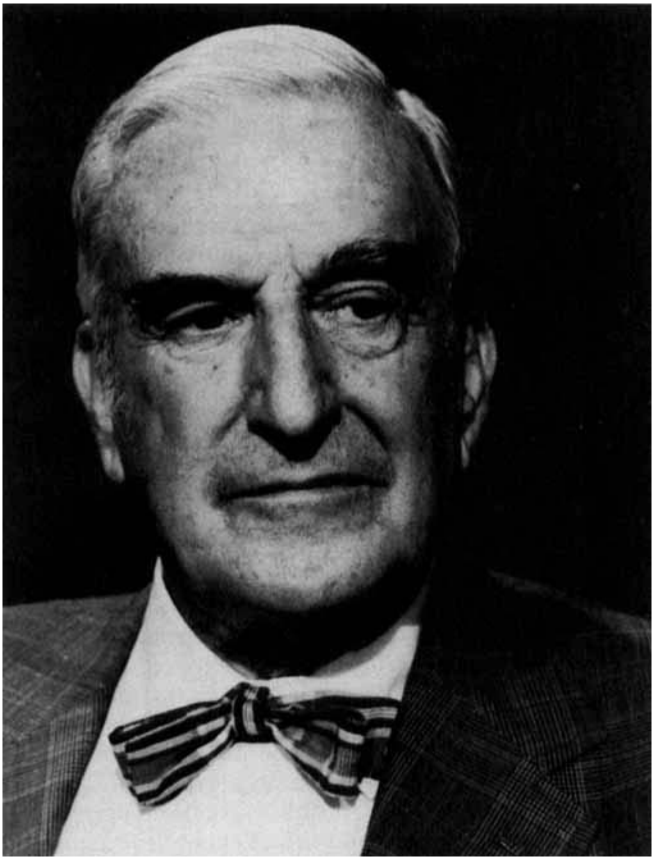
Health Physics Vol. 39 (December), pp. 851–874
Pergamon Press Ltd., 1980. Printed in the U.S.A.

SOME NONSCIENTIFIC INFLUENCES ON RADIATION PROTECTION STANDARDS AND PRACTICE THE 1980 SIEVERT LECTURE*



LAURISTON S. TAYLOR†

1. INTRODUCTION

IN THE practical application of the principles for achievement of protection against harmful radiation effects, our greatest obstacles today do not include a lack of knowledge about the biomedical effects of ionizing radiation. Today, we know about all we need to know for adequate protection from ionizing radiation.

Let me repeat that. Today we know about all we need to know for adequate protection against ionizing radiation. Therefore, I find myself charged to ask: why is there a radia-

*This lecture was delivered at the Fifth International Congress of the International Radiation Protection Association, Jerusalem, Israel, 9–14 March 1980.

†Past President, National Council on Radiation Protection and Measurements.

tion problem and where does it lie? In my opinion, it falls essentially in the area of radiation control with reference to the needs and any possible risks associated with a particular use.

The inquiry will take us into considerations well beyond science; into philosophical, sociological, political, economic, and moral areas wherever questions of the uses of radiation arise. It is through its relation to these fields that the problem of controlling radiation uses becomes today so complicated.

The sociological aspects of radiation control involve the public relations, both by and within the scientific community and thence through the news community to the larger society. Further, any treatment of the societal aspects of radiation control frequently raises questions requiring political solutions, that is, actions of prudence and sagacity in devising and pursuing measures to promote public welfare. Other aspects may not be as much protecting ourselves against radiation as protecting us against ourselves (Ta57a) and from our penchant for self-torment through our obsession with health.

The control and management of any toxic agent, including radiation, requires a critical knowledge of the properties, characteristics, and biomedical effects of the agent. Furthermore, if control is to be *absolute* in the scientific sense, there must be either (1) an establishable threshold below which there is no effect or (2) the total elimination of the toxic agent.

It is obvious that as far as we know today neither of the above requirements can be met fully for ionizing radiation. Therefore, we must resort to other considerations, largely sociological, to arrive at some acceptable solution to the radiation control problem.

In developing my theme I shall mention, at least briefly, some nonscientific factors which may influence protection practices directly or indirectly and hence, in turn, influence the setting of our numerical protection standards. By and large, it is usually the needs of practice that dictate the setting of standards and the standards themselves must always represent some degree of compromise between a politic use of radiation and its elimination.

Little said today can be new or innovative, but will be designed mainly as reminders to radiation protectionists of the things that they should be aware of and be prepared to discuss in public forums. Some items need to be promoted, some discouraged, others rationalized, and still others, defended. Throughout, in relations with the public, we must avoid being patronizing and avoid any appearance of self-promotion.

Let us turn now to a brief discussion about the state of our current knowledge of the biomedical effects of ionizing radiation.

2. THE SCIENTIFIC PROBLEM OF "THRESHOLDS"

Collectively, there exists a vast array of facts and general knowledge about ionizing radiation effects on animal and man. It cannot be disputed that the depth and extent of this knowledge is unmatched by that for most of the myriads of other toxic agents known to man. It is because of this knowledge, portions of which have become known to the public, that the public has come to expect sharp, clear, definitive, and undisputed answers to any questions involving radiation. This is an understandable, if somewhat irrational, position. However, it leads to the difficulty that when there may be some indication of a lack of knowledge by, or disagreement among, scientists, the public feels that somehow they have been let down or led astray by the scientific community. A good example of this is the current so-called "controversy" within the protection community centering around the effects of radiation delivered in low doses at low dose rates. Were it not for a few congressional committees, more interested in headlines than facts, aided and abetted by a willing press and a few publicity-seeking "scientists," it is likely that the question would drone on in the normal scientific meetings and committees at a proper pace, commensurate with its importance. It's not that it is unimportant, but its priority should be low compared with so many other insults that man faces.

Ionizing radiation, delivered in sufficiently large amounts, can cause determinable effects or injuries to any biological system. However, for any particular effect observed, radiation would not necessarily have to have been the causative agent. Practically any effect caused by radiation can occur from non-radiation causes.

Radiation effects are generally proportional to dose when delivered acutely in moderate amounts, say 100 rads upwards, to the regions observed. Precise proportionality is difficult to establish for the reason that radiation delivered to one part of the body may not necessarily produce any normally detected result in that area and yet have an effect on some other part of the body not necessarily exposed. However, for practical protection purposes, we postulate that for *acute* doses of radiation to any part of the body, the effect is proportionate to the dose.

There may be long latent periods between the time of exposure and the appearance of any effects that might reasonably be attributed to that exposure. Very large doses (above 500 rads) can show effects within minutes or hours. Low doses (below 50 rads) may not show any effects for periods up to several tens of years, if ever. In general, the lower the dose and the rate at which it is delivered, the longer will be the period of latency before the effect manifests itself. There is a generally inverse relationship between dose and latent period. The problem becomes especially critical in the low-dose region, say below 25 or 50 rads, *delivered acutely*, for which the latent period may be 3 to 5 decades.

During a long period any individual would be subjected to hundreds of other insults any number of which might produce the same effect as the radiation. Meaningful dose effect relationships can therefore only be obtained by highly sophisticated statistical methods. With all of our available statistical techniques of today, the number of subjects needed to show a statistically significant result one way or the other to exposure of a few rads per year runs into the millions and hence becomes impractical (We71).

Man has always lived in a radiation environment which, except for a very small increment due to weapons testing, has been essentially constant. Galactic radiation levels have changed little, except for rare but very large changes associated with reversals of the earth's magnetic field.

There is uncertainty about the existence of threshold effects for ionizing radiation; that is, dose levels above which an effect will almost certainly occur and below which it will almost certainly not. It is generally believed that there are very few threshold effects, although there are clearly some.

For the purpose of numerical protection standards, it is assumed that unless the contrary is clearly identified, any radiation will cause an effect, if not an injury. The development of a clearcut position on this question runs into complications depending upon the effects selected and how the effects are described. There are some demonstrated threshold effects in genetic dose-effect relationships. A skin erythema is definitely a threshold phenomenon. For internal body burdens of radium, there is what may be reasonably described as a "practical threshold," if not an absolute threshold. The threshold problem perhaps hinges about our ability to observe what may properly be described as an effect. It might well be that thresholds do indeed occur at exposure levels below those for which we have an observational capability. Under these circumstances, we face a situation where we cannot say with any certainty that there is or is not a threshold. This has lead to the adoption by the radiation protection community of the general postulation that thresholds do not exist and that therefore for any level of radiation, no matter how small, there may be an effect however undetectable. Here we encounter a further difficulty. If one is concerned about the degree of hazard in the region where effects cannot be found or identified, to what extent should an attempt be made to further "reduce the hazard" to some fraction of what could not be found in the first place? The question is "how large is half of something that cannot be measured?"

Dose effects are not cumulative. There must be some process of repair or recovery or replacement of cells, both of a genetic and somatic nature, if for no other reason, other than that based on modern radiation therapy techniques. It has been known for at least 50 years that the total amount of radiation delivered to a tumor and surrounding tissues can be enormously increased by the simple expedient of introducing "rest periods" between each treatment. Without some sort of recovery phenomena in play, there could be no reasonable radiation therapy today which, of course, is not the case.

