Atomenergie: Irrtümer und Fakten 1972

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Über den Autor: Ackerman war der Ansicht, dass professionelle Ingenieure zunehmend staatliche Vorschriften darüber entscheiden ließen, was in der Ingenieurpraxis „sicher" sei, und dabei ihre eigene ethische Verpflichtung zur Gewährleistung der öffentlichen Sicherheit vergessen hatten. Darüber hinaus war er der Ansicht, dass Ingenieure es versäumt hatten, bei der Entwicklung solcher staatlichen Vorschriften die Führung zu übernehmen und es Einzelpersonen überlassen hatten, denen das technische Verständnis der Ingenieure für die Sachlage und die feste Verpflichtung fehlten, Erwägungen wie Profit oder Zweckmäßigkeit bei der Gewährleistung des Wohls der Öffentlichkeit außer Acht zu lassen. Daher glaubte Ackerman, dass Ingenieure, die in Sicherheitsfragen administrative Richtlinien anstelle ihres unabhängigen ingenieurtechnischen Urteils anwendeten, Projekte ohne denselben Sicherheitsfaktor durchführen ließen, den sie selbst auferlegt hätten. Ein solches Vorgehen würde die ethische Verpflichtung des Ingenieurs zum Schutz der Öffentlichkeit verletzen. Tatsächlich verpflichtet Kanon 1 des ASCE-Ethikkodex Ingenieure, „die Sicherheit, Gesundheit und das Wohlergehen der Öffentlichkeit an erste Stelle zu setzen".

Zusammenfassung
Die erste Demonstration der Atomspaltung fand am 2. Dezember 1942 in einem Labor statt. Der erste Strom aus einem experimentellen Atomkraftwerk in den Vereinigten Staaten wurde am 18. Dezember 1957 produziert. Weniger als ein Dutzend Atomkraftwerke von signifikanter Größe wurden bis 1972 fertiggestellt und in Betrieb genommen; ihre kurzen Betriebserfahrungen sind als Grundlage für eine verantwortungsbewusste Planung (mit absoluter Sicherheit) und für die Verpflichtung zu großen zukünftigen Investitionen in diese neue Technologie völlig unzureichend. In der Versorgungsindustrie jedoch sind unternehmerische Weisheit und gutes Urteilsvermögen auf der Ebene des Verwaltungsrats durch massive Überverkaufskampagnen, unverantwortliche Propaganda und bewusste Täuschung pervertiert worden. Dieses Papier zeigt einige der häufigsten Irrtümer.

Dieses Papier wurde erstmals 1972 vorgestellt auf der gemeinsamen Tagung der Wisconsin Society of Professional Engineers und der American Society of Civil Engineers in Madison, Wisconsin. Er wird veröffentlicht hier als Fortsetzung des früheren Papiers des Autors "Atomkraft-Wer kümmert sich um die öffentliche Sicherheit?", das in der Mai-Ausgabe 1969 erschien.

Einleitung
Vor etwa einhundert Jahren erklärte der bekannte Wissenschaftler James Clerk Maxwell:
In der Tat ist der Respekt vor der Wissenschaft so groß, dass die absurdesten Meinungen aktuell werden können, wenn sie in einer Sprache ausgedrückt werden, deren Klang an eine bekannte wissenschaftliche Phrase erinnert. Wenn die Gesellschaft auf diese Weise bereit ist, alle Arten von wissenschaftlichen Lehren zu akzeptieren, ist es unsere Aufgabe, nicht nur für die Verbreitung und Pflege wahrer wissenschaftlicher Prinzipien zu sorgen, sondern auch für einen Geist der gesunden Kritik.

Heute können wir alle sehen, dass das explosive Wachstum der Wissenschaft im zwanzigsten Jahrhundert eine wissenschaftliche Revolution hervorbrachte, mit einer Vielzahl von "Super-Ereignissen" wie z.B.:

Super-Errungenschaften
1) Massenkommunikation durch Radio und Fernsehen
2) Massentransport zu Lande und in der Luft
3) Flächendeckender und effizienter Telefondienst
4) Flächendeckende Elektrizität im Überfluss.

Superkatastrophen
1) Landesweite Propagandatechniken und Diktaturen
2) Erster Weltkrieg, Zweiter Weltkrieg

3) Deutsche Gaskammern
4) Die Atombombe.

Die Atomspaltung wurde vom Obersten Gerichtshof der Vereinigten Staaten (U.S. Supreme Court) beschrieben als "der furchterregendste, tödlichste, gefährlichste Prozess, den der Mensch je erdacht hat.“ In diesem Zusammenhang erfordert eine kritische Betrachtung vor allem eine Perspektive auf die historische Stellung dieser neuen Technologie.

Die Offenbarung der Macht Gottes im Atom und der Mittel zur Vernichtung allen Lebens erfolgte am 2. Dezember 1942. (MB: an der Uni Chicago gelingt Enrico Fermi die erste nukleare Kettenreaktion.)
Drei Jahre später wurde die enorme Energie im Atom, die Albert Einstein Einstein 1905 mathematisch identifiziert hatte, plötzlich in eine "superkatastrophale" Realität umgesetzt.
Im Gegensatz dazu müssen die Aussichten auf eine "Superleistung" erst noch bewiesen werden; sie existieren heute weitgehend als undisziplinierte Behauptungen, optimistische Propaganda oder als eine Vielzahl von Selbsttäuschungen. Die bisherige Geschichte der Atomenergie summiert sich zu wenig Betriebserfahrung mit einer Vielzahl von Mängeln, Unzulänglichkeiten und Misserfolgen.
In diesem Stadium wurde ein verantwortbares Wachstum dieser neuen Technologie behindert durch eine noch nie dagewesene Art von Werbemaßnahmen, sowohl auf staatlicher als auch auf industrieller Ebene, sowie durch einen generellen Zusammenbruch der Verantwortung der Ingenieure und der Kontrolle der Sicherheit, die in einer nationalen Katastrophe gipfeln könnte.

Dieses Papier befasst sich nur mit der Entwicklung der Atomenergie für zivile Zwecke im Rahmen der traditionellen Disziplinen unserer freien Marktwirtschaft und der unternehmerischen Verantwortung. Atomenergie für militärische Zwecke ist eine ganz andere Sache!

