final tab failure. Had the experts in the solenoid valve case presented their technological evaluations in terms of realistic probabilities, they would of necessity have demonstrated the need for additional and more detailed examination of the physical evidence and for reconstruction of the mode of the final tab failure, the event that was crucial to the demonstration of technical causation. Additional tests to determine the size of the crack in the tab at the time of sale, as well as tests which would reveal the final failure of cracked tabs under operating conditions, were both feasible and desirable in the evaluation of such an inherently close technical question.

The Seriated Trial

We have emphasized the responsibility of the expert to assess realistically the physical evidence that he is asked to examine, and to communicate effectively the realities of his technological investigation. For the technologist to accomplish this, however, the litigation process in product liability trials must be altered so that this new role of the technical expert is encouraged. It should be possible to structure a product trial so that the questions related to product integrity and technical causation are treated apart from the other issues of liability. In cases where these questions could be considered and resolved by the jury independent of issues of injury and damages, an altered trial format would isolate and clarify these issues. Specifically, a trial format which we have termed "seriated" would have the jury answer the questions of technical causation and product defect before the specific injury and its consequences are introduced (*6*). This is but one example of how the legal community might be brought to respond to technological realities.

Conclusion

The refinement of the product liability litigation process requires a continuing substantive dialogue between the legal and technical communities. The common problem-solving orientation of the two disciplines bodes well for such interaction. We have shared in the exciting beginnings of this legal-technical interaction (*7*) and hope that in the field of product liability such joint efforts will lead to a more sophisticated and technologically sound litigation process, one in which the technologist can be true to himself while operating within a strong and responsive adversary system.

References and Notes

1. W. L. Prosser, *The Law of Torts* (Foundation Press, Mineola, N.Y., ed. 4, 1971).
2. J. W. Wade, *Southwest Law J.* **12**, 5 (1965).
3. While there is extensive literature dealing with various aspects of the law-technology interface, studies have not been focused on the establishment of the defect-causation link in strict liability litigations.
4. We maintain that the standards for strict liability recently set forth by the California and New Jersey courts in Cronin *v.* J. B. E. Olson Corp., 20 California Appellate Court 2d, 33, 501 Pacific 2nd 1153, 104 *California Reporter* 433 (1972) and Glass *v.* Ford Motor Co., No. L-17576-70 (New Jersey Superior Court, 3 May 1973) are seriously off the mark. These courts permitted the establishment of defect without reference to the "unreasonable danger" standard. However, while discarding the "unreasonable danger" standard, the California Supreme Court in the Cronin case did recognize that defect cannot be established without reference to some given standard.
5. Chestnut *v.* Ford, U.S. District Court for West Virginia, Docket No. 5778-R.
6. A. S. Weinstein, A. D. Twerski, H. R. Piehler, W. A. Donaher, *Duquesne Law Rev.* **12**, 425 (1974).
7. We have met with the Professional Engineers in Private Practice and drafted a document which addresses the procedures for qualifying an expert. We are also engaged in the activities of the newly created American Society for Testing and Materials Committee E-40, "Technical Aspects of Products Liability Litigation."
8. This research was supported by the National Science Foundation's Division of Exploratory Research in its program Research Applied to National Needs (RANN).

NEWS AND COMMENT

Green Revolution (I): A Just Technology, Often Unjust in Use

If the poor countries of the world are to grow enough to feed their swelling populations, peasant farmers must somehow produce more food from lands whose yields have remained static for centuries. The Green Revolution, a Western-style package of agricultural practices designed to bring about such a transformation, succeeded beyond expectation when introduced into India and Pakistan in 1967. But since its heady early progress, the revolution has run into technical problems and into sometimes bitter criticism that, far from breaking the chains of rural poverty, it has left poor farmers worse off than before. The latest blow is the energy crisis which has raised, sometimes beyond reach, the prices of the fertilizer, fuel, and pesticides on which the new techniques depend for much of their superiority.