Today we know enough about dose-effect relationships to state unequivocally that at least *for low LET radiations the relationships cannot be strictly linear over the whole dose range* and that even for high doses they are probably not linear. In general, the deviation from linearity has been such as to make our radiation protection standards more conservative or more restrictive than predicted by the linear relationship alone.

The difficulty, of course, is that since we do not know the precise relationship—and perhaps it doesn't make much difference anyway—it is assumed, as a matter of cautious procedure, that the dose-effect relationships are linear throughout the entire dose range. This assumption is constantly being subjected to hard scrutiny because, if taken too literally, it leads to unnecessary and unjustifiable restrictions on the use of ionizing radiations.

In speaking of the risks attendant upon the use of ionizing radiation, we accept the conclusion that they are reasonably tangible and identifiable for high acute doses, above 200 rads. Also, it is not too far afield to say that the risk would be proportinal to the dose. But, again, in the region of protracted low doses below 25 rads, we cannot find or define effects, nor can we define risks. The concept of risk is itself basically intangible because different individuals evaluate risks differently and relate them to various intangible factors which have no definable interrelationships.

From the mere fact that radiation may cause some identifiable effect, it does not follow that the effects are necessarily detrimental. To properly speak about radiation injury, it would appear that one should only refer to an effect which, in the eyes of proper medical authorities, is regarded as detrimental in some respect (Na54). For purposes of protection against ionizing radiation, we have to deal with effects; detrimental effects; risks; quantities observable or unobservable; and so on. We have now ventured outside of the scientific arena.

3. NON-SCIENTIFIC ASPECTS OF RADIATION PROTECTION

Over the past several decades, there has been a gradually developing consciousness of the inadequacy of scientific data or reasoning that alone will lead to the establishment of unequivocal numerical radiation protection standards. In the late 1940s, it was clear to the NCRP, and probably other bodies, that non-scientific factors would be involved in establishing permissible dose standards. In 1957, I argued (Ta57b): "Radiation protection is not only a matter for science. It is a problem of philosophy, morality, and the utmost wisdom." At later times I have added "economics, politics, and public involvement" but actually they are all segments of an overall idiological approach. I shall select a few of these for special comment.

From science to the social aspects of radiation control

Let us examine some of the problems engendered by acceptance of the common assumption by radiation protectionists today that radiation effects are linearly proportional to dose from high dose (above 100 rads) down to zero dose, and there is no threshold. Absence of a threshold leads immediately to the difficulty that there is no line of demarcation between the regions where scientific evidence does or does not exist; where evidence is not found, it is simply assumed to exist—a judgmental decision. It is obvious that in reaching such a decision, a very non-scientific matter would play an important role. I refer to the emotions not only of some scientists themselves but also of the lay persons who understand only bits and pieces of the problem and who recognize that they have to depend upon the sceintist. The obvious problem is that no matter how small the dose, there may be some element of risk.

Risks expressed in so many chances per million people exposed have little meaning to the man in the street. A risk per 3 billion (world population) would yield a number 3000 times larger and by itself appear shockingly high. What is not appreciated, however, is the fact that to achieve such a risk would require exposure of the world's population to whatever dose may be considered. Somehow we must develop a reasonable and rational explanation of radiation risk levels that can be understood by the public.

To consider some of these points, let us ask "What are the judgment elements entering into a standards setting process?" There are probably too many elements to consider a complete listing. Basically, however, the arguments would center around the degree of risk that those who were setting the standards would be willing to inflict on others or, as a part of the public, to accept for themselves.

How do you evaluate and quantitatively describe a situation, or more likely a combination of situations, each having its own set of values and its own descriptive units, and none having any unique relationship to ionizing radiation? For example, what is an effect and what is an injury and when is one not the other? Comparisons of effects and injuries have been attempted in a variety of ways, particularly in the last decade or so, and it would seem that the only comparison unit which has come to our imagination has been monetary, such as the dollar or the mark. The arguments for choosing monetary value seem at times to be frivolous, but for obvious reasons nothing better seems to have turned up. The problem becomes even more involved if one tries to evaluate, let us say, pain or mental anguish which can be two obvious "effects" that might be caused by radiation, but still short of death. Death, in fact, is probably the only endpoint which is positive and to which some kind of value can be applied.

Let us consider that risk, however we decide to describe it, is roughly proportional to radiation dose. Why are people willing to accept any risk at all? This argument applies to practically everything we do in life, with radiation being perhaps one of the smallest risks that we normally have to contend with. Do many people really plan many of their actions in terms of a risk or some kind? I doubt it. Perhaps, in a rather vague way, some individuals may think of what an action may do for them or provide for them by way of a benefit and what the consequences of a failure of the action might involve. Surely, people almost never do that in regard to driving a car, skiing, or smoking, or climbing mountains. These are well-known high risk actions.

Various radiation risk-benefit combinations complicate the setting of any acceptable risk standards (i.e. permissible dose standards). The simplest case would be when Person A takes some action where only he is at risk when he knowingly enters a marked radiation area. Then there would be an action by A where he unknowingly enters an unmarked radiation area due to negligence on the part of Person B who is not at risk. Or there may be the case where Person C is at risk while radiographing an aircraft part, the failure of which would put Person D at risk. Each of these risk situations could easily fall into a different classification scheme with consequent different numerical risk assignments and hence different permissible dose assignments. Any solution to such problems may depend more on judgment and opinion than on facts or mathematics.

For all practical purposes, it is only in the use of medical procedures involving radiation that the risk, if any, is compensated by some benefit to the person at risk. It is also the area where one is more likely to find the situation that the risk of not carrying out some action (for example, an X-ray examination) is more hazardous than any conceivable risk to an individual from the radiation.

Since risk questions do not really have discrete and scientific solutions, we are compelled to accept a philosophical approach—which I once heard described as "going wrong with confidence." What is needed, on top of our scientific knowledge, which I contend is adequate at this point, is a large supply of basic wisdom and understanding. Question: Who has it? To whom do you look for it? How far can it alone suffice to complete the problem and develop a rational action policy?

Where has the past supply of wisdom come from? Good or bad, it has come mostly from the scientists themselves, who consciously or unconsciously, recognizing the limits of their scientific knowledge, have made strong and important judgment actions regarding the amounts of radiation considered to be acceptable for radiation workers or the public or the patient. This has not been a bad thing because, after all, the scientists involved cover a wide range of disciplines, ways of living, nationalities, ethnic backgrounds, religions, and everything else that makes for an effective melting pot. That this has been effective is evidenced by what I consider to be the fantastically fine radiation safety records that they have accomplished. No one has been identifiable injured by radiation while working within the first numerical standards set by the NCRP and then the ICRP in 1934.

Let us stop arguing about the people who are being injured by exposures to radiation at the levels far below those where any effects can be found. The fact is, the effects are not found despite over 40 years of trying to find them. The theories about people being injured have still not led to the demonstration of injury and, though considered as facts by some, must only be looked upon as figments of the imagination.

I do not argue for leaving the philosophical decision process in the hands of the scientist where, by default if nothing else, it has largely rested for the past 60 years. Nor do I argue for removing the process entirely from his hands; a combined scientific and non-scientific approach is indicated. A difficulty here is the current public attitude that if a person has worked in a field (e.g. radiation) he must be suspected of some kind of conflict of interest if he becomes involved in any related decision-making process. Actually, because of their basic training and their having to be imbued with a basic sense of objectivity, a good argument can be made that scientists, as such, are about as devoid of special interests as any group that may be found.

Aside from our experienced scientists, trained in radiation protection, where do we look further for our supply of wisdom? Personally, I feel strongly that we must turn to the much larger group of citizens generally, most of whom have to be regarded as well-meaning and sincere, but rarely well-informed about the radiation problems that they have to deal with. Nevertheless, collectively or as individuals, they can be of great value in our radiation protection domain if they can be properly guided in the technical matters without implantation of illogical and unacceptable biases and emotions and self-promotion. I will insist that we will have to utilize these people in developing our total radiation protection philosophy. This is a situation demanding a new approach to our public education process and it covers many areas of concern other than just ionizing radiation. However, as far as radiation is concerned, this is where the radiation protectionists must find and establish their roles and work at them as carefully and as diligently as they do with their monitoring, measurement, and analytical techniques.

To return to the basic philosophical question of setting standards for protection, we can, with some over-simplification, reduce the problem to two choices. One is to more or less follow the present course of theorizing that we are dealing only with a single, linear, no-threshold, dose-effect relationship. However, in doing this we must take more specific steps in the future to keep in front of the public that (1) this is only an untested theory; (2) it is used only because we don't know the precise relationship; and (3) it is probably conservative for most practical purposes. At the same time, we should stop ourselves and others from putting before the general public such niggling numbers as how many people are going to be killed by one millirem average dose from a leaky reactor (Ca79a) or 5-millirem dose given needlessly to a patient on top of the unavoidable dose of whatever you want, say, 50 millirems. Comparable annual doses are received by millions of passengers in high-flying aircraft and by the air crews who receive much larger doses; yet little concern is expressed over the situation. This is not to be construed as advocating any relaxation of our standards or the allowance of careless and sloppy radiation procedures of any kind. It is only an example of the variations in philosophical approaches to radiation hazards—real or imaginary.

