Electromagnetic phenomena 26

1975—A space odyssey

by Professor E. R. Laithwaite*

These paragraphs have their origin in two letters on the subject of gyroscopes, one of which was sent to the *New Scientist*, from which an abstract was published in the 28th November, 1974, issue in "Ariadne's" column, and the other was sent to *Electrical Review*. Both deserve a considered reply, such as together occupy the space normally allocated to articles in this series.

The first letter was from Mr Christopher Hook who was kind enough to send me a copy of the letter he addressed to the *New Scientist* and which I now quote in full.

19th November, 1974

Dear Sir,

You imply that there can be no possible deviation from Newton 3 but I am a witness to a very disturbing case:

At the 7th Symposium of Naval Hydrodynamics in Rome which I attended in August 1968 as a member of the BAC team (being at the time their consultant on hydrofoils) there was a paper and a demonstration by Professor A. Di Bella, Director of the Institute of Naval Architecture at the University of Genoa. Title: "On propulsive effects of a rotating mass."

When he arrived with this model without props, paddles or jets I rather naturally showed scepticism, whereupon the Professor thrust his model into my arms. On being switched on the model frog marched me, in a mild manner, towards the door by the action of rotating masses inside.

The proposed application was for docking ships sideways and as such it did not retain much attention because of low efficiency but the force was a steady one without vibration.

In his abstract (a copy of which I can send you) the Professor writes:

"We emphasise the difficulty of understanding its operation perfectly . . ."

Since the force could be directed in any direction desired this could, of course, include upwards and to that extent I must take the side of Professor Laithwaite and ask you to investigate further in the interests of science.

I am acting as a witness, not as a specialist.

Yours sincerely,

Christopher Hook.

At present, witnesses are of much greater value than specialists, for the latter have usually made up their minds well in advance, as to what works and what doesn't, and being thus entrenched they do little else but provide the reporting of new phenomena with the very necessary, but time consuming publicity.

Professor Di Bella was granted a patent which discloses the mechanical system shown in Fig. 1. Rotation of the main drive motor spins the frame A (which can be regarded as the inner ring of a gyro) by rotation of the bevel gear B

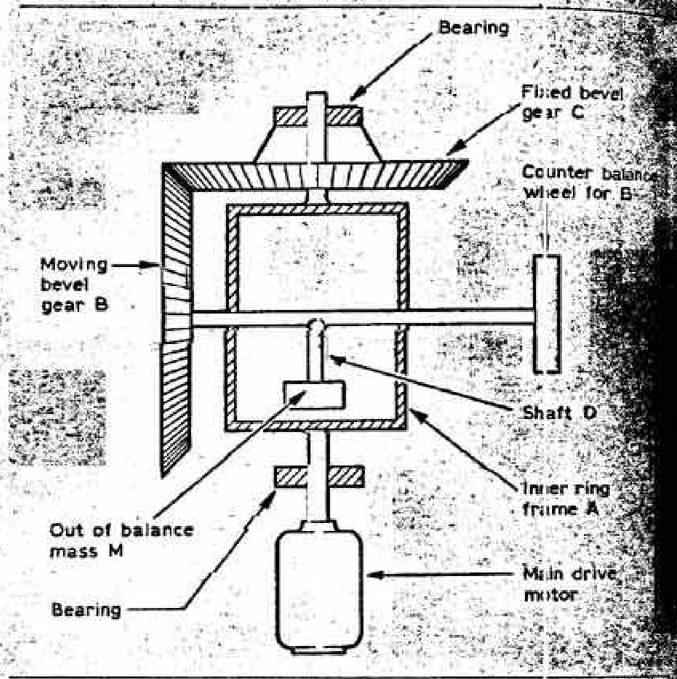

Fig. 1.—Di Bella's patent mechanical drive, which frog marched the holder across the floor

against the similar gear C, the latter being fixed to the frame of the instrument (to be regarded as the outer ring of the gyro). The gyro rotor is the shaft D carrying an out-of-balance mass M. The mechanical arrangement is not over complicated but the same cannot be said of the mathematical analysis required to assess what pushes what. The following points, however, should be noted.

(1) Had the rotor been a symmetrical wheel or cylinder it would have been in a state of forced precession against an outer ring which was nominally fixed. This would have therefore involved all points on the rotor with the effects of rate of change of acceleration (i.e. not coming within the accepted Laws of Motion).

(2) The rotor being eccentric adds a whole dimension of complexity to any analysis, for there is a fundamental difference between the equations:

Force = Mass × acceleration, and

Torque = Moment of inertia × angular acceleration

for the dimensions of each term of the second are each multiplied by length as compared with their counterparts in the first.

(3) The ability of the outer ring (i.e. case) of the instrument to move to a limited extent when held by a human and "frog marching" allows effective radii of certain axes to change continuously.