A major impediment to assessing the present state of the Green Revolution is the rhetoric that has accreted round it. Academic writers often attribute the overblown slogans to journalists. In fact they were helped into currency by the foundations and aid organizations trying to promote the new techniques. The term "Green Revolution" was coined by William S. Gaud, a former administrator of the Agency for International Development (AID). Before the term became unfashionable, the marvels* of "miracle wheat" were loudly proclaimed by the Rockefeller Foundation which, together with the Ford Foundation, supported the early work on wheat in Mexico and on rice in the Philippines.

The new agricultural techniques were oversold and, in general, overbought, by governments as well as journalists. Until the bad harvests of 1972, countries such as India and the Philippines believed they would soon attain self-sufficiency in food production, and economists fretted that exportable surpluses would send grain prices plummeting. These hopes were excessive, and the Green Revolution has failed to live up to them. After the initial overselling, the counter-reaction has been equally extreme. "The Green Revolution is a hoax," states Marvin

* Under the heading "Miracle in Wheat," for example, a Rockefeller Foundation report of 1969 mentions that introduction of the new wheat varieties into India "has increased yields up to sevenfold." The average yield of Green Revolution strains in India in 1968/69 was 3.49 times that of traditional varieties.

Harris, an anthropologist at Columbia University, pointing out that grain production per capita in India was less last year than before the Green Revolution started. "Even as a purely technical experiment the Green Revolution has shot its bolt," say the Indian and English authors of a tract announcing its death.

The Green Revolution is neither miracle nor hoax, nor has it shot its bolt. Before considering its social and economic impact, it is important to note that the acreage planted to Green Revolution crops—or high yielding varieties (HYV's)—is still increasing in almost linear fashion, although the average yields of HYV crops have ceased to be quite as spectacular as in the early years. By crop year 1972/73, some 41.6 million acres in Asia and North Africa were being planted to HYV's of wheat and 38.7 million acres to those of rice, amounting roughly to 35 and 20 percent respectively of the total wheat and rice areas in these countries.

Not included in these figures is Mexico, where the Green Revolution techniques were first developed by the Rockefeller Foundation's research institute, now known as CIMMYT. More than 90 percent of Mexico's wheat land is sown to the HYV's developed by Norman Borlaug, although CIMMYT's corn program, whose HYV's occupy less than 10 percent of the corn land, has been something of a frost by comparison.

The steady growth in acreage of HYV's masks several limitations in real progress. The revolution remains

This, the first of two articles on the Green Revolution, discusses the social and economic impact of the new agricultural practices on rural society. A second article, to appear next week, examines some of its technical limitations, including the consequences of transferring a principally Western technology to third world countries.

confined to wheat and rice. The HYV's by and large grow best on irrigated land. For this reason they remain heavily concentrated in just a few areas; 81 percent of the HYV wheat is grown in a small area of India and Pakistan, and four countries (India, the Philippines, Indonesia, and Bangladesh) account for 83 percent of the HYV rice.

Though HYV acreage has expanded each year, there has been a slow but steady decline in yield. According to Indian government statistics, yields of HYV wheats have dropped from nearly 4 to 2½ times those of traditional varieties over the last 6 years and rice yields have also fallen off (see Table 1). Bad weather probably contributed to yield declines in the 1970's, but the principal cause underlying the downward trend is simply that the best land tends to be planted first to HYV's. A rule-of-thumb estimate by Dana G. Dalrymple of the U.S. Department of Agriculture is that if HYV's and traditional strains were grown on the same quality land, the HYV package in irrigated areas would probably give yields about 50 to 100 percent greater for wheat and 10 to 25 percent greater for rice.

These are quite modest margins of superiority compared with the multiple yields often talked about—a sharp illustration of the gap between the farmer's field and the researcher's experimental plot. One of the chief troubles of the Green Revolution is that, though equitable in theory, it doesn't in practice work as well for everyone.