On the other hand, we must find an acceptable means for stopping or counteracting the endless prattlings by a few individuals, with whatever motives they may have for keeping the public stirred up, confused and alienated from the very technologists who are in the best position to properly inform and educate them (Br78b; Ta70).

A fundamental difficulty is the determination of a distinction between mischievous prattlings on the one hand and an occasional useful idea on the other. Normal "peer review" and analysis will take care of most of these situations.

The second choice in standards setting would be to follow the practices used for many decades by the toxicologists. For permissible concentrations of some toxic substance, they would set a level somewhat below that at which any effect could be found. This carried the implication of a threshold, but stopped short of saying there was a threshold. Actually, today the toxicologists are tending to adopt the linear, nonthreshold philosophy largely developed for ionizing radiations. A judicious blending of the two philosophies (and that is all they are) may well provide us with the most sensible solutions to the protection problem.

I am not suggesting anything new, but I am pointing to a basic responsibility of radiation protectionists to critically evaluate the problems and to place the facts before the world public in a manner that will assure the allayment of their fears and suspicions.

Before leaving the basic philosophical questions, there is one more item that must be considered and one which has personally worried me since the day that it was first introduced. That question relates to the system by which we have different kinds and classes of permissible exposures or dose limits for different classes of people. On technical grounds, I would not argue either as to the pragmatic need or to the acceptability of such a procedure. However, on philosophical grounds, we have problems. For example, in 1948 the NCRP had recommended a basic permissible dose for radiation workers of 0.3 r/week, and for children 0.1 of that value (Na54).

While the basic concern was centered upon a supposed greater sensitivity of children to radiation, the original purpose for a reduced permissible dose was intended to apply to the general population-at-large. This encountered objections from some members and resulted in a compromise applying the reduction factor specifically to children only.

Actually, this was done, you might say, with tongue in cheek, because it was perfectly obvious that if allowable levels for the exposure of children were set at levels less than for radiation workers, this would have to include the whole population since the two could not be separated. Indeed, that is the way it developed and gradually the differential factor of 10 became well entrenched in our numerical radiation protection standards. In fact, it was only the first of a series of numerical standards that were specified in terms of some fraction of the occupational MPD.

Technically, the differential is acceptable. It is to be expected that very few radiation workers would be permitted to receive the full 15 rems in a year, but that conceivably a much larger number of the population might be allowed to receive 1.5 rem in a year (medical plus fallout plus TV radiation, etc.). It is most unlikely that collective doses to the general population, however high on the average, would exceed the collective dose to the much smaller number of radiation workers even though a few might have annual exposures above, say, 1/3 of the MPD or 5 rem in a year.

A logical question may be asked—why should our workers be subjected to higher radiation levels than the general population? The answer is along the lines given above, but it is rarely understood that way. From a philosophical point of view, a strong argument could be made for setting the same standards for radiation workers and for the public. On the other hand, for sound pragmatic reasons, and because thus far there is no evidence of injury even to radiation workers, this would certainly introduce a tangible and unacceptable economic cost for a gain that cannot be quantitated.

Politics

The term "politics" or "political action" does not necessarily denote the association that most people have with party or national politics. In this section, I will use politics as a word without the often disparaging meaning that goes along with it. As already noted, to be politic means to be "prudent and sagacious in devising and pursuing measures adopted to promote public welfare." (Webster.) In my use of the term, I exclude some further modifications of Webster's definition with such shades of meaning as "cunning" or "artful."

In the sense of radiation protection and in many other matters as well, political consideration really means the pragmatic combination of all of the elements bearing on a particular situation. In fact, we might almost group all of the elements which I have listed above under politics and even add some, such as legal considerations, economic considerations, social considerations, etc. In this sense, the scientist generally, and the radiation protectionist particularly, must devote more thought and attention to constructive and objective politics, including direct approaches to people through the Congress, the press, or the telecommunications media. He must develop constructive and especially objective discussions and explanations for what is happening in the field of radiation.

In the profession of politics it is unfortunate that in the United States, and probably in many other of the advanced countries, it appears that we cannot exclude what is sometimes referred to as party politics, that is, politics primarily involving the vote-soliciting actions of individuals. This relates to the more crass interpretation in the definition of politics, perhaps coming under the head of artful. From 1946 to 1977 practically all federal matters in the United States relating to ionizing radiation were handled through the Joint Committee on Atomic Energy. This was a committee operated jointly between the House and the Senate—a very special and unusual organization. It may be an over-simplification, but perhaps adequate to say that its main objective was to promote and protect the growth of the nucelar industry and to protect the public from its potentially dangerous by-products.

The Joint Committee, with a stable membership from both the House and the Senate, was dedicated to bringing out facts and an understanding of atomic energy, rather than looking for newspaper headlines and votes. The Committee, over its 30 years of existence, accumulated a massive library of technical data related to atomic energy and ionizing radiation, a major portion of which is in the public domain. To the extent possible, the Committee developed any conflicting viewpoints if each could be supported in a reasonably responsible way.

Because the actions of the Committee were focused on atomic energy operations, it was not unnatural that it promoted the uses of atomic energy in various forms, especially as applied to medicine and nuclear power. These goals eventually aroused the ire of some of the environmentalists, anti-nuclear activists, and certain key figures in the administration, with the result that the Joint Committee was ultimately abolished in 1977 by Public Law 95–110.

In its place there are some two dozen committees, many lacking in stability and without an overview power. Rarely does the chairman or staff of these committees have any knowledge in depth of the broad subject of ionizing radiation. But equally distressing is their failure to keep each other informed as to their operations and intentions. On at least two occasions I have been able to supply the staff of one committee with material from another committee of which they had not even heard. This fragmented process is wasteful, unproductive and confusing to the public. The public's confusion and misconception is further aggravated by the manner in which some of the committees will start off their hearings with testimony from individuals who are known to attract newspaper headlines but who at the same time are not regarded as particularly reliable by their professional peers (Mo78; Ta78; Br78a; Mo67a; Ma78; St78; Mo67b).

In spite of shortcomings in technical background, both federal and state legislatures can and do exert strong influences on the development of numerical radiation protection standards. However, because of the likely influence on governmental committees by vocal but prejudiced witnesses or witnesses having some personal case to plead, we are today faced with the possibility of unreasonably restrictive limitations being placed on legitimate uses of ionizing radiation (Ma79; Br78; Ta70).

The media

When a scientific problem or issue enters the political arena, there is likely to be a problem of communication. There is a growing gap between many scientific developments and an understanding and appreciation of these developments by the general public or by their political representatives. Unless the scientific community is aware of this and takes measures to bridge the gaps, there may be serious difficulties. In fact, there already are.

Education of the public is not easily accomplished by the usual scientific articles and books. These must compete with the much more commonly available interpretations of controversial issues given by other media from television to comic books. This is a major problem influencing radiation control. The "news media" clearly dominate and herein lies one of the most fruitful areas in which the radiation protectionist can and must assist in the education of the public. First, however, we have to persuade the media (and I use the term rather broadly now) that they have a national obligation to assist the country in educating its public about radiation matters.

At a recent conference on this subject in Paris, I tried to point out that the education of the public in radiation matters was principally through the various news media and that the media were failing in their job. I was critical because the media insist on displaying the sensational side of any radiation story to the neglect of the facts which in most cases were far less alarming (Wa79b). I was roundly criticized for this statement by one of the representatives from the Paris paper, *LeMonde*, who insisted that the newspapers reported only the facts (Tu77).

Attacks on the news media for one reason or another are common as is their defense under the First Amendment. The First Amendment to our Constitution in the United States is an essential bulwark of freedom and is not paralleled by many other countries as far as I am aware. However, in my opinion, the First Amendment also carries with it an implied obligation on the part of the press to completely and properly report the news.

In the case of ionizing radiation which, of course, is the area with which I am most familiar, there are constant and continuous violations of this principle. The press will report and accent the news items and details which it thinks the public wants to hear about and that will help sell their papers, the latter apparently being their prime objective. The media must make money to stay alive and viable. They must sell their products and avoid wasting time on non-paying items. Thus, consciously or unconsciously, a selective process begins. The newspapers say that they are supplying what the public wants. As far as the public is concerned, they take that because it is the only thing they can get. Unfortunately, we do not have the same kind of enormous economic pressure which could keep the press in line with regard to education of the public in radiation matters—and presumably many other matters as well.

Here again I do not want to be misunderstood. As inept as our press may be in the United States in some respects, it is at least open and uncontrolled by the government—uncontrolled even to the point where it will publish such stolen government secrets as can be found. I have often wondered how the First Amendment protects the press from prosecution for the compounding of felonies (c.f. the Ellsberg Papers case).

The fact remains that we need greater responsibility on the part of the news media in the objective presentation of uneditorialized news. This requires a high degree of professional integrity. At the same time, the public wants a variety of stimulating news stories. The result is a complex of conflicting objectives—sales versus truth.

As far as radiation is concerned, our people must somehow persuade the press that it is irresponsible to subordinate radiation facts in order to stimulate sales. This will be a slow and difficult process, but any gain is worth the effort. I am not sure whether there is any equivalent to our First Amendment in most other countries, but I am sure most of the world press presents the same difficulties for scientific understanding as coming from the American press.