It is not surprising that the Professor warned "We emphasise the difficulty of understanding its operation perfectly . . . !" My only comment at this stage is first that I must believe the reliable witness and second, the

*Imperial College, London.

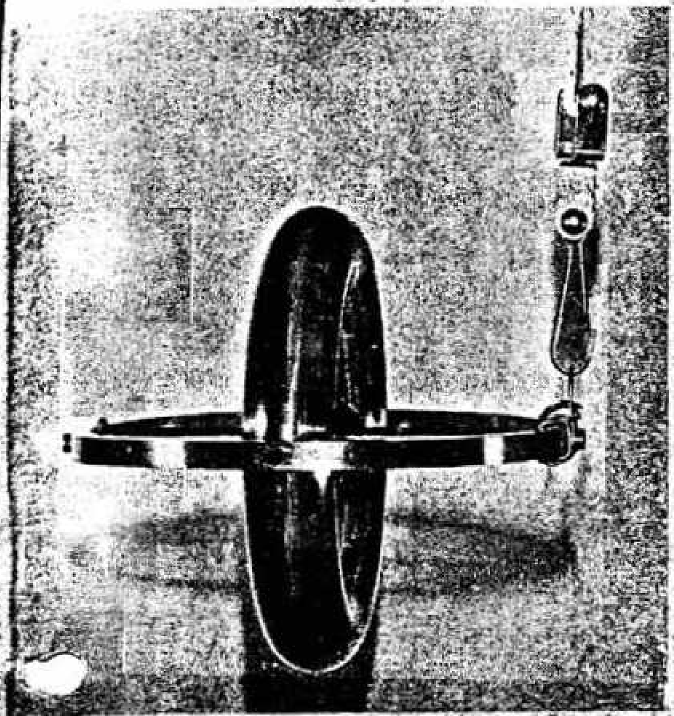

Fig. 2.—The orbiting gyro on a 50ft cord

machine had all the "ingredients" necessary for a non-Newtonian behaviour.

The second letter relates to the Royal Institution Christmas Lectures which I was privileged to give some few weeks ago and which were televised by the BBC. The letter reads:

18th February, 1975

Dear Sir,

The article by Professor Laithwaite on gyroscopes (*Electrical Review*, 14th February) leaves some doubts and may be an example of the technique which persuades Eskimos to buy a freezer. At the end of one of his lectures, Professor Laithwaite hung a gyroscope on the end of a rope suspended from the ceiling and it began to precess. May I enquire whether this experiment has been repeated and the deflection of the rope measured? This [illegible] enable the value of the centrifugal force to be calculated and it could be compared with that due to the same non-gyroscopic weight revolving about a vertical axis.

Yours sincerely,
E. W. Crew.

The lecture theatre at the Royal Institution is some 50ft high. A pendulum suspended from such a ceiling is divested of many of the imperfections that destroy "the interesting bits" of fundamental experiments. (Such trivia as air resistance, bending moment in the suspending cord, etc.). Prior to the lecture, a plumb line had been hung from the proposed suspension point and a mark had thereby been made on the lecturer's bench, *directly beneath* the point of support. For many hours, the gyro shown in Fig. 2 had been hung by one of its pivot extensions, from the chosen suspension point, with its rotor stationary. In this way all torsional forces between *cord and gyro* had been allowed to resolve themselves until all visual torsional movement of the gyro had ceased.

At the start of the experiment proper, the gyro axle was raised to the horizontal as shown in Fig. 3, the rotor was spun by friction contact with a rubber wheel driven by an electric motor to a speed of approximately 2,000 rev/min. The gyro weighed some 16 lb. It was released with its axis