Verantwortung für die öffentliche Sicherheit
In der Vergangenheit war ein grundlegender Faktor bei wissenschaftlichen und technischen Unternehmungen das Konzept, dass die öffentliche Gesundheit und Sicherheit der Bevölkerung die vorrangige Verantwortung von professionell ausgebildeten Ingenieuren ist, mit allem, was dies mit sich bringt. Dieses Konzept wurde eindrucksvoll formuliert vom Ingenieur Thaddeus Merriman, der erklärte:
Die Pflicht des Ingenieurs besteht nicht nur darin, ein Maximum des Geldes seines Auftraggebers zu sparen. Sie verlangt absolut, der Öffentlichkeit ein Höchstmaß an Sicherheit zu bieten. Wenn ein Kunde nicht willens oder in der Lage ist für dieses Maximum zu zahlen, sollte er sein Projekt nicht bekommen.
Und was für einen privaten Auftraggeber gilt, gilt genauso wenn der Ingenieur für die öffentliche Hand handelt:
Er muss die Öffentlichkeit schützen - niemand sonst kann diese Funktion erfüllen.Eine klare Definition von "Verantwortung" wurde mit diesen Worten festgelegt:
"Verantwortung ist ein einzigartiges Konzept: Sie kann nur in einer einzigen Person liegen und verankert sein… Wenn Sie nicht mit dem Finger auf den Mann zeigen können, der verantwortlich ist, wenn etwas schief geht, dann hat man nie jemanden, der wirklich verantwortlich war."
Im Gegensatz dazu haben wir bei den neuen Nachkriegstechnologien viele Vorschläge für beeindruckende wissenschaftsbasierte Projekte gesehen, aber sie werden hauptsächlich von Wissenschaftlern und Bürokraten unter politischer Vorherrschaft gefördert, ohne jede finanzielle Verantwortung und unter bewusster Zensur jeglicher Opposition.
Wissenschaftler haben die Ingenieure in der öffentlichen Meinung verdrängt. Aber wir sollten uns an Dr. Edward Tellers Definition eines Wissenschaftlers erinnern:
"Die häufigste Tätigkeit, mit der sich ein Wissenschaftler beschäftigt, ist Fehler zu machen, sie zu erkennen und zu korrigieren, und daraus kommt die Entdeckung."
Im Gegensatz dazu ist der Ingenieur darauf trainiert, keine Fehler zu machen- ein einziger schwerer Fehler kann seine Karriere ruinieren. [1]
Infolgedessen erleben wir Zusammenbrüche in den Bereichen der beruflichen Verantwortung, ethischen Standards, der Rechtsstaatlichkeit, der öffentlichen Sicherheit, der Finanzkontrollen und der Buchführung über öffentliche Gelder. Besonders gravierend ist diese Situation bei der Entwicklung der Atomenergie und der Öffentlichkeit in allen Teilen des Landes geworden. Eine

umfassende professionelle Analyse und Dokumentation der Vor- und Nachteile dieser neuen Technologie könnte ohne weiteres ein Buch füllen (…wäre noch zu schreiben). Wir können hier jedoch kurz auf einige grundlegende Probleme eingehen, die jetzt allgemein anerkannt werden.

Irrtümer und Fakten zur Atomkraft
Irrtum 1: „Die Technologie der Atomkraft für friedliche oder kommerzielle Zwecke ist in der amerikanischen Wirtschaft gewachsen, wie jede andere unserer Basistechnologien."
Fakt: Die kontrollierte Freisetzung der Kernspaltung war eine erste Demonstration eines streng geheimen staatliches Monopols, aus dem die Hiroshima- und Nagasaki-Bomben entwickelt worden waren.
Nach dem Zweiten Weltkrieg wurde die Atomic Energy Commission (AEC) gegründet, um dieses Monopol zu verwalten, und im Laufe der Zeit wurden einige Unternehmungen für die zivile Nutzung dieser neuen Technologie im Rahmen des "Atoms for Peace"-Programms. Die AEC hat jedoch eine strenge monopolistische Kontrolle und eine Politik der Geheimhaltung aufrecht erhalten, zusammen mit der Produktion von Uran-"Brennstoff" für Kernreaktoren.

Irrtum 2: In Fragen der "Ingenieurverantwortung" für den Bau von Atomkraftwerken haben die Gründergesellschaften des Berufsstandes angemessene Richtlinien und Grundsätze der Planung und Konstruktion aufgestellt, um ein Maximum an öffentlicher Sicherheit zu gewährleisten.
Fakt: Als der Kongress 1954 ein Gesetz zur Genehmigung der kommerziellen Entwicklung der Atomenergie erließ, haben die Gründergesellschaften einen gemeinsamen Ad-hoc-Ausschuss (dem der Autor angehörte) einberufen, der die Aufgabe hatte eine Erklärung über die Politik und die technischen Grundsätze zu formulieren, die als "magna carta" für alle Ingenieure dienen sollte. Leider hat sich die Arbeit dieses Ausschusses allmählich verschlechtert bis zu dem Punkt, an dem die "öffentliche Sicherheit" als erstes Kriterium der Konstruktion beiseite geschoben, und die"kommerzielle Machbarkeit" Vorrang erhielt. Dies ist eine große historische Tragödie für den Berufsstand und für die Nation [2] .

Irrtum 3: In Fragen der Sicherheit liegt die gesamte Verantwortung für die Auslegung eines Atomkraftwerks und für die Sicherheit der Öffentlichkeit in der Umgebung in den Händen der AEC. (MB: Das wäre bei uns das ENSI)
Fakt: Dies ist ein weit verbreiteter Irrglaube, der vor allem bei Vorständen verbreitet ist, die ihre Unternehmen auf die Aufnahme von Atomkraftwerken verpflichtet haben. Allerdings hat einer der AEC Kommissare für diesen grundlegenden Irrtum folgende Worte gefunden:
Es darf nie vergessen werden, dass die Verantwortung für die Sicherheit der Anlage beim Eigentümer oder Betreiber liegt.
Die Regulierungsbehörden, egal wie gründlich sie ihre Aufgabe wahrnehmen, können keine Gewähr dafür bieten, dass die öffentliche Gesundheit und Sicherheit bei einem Reaktor oder Reaktor-Projekt angemessen geschützt wird…

Irrtum 4: Da die Regierung der Vereinigten Staaten sich durch die AEC-Behörde um alle Probleme der öffentlichen Sicherheit kümmert, kann das amerikanische Volk sicher sein, dass alle möglichen Gefahren in Atomkraftwerken beseitigt sind. (MB: 1977 ging die Verantwortung an die Energiebehörde DOE; die Aufsichtsbehörde NRC wurde gegründet)
Fakt: Durch viele Jahrzehnte loyalen und gewissenhaften Dienstes in einigen der älteren Regierungsbehörden hat die amerikanische Öffentlichkeit ein hohes Maß an Vertrauen entwickelt, dass sie vor einer Vielzahl von Gefahren geschützt sei. Ein gutes Beispiel dafür ist das U.S. Bureau für öffentliche Gesundheit und die bemerkenswerten Verdienste von Dr. Frances Kelsey bei der Verhinderung der Vermarktung von Contergan-Pillen in diesem Land. Bei der neuen Technologie der Atomenergie hat jedoch das unglaubliche Spektakel - Opportunisten in und außerhalb der Regierung, die erst einsteigen und dann die sich abzeichnenden Tatsachen betrachten - eine Situation geschaffen, die sich heute am besten als "massives Chaos" beschreiben lässt. (Im Original: However, in the new technology of atomic power the awesome spectacle -opportunists in and out of government first leaping in and then looking at the emerging facts- has created a situation which today can best be described as a "massive chaos.")