Morality

What can we say in dealing with the problem of protecting people from possible adverse effects of ionizing radiation or from any other agent that might be expected to carry some risk of cancer? It must be clear from the discussions above that a slightly higher radiation exposure permitted to a group of people under a given set of conditions may cause one or two or "*n*" more injuries to that group and in reaching a decision as to what to recommend for their permissible exposure we are faced with deep moral considerations.

For example, the theoretical risk for radiation workers receiving the full MPD (5 rem/year) is ten times the risk for individuals in the public who receive the full Dose Limit (0.5 rem/year). At the same time the number of radiation workers (10^5) is only 1/2000th of that of the U.S. population (2×10^8) so that the *per capita* contribution of occupational exposure is only 1/200 the contribution of the non-occupational exposure. Such an unqualified statement by itself is just part of a simple and immoral numbers game of which we already have too many in the broad radiation protection field. (It might be remarked that only rarely does any radiation worker or any member of the public receive the normally specified MPD or Dose Limit respectively.)

An equally mischievous use of the numbers game is that of calculating the numbers of people who will die as a result of having been subjected to diagnostic X-ray procedures. An example of such calculations are those based on a literal application of the linear, non-threshold, dose-effect relationship, treating the concept as a fact rather than a theory (Mo67a). By this procedure it has been calculated that up to 30,000 deaths per year result from X-ray diagnosis and these statements are made to appear very convincing to the untrained listener. Of course, there has been no statistical or other verification of this calculation, but nevertheless the statement is so often repeated that it gains some credence among those uninformed about the fallacies involved. Unfortunately, the technique has been picked up by others (Go71; Na67). These are deeply immoral uses of our scientific knowledge.

Morality cannot be dictated by law or subjected to rule or control. Morality is almost invariably an individual matter and the best and most sincere and thoughtful of people probably have widely variant moral viewpoints on a given question. On the other hand, we cannot sweep our moral obligations under the rug, nor can we settle them or bring them into agreement by vote or edict or law. Dealing with the moral aspects of radiation protection problems demands a kind of leadership and guidance and overall understanding that is not easily found by advertising the availability of civil service positions—or any kind of position.

Laws and regulations

There is no question but that the legal, legislative, and regulatory actions in relation to radiation protection present one of our most formidable two-edged swords. On the one hand, they aid in providing a needed degree of uniformity in radiation protection procedures and they provide a base upon which action for redress can be taken as might be needed under a variety of circumstances. On the other hand, the very power behind the legal system tends to stifle initiative and innovation in many areas and invites litigation and other legal actions and greatly increases the cost of radiation, not only in industry but perhaps more importantly in medicine.

I recall attending a conference at Princeton University in the late 1950s in which one of the speakers, an attorney, gave a little anecdote which clearly foretold of things to come. He said it used to be that when a young man seeking guidance as to his life work might come to him for advice, years ago the reply would have been "Go West young man, that is the land of growing opportunity." Now, if he were asked the same question, he would reply, "Go into atomic and radiation law, young man. That is the land of growing opportunity." He was so right.

As far as radiation matters are concerned, we cannot live without a substantial legal system to protect both industry and the public, but there are times when we wonder if the atomic energy and radiation oriented industries can survive much longer within the complex of laws and regulations that have been spun, especially over the last 10 or 15 years. A detailed discussion or even outline of the impact of the law upon radiation matters would be much too long and complicated for consideration in this paper. Instead, mention will be made of a few of the situations that as radiation protectionists we should be concerned with. Moreover, they represent examples of problems which are almost at the point of requiring some political activist type of approach on the part of the radiation protection community. I shall cite the rapid growth of federal and state bureaucracies, newly established in many instances, for the sole purpose of carrying out the requirements of radiation legislation. I shall cite the interagency rivalry in setting new numerical radiation protection standards, and finally I shall cite one of the problems growing out of workman's compensation and radiation injury litigation.

The demand and encouragement for radiation control legislation is multifaceted. For those who fear the misuse of radiation, the easy way out is to ask somebody else to regulate it. This plea may come from the man in the street, the technician, the doctor, the radiation protectionist, or the legislator. Their reasons will probably all be different.

The growth of bureaucratic involvement in radiation matters during the past two decades in the U.S. Government almost boggles the imagination. The programs may be divided into four categories. (1) Those involving radiation as a tool, such as the analysis of crystal structure or radiographic inspection of materials. (2) Research and development on radiation uses and applications, such as measurement and protection, biology and medicine, or industrial processing. (3) Regulation of the safety and uses of radiation and radioactive materials. And (4) military applications. I shall deal briefly with Numbers (2) and (3).

The first identifiable radiation program in the U.S. Government was that of the National Bureau of Standards (NBS) starting in 1913 and almost entirely devoted to measuring radium preparations for use in medicine. It was essentially a one-man effort. The first wide-range radiation program was also begun at the NBS in 1927 and was directed primarily to X-ray measurement, protection, equipment, and medical dosimetry. The radiation protection standards used in this country have been derived primarily from NBS programs.

In the middle 1930s the Public Health Service had some scattered programs having to do with the distribution of radium for medical uses and one study on diagnostic radiological apparatus. That about summed up the U.S. Government involvement in radiation matters until the start of the Manhattan District programs in the early 1940s.

Post-war radiation activities were largely concentrated under the aegis of the U.S.A.E.C. and included all four categories above. Outside of that and the military R&D, the NBS was still the major radiation center in the government structure and by the mid-1950s had a staff of some 125 persons. (This is to be compared with literally thousands of persons directly or indirectly under the AEC and the military.) Without attempting to be complete as to numbers or details, let us make a listing of the more or less current government units embracing major interests in matters of ionizing radiation.

National Bureau of Standards (NBS) (Category 2)

Department of Health and Welfare (DHEW) (Categories 1, 2, 3)

Food and Drug Administration (FDA) (Categories 2, 3)

Bureau of Radiological Health (BRH) (Categories 2, 3)

National Cancer Institute (NCI) (Category 2)

National Institute of Occupational Health and Safety (NIOSH) (Category 2)

Department of Defense (DOD) (Categories 1, 2, 4)
Department of Transportation (DOT) (Category 3)
Department of State (DOS)
Department of Energy (DOE) (Category 2)
Environmental Protection Agency (EPA) (Category 3)
Nuclear Regulatory Commission (NRC) (Category 3)
Occupational Safety and Health Administration (OSHA) (Category 3)
Federal Radiation Council, 1959–1970 (FRC) (Advisory)
Council on Environmental Quality (CEQ) (Advisory)
Office of Management and Budget (OMB) (Administrative)
General Accounting Office (GAO) (Investigative)

Congressional Committees (Senate)

- Commerce, Science, and Transportation
  - Subcommittee, Science, Technology, and space
  - Subcommittee, Labor, Health, Education, and Welfare
- Energy and Natural Resources
  - Subcommittee, Energy Production and Supply
  - Subcommittee, Energy Research and Development
- Environment and Public Works
  - Subcommittee, Environmental Pollution
  - Subcommittee, Nuclear Regulation
- Finance
  - Subcommittee, Energy and Foundations
  - Subcommittee, Health
- Governmental Affairs
  - Subcommittee, Energy, Nuclear Proliferation and Federal Services
- Human Resources
  - Subcommittee, Health and Scientific Research
  - Subcommittee, Labor

Congressional Committees (House of Representatives)

- Education and Labor
  - Subcommittee, Compensation, Health, and Safety
- Government Operations
  - Subcommittee, Environment, Energy, and Natural Resources
- Interior and Insular Affairs
  - Subcommittee, Energy and the Environment
- Interstate and Foreign Commerce
  - Subcommittee, Consumer Protection and Finance
  - Subcommittee, Health and the Environment
  - Subcommittee, Energy and Power
- Science and Technology
  - Subcommittee, Advanced Energy Technologies and Energy Conservation, Research, Development, and Demonstration
  - Subcommittee, Space Science, Research, and Technology
  - Subcommittee, Fossil and Nuclear Energy Development and Demonstration
- *Ad Hoc* Committee on Energy
- Armed Services
  - Subcommittee, Intelligence and Military Application of Nuclear Energy
- Environmental Study Conference

There is no assurance that these lists are either complete or that all units mentioned are active at any one time.

With perhaps 17 agencies and some 24 congressional committees, each vying for its piece of the budgetary pie or prestige with its constituents, is it any wonder that there is competition, overlap, and confusion in the radiation regulatory field? The wonder is that there is not more. An excellent example of recent vintage was the struggle for leadership in the development of radiation protection standards, primarily between the EPA and NRC, but with DOE and BRH anxiously watching from the wings. This led to the so-called "Libassi Study" of all radiation matters in the government (Li79). A remarkably fine report was produced, including organizational recommendations made to the President. However, the retiring Secretary of HEW, in presenting them to the President, recommended such modifications as to dilute and vitiate the principal objectives of the study (Ca79b). In the meantime, the EPA continues (with the concurrence of NRC?) to try to make its imprint on the radiation world by setting new radiation exposure standards at levels on the order of 10% of man's unavoidable exposure (to natural and medical radiation).

