search Laboratories in Basel, Switzerland. Shortly after its publication, Japanese laboratories especially became strongly interested in the practical potential of the new electro-optical field effect, whereas in Europe and in the US almost all laboratories continued to work on dynamic scattering LCDs discovered by Heilmeier and collaborators[3] at RCA in 1968.

Since hardly any liquid crystals with positive dielectric anisotropy were known at the time Schadt and Helfrich published their effect, novel liquid crystals that could be used to demonstrate the commerical applicability of TN-LCDs had to be developed. This was achieved for the first time in 1972 by A. Boller and collaborators[4], who published the first low-voltage nematic mixture (Schiff bases) for TN-LCDs which is still today used by some companies; these compounds were described 2 years before George Gray of Hull University, England, published the biphenyls[5] referred to by Frederic Kahn and Litster. It is correct that biphenyls, which do not hydrolize like Schiff bases, are more practical to handle. Therefore, biphenyls became commercially much more important after Japanese scientists managed to replace the early glass frit seals in TN-LCDs by plastic seals, using new production technologies. However, besides Schiffs and biphenyls, a number of other LC-classes and mixtures with novel electro-optical properties that open up new applications for LCDs were—and still are—developed mainly by the Merck group[6] in Germany, at Hull University in England and by F. Hoffmann-La Roche in Switzerland.

There exists a US patent on TN-LCDs obtained by Fergason. However, his filing date is two months later than the filing date of Schadt and Helfrich. Fergason obtained a US patent despite the earlier priority by Schadt and Helfrich because of the US patent law gives preference to US inventors.

References

1. D. W. Berreman, J. Opt. Soc. Am. **63**, 1374 (1973) or T. Sasaki, Mol. Cryst. Liq. Cryst. **63**, 288 (1981).
2. M. Schadt, W. Helfrich, Appl. Phys. Lett. **18**, 127 (1971).
3. G. H. Heilmeier, L. A. Zanoni, L. A. Barton, Proc. IEEE **56**, 1162 (1968).
4. A. Boller, H. Scherrer, M. Schadt, P. Wild, Proc. IEEE **60**, 1002 (1972).
5. G. W. Gray, K. J. Harrison, J. A. Nash, Electron. Lett. **9**, 98 (1974).
6. R. Eidenschink, D. Erdmann, J. Krause, L. Pohl, Angew. Chem. **89**, 103 (1977).

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THE AUTHOR COMMENTS: Introducing the May 1982 issue of PHYSICS TODAY, I briefly remarked on the significance of some events of the past 15 years. This was dangerous, since we all view our activities and those of our close colleagues differently than the community at large does. I have undoubtedly disappointed others besides von Planta, and I apologize to them, too.

My remarks on the twisted nematic (TN) display came from my recollection of events and not from Fred Kahn's article. As I recall it, James Fergason conceived of the TN device in Kent, Ohio, in late 1969 and reduced it to practice in early 1970. Wolfgang Helfrich and Martin Schadt applied for a Swiss patent on the same device in December 1970. I believe that they and Fergason independently and approximately simultaneously conceived of the idea; therefore, credit for this scientific discovery should be shared by all three scientists. I am happy to add that Helfrich has made several contributions of equal or greater importance to liquid-crystal physics. Legally, as von Planta reminds us, the invention was assigned to Jim Fergason.

Von Planta incorrectly quotes my remark about materials. As Fergason, Helfrich, and Schadt demonstrated, TN devices were practicable in 1970. However, I regard the cyano biphenyls synthesized by George Gray's group as a genuine breakthrough and the first materials to make TN displays practical.

Finally, my remarks on TN-LCDs were intended not to offend, but to call attention to Fred Kahn's point that attempts to compete technologically by restricting the flow of basic knowledge will ultimately fail. The historical details given by von Planta strongly reinforce this view. The answer, clearly, is to stay ahead in basic research and discovery and then not to abandon the commercial development to others.