Irrtum 5: Bei der Genehmigung von Kernkraftwerken berücksichtigt die AEC angemessen alle Faktoren, die sich nachteilig auf die Umwelt auswirken könnten.
Fakt: In einer aktuellen Entscheidung hat der United States Court of Appeals entschieden, dass die AEC bei bestimmten Kernkraftprojekten keine „Umwelt" Sicherheitsvorkehrungen getroffen hat. Das Gericht hat einen vorübergehenden Baustopp für das 300-Millionen-Dollar-Kraftwerk Calvert Cliffs in Maryland angeordnet, und das Urteil veranlasst die AEC, die Entwürfe von mehr als 80 anderen Projekten zu überprüfen. Dies hat zu einem neuen Wirrwarr und zu ernsthaften Verzögerungen im gesamten Atomprogramm geführt.

Irrtum 6: Die Vorstände der öffentlichen Versorgungsunternehmen sind Menschen mit außergewöhnlicher Kompetenz und Urteilsvermögen und würden nicht zulassen, dass ihre Kunden und ihre Gemeinden einer katastrophalen Gefahr ausgesetzt werden.
Fakt: Es gibt Beweise dafür, dass die Vorstände bestimmter Energieversorgungsunternehmen und -Agenturen die Mängel und Fehler der Atomtechnologie nicht kennen und dass sie es versäumt haben, ihre persönliche Verantwortung, die sie mit der Genehmigung eines Atomkraftwerks übernehmen, zu analysieren.
Dies lässt sich anhand zweier grafischer Darstellungen zeigen; Abb. 1 und 2, die die historischen Erfahrungen der Energiewirtschaft in Bezug auf die installierte Kraftwerksleistung und der Energieerzeugung aus fossilen Brennstoffen. In beiden Fällen ist die Stellung der Atomkraft so gering dass sie in diesen Diagrammen kaum sichtbar ist. Im Hinblick auf Abb. 2 ist es besonders wichtig, sich an die Dampfkraftwerke der ersten frühen Jahrzehnte und die große Anzahl von Ausfällen in Dampfkesseln zu erinnern. Aus diesen Ausfällen wuchsen die Lehren für Konstruktion und Fertigung (und das Verantwortungsbewusstsein der Ingenieure), zu den heutigen Errungenschaften der Sicherheit in großen Hochdruck-Dampfkesseln. Wichtig ist auch, dass diese Sicherheitsstandards durch die ständige Mitarbeit und die von den Versicherungsgesellschaften auferlegten Einschränkungen gewachsen sind, so dass heute alle Dampfkessel, die den anerkannten Herstellungs- und Installationsvorschriften entsprechen, zu 100 Prozent zertifiziert sind und versicherbar durch kommerzielle Unternehmen.
Die Erfahrungen mit Kernreaktoren sind im Vergleich dazu unbedeutend. (Kein Direktorium würde die Installation eines Dampfkessels genehmigen, der nicht für eine solche Zertifizierung qualifiziert ist. Andererseits ignorieren einige Verwaltungsräte von Atomkraftwerken offen diesen disziplinarischen Einfluss zum Schutz der öffentlichen Sicherheit).

Irrtum 7: Die Atomkraftwerke im Besitz der Stromversorgungsunternehmen und öffentlichen Einrichtungen sind genau wie ihre Dampfkraftwerke voll versichert.
Fakt: Diese einfache Aussage klingt recht beruhigend für eine uninformierte Öffentlichkeit, die ihr Vertrauen in Amerikas große Industrieunternehmen setzt. Doch eine sorgfältige Analyse der Fakten entlarvt diese Erklärung jedoch als großen Schwindel oder als vorsätzlichen Betrug an einer vertrauensvollen Öffentlichkeit. Kurz gesagt, als das erste Atomkraftwerk in der Nähe von Detroit 1957 kurz vor der Fertigstellung stand, wurde festgestellt, dass die amerikanischen Versicherungsgesellschaften nicht bereit waren, die herkömmliche Sach- und Haftpflicht-versicherung für dieses Kraftwerk abzuschließen.
(Der "Brookhaven Report" der AEC schätzte damals, dass ein schwerer Unfall viele Menschenleben kosten und einen Sachschaden von mehr als 5 Milliarden Dollar verursachen könnte.)
Zu diesem Zeitpunkt machte sich die Leitung des Kraftwerks offenbar wenig Gedanken über die Abschaltung dieses Kraftwerks. Stattdessen eilten ein paar so genannte "Pioniere der Atomenergie" nach Washington und überredeten den Kongress zum Erlass des Gesetzes über die Haftung gegenüber Dritten **(Price-Anderson Act)**. Im Wesentlichen erlaubt dieses neue Gesetz die Zahlung von bis zu 500 Millionen Dollar aus der Staatskasse für jeden einzelnen Ausfall eines Atomreaktors und entlastet die Energieversorger und Versicherungsgesellschaften von einem enormen finanziellen Risiko bei Schäden. (Die privaten Versicherungsgesellschaften tragen nur eine "symbolische Beteiligung“, die 1 Prozent des Risikos abdeckt, und haben eine "Ausschlussklausel für Nuklearschäden" in jede Hausratversicherung aufgenommen
Auf der Ebene der Vorstände der Energieversorgungsunternehmen scheint die allgemeine Haltung zu sein: "Das kann nicht passieren" oder "Das geht uns nichts an“.