The Kemeney Report to the President on the Three Mile Island incident directs attention to ".... a preoccupation with regulations" by the NRC. It goes on "... we are convinced that regulations alone cannot assure safety. Indeed, once regulations become as voluminous and complex as those regulations now in place, they can serve as a negative factor in nuclear safety." And later it states "... the nature of some of the regulations .... may in some instances have served as a deterrent for utilities or their suppliers to take the initiative in proposing measures for improved safety." (Ke79; Po79c.)

This observation fits closely to my own reasoning as to why regulatory protection standards should not be derived on the basis of keeping the exposure of radiation workers (or the public) "as low as practicable" (ALAP). Use of that principle, which cannot be considered as scientifically or technically based, should be reserved to allow for the very initiative and innovation which is barred by specific numerical regulations (Ta72).

The implications arising from the attempted use of the "least practicable" concept in regulations are now a cause of concern. It is generally accepted that laws or regulations should be uniform in their application to all within their jurisdiction. Indeed, this is one of the prime virtues of laws or regulations. The "low as practicable" concept, however, has merit precisely because it allows deviation from the radiation protection standards which are, indeed, designed to be applicable to all. The attempt to specify by regulation what is "least practicable" appears to be an unfortunate melding of concepts which vitiates the merits on each side. It undoes the assured uniformity of regulations because deviation on a case-by-case basis would appear essential, and yet removes from those subject to the regulation the responsibility for ascertaining what need be done to meet the "least practicable" criteria.

Application of the ALAP principle should be primarily a political-management action presumably designed to promote the public welfare. But is it? Surely not, if it impedes independent initiative and innovation.

(On the question of initiative and innovation, an interesting statement of USSR philosophy is expressed in a paper presented to the ICRP in 1972 by A. A. Moiseev. He stated, "Today radiation protection in our country is governed by a fairly large number of regulations. So sometimes they say that the basic principle of legislation in the field of radiation protection is 'everything which is not specifically permitted is prohibited'." I doubt that this is official policy, but it does reflect an attitude toward, or result of, complex regulations.)

The establishment of a regulatory program for radiation—or anything else—is always accompanied by a far-reaching action and continuing activities. Let us develop a scenario for what happens.

To have regulatory authority, it is first necessary to have radiation legislation. Of course, the next step is to develop a pattern of regulations and that requires a few people on some public payroll. The problem then is that no radiation legislation and regulatory body ever stood still. They seem to have to grow and before long there is a new organization box in some bureau under a section chief, with an assistant section chief, an administrative aide, and even a few workers. The next obvious step is to have a new Bureau.

However, the Division or the Bureau, having once completed the job for which it was established, will find itself with nothing to do and, of course, this is never allowed to happen; new jobs are sought to replace completed ones. The basic principle in bureaucracy is that it either expands or it dies. It cannot even stand still, so we are soon caught in a web of increasingly complex and restrictive regulations, further removing from commerce and putting into the government those actions which were once designed to promote initiative, innovation, and most effective use of our scientific and technical blessings, whatever they may be.

In a country such as the United States, or a group of countries as in the European

Economic Community, any central government finds that however massive its bureaucracy may be, it needs help from lower governmental echelons and so there are almost immediate steps taken to set up a structure of state controls, state regulations, state organizations, state bureaucracies. But in states, you cannot have a small bureaucracy. It must be some critical size even if it be only ten or twelve people. Multiply this by 50, in our case, and a new kind of problem arises. How are these organizations going to be staffed? Where are the people coming from? Where are they getting their training? We are now in the big employment and big money business. While I believe I might personally prefer the concentration of such effort to be at the state level, I can recognize many problems—states' rights, inspection power, policing power, court power, uniformity or non-uniformity of standards, susceptibility to local pressure groups—each demands its own little bureaucracy. I have not even mentioned the fact that in many of our major cities we again run through the duplicative process with a new set of variants. These variants are apt to come about through the normal tendency of individuals or organizations to put their own imprint on whatever regulatory pattern they may have inherited or had passed down from above. There have been some nearly diastrous examples of new and inexperienced radiation control groups who felt the need to improve on the recommendations that had already stood the tests of time and experience. It is a tendency against which warning must be issued.

It is natural, to be expected, and to a certain extent, productive that within a short time we have informal organizational ties between the national and state controls, and between the state and city control groups. It makes for very convenient political communication when Washington wants to expand its program or is fighting off some budget-conscious appropriations committee. There is immediate communication with the state counterparts who know what to do and who are in a position to bombard their elected representatives at the federal level with whatever pleas might fit the situation. There is nothing unique or sinister about the way most free governments work and, I might add, it works the other way, too—the help from Washington can be sought either individually or collectively by the states. The picture needs no further painting. What is needed is a conscience and a consciousness on the part of the users of radiation and those who work with it. They should recognize that if this type of situation is allowed to develop in uncontrolled fashion, they and their objectives in the field of health and safety will become one of the endangered species, if for no other reason than a lack of money.

Unless we do something to control our appetite for legislation and regulation in practically every field in this country, we are going to be in real trouble. At this point, I happen to be speaking about medico-legal problems, but I should mention a commonly-heard phrase in the U.S., and probably everywhere else, "If you have a problem, make a law." What is not said is that we will primarily be contributing to a legal paradise—for someone else.

Another difficulty involving legislation relates to health, safety, and medical care from the cradle to the grave. A point of interest here has to do with Workman's Compensation in the nuclear or radiation industry. (Let me hasten to add that I personally believe in Workman's Compensation as a legitimate charge against industry.) In the U.S. we are having a gradual increase in the number of "radiation injury" compensation cases settled in favor of the worker, usually by compensation boards, but also by the various courts. Most of these cases center around individuals who have had very low doses in the course of their radiation work, but who have developed malignancies. Of the cases that have come to my attention so far, most have incurred a lifetime exposure of not more than 5 or 10 rads acquired over a period of several years.

A malignancy may, as we know very well, be caused by radiation, although on the basis of our knowledge of dose-effect relationship, the likelihood would be extremely remote at the levels mentioned. By whatever route, many of the cases are settled in favor of the plaintiff in spite of evidence in some cases that the particular type of cancer that developed had never been known to result from an identifiable radiation exposure.

The problem here is not that settlement for the plaintiff is necessarily reprehensible, but rather, by our judicial system, precedents are set for future cases. The courts are settling by law scientific questions that cannot be resolved by science. By legal edict they are "establishing" dose-effect relationships which are contrary to the best scientific observations that we have today.

Litigation in some of the cases has been extremely expensive and some of the settlements outrageous and unreasonable. See, for instance the "Silkwood Case" (Si79). On occasions I have said, sometimes seriously and sometimes facetiously, that it would be less expensive and perhaps more humane if it were decided that any time a person who had worked at any time during his life with radiation and subsequently developed a cancer which might be ascribed to radiation at any level, he be given free treatment, together with what would be a normal compensation for the family. With all of our national health plans in being or in prospect, this would scarcely add a drop in the bucket to overall health care in this country.

Economics

The possible influence of economics on the standards for radiation protection must be so obvious that it scarcely needs mentioning. There is constant pressure on the part of some radiation protectionists as well as "consumer advocates" and generally concerned members of the public to further increase the stringency of our radiation protection standards. Too often, their arguments are based mainly on the theoretical estimates of effects that have never been observed and in turn on calculations of deaths or cancers due to specific sources of radiation exposure.

However, the meeting of whatever numerical standard that may be promulgated is directly amenable to well established scientific, engineering, and manufacturing evaluation and planning. Essentially any degree of protection can be achieved—at a cost. The problem is to evaluate the risk, the cost of reducing it, and the gains to be achieved. The process is frequently referred to as "balancing the risk against the benefit." The principle is so simple as to be disarming. The difficulty lies in the quantitative elusiveness of both risks and benefits.

Consider a couple of examples. It was once proposed that leakage radiation from a deep therapy X-ray tube be reduced by a factor of 2, such that the nonuseful radiation striking a patient will drop from 1% to 1/2% of the level in the useful beam. First, one might consider the common sense of the action. How important is it to eliminate 25 rads of stray radiation in comparison with a therapeutic dose of 5000 rads to a person who is already suffering from cancer? It might be noted also that relatively rarely will it be possible to administer that large a dose with an accuracy better than ± 100 rads.

If one still wished to reduce the stray radiation, it could be accomplished in a straightforward way simply by adding lead around the tube. This might require a slight redesign of the encasement but this is easily costed. What is somehow overlooked is illustrated by the fact that by increasing the weight of the tube enclosure, the weight of the counter balances must also be increased and in turn this could require redesign of the stanchions holding the equipment. (One half value layer for 400 kV is 2.5 mm of lead; we are talking about several hundred pounds.) It is even conceivable that under some circumstances the overall increase in weight of a piece of equipment might require structural changes in the room because of the floor loading. It can be done and the cost can be assessed, but of course this extra cost is one of the many that are passed on to the consuming public.

In the case of power reactors, the economics would be much more difficult to evaluate. Were it thought necessary to further reduce the radiation passing through the containment system by a factor of 2 or 5, a whole new kind of chain reaction of costs would be involved. Where the different radiation levels from a particular reactor are known, they are likely already to be too low to evaluate except in terms of *assumed risk* by such theorizing as has already been discussed. So this is a case of reducing by a factor of 5 something that you did not know in the first place. There has to be some point below which further reductions are unjustifiable. This would call for the recognition of a *de minimis* level for radiation below which it would cease to be a matter of concern. It might be pointed out that if someone today were to decide on a reasonable *de minimis* level for radiation exposure, it would probably be found that most of our radiation installations are already well below it (Ad75).