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THE AUTHOR COMMENTS: As pointed out in my article, "The spectacular growth in LCDs over the past 14 years has been made possible by the efforts of physicists, chemists, and engineers exchanging materials and technology relatively freely across international borders." The Swiss company F. Hoffmann-La Roche and its scientists, including Schadt, Helfrich, and Boller cited in von Planta's letter, certainly played a significant role in this growth. Many others not cited in my article also made significant contributions. Unfortunately, it would have been virtually impossible in an article of the length publishable in PHYSICS TODAY to recognize all those efforts and materials in perspective and still convey to the reader the important physical principles underlying those developments. The latter was the object of my article and I hope all those not cited will understand.

Nevertheless, I stand by my statement that "the first truly reliable and stable liquid crystal materials useful for devices" were synthesized by George Gray and his coworkers at Hull University in England. I believe this development of stable liquid crystals suitable for use in relatively low-cost, plastic-sealed TN-LCDs was the primary materials development underlying today's widespred use of TN-LCDs.

As to who invented the TN-LCD, a topic not addressed in my article, von Planta accurately points out that James Fergason is recognized in the US as the inventor of the TN-LCD. Fergason published the first description of a twisted-nematic, electric-field effect device in January 1970.[1]

The TN-LCD was apparently invented independently by several different workers in different parts of the world. The first time I learned of the TN-LCD electric field effect was in 1970. I was at Harvard University to present a seminar on electric field effects in liquid crystals and was told privately by Robert Meyer, then at Harvard, of his epxeriments demonstrating this effect. He neither published nor patented this work. In May 1971 I attended the International Symposium of the Society for Information Display in Philadelphia. James Fergason showed me privately a TN-LCD numeric display operating at room temperature and with good viewing angle. About the same time, the *Applied Physics Letter* of W. Helfrich and M. Schadt,[2] the first detailed description of this effect was being read throughout the world. Schadt and Helfrich are widely recognized by the scientific community for discovery of the TN-LCD on the basis of this publication and by the foreign legal and business communities on the basis of their filing date for the TN-LCD patent. Due credit should go to all these workers for their independent research and discoveries. Credit should also go to BDH, E. Merck, F. Hoffmann-La Roche, and other chemical companies for providing high-quality liquid crystals for research and manufacturing.

References

1. J. L. Fergason, T. R. Taylor, and T. B. Harsch, Electrotechology **85**, 41 (1970).
2. M. Schadt and W. Helfrich, Appl. Phys. Lett. **18**, 127 (1971).

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Chinese vs. Japanese

With reference to the inverted photo of Yukawa and Feynman in April 1982 (page 43), noted by Peter Lee (September, page 13), Lee's translation of the characters in the photo is not correct; the characters mean "extra limited-expresses," announcing a special schedule of the railway during a definite period.

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THE AUTHOR COMMENTS: The first two of the Chinese characters ("Kanji" in Japanese) actually mean "temporary," the third means "special," and the fourth means "urgent" or "express." I could not have guessed that the four characters put together constituted a time-schedule notice for limited express trains. My sincere thanks to Tatsuo Tabata for pointed out my error, and especially for reminding me that a Japanese Kanji does not always have the same meaning in Chinese.

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Role of the teacher

The article by Robert Fuller in September (page 43) illustrates a serious problem in physics education. Fuller cites a study in which students were asked (among other questions) for the trajectory of an object dropped from a moving airplane; many students responded that the object would fall straight down, rather than giving the "correct" answer, which assumes that the object would maintain the horizontal component of velocity of the airplane. Fuller then concludes that "The mind of today's student is . . . a jungle of . . . false ideas," which the teacher should have the students "unlearn."

In fact, under reasonable assumptions about the airplane's speed and altitude and about the aerodynamic properties of the falling object, the students' answer that the object would fall straight down can be much more nearly correct than the answer Fuller wants. However, my purpose is not to accuse Fuller of a physics mistake—I do not suppose that he seriously believes that one should neglect the effects of the atmosphere on a small object traveling at hundreds of miles per hour—but rather to point out that he displays a disparaging attitude toward students which, in my opinion, can make education impossible. It is my belief that the ideas students bring with them to the classroom can furnish a firm starting point from which to develop an understanding of physics. Of course, these ideas tend to be vague and unsystematic; it is the role of the teacher to lead the student to understand how ideas generated by everyday experience can be extended, and then