Irrtum 8: Der Kongress war sich der Auswirkungen des Price-Anderson-Gesetzes bewusst, glaubte aber, dass die junge Industrie in dieser neuen Technologie einen besonderen Anreiz benötigte.
Fakt: Als diese Gesetzgebung 1957 geprüft wurde, erhob einzig der Repräsentant Chet Holifield eine Gegenstimme. Seine Erklärung: Es würde eine weitere staatliche Subvention für die Entwicklung der Atomenergie bedeuten ohne entsprechenden Nutzen für die Steuerzahler und Stromverbraucher. Es würde der Bundesregierung eine enorme potenzielle Haftung auferlegen, die sich auf mehrere hundert Milliarden Dollar betragen könnte. Dieser Gesetzentwurf wird von seinen Befürwortern als ein Gesetz zum Schutz der Öffentlichkeit angepriesen.... Der Gesetzentwurf diene dem Schutz großer Versorgungsunternehmen, Industrieunternehmen und Versicherungsgesellschaften, die nicht bereit seien, sich an die Grundsätze des freien Unternehmertumes zun halten.... *Sie, die Mitglieder des Kongresses, tragen die persönliche Verantwortung für die Ausarbeitung eines Entschädigungsgesetzes, das diesen Unternehmen die gewünschte finanzielle Absicherung bietet. Sie werden in Ihrem Herzen und in Ihrem Bewusstsein die Verantwortung tragen für den Fall, dass es in diesem Bereich zu einer Katastrophe kommt.*
Leider wurde diese historische Warnung ignoriert. Die Lobbyarbeit für dieses Gesetz war offenbar so geschickt geführt worden dass das Gesetz von beiden Kammern des Kongresses verabschiedet wurde ohne dass die Abstimmungsergebnisse protokolliert wurden.

Irrtum 9: Die Öffentlichkeit ist über das Price-Anderson-Gesetz und über den Versicherungsschutz, den es bieten soll, gut informiert.
Fakt: Die Öffentlichkeit ist hier mit einer hochentwickelten neuen Technologie konfrontiert, und die kontroversen Fragen werden trotz ihrer Bedeutung nur von sehr wenigen verstanden. Der allgemeine Mangel an Besorgnis in der Öffentlichkeit spiegelte sich in der mangelnden Reaktion auf die Ankündigung im August 1965, als der Senat das Price-Anderson Gesetz um weitere zehn Jahre verlängerte (ohne auch nur ein Protokoll der Abstimmung).

Irrglaube 10: Die großen Hersteller würden nicht im grossen Atomkraft-Spiel mitmachen, wenn es nicht in jeder Hinsicht ein gutes Geschäft wäre.
Fakt: Im ersten Nachkriegsjahrzehnt waren die konservativen Energieversorgungsunternehmen nicht bereit, das Risiko eines Wechsels von fossilen Brennstoffen auf die Kerntechnik auf sich zu nehmen, und nur wenige kleine Atomkraftwerke wurden gebaut, hauptsächlich zu Versuchszwecken und um Erfahrungen zu sammeln. Doch mit der Verabschiedung des Price-Anderson-Gesetzes im Jahr 1957 kam ein revolutionäres neues Konzept in die Industrieszene: die Perversion der Verantwortung und das Aufgeben der primären Sorge für die öffentliche Sicherheit durch Ingenieure und verschiedene Vorstände in der Energiewirtschaft. Sie beschlossen, sich dem Boom anzuschliessen und in die Atomenergie einzusteigen. Außerdem war die Zeit für den kommerziellen Verkauf von Atomkraftwerken gekommen, und der Sprecher eines großen Herstellers erklärte: „Unsere Leute haben verstanden, dass dies ein Spiel mit hohen Einsätzen ist, und wenn wir die Energieversorgungsunternehmen nicht zwingen würden, diese Kraftwerke ans Netz zu bringen, würden wir am Ende mit nichts dastehen." Dieses Produktionsunternehmen ging sogar so weit, die traditionellen Ingenieurdisziplinen für die öffentliche Sicherheit beiseite zu wischen und komplette "schlüsselfertige" Atomkraftwerke zu verkaufen, indem sie nicht nur den Reaktor, die Stromerzeugungsmaschinen und elektrische Hilfsmittel baute, sondern auch die volle Verantwortung für den Bau der gesamten Anlage übernahm - Ziegel, Mörtel, Stahl, Beton und so weiter - zu einem Festpreis [3]. Niemand konnte damals das „Schlüsselfertig - Fiasko" vorhersehen, bis dieses Unternehmen Anfang 1966 aufhörte, Angebote für schlüsselfertige Anlagen abzugeben, nachdem sie weit über 200 Millionen mit solchen Verträgen verloren hatte. Neben diesem finanziellen Verlust erklärte einer der Reaktorhersteller gegenüber einem Kongressausschuss, dass "wir es uns einfach nicht leisten konnten, unsere Investitionen in diese Industrie und vielleicht auch in andere Unternehmen, durch die Übernahme (Assumption = Annahme, Vermutung, Voraussetzung) von Sicherheitsrisiken zu gefährden. Ich habe keinen Zweifel daran, dass die gesamte Branche diese Ansicht vertritt."

Irrglaube 11: Kein Zivilist ist bisher durch den Betrieb von Atomkraftwerken ums Leben gekommen; daher ist das Price-Anderson-Gesetz nicht von großer Bedeutung.
Fakt: Derzeit liegen dem Kongress Vorschläge zur Aufhebung des Price-Anderson-Gesetzes vor, und dies könnte zweifellos eines der heilsamsten Ereignisse für die Entwicklung sicherer

Atomkraftwerke sein. Als jedoch im Juni 1965 neue Ausschussanhörungen zur Frage der Verlängerung dieses Gesetzes um weitere zehn Jahre stattfanden, erschienen insgesamt 30 Zeugen und plädierten für eine Verlängerung. Als einer der Kongressabgeordneten fragte, welche Auswirkungen es hätte, wenn das Price-Anderson-Gesetz nicht verlängert würde, antwortete einer der Zeugen aus der Versicherungsbranche: „Ich würde vermuten, dass das jetzige System der wirtschaftlichen Kanalisierung, das Price-Anderson mehr oder weniger fördert, sehr wohl zusammenbrechen könnte … Und es würde weitgehend von der finanziellen Verantwortung und Integrität jedes einzelnen Atomkraftwerksbetreibers abhängen." (Hervorhebung hinzugefügt.)