Today we think in terms of balancing risk against benefit by some means, however vague and indefinite but, as already noted, there is no way to make a positive evaluation of risk at the low dose and dose-rate levels commonly encountered in medicine and industry under normal conditions.

By adhering to the theory of a linear, no-threshold dose effect relationship, risk comparisons can be made between effects at high doses where we do have information and those at low doses where we have no information. The numerical values of these risks are possibly basically without meaning, but are at least internally consistent and so evaluation of the costs of increasing or decreasing protection in a given installation can be made in terms of the arbitrary risk numbers. In practical application, this would be useful to the extent that it helps meet what someone has set as a risk goal, whether or not he knows what it really means.

A different kind of economic problem arises in connection with regulatory operations. In the process of defending, say, a budget request, a federal agency will work up an elaborate cost-benefit tree designed to show how, by a certain addition to their facilities or program, they can save so much radiation exposure per person averaged over the public. This, in turn, will reduce the risk to the public and hence reduce the number of radiation effects. But the bottom line is to show that these imaginary effects will reduce hospitalization and Medicare, so that there is an overall saving to the taxpayer. I've seen at least one example where an agency showed a particular saving for a given program and someone on the outside, by using precisely the same input information, showed—by what appeared to be equal logic—that it would make a much more costly program over all.

I'm afraid that any attempt at evaluation of real economics of radiation in general or of radiation protection in particular must remain very subjective and be so based on individual opinion as to be impractical for most purposes. There are many factors on both sides of the question such as outlined above where the radiation protectionist can and should play an intelligent and productive role, at the same time avoiding the biases and partisan aspects of the situation.

4. POSSIBLE CORRECTIVE ACTIONS NEEDED

Education

In the development of an overall understanding and acceptance of radiation as one of man's most invaluable tools, we need two things: (1) a better communication within and between scientific and technical groups on the one hand and the general public on the other; and (2) much broader education of and dissemination of information to the public. Perhaps a third item should be added. These communication and educational projects should be carried out basically by non-governmental organizations, aided and assisted, however, by some government support.

Communication is an essential part of education. The problem here is, first, to develop an adequate level of respect and confidence each for the other. In the fairly recent past, there was a high level of respect, confidence, and pride on the part of the general public for science and the scientist generally. For a variety of reasons, this has been seriously eroded within the past few years to the point where there is now some occasional outright distrust of the radiation scientist (Re79; Bu79). I will argue that this is basically undeserved and yet that some of the reasons for the distrust are fairly clear and must be corrected in the future.

As far as the public is concerned, there has been an aura of mystery—almost of mysticism—about radiation and for reasons, some valid and some not, the public has come to realize that it has on occasion been told untruths or part truths about some radiation matters, primarily by government agencies. As far as government responsibility in these affairs has been concerned, it can probably be argued that at the time information was concealed or distorted, there were considered to be acceptable political or economic reasons to warrant it. In a time of international threats, ventures in Asia, subversions at home, problems in Iran, I believe a good case can be made for some of the misinformation that may have been supplied to the public. In the present period, I do not visualize any such reasons for current concealment, but at the same time it is next to impossible to go back and correct most of the earlier mistakes.

I suggest the futility of trying to correct the mistakes of the past. The important thing now is to minimize the making of any further mistakes. If further mistakes surface, as some surely will, we should acknowledge them, explain, and correct them to the best of our ability; and, above all, bring an end to this dangerous game of sueing today for every conceivable honest mistake made by the parents of yesterday. To repair the communication situation requires a much greater effort on the part of scientific, technical, and governmental communities to at least identify and to the extent possible isolate the small handful of prophets of doom who supply the media and the public generally with partial or deliberately deceptive information about radiation matters. I cannot offer a solution to this problem. Condemnation of one individual in this country has been attempted and while he no longer has any credibility among his professional colleagues, the public is not so informed and he is still given a public platform on which to stand and peddle his shoddy wares (He71).

In the matter of communication, the radiation protection profession must play a major role, together with coordinated and concerted effort by several other nationally and internationally recognized organizations having long familiarity and responsibilities with problems of radiation and protection measurements. This is not the place to try to outline the technique for accomplishing this.

Let us return for a few moments to the role of the news media in radiation protection matters. (I will hereafter simply refer to it as the media.) I have already referred to the 1977 Paris conference entitled "A Colloquium on the Psycho-Sociological Implications of the Development of the Nuclear Industry." This colloquim was designed to try to identify and focus attention on some of the social and psychological aspects of dealing with the overall problems, not just of radiation, but of the whole nuclear industry. It was clear from many of the discussions that inadequate education of the public was basically the cause for much of the public concern, distrust, and misunderstanding of the overall nuclear problem (Tu77).

It is my belief that much of the blame for the public's fears and apprehensions with respect to radiation matters are due to our media—newspapers, magazines, radio, and television. No particular one is better or worse than the other. The difficulty here is that, of the general public, only an exceedingly small fraction of what we sometimes refer to as the better educated people have the willingness and capability to absorb and evaluate the burgeoning information concerning the nuclear industry generally and radiation hazards specifically. Where do people get their information? Primarily, it is from the press and, in my opinion, the press is failing in its unwritten responsibility under its Constitutional freedoms (Se79). Let us make one simple fact clear before continuing. The media are in existence primarily to make a profit under our free enterprise system. At the same time, the media enjoy special protection under at least our First Amendment in the gathering and dissemination of information, not to mention their editorial treatment, which is not news but opinion. We must not take any action which could conceivably destroy this basic freedom. But perhaps we should seriously consider some restrictions and/or penalties for responsibility failures. For example, let us require that in reporting a news event, the media report it all as it occurs, not only that segment that is in line with their publication policy. Mistakes in observation will be made; these are excusable. Mistakes, however, of selecting only certain aspects of a news item and suppressing others is a general, but totally unacceptable practice.

I have a practice of "calibrating" a newspaper or radio station or magazine. In reading about situations with which I might be familiar in some detail, I judge the integrity of the particular medium by the degree to which it reports or slants or editorializes a particular news item. If I find unreliable or biased reporting on something about which I know a great deal, I have to assume that this will apply to everything else in that particular source.

I must add that this procedure is not a comforting one because it develops that hardly any one of the media that I have encountered has what I would consider a reasonable aura of reliability and authenticity. When I complain about this, as I do frequently, I am told that the only solution is to read a variety of the newspapers or magazines. In the first place, this is impractical for busy people. In the second place, it is interesting to find that there is not that much difference between comparable media and you sometimes wonder why. I think I know the reason why, and I have been told this directly by more than one publisher or editor. The answer to this is that they are interested only in publishing material that they believe will promote the sale of their wares. However iniquitous this may seem, a certain amount of it has to be accepted because the alternatives would be government controlled and supported media which totally reflect the policies of the government. That would be intolerable! Can we reconcile ourselves then to the fact that a free press can survive only if it makes a profit. What has happened in those countries where people believed you could have limitless freedom without responsibility?

Insofar as radiation is concerned, it would be an interesting, noble, and possibly critical experiment for the various media over a period of several years to report clearly, sharply, and correctly only that information which is verified. At the same time they should avoid editorializing, guessing for hidden meanings, or making technical interpretations which, smart as the well-trained reporters may be, they and their editors are not in position to do properly. If the media would so limit their courage, an enormous amount of help from trained and responsible radiation protectionists would be required—and I am certain can be had for the asking. But however high a level of integrity there might be among those chosen to help, there would still be a need for a technical oversight program to ensure their objectivity and absence of bias. As I say, it would be a noble experiment. I dare some responsible news medium to undertake it for some reasonable period of perhaps several years. If such an experiment was in any degree successful, all of the media would have to comply; and then, as far as radiation is concerned, we would find ourselves in a new kind of radiation conscious world.

The U.S. Six

There is yet another, if related, criticism that must be directed to the media, namely, their constant use of a small number of individuals who are clearly out of step with the radiation protection community. In the U.S. alone there are some 3500 health physicists and 1800 radiological physicists. The National Council on Radiation Protection and Measurements has, over the years, utilized over 550 scientists covering every professional field having any conceivable bearing on radiation protection standards and yet the media will, for some newly breaking news story, seek out some of a half dozen individuals who are willing to make wilfully deceptive statements regarding radiation. Collectively they account for more news lines than the hundreds of reliable professionals accepted by their peers. (I refer to them as the U.S. Six.) If the media want to improve their professional image, they must studiously avoid the sensationalism produced by the U.S. Six, but which they presently believe sells their wares.

The U.S. Six has a strange mixture of talents. One or two still have some degree of professional reputation left and, as self-protection from their colleagues, they will carefully hedge their statements. At the same time, however, their statements are interlaced with enough of the usual fear catchwords which are often the only part captured by the reporter inexperienced in the nuances in matters of radiation protection. The others are mainly individuals who have been rejected by their colleagues and seem indifferent to their loss of professional acceptance which has been replaced by media acceptance.