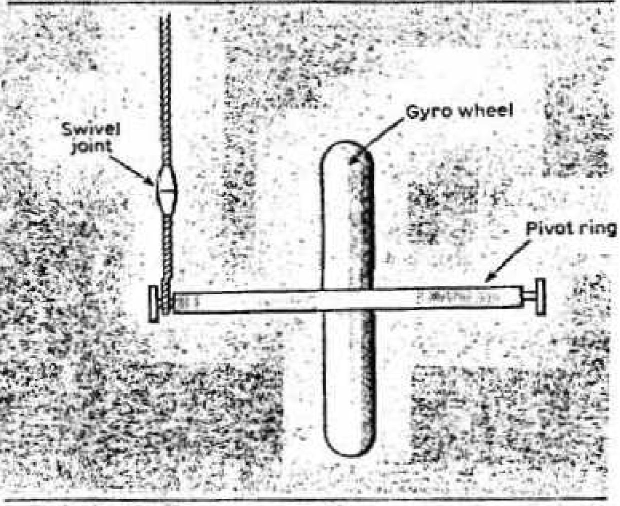

Fig. 3.—The starting position for the large orbiting gyro

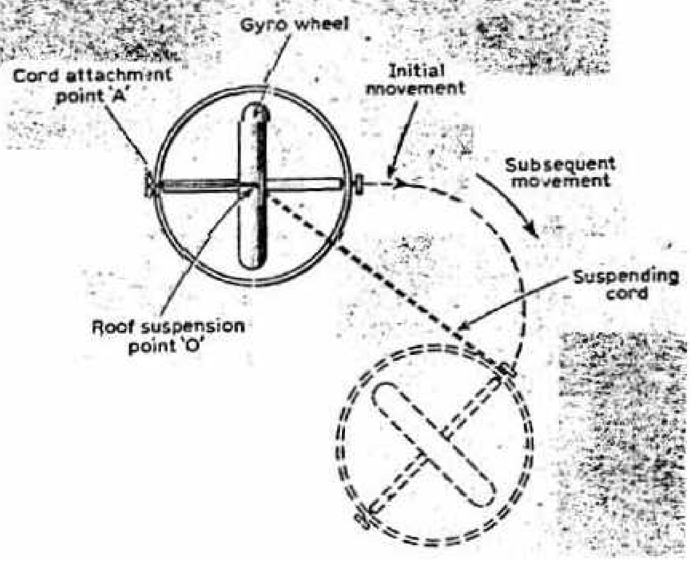

Fig. 4.—The initial path of the orbiting gyro

horizontal and with its mass centre directly over the bench mark, on the grounds that it might then precess about the vertical axis from this point.

The first part of its motion is illustrated in Fig. 4, and can probably be explained by the persuasive statement that a precessing gyro transfers its mass to its first point. If that be so, then point A, being located to one side of the support point O, moves towards O and overshoots, as would any "dead" pendulum,* after which precession becomes apparent and the whole wheel spirals outwards, reaching an apparently circular orbit of about 2ft diameter in about 15 seconds. (Note that the pivot opposite to the tethered end leads the way all around the orbit.)

To the untrained eye, the spiral egression appeared to continue, but as we now know, the 2ft orbit has some form of temporary stability. For the audience, the distance from gyro to bench marker continued to increase until the wheel was constrained in a circular orbit of about 10ft diameter.

*Not only does one get a sense of "aliveness" when handling an ungimballed gyro, but also one senses a perverseness, in my experience, mostly to be found in the fairer sex, in that if a desirable course of action is offered, it is refused "on principle." Like a mariner thinks of his ship, I think of a gyro as a "she"!

It was a wonderful sight, as it circled silently over the front row of the audience, passing the end of my nose so closely that I leaned back, just an inch or two, on each passing (which is how I knew it had reached a stable orbit). Then we noticed that the wheel axis had "drooped," that is the free end of the pivot was now situated well below (about 2in) the tethered end, and most of us, I think, put this down to air friction by comparison with the toy gyroscope that soon droops from its Eiffel Tower due to pivot friction.

But the gyro had other surprises for us yet. After four or five of the big orbits, she began to spiral *inwards*, and as she did so, the axis returned slowly to its horizontal position and we realised that the droop was due only to the desire of the gyro to maintain her centre of mass at a precise height. It should be noted at once that had the axis remained horizontal during the outward spiral, that single phenomenon would have been sufficient to smash the Second Law of Thermodynamics, and we are not quite ready for that event, yet!

After a few small orbits at 2ft diameter, out went the gyro again in an increasing spiral and when we had all mentally picked ourselves up off the floor one was almost bound to gasp "The Bohr atom!"

I am not suggesting that the analogy between the structure of the atom and this gyro is a strong one, even though most people's idea of the Modern Electron, is a smooth body rotating in a frictionless medium (younger readers please note that the "Olde Electrone" used not to spin!). What is more, I have not yet had time to do the mathematics for the gyro motion. The equations governing a conical pendulum are simple if one believes (as many have already indicated in print) that a precessing gyro exhibits the same centrifugal force about the precession axis as if it were a "dead" thing, but the critics, along with the rest of us, will be pushed to predict at what instant and why, she "decided" to embark on an inward journey away from the simple orbit. The fact that the droop was restored (so far as the eye could judge virtually completely), pays tribute to the bearings and demands that loss of wheel speed be ignored in any "classical" explanation of the phenomenon.