Irrtum 12: Atomkraft ist die größte Entwicklung für die Elektrizitätswirtschaft, für die Öffentlichkeit und für unser Land.
Fakt: Als der Boom der Atomkraft einmal begonnen hatte, wollten sogar einige der besseren Ingenieursfirmen ins Geschäft kommen, ohne jedoch die traditionelle Verantwortung des Ingenieurs für die öffentliche Sicherheit zu übernehmen. Sie waren bereit, diese Verantwortung der AEC und dem Price-Anderson-Gesetz zu überlassen. Unter den Richtlinien der AEC wurden willkürliche Standards für „postulierte Designs" festgelegt, die eine begrenzte Anzahl „glaubwürdiger" Unfälle berücksichtigten. Strengere Konstruktionskriterien, die die Kosten eines Atomkraftwerks erheblich erhöhen könnten, wurden in die Kategorie „unglaubliche Unfälle" eingeordnet und bei weiteren Überlegungen außer Acht gelassen.

Irrtum 13: Selbst wenn ein Reaktor ausfallen und seine hochradioaktiven Spaltprodukte freisetzen sollte, würde keine dieser zerstörerischen Kontaminationen die Umgebung erreichen, da sie vollständig in einer speziellen Sicherheitshülle eingeschlossen wären, die über dem Reaktor und seinen Nebenaggregaten errichtet wurde.
Fakt: Dieses neue Konstruktionskonzept erschien in den früheren Atomkraftwerken in Form einer relativ dünnen Stahlkuppel. Diese malerische Struktur bot den Konstrukteuren, die glaubten, besondere Sicherheitsvorkehrungen getroffen zu haben, ein gewisses Maß an mentaler Beruhigung, aber mit der Zeit begann das Vertrauen in solche Strukturen zu schwinden. In den neueren Anlagen sind die Reaktoren in stark verstärkten Betonsilos untergebracht, aber deren Schutzwert für die umliegende Region ist immer noch zweifelhaft.

Irrtum 14: Investoren können ihre Ersparnisse getrost in den Bau eines Atomkraftwerks investieren und sich dabei sicher sein, eine angemessene Rendite zu erzielen.
Fakt: Nach den von der AEC festgelegten Lizenzierungsverfahren erhält ein Versorgungsunternehmen lediglich eine Baulizenz und kann mit dem drei- bis fünfjährigen Planungs- und Bauprogramm fortfahren, ohne vorherige Zusicherung, dass die AEC schließlich eine Betriebslizenz erteilt. In der Zwischenzeit wird davon ausgegangen, dass während der Bauzeit die erforderlichen Untersuchungen durchgeführt werden, um etwaige Konstruktions- oder Sicherheitsprobleme zu lösen. Nach Abschluss der Bauarbeiten wird in einer weiteren Anhörung der AEC die Angemessenheit aller Sicherheitsmerkmale als Voraussetzung für die Erteilung einer Betriebslizenz festgestellt. (Leider enthält der Finanzprospekt des Kreditnehmers keine klare und angemessene Warnung, um die Investoren auf diese Gefahr für ihre Investition aufmerksam zu machen.)

Irrtum 15: In einem Atomkraftwerk erzeugter Strom ist billiger als die Energie, die in kohle- oder ölbefeuerten Dampfkraftwerken erzeugt wird.
Fakt: Diese Behauptung wird zunehmend als Schwindel erkannt. Wir täten gut daran, uns an den bemerkenswerten Kommentar eines ehemaligen AEC-Direktors für Reaktorentwicklung zu erinnern: „Die in der Literatur angegebenen Zahlen zu den geschätzten Kosten der Atomenergie schwanken um mindestens den Faktor 10. Ich werde zu diesem Zeitpunkt nicht versuchen, Ihnen genauere Kostenzahlen zu nennen, und zwar aus drei sehr guten Gründen: (a) Sie existieren nicht einmal innerhalb der Atomenergiekommission. (b) Wenn sie existieren würden, könnten sie aus Sicherheitsgründen nicht veröffentlicht werden. (c) Wenn sie existierten und veröffentlicht werden könnten, würde ich ihnen sowieso nicht glauben. Dies kann bestätigt werden, wenn wir die komplexen Verarbeitungsprozesse betrachten, die mit der Umwandlung von Uranerz in Brennstäbe für einen Reaktor verbunden sind. Diese Verarbeitung verbraucht enorme Mengen an Elektrizität und die AEC wird allgemein als der größte Stromverbraucher dieses Landes

angesehen. Angesichts der Tatsache, dass die AEC in einer Vielzahl von Aktivitäten tätig ist, scheint es vernünftig anzunehmen, dass in der Nachkriegszeit der größte Teil des Stromverbrauchs der AEC in die Produktion von Kernbrennstoffen geflossen ist. Die in Abb. 3 dargestellten Fakten zeichnen eine beeindruckende Geschichte. Seit dem Ende des Zweiten Weltkriegs beträgt der kumulierte Gesamtstromverbrauch der AEC 805,2 Milliarden kWh, während der von allen derzeit in Betrieb befindlichen US-Atomkraftwerken erzeugte Strom nur 86,04 Milliarden kWh beträgt. Dies hilft, den grundlegenden Irrtum zu entlarven, dass Uran nur ein Ersatz für Kohle oder Öl ist.

Irrtum 16: Atomkraft ist die billigste und wirtschaftlichste Art von elektrischer Energie.
Tatsache: Angesichts der hohen Subventionen, die mit der Produktion von Kernbrennstoff verbunden sind, ist eine faktische Demonstration grundlegender Wirtschaftlichkeit im Vergleich zu kohle- oder ölbetriebenen Anlagen nie veröffentlicht worden und wird derzeit nicht als im Bereich der Machbarkeit liegend betrachtet.

Irrtum 17: Insgesamt 128 zivile Reaktoren sind derzeit „betriebsbereit", 53 große Atomkraftwerke befinden sich im Bau und 34 weitere Anlagen sind in Planung.
Fakt: Zu den 128 „betriebsfähigen" Reaktoren gehören 109 kleine Test-, Forschungs- und Universitätsreaktoren. Dies reduziert die Zahl der Kraftwerksreaktoren laut offiziellen AEC-Statistiken rasch auf 19. Von den 19 Anlagen, die Ende 1970 als „betriebsfähig" erklärt wurden, hatten 6 weniger als ein Jahr Betriebserfahrung mit den unvermeidlichen „Anlaufschwierigkeiten", und weitere 4 Anlagen erlebten eine Reihe von Abschaltungen, die ihre Kapazitätsfaktoren für das Jahr auf weniger als 50 Prozent brachten. Damit bleiben nur 9 Anlagen übrig, aber diese haben nur Nennkapazitäten zwischen 200 und 575 MWe. Dennoch haben die Leiter der Elektrizitätswirtschaft ihre Unternehmen und Behörden auf etwa 85 große Reaktoren mit einer Gesamtkapazität von über 79.000 MWe festgelegt, wobei viele Reaktoren eine Leistung von 750 bis 1.000 MWe haben - erheblich mehr als jeder Reaktor, der Ende 1970 in Betrieb war.

