THE CASE OF THE PARADOXICAL INVENTION

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This invention clearly won't work according to well-established laws of physics. The only trouble is, that if it doesn't work, then certain other well-established laws of physics have been demolished. Because if it does work, the Law of Conservation of Energy just went down the drain. But if it doesn't work, then cyclotrons aren't possible, and betatrons are clearly nonsense. Our physicist readers are cordially invited to find the catch . . . or the loophole, whichever you choose to call it!

It was remarked in these pages some years ago that a paradox in logic is analogous to the artificial smell that gas companies put into natural gas. The smell adds nothing at all to the properties of the gas, but it *does* serve as a warning when there's a leak—in other words, when something is wrong. Similarly, a paradox in a logical or philosophical proposition indicates that something is wrong in the fundamental concepts which lie behind it. To produce a rigorous resolution of such paradoxes, a completely novel approach to the problem is usually required, and often the development of new disciplines.

A paradox in logical theory is one thing; a paradox in engineering is quite another. When such a contradiction in terms arises from the application of well-known physical laws of long standing, it would seem that something is very wrong indeed.

This article is concerned with precisely such a situation. It deals with an invention—a charged particle motor—which apparently creates a genuine paradox from which there seems to be no escape but the alteration of a fundamental law of physics. The motor *must* work, but it *cannot.*

The invention in question was conceived by Ellsworth Edling and myself in 1961 as a method of utilizing the energy of radioactivity which didn't suffer from the usual Carnot-cycle

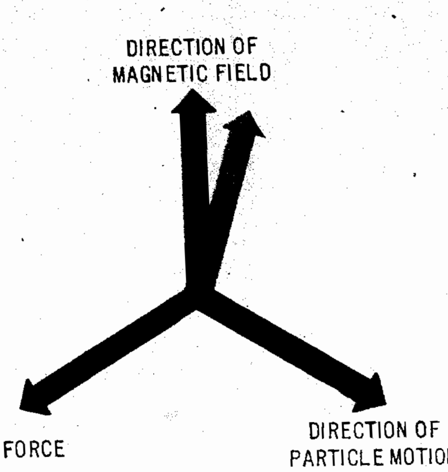

Figure 1. Fleming's Motor Rule

limitations. The theory of its operation was explored and, in due course, a patent application was filed on it. Since the device made use of the kinetic energy of charged particles—*any* source would do, but the invention was conceived with radioactive nuclei in mind—via a direct motor action, it was called originally an atomic motor. The name "charged particle motor" more accurately describes its basic method of operation.

The principle of the device is actually a direct application of Fleming's motor rule, the so-called left-hand rule, which underlies much of modern electrical technology. According to this principle, which is shown schematically in Figure 1, charged particles moving in a transverse magnetic field are acted upon by a force—the Lorenz force—which is perpendicular to both the direction of the field and the direction of particle-motion.