The most distinctive of the Green Revolution package of practices is the seed. Traditional varieties of wheat and rice cannot make proper use of fertilizer since it causes them to grow too tall and topple over. The HYV's incorporate a dwarfing gene which gives the plant a short, stiff straw and enables it to respond to fertilizer with larger yields. Other genetic improvements include resistance to certain pests —but chemical pesticides need to be applied as well—as well as insensitivity to day length, and shorter maturation, characteristics which together mean that a second crop can sometimes be squeezed in before the end of the growing season. Besides fertilizer and pesticides, most HYV's developed so far also respond best to controlled supplies of water, which requires the land to be irrigated, not just rain fed.

These techniques may sound simple, but their impact is felt forcefully, if variously, throughout the fabric of the rural society. "For the poor, the Green Revolution in Java offers only the choice between servitude and homelessness," says Richard W. Franke of Montclair State College, New Jersey. Yet in the Indian Punjab, according to S. S. Johl of the Punjab Agricultural University, "there has been a definite and discernible improvement not only in total employment but also in earnings of the agricultural labourers and artisans over the Green Revolution period."

The impact of the new techniques varies so widely from country to country, and from one observer to another, that few general truths can yet be arrived at. But the broad trends so far apparent tend to corroborate, at least in part, the fears of economic injustices expressed by early observers such as Wolf Ladejinsky of the World Bank, Clifton R. Wharton, president of Michigan State University, and Walter P. Falcon, now with the Food Research Institute at Stanford.

Mechanical reapers replace the sickle in Northern India. By speeding the process of mechanization, the Green Revolution may ultimately destroy more jobs than it creates. [Photo: Rockefeller Foundation]

The most frequent criticism made of Green Revolution technology is that it benefits rich farmers more than the poor. The verdict of most who write on the subject is that in many countries this has turned out to be the case. Generally the poor do benefit, but the rich benefit more, and income disparities grow worse. Such an outcome is almost inevitable. In most countries the small farmer will find it hard to raise the credit necessary to buy the HYV seeds and chemicals. If he has only one crop between his family and starvation, it makes sense to let others take the first risk on new methods. Hence it is usually the larger farmers who adopt the new techniques first and make the biggest profits.

If prices and credit structure are right, small farmers will generally follow their lead quite quickly, but profits tend to be less for those who adopt later, in part because of increased supply, in part because the government may by then have reduced the usual subsidy. For Mexican wheat farmers, among whom the Green Revolution has gone through its full cycle, both prices and costs have dropped steadily since the new seeds were first introduced. The net result is that "farmers' profits from wheat growing have settled back to about where they were before it all began," according to a study by William I. Jones of the World Bank. In Mexico the ultimate beneficiary is the urban consumer, who pays less for wheat. (The Mexican poor eat corn, but they stand to benefit indirectly in that the government need not spend foreign exchange on wheat imports.)

The income disparities caused by the Green Revolution thus depend partly on the stage of the adoption cycle a country has reached, being greatest at its outset. They also depend critically on land distribution, being grosser the less justly land is held. Both in Mexico and the Indian Punjab, the two leading showcases for the Green Revolution, land distribution is comparatively equitable.

A second major criticism made by economists and sociologists is that the Green Revolution displaces labor and increases rural unemployment. Like almost every other effect the revolution is praised or blamed for, rural unemployment existed and was on the rise before the new techniques were introduced. The Green Revolution should in theory be labor-intensive. The HYV's require more care and attention in ground preparation, planting, and harvesting. Where they make it possible to get a second crop into the growing season, they double the need for labor. But in part because of its labor-intensity, the Green Revolution also offers the incentive—and profits—for the larger farmers to mechanize.

Table 1. HYV yields in India as multiples of yields of traditional varieties. [From D. G. Dalrymple, *Development and Spread of High Yielding Varieties of Wheat and Rice in the Less Developed Nations* (USDA, June 1974)]; this is also the source of all quoted figures on HYV acreage.

