

## letters

be able to acquire such a technology on their own if they wished, and I also believe that they would have an extra incentive to do so if the developed countries withheld the present technology from them.

► I believe that nuclear technology, on the balance, has been of immense benefit to mankind and therefore it would be very detrimental to halt its further evolution or to withhold its results and products from the developing countries.

MICHAEL J. MORAVCSIK

University of Oregon  
Eugene, Oregon

11/20/79

## Einstein and Maxwell

I feel that another centenary should be mentioned, if not celebrated: James Clerk Maxwell died in 1879, the year Einstein was born. The opening sentence of Einstein's first paper on relativity: "It is known that Maxwell's electrodynamics—as usually understood at the present time—when applied to moving bodies, leads to asymmetries which do not appear to be inherent in the phenomena." Considering the fact that Einstein's theory of relativity was born out of considerations based on Maxwell's theory of electrodynamics, the coincidence is striking!

P. HALEVI

Universidad Autonoma de Puebla

10/22/79 Puebla, Mexico  
Our opening paragraphs to the "Einstein" issue (March, page 26) made brief mention of the coincidence. *The Editors*

## Jovian issue

In August (page 15), Leonard Larks proposed that the "immiscible" character of the swirling vortices in the Jovian atmosphere might be caused by electromagnetic interactions.

There are two problems with this hypothesis. The first is that there is no detectable correlation between atmospheric and magnetic field features (see, for example, page 806 of *Jupiter*, T. Gehrels, ed., University of Arizona Press, 1976). Since the data have limited resolution, it might be contended that this is not a compelling argument.

A second, more convincing argument (at least from a theoretical point of view) can be made by considering the electrical properties at the relevant level of the atmosphere ( $T \approx 130$  K,  $P \approx 0.5$  bar). This is well below the ionosphere, yet well above the deep, conducting regions of the planet (see my review paper on page 395 of *The Origin of the Solar System*, S. Dermott, ed., Wiley, 1978). At this level, the only charge carriers would be non-equilibrium species produced by cosmic rays, thunderstorms, and so forth. Al-

though thunderstorm activity may be greater on Jupiter than on Earth (but not by much) it is difficult to justify an electrical resistivity much less than around  $10^{15}$  ohm-cm, the value that characterizes the sea-level atmosphere on Earth (See the *CRC Handbook of Chemistry and Physics*). For this value, it is easy to show from the dynamo and magnetohydrodynamic Navier-Stokes equations that the ratio of Coriolis force to Lorentz force is around  $10^{10}$ . Electromagnetic effects are not, therefore, directly important (for the same reason that they do not directly modify circulation in the Earth's atmosphere).

There is, of course, the possibility of an indirect effect. It is known, for example, that there is a correlation between solar activity and photometric brightness of Uranus and Neptune (G. W. Lockwood, *Icarus* 35, 79, 1978). It is conceivable, therefore, that the behavior of the ionosphere or magnetosphere may affect the behavior of the neutral atmosphere. However, this would hardly constitute an explanation for the "immiscible" character of the motions detected by the Voyager Spacecraft.

DAVID J. STEVENSON

University of California  
8/23/79 Los Angeles, California

THE AUTHOR COMMENTS: David Stevenson appears to represent the "conventional wisdom" as applied to the fascinating behavior of the Jovian atmosphere.

I agree completely that data of limited resolution do not form a compelling argument against my hypothesis, and while I have not had the opportunity to study the properties of the Jovian atmosphere in depth, I feel that there may be problems with Stevenson's analysis.

Stevenson states that he cannot justify a resistivity of the atmosphere (at the altitude imaged by Voyager's cameras) of less than the order of  $10^{15}$  ohms, which would make the atmosphere a poor conductor or a reasonable insulator. If this estimate is correct, and if the current flux tube between Jupiter and Io, estimated in NASA publications to be on the order of  $10^6$  amperes (and a possible energy source according to some reports for the volcanic activity on Io), really exists, then the potential difference across the atmosphere where the flux tube penetrates it is on the order of  $10^{21}$  volts. This is well above the atmospheric breakdown voltage given by the *CRC Handbook* for the Earth sea-level atmosphere as  $10^9$  volts. In the absence of large amounts of atmospheric discharge phenomena near the Jovian terminus of the flux tube one must conclude that

- the atmospheric resistivity is much lower or
- the current in the flux tube is lower than estimated or
- the electrical discharge characteristics

*continued on page 82*

# WHEN HALF THE POWER



# WILL DO THE WHOLE JOB!

If your application requires only moderate power, ENI's new Model A150 will do the job. All it takes is a laboratory signal generator and you've got a perfect match for RFI/EMI testing, NMR/ENDOR, RF transmission, ultrasonics and more.

Capable of supplying more than 150 watts of RF power into any load impedance, the A150 covers the frequency range of .3 to 35 MHz.

We could mention unconditional stability, instantaneous failsafe provisions and absolute protection from overloads and transients, but that's what you expect from any ENI power amplifier, and the A150 is no exception!

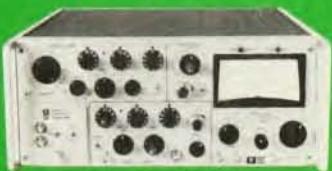
For additional specifications, a demonstration, or a copy of our new, full-line catalog, contact ENI, 3000 Winton Road South, Rochester, New York 14623. Call 716-473-6900 or Telex 97-8283 ENI ROC.