I have certainly partaken of a space journey during these last few months. Fig. 5 shows me supporting an 18 lb wheel revolving at 2,000 rev/min on a 6 lb shaft, 22in long on my little finger with my arm fully extended towards the camera. It is not posed; it is an action shot and I am rotating at about 1 revolution in 2 seconds about a vertical axis, dragging the gyro around faster than its natural precession speed under gravity. The wheel is rising quite rapidly (about 3ft vertically in half a revolution of me). What is most dramatic is my ability under this forced precession condition to lift the other end of the rod also. Had the gyro merely transferred its mass to its first point, i.e. my finger, I could not have supported 24 lb at arm's length, let alone accelerated it upwards. Had there been the usual centrifugal force it would have been $\frac{Mr\omega^2}{g}$, which with $M = 18$ lb, $r = 3$ft and $\omega = \pi$ rad/s, works out at about 17 lb, the shaft would certainly have been snatched from my finger. Photographs, of course, can be faked, but anyone can repeat the experiment for themselves. Perhaps the last word for now should go to the young man (science sixth-former, I would guess), who at the end of the fourth (gyro) lecture of the RI Christmas series asked me: "Is this why everything we can see in the sky through a telescope is spinning?" We may not have to wait until 2001 for our trip to Saturn!*

* "2001, A Space Odyssey" by A. C. Clarke (Arrow Books).

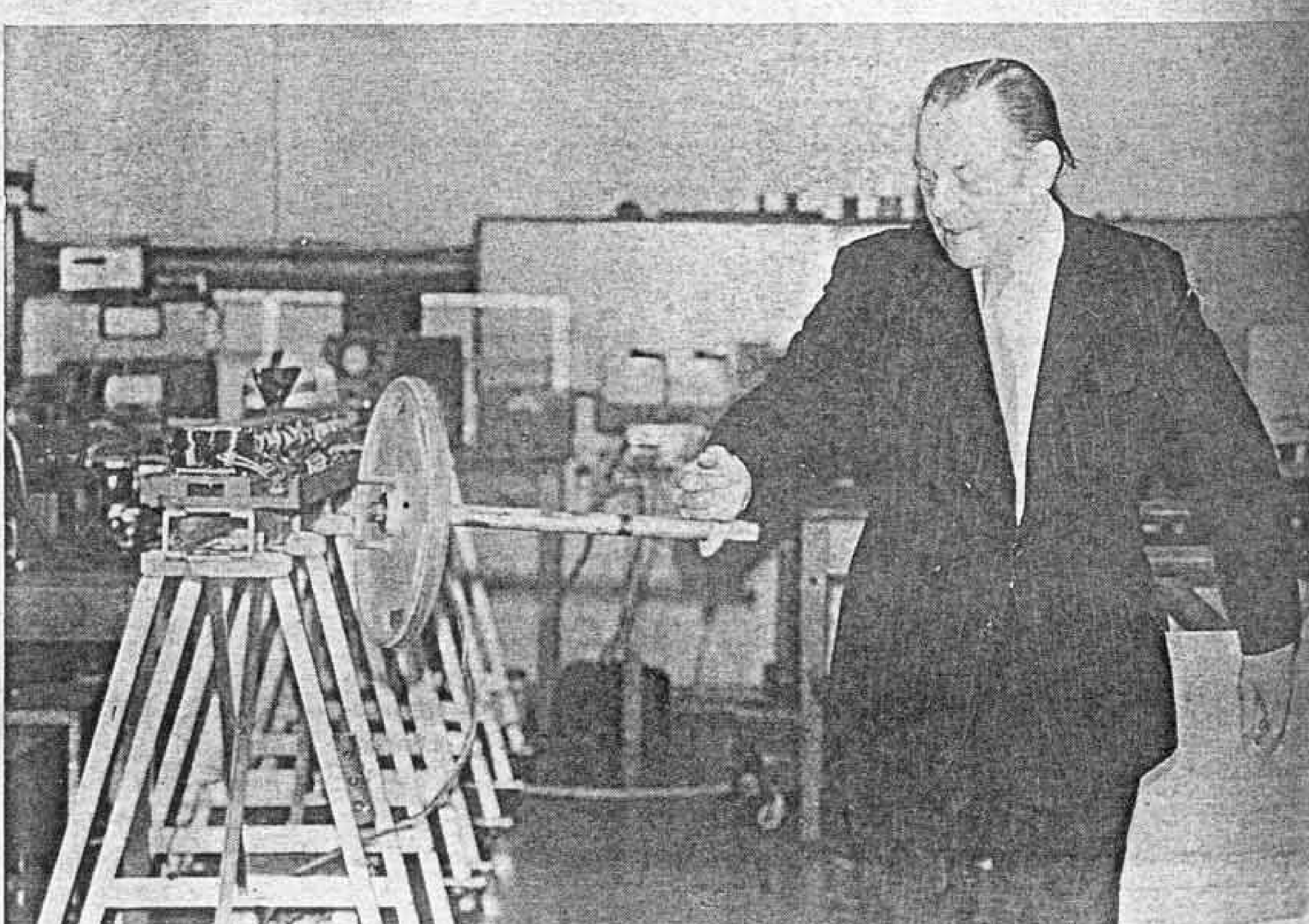

Fig. 5.—A 24 lb gyro rising from the action of a little finger