The motor was designed to utilize

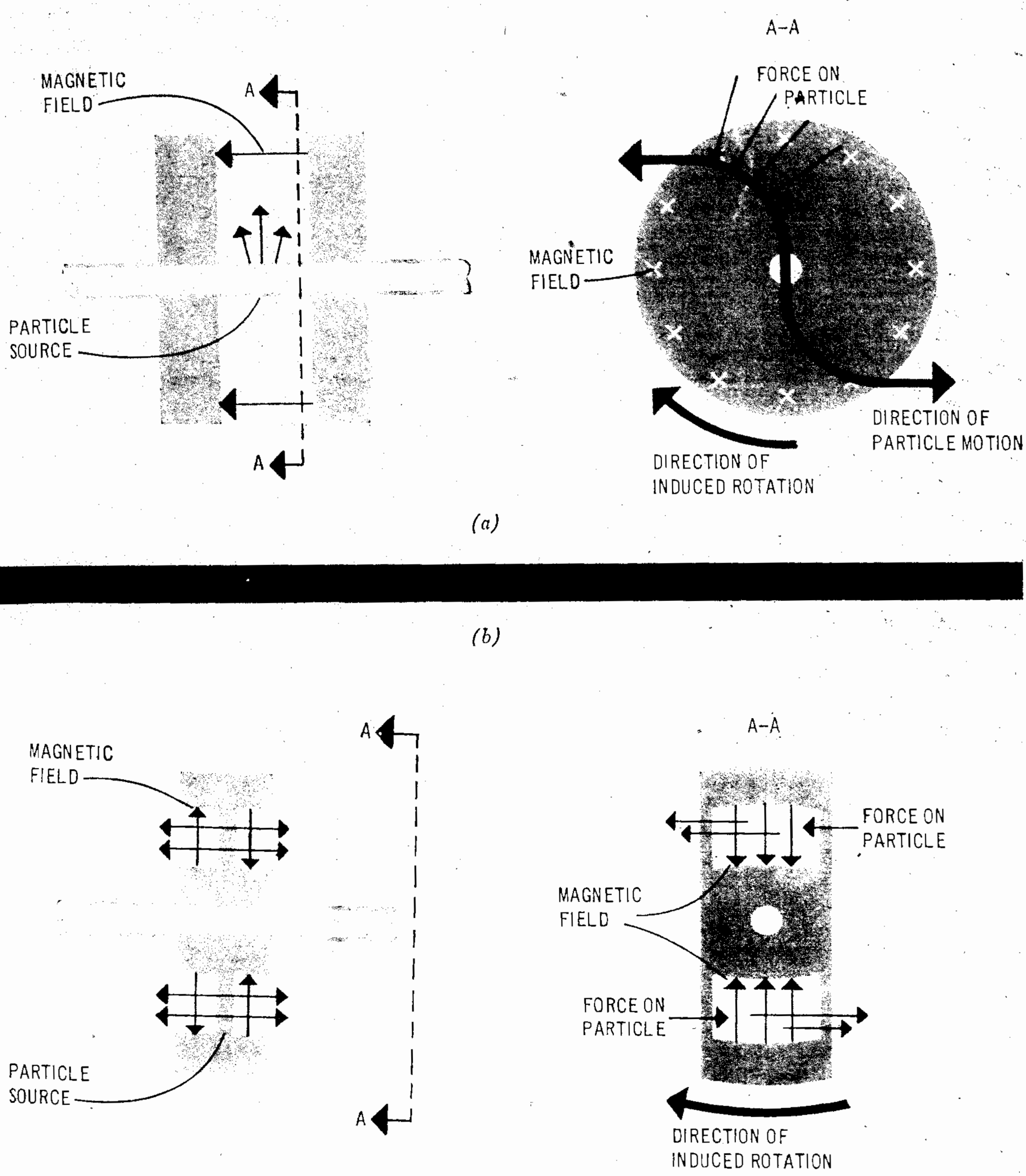

Figure 2. Schematic Configuration of the Charged Particle Motor

a source of charged particles mounted longitudinally in the center of an axial "picket-fence" magnetic field, as shown in Figure 2(a). It was assumed that the particles would all be either positive or negative—easy enough to arrange in practice. They would be emitted radially, the magnetic field would exert a force on them as shown, and they would be deflected in a more-or-less tangential direction. By simple reaction, an equal and opposite force would be exerted on the field and the structure supporting it. If the latter were a properly designed rotor, the force—actually a torque—would produce rotation. This could then either be used directly or converted to electricity by generator action.

Other variations on the same theme are possible. For example, the particle source and the magnetic field could both be arranged radially, as shown in Figure 2(b). The particle motion would then be axial, but the induced forces would still be additive on opposite sides of the axis and the result, again, would be torque.

In all cases, the particles would exit from the field-and-rotor system and be collected on impingement targets.

In practice, of course, there would be problems. Particles are emitted from radioactive nuclei at random, for one thing. Thus, some of them would move more-or-less axially and their torque-producing effect would largely be lost. Furthermore, an actual particle-source would have a finite geometry; therefore, some of the particles would be emitted internally and would serve only to produce unwanted heat in the body of the source. Also, if the source were a radioactive beta-emitter, a considerable particle velocity-spectrum would exist, which could be expected to produce further losses in performance. However, these are only design problems, not fundamental objections.

The actual force exerted in such a particle-field interaction depends on the magnetic field strength, the value of the charge and the velocity of the particle; for any individual particle, it is very small. However, since the number of particles which would pass through the field at any given time could be expected to be quite large in practice, the integrated result—torque per unit time, or power—can be considerable. Without going into details, a somewhat idealized performance equation was derived which would seem to be at least approximately correct:

$$P = \frac{\pi}{4r} Nmv^2 (R_2 - R_1)$$

where P is the power in dyne-centimeters per second, N is the number of particles per second, v is the particle velocity in cm/sec, R_2 and R_1 are the outer and inner limits of the magnetic field respectively and r is the radius-of-turn of the particle's path—dependent on the field strength, the charge, M and v. A further simplification can be made, at least for the case of low-mass, high-speed particles, such as beta particles: $(R_2 - R_1)$ and r can be made approximately equal. As a result, the basic simplified performance equation is:

$$P = \frac{\pi}{4} Nmv^2$$

Insertion of appropriate numerical values into these equations will show that the potential performance of the device would be superior to that of any of the conventional conversion techniques. However, superior or not, the size of the power output is only of incidental concern here. The issue at stake is the existence of any motor effect at all.

