a huge question mark.

For St. Thomas, on the other hand, the position was not so awkward. He may have been at a loss for the ramifications of the electron theory, but he certainly was not at a loss for what could have caused the motion of such objects as electrons. If electronic motion were described to him as some type of orbital movement that was ultimately the physical cause of all other motion in bodies, that it was not produced by direct contact with other bodies, and that the revolving bodies were not changed or altered in any way while in that type of motion, there is little doubt what his answer would be. He would have said that it was caused by the same movers he had centuries ago assigned to the heavenly bodies—in a word, that it was caused by the angels.

Does that mean that we must think of the electrons in our alnico magnet as being pushed around individually by busy little angels? No, we need not carry our answer to that extreme. The quantum-electron picture is still very much of a provisional one, and as we have seen, not very clear at that. It would be better, instead, to frame our question in this way. Have the advances of modern science given such an airtight answer to the magnet problem that there is no room left for the angels? Stated this way, we'll leave the reader to answer it for himself.

Of course, there is another alternative—the angels are not absolutely necessary. We could still leave room for magic . . . but *that* would not be very scientific, would it?

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