They are a difficult group to deal with because they make such unexpected and scientifically unsupportable statements. Any professional who tries to respond to them quickly finds that the statement becomes modified and he finds himself struggling against a "moving target." Even worse, he cannot shoot at that target with the same ammunition used by the other person. The provocateur no longer has a substantial reputation at stake by making outrageous statements, whereas if the individual who may be debating with him makes a single transgression from the accepted fact, he is disparaged and criticized by his colleagues. This small group of individuals are well known in the radiation protection and other scientific communities.

Scare books and articles

Let us turn briefly to one other means of communication and education not normally included under the heading of media. That is the writing and publication of books to be sold individually over the counter. I have a small collection of "popular" books published over the last decade or so dealing with radiation matters. There is not a single one which is not riddled with half-truths, untruths, and evidence of basic lack of knowledge of the subject (see list following references). The one common item that all of the books have is a high level of sensationalism and an eye-catching title or subtitles. These books are written mostly by individuals who have no basic background knowledge of nuclear energy or radiation. They can write equally authoritatively about vegetable soup, ionizing radiation, or travel in India, in quantity and at a profit.

Unfortunately, many people—and especially those who are sincerely concerned about many of our present-day problems in the nuclear field—read these books and believe that they read the facts. This happens simply because they do not know enough about the subject to recognize much or any of the guileful and misleading statements.

I have talked to young people who have read several of these books and when I try to explain their unreliability, they come back with "Not only is it this author but it is that author and that author and they all agree on the same thing." Here you encounter an immediate difficulty when you try to explain the truth, namely, that these particular writers largely feed on each other. The authors cannot go to reliable technical sources because they cannot understand them even if they exist in reasonably popular form—and there are unfortunately very few of those. Why? You know the answer. The answer is that they cannot be sold in adequate quantity and at a profit because they cannot be objective and sensational at the same time.

The books that I have been speaking about have largely been written with a profit motive. There are occasional others, such as a pair of books written by Gofman and Tamplin, individuals who have a substantial scientific background and radiation experience. Their books are obviously written to support their opposition to nuclear power, government research support policies, and so on. In spite of being written by one-time scientists, their books carry all of the sensationalism of the media. They undoubtedly sell well and are read by many people who are in no position to exercise any critical judgment as to the authenticity of their claims. Their arguments for lowering radiation protection standards have been repudiated by the National Academy of Sciences and failed of adoption by the ICRP and NCRP (Be72).

Before leaving this part of my discussion, I invite attention to one of the insidious practices designed to keep the public alarmed about radiation matters. This is the constant linkage made between the atomic bomb and any discussion about radiation, even including medical applications. In spite of the fact that man has lived in an environment of radiation since his beginning and since we have had in the world acceptable standards for radiation protection many years before atomic energy, as we think of it today, was "discovered," there was little public awareness of these facts and essentially no public concern except in isolated situations about radiation injuries and radiation uses. Until about the mid-1920s the only people being noticeably injured by radiation were physicians who used radiation in their medical practices. Unless protection for them could be provided, they might have had to give up all use of radiation for medical purposes, a situation which was clearly recognized as a world disaster and totally unacceptable. Patients were rarely injured and the public essentially never injured. Numerical protection standards were developed nationally and internationally in the early 1930s and, as pointed out above, for individuals working within these standards there has never been a directly identified case of injury. The same standards were used by the Manhattan District in the development and construction of the first nuclear weapon. It is a fact that of all of the heavy industry we know of today, the nuclear industry has had one of the best overall safety records.

Without going into detail, general public awareness of radiation came first with the destruction of the two Japanese cities. There was concern about military uses of atomic weapons, but there was little concern about radiation as it might affect our own safety. The situation changed rapidly with the detonation of large weapons in the 1950s and the recognition that fallout from these weapons could reach every person in the world. It was that situation which irrevocably engendered the fear, the consternation, and apprehension about radiation which we have today, a fear on the part of a generally uninformed public. Those of us who had worked with ionizing radiation for 25 or 50 years knew it could be coped with and are living examples of the fact. Of my many colleagues in this field the world over, I do not know of any who have died of what might in any way be ascribed to their exposure to radiation which, in several cases, has amounted to hundreds of rads over several years. We work with the stuff, we fear the stuff, but we control the stuff. The problem is to convince the public of these facts and further that radiation can be adequately controlled as far as they are concerned. However, this goal is not even going to be approached until we do something with the common fault of all of the media and most of the books that are available to the public.

In a television documentary presentation on ionizing radiation or a news story about some small accident in a nuclear installation, or a large or small accident in a nuclear power plant, practically the first thing that is presented to the reader or the viewer is a story about a bomb, a picture of a bomb exploding, reference to radiation through the term "fall-out," and so on *ad nauseam*. These are the catchwords. Why should a discussion about radiation protection problems in the medical industry be preceded by some statement or picture of a bomb? (Wt79). Why should some story about exposure of radiation inspectors in an aircraft factory make reference to a bomb? More understandable, but equally preposterous, is why should an article about a nuclear reactor accident such as the TMI case always be preceded by some reference to the bomb or an explosion and fallout, the standard warfare terms, when the public has been informed by good and reliable sources that a power reactor simply cannot explode like a bomb. It was amazing how rapidly the hydrogen bubble was described in bomb terms. Radiation measured up in the air was described as "fall-out." It was known by those who understood the problem that the hydrogen bubble was not a bomb—it was admittedly a problem but it was also known that the gas would readsorb and disappear safely. It was known by those who understood that even under the worst conceivable situation, namely a loss of control (commonly called a meltdown) this was not going to be something like a bomb, nor was it going to burn a hole through to China—hopefully, only to Hollywood. It was also known that in spite of all manner of mistakes, poor judgement, poor planning, or whatever you wish, the Three Mile Island reactor had enough protective redundancy built into the system so that it did as was expected and shut itself down. There is no question but that it was a serious accident, but no one was killed or even injured by falling off a scaffold somewhere, but was this the way it was reported in the press? Hardly!

The most direct and honest reason for that kind of reporting was given by an article in the *Washington Post* from which I quote (Po79a):

"The press, no matter its nationality, thrives on red meat. Red meat is disaster, tragedy, conflict—wars, assassinations, Jonestown massacre, exploding coal mines.

"The Three Mile Island nuclear accident was red meat, of a sort never before experienced by the press; all the fine fibre of a Delmonico. It was a story of technology run amok, man forced from his home by the peaceful atom, the prospect of a stretch of the eastern seaboard being turned into an irradiated wasteland."

Credibility of scientists

I've already mentioned that one of the difficulties against which we must work today in providing better public communication and education is to somehow restore the credibility of scientists. Scientists are scientists and that's their karma. But as I've already emphasized, they are also human beings, citizens, come from families, and have families. Therefore, scientists make mistakes of judgment and of fact as do all of us.

In some respects, the scientist stands apart from most other individuals who can be placed in some definable pattern. In the first place, the average scientist starting in research is not very likely to have financial gain as his prime objective. He does have to earn enough to live in reasonable comfort, have some freedom from financial worries, and to have a family life. For the true researcher, the man at the bench, the highest real reward is in terms of a professional reputation, acceptance among his colleagues, his reputed objectivity, and his reputed intellectual honesty. If he fails in any one of these elements, he is destroyed. Of such people, then, why should the media and the public always be seeking some ulterior motive in whatever the scientists do or say?

A scientist, having selected some challenging field which interests him, tries to read all of the literature pertinent to his problem, carefully identifying those portions which are theory or postulation and those which are strongly or weakly supported by experimental evidence or facts. Upon digesting this, he then maps out a course of action, but one thing a scientist never does is to start out with a pre-conceived idea of what the final results will be.

Many times when a particular goal is not reached, something else of importance is; or he may be testing to see if some theoretical concept is borne out experimentally, but again the final result is not preconceived. Some of the critical scientific discoveries that have come about in the past have not agreed with theory and the theories had to be changed. The scientist's professional reputation comes from reporting exactly what he finds, no matter what it may seem or where it may lead. No pressures can force him to report something which he did not find. Unless he is willing to risk a loss of his professional reputation, no scientist is likely to be suborned by the people or organizations that support him and make his work possible. It would be, of course, ridiculous to assume that the whole body of scientists engaged in a field such as nuclear physics would enter into a mass betrayal of their professional standards.

In recent times we have witnessed many attacks or accusations against the work of scientists, primarily by the press, and usually by individuals not having scientific or technical backgrounds themselves. Great play has been given to the disagreement between some scientists either as individuals or as part of some scientific groups. This is pictured as being chaotic, self-serving, a cover-up, or such. Actually, it is normal, proper, and healthy intercourse of scientists and means only one thing—the data they have to work with are incomplete and may be even unobtainable within our known capabilities. The research is still incomplete; there are conflicting interpretations of the same or different results. In other words, they are not yet ready to achieve the one overall acceptable solution to the problem and no amount of public screaming, accusations, Congressional hearings, editorials, letters to the editor, laws or regulations, or what-not will force a solution.