The potentially superior performance of the device, in any event, attracted considerable attention among various interested parties and it was evaluated with a view toward exploitation. In the course of these evaluations, an objection was raised to the basic workability of the whole principle. This objection was quite fundamental and apparently valid. Needless to say, it ended any licensing negotiations.

The objection which seemed to unseat the device so unceremoniously can be summarized briefly as follows: when charged particles pass through a transverse magnetic field, it is well-known that they change only their direction and not their speed. Thus, in the present case, although they're turned through some positive angle, the particles exit from the magnetic field still possessing their full original quota of kinetic energy. In short, they're still free to do the same amount of work that they would have done had they never passed through the magnetic field at all. Therefore, if any work is done by the particles on the magnetic rotor, the conservation of energy will have been violated—and upon the conservation principles, of course, hang all of science and technology. Thus, it was stated, no work can be done on the rotor—in other words, the device can't work.

The further logical extension of these arguments, however, creates more problems than it solves. It will be found, in fact, that the entire objection is self-defeating. For one thing, if the turning force produced by the magnetic field on the particles does *not* result in an equal and opposite reaction force on the field—causing torque in this case—then what has happened to the third law of motion? The latter is fully as sacrosanct in science as is the conservation law.

Thus, an extraordinary situation has arisen: the invention *cannot* work by virtue of one basic law, yet it *must* by virtue of another. Obviously, something must be wrong.

The only alternative to this would seem to be that the *objection* to the device must be incorrect. Inasmuch as the core of this objection is the constant-speed particle characteristic, the obvious question must now be asked: does the particle speed *actually* remain constant during the particle's

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transit through the magnetic field?

A vast body of scientific knowledge and technological experience exists on this subject. The design of such diverse equipments as mass spectrographs, cyclotrons and cathode-ray tubes, to name but a few, is based on this same charged-particle-magnetic-field interaction. The principle, as applied in these cases, demands that the velocity remain constant; that it might *not* be so seems virtually inconceivable.

And yet the possibility that the particle velocity—and therefore the kinetic energy—might decrease *under some conditions* must at least be considered, for the reaction-force must exist. The difficulty may stem from the fact that all of the above-mentioned devices which use the same physical principle have been, by definition, "stationary field" devices; they certainly have not been designed to register any reaction forces acting on the field. The inertia of the structures supporting or producing the magnetic fields in these cases would be far too great for the small reaction forces that would exist in practice. In other words, the velocity has always been observed as constant because the magnetic-field structure has always been unable to yield the reaction-force produced—and thus presumably to carry off any of the particle's kinetic energy—even when the geometry of the particle-motion—that is to say, something less than a full-circle path—would permit a net reaction-force to exist. A light-weight properly designed rotor structure would presumably yield to the reaction-torque, causing the particles to lose energy in the process.

If this is the case, then the basic tenet of the original objection—that the speed of the particles remains constant *under all conditions* during the interaction, and that this constancy renders the invention workable—is wrong. Admittedly, the idea that the velocity *can* decrease necessitates some changes in motor design philosophy. For example, if the velocity decreases, the radius also decreases as the particles move out from the source—since the radius is proportional to the velocity. Therefore, either the extent of the field must be carefully limited or the strength of the field must decrease with radial distance if the particles are not to turn back into the field and cancel any reaction. Once again, however, this is simply an engineering design problem. Other than this, the device must work as originally specified. What is more important, the loss of kinetic energy by the particles in inducing an opposite motion in the field demands some alteration of the field-particle interaction law.

If this is *not* the case—if the velocity does, in fact, remain constant under all conditions—then the original objection stands. But this leads directly into a singular dilemma.

The core of the dilemma is this: do the particles produce a reaction force on the field, or not? If they do, then the conservation of energy is apparently violated, since the work done on the rotor would have to come from no evident source. If they do *not*, then the third law of motion has been violated. In other words, where does the energy necessary for moving the rotor come *from* in the first case—or *to* where does the energy go that should result from the reaction on the field, in the second case?