Irrtum 18: Es wird die pauschale Behauptung aufgestellt, dass Atomkraftwerke mit einem so hohen Maß an Sicherheit betrieben werden, dass die Öffentlichkeit sich keine Sorgen über radioaktive Strahlung machen muss.
Tatsache: Die Gesamtheit der bisherigen Erfahrungen mit den wenigen derzeit in Betrieb befindlichen Atomkraftwerken ist so gering, dass es völlig unmöglich ist, zuverlässige Schlussfolgerungen für die Zukunft in Bezug auf Fragen der langfristigen Sicherheit zu ziehen. Die Weigerung der privaten Versicherungswirtschaft, einen angemessenen finanziellen Schutz zu bieten, spricht für sich [4]. Die Möglichkeiten einer massiven Katastrophe im Falle des Ausfalls oder der Sabotage eines großen Atomkraftwerks liegen jenseits menschlicher Vorstellungskraft.

Irrtum 19: Bei der Konstruktion und dem Standort eines Atomkraftwerks sehen die AEC Vorschriften ausreichende Schutzmaßnahmen gegen alle Gefahren vor.
Tatsache: Im April 1967 veröffentlichte die AEC schließlich die Vorschrift 10 CFR, Teil 115, die die Konstruktion und den Standort von Atomkraftwerken ohne vollständigen Schutz der Öffentlichkeit gegen die Gefahren von Sabotage aller Art genehmigt. Offensichtlich trägt die Beseitigung dieser Konstruktionsanforderung dazu bei, die Kosten für den Bau eines Atomkraftwerks zu senken; aber das Endergebnis ist eine offene Einladung zur Sabotage, die genauso katastrophal sein könnte wie die Folgen einer Atombombe. (Diese Gefahr ist besonders groß, da spaltbares Material für die Zwecke zweckentfremdet werden kann.)

Irrtum 20: Es gibt kein Problem bei der Entsorgung der radioaktiven Abfallprodukte eines Atomkraftwerks.
Fakt: Das allgemeine Problem der Entsorgung hochradioaktiver Abfallprodukte wird immer größer und es laufen verschiedene Studien, darunter die Lagerung solcher Produkte in verlassenen Salzminen und anderen Entsorgungsstätten, wo die verbleibende Radioaktivität über viele Jahrhunderte abklingen könnte.

Irrtum 21: Uns gehen Öl und Kohle aus und wir müssen auf Atomkraft umsteigen, um die Zukunft zu retten.

Fakt: Dies ist eine reine Propagandaaussage. Weder kennt jemand das Ausmaß der in der Erdkruste verborgenen nützlichen Ressourcen, noch weiß jemand, was sich zukünftige Generationen einfallen lassen werden, um derzeit unbekannte Energieressourcen zu finden und zu nutzen. Andererseits wäre es angesichts des derzeit begrenzten Wissens über Uranvorkommen einfacher zu behaupten, dass diese völlig unzureichend sind, um die von den Befürwortern der Atomkraft visualisierten Anforderungen zu erfüllen.

Irrtum 22: Die glänzende Zukunft der Atomenergie liegt im „Brutreaktor", der mehr Brennstoff produziert als er verbraucht.
Fakt: Diese propagandistische Behauptung wird voraussichtlich in zehn oder mehr Jahren Realität. Propagandisten ist es tatsächlich gelungen, Reden für Staatschefs zu schreiben, die schlicht behaupten: „Unsere beste Hoffnung, den wachsenden Bedarf der Nation an wirtschaftlicher, sauberer Energie zu decken, liegt in einem schnellen Brüter. Aufgrund seiner hocheffizienten Nutzung von Kernbrennstoff könnte der Brüter die Lebensdauer unserer natürlichen Uranbrennstoffversorgung von Jahrzehnten auf Jahrhunderte verlängern…"
(MB: Der heutzutage erträumte Fusionsreaktor wird das gleiche Schicksal erleiden wie der Brutreaktor, nachdem Unsummen verbraten und Menschenleben geopfert wurden auf dem Altar des Fortschrittes

Irrtum 23: Die gesamte Grundlagenforschung wurde von der AEC abgeschlossen und es gibt keine großen Unbekannten bei der Konstruktion von Atomkraftwerken für maximale öffentliche Sicherheit.
Fakt: Erst in den letzten Monaten haben verantwortliche Wissenschaftler offengelegt, dass einige der Testprogramme der AEC darauf hindeuten, dass die Notfallsicherheitssysteme im Falle eines Kühlwasserverlusts eines Reaktors (Kühlmittelverlustunfall) möglicherweise nicht ausreichend funktionieren. Sie erklärten: „Unter solchen Umständen wäre zu erwarten, dass der Reaktorkern schmilzt und alle Sicherheitsstrukturen durchbricht, wobei sehr wahrscheinlich ein beträchtlicher Teil der Spaltprodukte freigesetzt wird. Die daraus resultierende Katastrophe und der Verlust an Menschenleben übersteigen möglicherweise alles, was dieses Land jemals erlebt hat."

Zu diesem späten Zeitpunkt bittet die AEC den Kongress derzeit um mehr Geld zur Unterstützung der Forschung zur Sicherheit konventioneller, wassergekühlter Kernreaktoren, da weiterhin erhebliche „Unsicherheiten" hinsichtlich der Leistung der Reaktoren vorhanden sind und noch „dringende" Arbeiten zur Lösung dieser Unsicherheiten durchgeführt werden müssen. Parallel zu den Bemühungen, die Erforschung dieser Gefahr zu beschleunigen, hat die AEC eine Erklärung veröffentlicht, in der es heißt: „Nach der ingenieurmäßigen Einschätzung der Aufsichtsbehörden ist eine Kernschmelze im Reaktorkern nach einem Kühlmittelverlustunfall nicht glaubwürdig, und daher werden die Folgen einer Kernschmelze bei unserer Bewertung der Sicherheit von Kernkraftwerken nicht berücksichtigt."