CONCLUSIONS

I plead that we cease the seemingly endless procession of studies, committees, and hearings on the problem of "low level ionizing radiation," just to choose one of the problems that plagues us today. About this, we know what we know and we know what we do not know; there is reasonable and rational agreement as to the degree of disagreement. We know that the full and final solution to the dose-effect relationship for low doses (less than, say, 5 or even 10 rads) delivered at any dose rate, is not in sight and will not be attainable within any of the capabilities that can be visualized today. There are sound and agreed technical reasons for this statement. But, and most importantly, we also know that regardless of the precise relationship between the effect and doses below, say 5 rads, whatever the effects may be, they are miniscule if they exist at all; and they cannot be identified as radiation effects among all the other similar effects that occur due to otherwise unidentified sources.

So where does this leave us? Either we forget the whole "problem" or we theorize or postulate a dose-effect relationship. The latter has, in fact, been done for the past two decades or more, and is used by radiation protection scientists as a theoretical upper limit to the theoretical effects.

However, this is what has led to our present dilemma because of the fact that our technical verification has boundaries of limitation. The limitation has been grasped (even if not understood) by some Congressional Committees, by some government agencies, and by the public. Each, in different ways, has interpreted and treated the theoretical estimates as if they were experimentally established facts rather than as the scientific speculations and provisional pragmatic solutions which they are. Thus has been opened the door to wildly imaginative statements as to what may be happening at the low doses where no effects can be found. Perhaps in hindsight it might have been better had the radiation protectionists not brought this miniscule monster out of their closet—but it is out of the closet and the world is alarmed. So now it is up to the scientist to find the most practical solution to our dilemma—but he will need the assistance of the same public and media which have been his prime attackers.

For the failures of the public to recognize the situation outlined above, we are forced, in part, to blame the media. Although the scientific community is not without blame of its own, at least the responsible part of the protection community has not presented deliberately distorted facts and hidden meanings to the press or to anyone else.

As already noted, whether recognized or not, the press in dealing with our protection problems lends favor to charlatans—individuals who know how to make headlines and become known to the public as "the authorities."

The media seem firmly to believe that this sort of sensationalism is essential to their survival; they fail to appreciate that they must work hard for the real freedoms under which they operate and they must recognize the obligations entailed by the protection of that freedom. Most crucial among their obligations is their collective duty to help educate the conglomerate public to keep our nation a strong nation. Also, the radiation protectionist must learn to work hand-in-hand with the media—the two cannot stand aloof from each other.

Regardless of anything else we do at all levels of government and society, the media have, for all practical purposes, been designated by our Constitution as the guardian and promoter of communication for the general education of the public.

REFERENCES

Ad75 Adler H. I. and Weinberg A. M., 1975, "Approaches to Setting Exposure Standards for Environmental Agents Present in Low Concentrations over Long Periods of Time", Institute for Energy Analysis, Oak Ridge Associates Universities, Research Memo IEA (M)-75-8, Nov.

Be72 BEIR, 1972, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiations", NAS/NRC Report, pp. 183–188.

Br78a Bross I. D. J., 1978, "Testimony at Hearings", H. R. Subcommittee on Health and Environment, Committee on Interstate and Foreign Commerce, Ser. No. 95–179, p. 905.

Br78b Bross I. D. J., 1978, "Hazards to Persons Exposed to Ionizing Radiation (And to Their Children) from Dosages Currently Permitted by the Nuclear Regulatory Commission", NRC Public Meeting, 4-7-78 (7590-01) (5 USC-552(a)); see also comments by K. J. Rothman and letter comments by Lauriston S. Taylor, both of which are part of the public hearing record.

Bu79 Buckley W. F., 1979, "Scientists Under Attack", *Washington Star*, 18 April 1979.

Ca79a Califano J. A., 1979, See *New York Times* 4 May 1979.

Ca79b Califano J. A., 1979, Memorandum, Secretary HEW to the President, 2 August 1979 (probably available at HEW).

Go71 Gofman J. W. and Tamplin A. R., 1971, *Poisoned Power—The Case Against Nuclear Power Plants* (Emmaus, PA: Rodale Press).

He71 Health Physics Society, 1971, Statement by the President and Past Presidents with regard to presentation by E. J. Sternglass, 14 July 1971, *Radiology* **101**, 703.

Ke79 Kemeney J. G., 1979, *Report of the President's Commission on the Accident at Three Mile Island*, pp. 9 and 20. Pres. Comm. 2100 M Street, N.W., Washington, DC 20037.

Li79 Libassi F. P., 1979, *Interagency Task Force on the Health Effects of Ionizing Radiation*, Office of Secretary, Department HEW.

Ma78 Mancuso T., 1978, "Testimony at Hearings", H. R. Subcommittee on Health and Environment, Committee on Interstate and Foreign Commerce, Ser. No. 95–179, p. 523.

Ma79 Mancuso T., 1979, See "Low-level Radiation: A High Level Concern", *Science* **204**, 155; also following article, p. 160.

Mo67a Morgan K. Z., 1967, "Testimony at Hearings", H. R. Subcommittee on Public Health and Welfare, Committee on Interstate and Foreign Commerce, Ser. No. 90–11, pp. 370–373.

Mo67b Morgan K. Z., 1967, "Testimony at Hearings", Committee on Commerce, U.S. Senate, Ser. No. 90–49, p. 54.

Mo78 Morgan K. Z., 1978, "Testimony at Hearings", H. R. Subcommittee on Health and the Environment, Committee on Interstate and Foreign Commerce, Ser. No 95–179, p. 4.

Na54 National Committee on Radiation Protection, 1954, *Permissible Dose from External Sources of Ionizing Radiation*, p. 27.

Na67 Nader R., 1967, *Manmade Environmental Hazards: Styles of Violence and Modes of Doubt*, Radiation Control for Health and Safety Act of 1967, Committee on Commerce, U.S. Senate S. 2067, p. 219.

Po79a *Washington Post*, 1979, "The Media Corps' All-out Invasion", p. A16, 9 April 1979.

Po79b *Washington Post*, 1979, "No damage Done in Blaze Near Calvert Nuclear Plant", p. B6, 23 May. (A 55 sq. ft. trash dump, 1 mile away.)

Po79c *Washington Post*, 1979, "A Great Regulatory Program with a Hide of Steel", 21 October 1979.

Re79 Reeves R., 1979, "The Experts: Either Fools or Liars", *Washington Star* 18 April 1979.

Se79 Seib C. G. 1979, "The Press/People Gap", *Washington Post*, 14 September 1979.

Si79 Silkwood K., 1979, See *Beaumont Enterprise*, p. 16-A, 8 May.

Sta79 *Washington Star*, 1979, "Reactors Stir Reactions", Maureen Dodd, Response by L. S. Taylor and S. Landgried, Star Letter to Editor, 4 September. The Facts, NBS Standard p. 8, 14 Nov.

St78 Stewart A., 1978, "Testimony at Hearings", H. R. Subcommittee on Health and Environment, Committee on Interstate and Foreign Commerce, Ser. No. 95-179, p. 523.

Ta70 Tamplin A. R. and Gofman J. W., 1970, *Population Control Through Nuclear Power* (Chicago: Nelson-Hall).

Ta78 Tamplin A. R., 1978, "Testimony at Hearings", H. R. Subcommittee on Health and Environment, Committee on Interstate and Foreign Commerce, Ser. No. 95-179, p. 21.

Ta57a Taylor L. S., 1957, "The Philosophy Underlying Radiation Protection", *Am. J. Roent.* **77**, 914 (from address on 7 Nov. 1956).

Ta57b Taylor L. S., 1957, "Radiation Exposure and the Use of Radiosotopes", *Impact* **7**, 210.

Ta72 Taylor L. S., 1972, *The Development of Radiation Protection Standards*, AEC Hearings on 10 CFR 50 (ALAP), 12 January 1972.

Tu77 Tubiana M., 1977, *Colloquium on the Psycho-Sociological Implications of the Development of the Nuclear Industry*, Societé Francaise de Radioprotection, Paris.

We71 Weinberg A. M., 1971, Letter to Editor, *Science* **174**, 546.

Wt79 WTHR Television, 1979, *Radiation Series–Six Stories*, 28 May–1 June, 1979; Channel 13, 1401 North Meridian Street, Indianapolis, IN 46206.

Scare Books

Population Control Through Nuclear Pollution, A. R. Tamplin and J. W. Gofman (with Foreword by Paul R. Ehrlich, author of *The Population Bomb*). Nelson-Hall, Chicago (1970).

Poisoned Power, J. R. Gofman and A. R. Tamplin (with Foreword by Senator Mike Gravel). Nelson-Hall–Rodale Press, Emmaus, PA (1971).

Our New Life with the Atom, R. Rienow and Leona T. Rienow. Vail-Ballou Press, Binghamton, NY (1959).

No Place to Hide, D. Bradley. Little, Brown & Co., Boston, MA (1948).

Silent Slaughter, J. Griffiths and R. Ballantine. Henry Regnery Co., Chicago (1972).

Atomic Suicide, Walter and Lao Russell, University of Science and Philosophy, Swannanoa, Waynesboro, VA (1957).

Are You Radioactive? How to Protect Yourself, Linda Clark, Devin Adair Co., Old Greenwich, CT. (Contains a collection of remedies for fallout, radioactivity, fluorescents, mucus, etc.) (1974).

Perils of the Peaceful Atom, Curtis & Hogan.