The voice of orthodox physics will probably raise at this point an as yet unconsidered characteristic of charged-particle-magnetic-field interaction—the so-called "synchrotron radiation"—and thus assume that the second case above is the pertinent one. The synchrotron radiation is simply electromagnetic radiation produced by the centripetal acceleration given the charged particles by the field; its energy is proportional to the fourth power of the particle energy and inversely proportional to the radius of the turning motion. It might be an ample enough mechanism for "carrying off" the reaction-force energy, but it is a most selective and unlikely one. However, the existence of the synchrotron radiation itself raises another possible point of issue: is the radiation actually emitted as a result of the transverse acceleration of the particles by the field—or is the particle interaction with the field simply such that a transverse radiation is emitted as a result, thus accelerating the particle transversely by simple momentum? In other words, is the radiation a *result* of the particle's turning motion, or is it the *cause*? If the latter were the case, then the motor would indeed not work. The action-reaction would be confined to the particle and the radiation.

However, the synchrotron radiation is really of no consequence whatever in the present paradox. If it is assumed that the radiation *is* the actual cause of the transverse force on the particle—there is no valid reason for assuming this; in fact, the turning acceleration on the particles is almost unquestion-

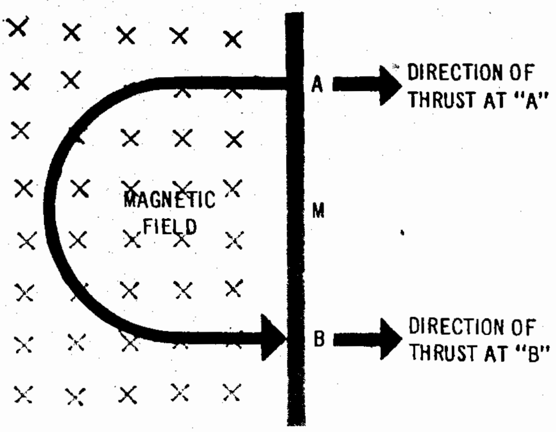

Figure 3. Schematic Reactionless Thrust System

ably a centripetal acceleration caused by the field—then a contradictory unilateral thrust device, which is outlined below, must be possible. If, as conventional theory maintains, it is simply produced by the field-induced centripetal acceleration of the particles, it still only tends to reinforce the unilateral thrust of the same improbable device, unless a reaction-force acts on the field.

The principles of this singular reactionless propulsion technique can be described quite briefly; they are really just those of the mass spectrograph. The principles of the original invention are extended so that the charged particles are turned through a full 180-degrees before leaving the field. In this case, as shown in Figure 3, the following conditions prevail:

The particles are ejected from their source at A, producing a conventional and unquestionable reaction-force in the opposite direction on the source-structure M, as shown. They're turned through 180-degrees by the magnetic field—with no reaction-force on the field, now, since this is the condition demanded by the argument against the possibility of work being done on the rotor in the original device—impacting the source again at point B and once again producing a conventional reaction-force on M in the same direction as that produced at A! Thus, under the terms of the original objection to the motor invention, a unidirectional reactionless propulsion technique would appear possible that not only defies the third law of motion but the conservation of energy as well, since the particles would presumably be reusable or usable for other purposes, particularly if they were electrons.

The point is that, if the particle's kinetic energy is undiminished and the original motor concept does *not* work, then the above-described reactionless drive *must*. The choice is: either violate the conservation of energy, or violate both the conservation of energy *and* the third law of motion. The only alternative to this incredible situation is the workability of the original motor-device in which the particles lose energy to the rotor and do work in the process. As has already been pointed out, this alternative also demands some revamping of its underlying laws.

It should be emphasized that the 180-degree reactionless drive outlined above should not be taken too seriously. It was introduced only to illustrate that the argument against a reaction torque in the original form of the invention had to be wrong. For the reaction-force is a centrifugal force. The existence of a centrifugal reaction can scarcely be denied in this single case of curvilinear motion and demanded in every other case.

In the end, there is no hard and fast answer to the original problem. Perhaps the existence of the paradox serves to verify the conclusions of Dr. William Davis and his concept of "critical action time." (See "The Fourth Law of Motion" by Dr. William O. Davis, Analog, May, 1962). Certainly the action times in the present case are extremely small; average velocities of alpha particles are on the order of 10^9 cm/sec, while beta particles often approach light speed.

In any case, it seems unavoidable that one or another fundamental law must be altered to some degree. At the very least, the law governing the interaction of charged particles moving in a transverse magnetic field must be amended. The potential value of the original device as an energy-conversion mechanism is almost immaterial at this point. The big question is a theoretical one: why should such a contradiction in basic laws be possible?

Whatever the solution, it is a question much in need of answering. ■