Irrtum 24: Amerikanische Ingenieurhochschulen bilden kompetente Diplomingenieure für diese rasch wachsende neue Technologie aus.
Fakt: Die meisten Universitäten, die Kurse in Nukleartechnik anbieten, haben Lehrpläne entwickelt, die sich in erster Linie mit der Wissenschaft der Nukleonik und mit Grundlagen-forschung befassen, im Gegensatz zu einer gründlichen Ausbildung in beruflichen Verantwortlichkeiten und Disziplinen. Kein Vorsitzender einer Nukleartechnik-Fakultät hat sich als Sprecher der übergeordneten ethischen und beruflichen Disziplinen etabliert und wird als solcher anerkannt, und dies gilt auch für Dekane der Ingenieurwissenschaften.
Zusammenfassend kann festgestellt werden, dass die „wissenschaftliche Revolution" des 20. Jahrhunderts in unserem Land vom „politisch-wissenschaftlich-militärischen" Komplex ausgenutzt und unterwandert wurde. Dieser Komplex hat bei der Entwicklung der neuen Technologie der Atomkraft bewusst unser traditionelles System verworfen, in dem die Planung und Organisation produktiver wissenschaftlicher Unternehmungen in den Händen verantwortungsbewusster professioneller Ingenieure lag, deren oberste Pflichten darin bestanden, die öffentliche Gesundheit und Sicherheit zu schützen und den Interessen der Öffentlichkeit zu dienen. Stattdessen hat dieser Komplex unter anderem eine revolutionäre neue Politik für die Erzeugung von Atomkraft durch

Kraftwerke etabliert, deren Sicherheitsfaktoren so niedrig sind, dass sie nicht in der Weise für einen vollständigen Versicherungsschutz in Frage kommen, wie dies traditionell bei fossil befeuerten Dampfkraftwerken der Fall war. Die volle Bedeutung dieser Situation wird wahrscheinlich erst nach einer Atomkatastrophe verstanden werden. Insbesondere die Ingenieurberufe müssen sich zwei tiefgreifende Warnungen von Herbert Hoover stets bewusst sein:
1) Technologie ohne intellektuelle Ehrlichkeit wird nicht funktionieren.
2) Unsere größte Gefahr geht nicht von einer Invasion ausländischer Armeen aus. Unsere Gefahr besteht darin, dass wir durch moralische Nachgiebigkeit Selbstmord von innen heraus begehen. Oder durch öffentliche Toleranz von skandalösem Verhalten. Oder durch zynisches Akzeptieren von Schande. Diese Übel haben in der Geschichte der Menschheit schon oft Nationen besiegt.

Referenzen

[1] A.J. Ackerman, „Langsamer Tod eines freien Berufs“, IEEE Trans. Aerospace and Electronic Systems, Bd. AES-7, S. 418-428, Mai 1971.
[2] -, „Atomkraft – Ein Versagen in der technischen Verantwortung“, Trans. ASCE, Bd. 128, Teil 5, 1963.
[3] „G.E.s kostspieliges Wagnis in die Zukunft“, Fortune, S. 93, Oktober 1970.
[4] A.J. Ackerman, „Atomkraft – Wer kümmert sich um die öffentliche Sicherheit?“, IEEE Trans. Aerospace and Electronic Systems, Bd. AES-5, S. 363-375, Mai 1969.

Adolph J. Ackerman 1901 -1991
Zu seinen Erfahrungen in der Planung und dem Bau von Kraftwerken gehörte ein sechsjähriger Auftrag in Brasilien, wo er für die Planung und den Bau eines Gigawatt-Kraftwerks verantwortlich war, darunter die ersten großen unterirdischen Wasserkraftwerke der westlichen Hemisphäre. Mehrere Jahre lang arbeitete er für die Weltbank und erstellte Machbarkeitsberichte zu Kraftwerksentwicklungen, die hauptsächlich in Südamerika und Indien angesiedelt waren. Mit dem Aufkommen der neuen Atomkrafttechnologie widmete er der Planung und dem Entwurf unterirdischer Atomkraftwerke besondere Aufmerksamkeit und führte in den vergangenen dreizehn Jahren eine umfassende Übersicht über die Entwicklung der Atomkraft in den Vereinigten Staaten. Ab 1952 war er unabhängiger beratender Ingenieur für die Entwicklung von Strom und Wasserressourcen. Adolph Ackerman war Mitglied des American Institute of Consulting Engineers, der American Society of Civil Engineers, der American Society for Mechanical Engineers, Eta Kappa Nu, Tau Beta Pi und Chi Epsilon. Er war eingetragener Berufsingenieur in Pennsylvania, New York, Tennessee, Kalifornien und Wisconsin.

Atomic Power—Who Looks After Public Safety?

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Editor's Note: This paper marks a departure from our usual practice of publishing communications as correspondence. The discussions prepared for the ASME Meeting follow directly after the text.

Although this paper deals mainly with the use of atomic power in generating stations, it is included because G-AES is concerned with power generation in space and possibly, someday, the nuclear-engined airplane.

Abstract

In this new technology the history to date adds up to a very small record of operating experiences, along with a variety of deficiencies and failures. At this stage the development of atomic power suffers from a surge of over-optimistic promotion plus a general breakdown in engineering responsibility and control of safety that could culminate in a national catastrophe.

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Introduction

In reviewing the emerging technology of atomic power, this paper is primarily concerned with questions of basic policy and public safety, and with the deficiencies in these areas. There is an urgent need for rectifying current trends in the power industry, and this calls for renewed emphasis on the obligations of local utility managements and their Chief Engineers who have the ultimate responsibility for public safety. The adoption of higher standards of safety for the protection of the public is of utmost importance; furthermore, this is a valid and feasible objective.

This review is directed primarily to the "decision-makers" and "policy-makers"—past and present—and no reflection is intended on the people currently employed in this new technology. Obviously, the sincerity and dedicated efforts of all these people are not in question, but the policies under which they have been obliged to work are very much in question.

The objective here is to promote a higher level of integrity in atomic power policy, both in industry and government, and higher standards of engineering in which the ultimate responsibility for public safety is clearly identified.

Such a review is not only in keeping with our professional right of analysis and discussion; it is, in fact, a professional *duty*—and responsive to the purpose for which our professional societies have been established. It is also responsive to the philosophy of Cicero: "The safety of the people shall be the highest law."

In the new and unprecedented science of atomic energy, unfortunately, the philosophy of engineering responsibility has been allowed to fall by the wayside, or it has been deliberately dismissed. This is a matter of such importance that a conclusive exposition could fill a book; hence, a brief review such as this can only sound an alert on current deficiencies.