Crop year	HYV yields	
	Wheat	Rice
1966/67	2.87	2.58
1967/68	3.70	2.18
1968/69	3.49	2.05
1969/70	3.68	2.26
1970/71	3.44	2.27
1971/72	2.50	2.03
1972/73	2.35	1.76
1973/74	2.59	1.71

The mechanization that in practice accompanies the Green Revolution is itself double-edged; the use of tractors for rapid land preparation, for example, may create extra jobs by giving time for a second crop. But overall, mechanization is job destroying. According to one estimate, nearly 20 percent of labor in the Punjab will be displaced by machines by 1984.

For the moment the job creating aspect of the Green Revolution generally predominates over the job destroying influence of mechanization. Falcon, for example, estimates that with the new technology perhaps 30 percent more labor is used per acre. (Less labor is needed, however, per ton of food produced, which may entail fewer jobs once the country attains self-sufficiency.) In the longer run, unless fuel prices remain prohibitive, and if governments persist with tariff policies that favor imports of tractors, the positive impact of the Green Revolution on employment is likely to be swamped by mechanization. Yet the less developed countries, with no large industrial base to mop up labor, cannot easily afford to undergo the same kind of agricultural revolution that in the United States has forced some 30 million people to leave their rural homes for the city.

Unemployment, income disparities between classes and regions, and other untoward consequences of the Green Revolution are often said to be threatening the social and political fabric of society. "Far from reducing social tensions in rural areas," warns a World Bank working paper on agriculture, "the spread of the new technology is likely to sharpen them, and to lead to greater demand for the implementation of measures, such as land reform, for the redistribution of income and wealth." According to political scientist Francine Frankel* of the University of Pennsylvania, the evenhandedness of the scientific method—the fact that the Green Revolution evidently works as well on the aristocrat's estate as on the sharecropper's plot—engenders the dangerous notion that all classes should benefit from it equally:

> The Green Revolution, therefore, is the instrument of ever more complete erosion in traditional social and political forms. In those areas where the new technology has been most extensively applied, it has accomplished what centuries of disruption under colonial rule failed to achieve: the virtual elimination of the stabilizing residium of traditional society, the recognition of mutual, non-symmetric obligations by both the landed and landless classes.

Such predictions of social disruption have not yet been widely realized, though that may be only because the Green Revolution has been slower than expected in expanding out of its base areas. Whether the social changes in question should be chalked up to the Green Revolution's credit or debit is something else again.

Is the Green Revolution an equitable technology, in the sense of being equally accessible to small farmers and large? Inequity is "absolutely implicit" in Green Revolution technology, according to Donald K. Freebairn of Cornell, because the inputs and skills it requires are not evenly distributed among members of the society. On the other hand, Dalrymple and Jones consider the Green Revolution to be "as close as we will ever get to a massively adopted, inherently equitable technology." Provided that a government ensures equity in the provision of credit and supporting services, the technology itself will perform as well in a small field as in a large, and is generally neutral to scale. An important exception, according to Frankel, is that, in India at least, farmers whose plots are smaller than 10 acres or so may find it uneconomical to invest in a tube well, and too risky to grow HYV's without one.

In a more general sense, however,

* F. Frankel, in *Food, Population and Employment*, T. T. Poleman and D. K. Freebairn, Eds. (Praeger, New York, 1973).

technological change is bound to favor the large farmers who are better equipped to understand and take advantage of it. If the flow of research innovations is continuous, the large farmer's advantage may be rendered permanent. The technical problems raised by the Green Revolution (discussed in an article to appear next week) may in fact demand that farmers master a steady flow of technical solutions. Yet even if socially disruptive, the Green Revolution does enable more food to be produced, and the problems of abundance are preferable to the problems of scarcity. Progress with disruption is better than no progress at all.—NICHOLAS WADE

Council for a Livable World: Dispute over Campaign Finance Disclosure

The Council for a Livable World (CLW), a group founded by the late Leo Szilard which lobbies for arms control and raises money for sympathetic Senate candidates, is one of the principal parties in a surprising controversy over campaign finance disclosure. At the moment, the controversy consists of a war of words on two fronts. One front is in Washington. There, the CLW, which raised $336,500 for 17 Senate candidates during 1973 and 1974, is engaged in a dispute with the office of Secretary of the Senate Francis R. Valeo, who is responsible for supervising Senate campaigns for compliance with the Federal Election Campaign Act of 1971. The CLW is taking issue with a determination by Valeo's office in October that called for some preelection disclosures not previously required.