# ENI

*The World's Leader in Power Amplifiers*

Circle No. 13 on Reader Service Card

# In Lock-In Amplifiers...



## Everything else is a compromise.

The Model 124A Lock-In Amplifier, the recognized benchmark in phase sensitive detection, provides the researcher with such unique capabilities as:



### • Plug-in preamplifiers



### • Full range calibrator



### • Five-way selectable signal channel



### • Power reference oscillator



### • 0.2 Hz to 210 kHz operation



### • Tracking reference channel

When you can't compromise on performance you can't use anything but the Model 124A Lock-In Amplifier. For more information, write or call today: EG&G PRINCETON APPLIED RESEARCH, P. O. Box 2565, Princeton, NJ 08540; 609/452-2111.

 **EG&G**  
PRINCETON APPLIED RESEARCH

## letters

continued from page 15

of the Jovian atmosphere are not well represented by an Earth model.

In addition, in 1875, Henry Rowland demonstrated that a rotating insulator (he used ebonite) with an electrical charge on it behaves exactly as does a conductor carrying a current; thus counterrotating insulators may develop large voltages and associated currents.

Finally, the night-side photographs of Jupiter reveal a large amount of electrical activity in the form of auroral and lightning displays.

It seems clear that our understanding of the Jovian atmosphere will be better when we have obtained more high-resolution data in the form of direct measurements, and it may then be more meaningful to evaluate the use of the Navier-Stokes viscous fluid equations on the similar Chapman-Cowling magnetohydrodynamic equations to understand this atmosphere.

Our next opportunity for direct measurements will be the flight of the Galileo spacecraft, and those measurements are eagerly awaited. I hope that all of the members of the scientific community will pressure NASA to ensure that there are no unnecessary delays in the flight of this spacecraft. If there are problems with the primary launch vehicle (space shuttle) which may not be ready as scheduled, a more traditional launch vehicle would do.

LEONARD LARKS  
West Covina, California

## MIS solar cells

I enjoyed Henry Ehrenreich and John H. Martin's article "Solar Photovoltaic Energy," (September 1979, page 25). The authors have addressed several important questions, which are of great importance in the ultimate commercialization of photovoltaics. However, in my opinion the authors could not bring to the attention of readers a very important photovoltaic device, namely the metal-insulator-semiconductor (MIS) solar cells.<sup>1,2</sup> Such cells rely on an ultra-thin interfacial layer (approximately 10-30 angstroms) between the top conducting contact (metal or oxide semiconductor or their combination) and the base semiconductor. These cells have advantages over conventional p-n junctions:

- device processing at lower temperature results in longer minority carrier lifetimes
- the collecting junction is located right at the surface of the base semiconductor
- elimination of heavy doping effects.

Efficiencies as high as 17.6% (area = 3 cm<sup>2</sup>, AMI, 28°C) have been reported for single-crystal silicon MIS solar cells.<sup>3</sup> The open-circuit voltage (660 mV) observed in these devices is the highest that

has been reported for any other p-n junction solar cells.<sup>4</sup> These developments are very encouraging and offer one of the best prospects for the production of cheap photovoltaic electricity.<sup>5</sup>

## References

1. M. A. Green, F. D. King, J. Shewchun, *Solid State Electron.* 34, 860 (1974).
2. R. Singh, J. Shewchun, *Appl. Phys. Lett.* 28, 512 (1976).
3. R. B. Godfrey, M. A. Green, *Appl. Phys. Lett.*, 34, 790 (1979).
4. *Solar Age*, September 1979, page 13.
5. R. Singh, K. Rahaman, "An Outlook for Automated Conductor-Insulator-Semiconductor (CIS) Solar Cells Factory," Accepted for presentation in the 14th IEEE Photovoltaic Specialists Conf 1980, San Diego, California.

R. SINGH

Colorado State University  
Fort Collins, Colorado

10/16/79

## Incident at IAU

As an invited participant of the US National Committee at the General Assembly of the International Astronomical Union last August in Montreal, I am shocked and outraged by the actions and attitudes of certain officials of the Canadian Organizing Committee in connection with an incident that occurred on Monday 20 August. In a truly multinational effort I and my colleagues Leo Goldberg, Gerhard Herzberg and Arno Penzias were collecting signatures on a petition of support for two of our Soviet colleagues, Jacob Alpert and Vladimir Dashevsky. Alpert and Dashevsky were fired from their positions after applying to emigrate some years ago, and now find themselves in the untenable position of being allowed neither to emigrate nor to continue their scientific work, in contradiction to the Universal Declaration of Human Rights, the Helsinki Final Act, and all principles of scientific freedom. Dashevsky in particular is in a very precarious situation, facing possible charges of "parasitism" and its attendant prison term. We felt that a direct expression of concern by the world's astronomers meeting in Montreal, would help alleviate their plight.

I would like to stress that our efforts during the IAU meeting in collecting signatures for the petition were not sponsored or endorsed by either the IAU or the Canadian Organizing Committee. This was solely an action taken by free individuals during breaks from the scientific meetings. It was conducted in such a way as to cause no embarrassment to either the Canadian Organizing Committee or any of the conference participants. On Friday 17 August I put copies of the petition on a table outside the cafeteria near the meeting rooms so that conference participants, of their own free will, could see it and sign it if they wished to do so. Goldberg and Herzberg had been assured