The other front is in North Dakota, where, at this writing, the race between Senator Milton Young, the Republican incumbent, and William Guy, a former Democratic governor, is still undecided pending a recount (Young had a 177-vote edge on the initial count). In the last month of the campaign, Guy found himself under heavy attack for having accepted a total of over $27,000 in checks from some 2000 CLW supporters without disclosing from the outset the council's role in soliciting the checks and "bundling" them for delivery. Ironically, one of those raising the issue of disclosure was an independent candidate, James R. Jungroth, a former state chairman of the North Dakota Democratic party who had himself once sought CLW support but failed to get it.

Despite the fact that disclosure of the CLW's intermediary role in fund-raising had not been legally required, several North Dakota newspapers hit Guy hard on this issue. For instance, the Fargo *Forum*, noting that Guy had pledged not to accept money from "special interest groups," gave him a "high hypocrisy rating."

For his part, Guy, although he had authorized the CLW to solicit funds on his behalf, expressed surprise at the amount of money he received from council supporters. On 22 October, Guy made the following comments to a television interviewer in Bismark, N.D.

> When we started our campaign in January we decided we would accept contributions only from individuals. . . . And we also said we would welcome endorsements by responsible groups, but no money. . . . That is, no block grant from any special interest group . . . because then the membership of that special interest organization would be denied the individual choice that I think they should have.
>
> We've followed that policy very closely. . . . In each instance we've said that this endorsement will be accepted *only* if it carries no commitment whatsoever, and no organizational financial support. But if your members want to support us, fine. . . . And this is the way it has worked. I didn't realize that more than 1600 Americans from all over the country would send me money as members of the Council for a Livable World. . . .

The lines were drawn in the Washington controversy when the CLW chose not to follow the determination by Valeo's office on 18 October that it should make public disclosure prior to the November election of the sums raised for Senate candidates. Indeed, council leaders and their attorney, Terry F. Lenzner, formerly assistant chief counsel for the Senate Watergate Investigations Committee, have not even conceded that there has been such a ruling.

They contend that the only thing the council had received was a "preliminary" interpretation by Valeo's staff of disclosure requirements, and that no binding ruling on disclosure had been issued by the secretary's office—a difficult position to maintain inasmuch as the staff determination was approved by Valeo himself. According to Orlando B. Potter, consultant to the secretary on election campaign matters, "He [Valeo] reacted very emphatically, and said that the council was accountable under the [1971] act and had to make the disclosures we were requiring."

The council has never tried to conceal from the general public the identities of the candidates chosen to benefit from its fund-raising efforts. With mailings to "supporters"—or previous contributors—going out to some 32,500 persons, secretiveness would be impossible even if it were desired. But, as to preelection disclosure of the results of CLW solicitations, the council has left this to the discretion of the candidates themselves.

The president of the CLW, William Von E. Doering, a Harvard chemistry professor, has offered two principal arguments in support of the council's position.

One is that, as a group devoted not merely to fund-raising but also to advising senators on arms control issues through lobbying and seminars, the CLW could be hurt should its support for candidates become an issue in elections. This argument seems curious in light of the fuss that arose in North Dakota not from early disclosure but partly from the absence of it.

The other argument is that disclosure may make trouble for some CLW supporters whose donations are large enough (over $100) to be reported by name and who live or work in a place where arms control issues happen to be intensely controversial. In states where right-wing political factions tend to be strong, the CLW is often falsely accused of championing "unilateral disarmament." Thus, in Doering's view, mandatory disclosure could constitute an infringement on an in-