This initiative, of necessity, is a highly personalized responsibility, reflecting professional experiences and judgments which extend beyond conventional technical analyses and conclusions derived from statistics. In essence, this review reflects a decade of continuing analysis of the social, economic, and political experiences in this new technology of atomic power. There is only one objective—to serve the best interests of the public and of the engineering profession.

I. Responsibility for Public Safety

The public health and safety are, first and foremost, the responsibilities of professional men. The distinctive marks of a professional man include a motive of service to meet a social duty, the ability to carry high individual responsibility, and a commitment to uphold the ethics of his profession. The application of science and technology is a

difficult and personalized *art* in which the engineer in charge commits himself to serving the public interest above all others, and he carries this responsibility in his conscience. On him rests the ultimate responsibility for public safety.

In 1939 Thaddeus Merriman, the former Chief Engineer of the Board of Water Supply for the City of New York, declared [1]:

> The engineer's duty does not lie only in saving a maximum of his client's money. It demands absolutely that the public be afforded a maximum of safety. If the client is unwilling or unable to pay for that maximum then he should not have his project. And what is true in the case of a private client is just as importantly true when the engineer acts for public authority—he must still protect the public—no one else can perform that function.

And "responsibility" has been clearly defined by Admiral Hyman G. Rickover [2]:

> Responsibility is a unique concept: it can only reside and inhere in a single individual. . . . If responsibility is rightfully yours, no evasion, or ignorance or passing the blame can shift the burden to someone else. Unless you can point your finger at *the man* who was responsible when something goes wrong, then you have never had anyone really responsible. . . .
>
> Service ceases to be professional if it has in any way been dictated by the client or employer. The role of the professional man in society is to lend his special knowledge, his well-trained intellect, and his dispassionate habit of visualizing problems in terms of fundamental principles to whatever specific task is entrusted to him. Professional independence is not a special privilege but rather an inner necessity for the true professional man, and a safeguard for his employers and the general public. Without it, he negates everything that makes him a professional person and he becomes at best a routine technician or hired hand, at worst a hack.

This concept of an engineer's responsibility together with the confidence of the public in the engineering profession comprise a rich heritage which stand as the primary bulwark for the protection of the public in the application of science and technology. Political interference or arbitrary executive displacement of a Chief Engineer's responsibilities would clearly be a violation of public trust. The public has a right to expect absolute intellectual honesty in matters of public health and safety. Herbert Hoover has stated most precisely that "technology without intellectual honesty will not work."

Abdication of Professional Responsibility

Regrettably, however, this concept of responsibility is not being perpetuated in the new postwar technologies, and the engineering profession is allowing itself to be subordinated to governmental authority. During the past decades we have seen many proposals for impressive scientific and engineering projects, but they are being promoted under political domination, completely devoid of financial responsibility, and under deliberate censorship of any opposition.

Notwithstanding the magnitude of such projects, there are relatively few "experts" employed in this type of planning. Unfortunately, most of them tend to ignore the harmful implications. In addition, many politicians are eager to make long-term commitments, supposedly for plausible objectives—but also to maintain their political positions. They encroach on engineering independence and responsibilities, they dominate the establishing of debased planning policies for monumental projects, and they insist upon open-ended financial commitments and the use of arbitrary "legal" strategies. The net result is a breakdown in the areas of professional responsibilities, ethical standards, the rule of law, public safety, financial controls, and the accounting for public funds.

This debased planning technique is emerging currently on a large scale and on a nationwide basis. The most terrifying example is to be found in the development of atomic power, where the traditional professional disciplines and responsibilities of the independent engineer have been completely disrupted.

To understand how this came about, we need to go back to 1957 when Congress was persuaded to adopt a revolutionary change in insurance practices through the enactment of the Third Party Liability (Price-Anderson) Act. Under this act, in the event of a failure or accident in an atomic power plant, the major part of the cost of the destruction in life and property will be transferred to the victims and to the taxpayers of the nation. This legislation must be regarded as a great historical tragedy for two reasons: 1) it has destroyed the traditional concepts of *responsibility* and *corporate liability*, and 2) it has led to the exploitation of public confidence in the engineering profession and in the American system of private enterprise. (The history of this revolutionary change has been examined in greater detail elsewhere [3].) In essence this new law relieves the utilities and insurance companies of a huge financial risk against damages which could exceed 5 to 7 billion dollars. Private insurance companies are carrying only one percent of the peril, and the law authorizes payments of another ten percent of the estimated peril, a maximum of $500 000 000 from the public treasury, on any one failure of an atomic reactor.

U. S. Congress Ignored Warning

When this legislation was being considered in 1957 by the Joint Committee on Atomic Energy (JCAE), and in the U. S. Congress, Representative Chet Holifield, as the lone dissenting member of this 18-member committee, declared himself opposed to the Price-Anderson Act in these words [4]:

> It would provide another government subsidy to atomic power development without any commensurate benefits to taxpayers and power consumers. It would place upon the federal government an enormous potential liability that could reach several hundred billion dollars. . . .

> This bill is put forth by its proponents as a bill for the protection of the public. This amounts to making a virtue out of a subsidy. The bill is protective of large utilities, industrial companies, and insurance companies which are not willing to adhere to the tenets of free enterprise. . . .
>
> This bill is not a minor technical amendment to the Atomic Energy Act. It is a major piece of legislation. It goes far beyond anything I know in committing the federal government to future liabilities without any clear understanding or basis in experience as to the nature or the magnitude of those liabilities.

Later, during the debate in the House of Representatives, Holifield declared [5]:

> . . . You Members of Congress are taking upon your shoulders the personal responsibility for writing an indemnity bill which will give these people the coverage that they want *financially* and you will have upon your hearts and upon your minds and upon your souls the responsibility in case there is a blowup in this field.

Unfortunately this historic warning was ignored. The lobbying for this bill apparently had been managed so skillfully that the Act was passed by both Houses of Congress without even recording the voting.

High-Pressure Propaganda

Once the Price-Anderson Act had passed, it brought with it a new concept (or "fourth dimension") in atomic power development—*the perversion of responsibility* and the widespread application of "emotional engineering." As a consequence an aggressive promotional effort was launched, ostensibly to accelerate the development of atomic power. Advertisements deteriorated into unsupportable claims of low cost, safety, and abundance of electricity for everyone, and into emotional propaganda. Engineering conferences invariably featured the wonders of this great new energy resource, and professional papers forecasting a new utopia were given special recognition. Against the traditional professional disciplines and moderating influences of responsible engineers and fully responsible insurance companies, the new atomic scientist–administrators argued [6], "This simultaneous pursuit of programs of research, development and construction has become standard in the fast-moving field of atomic energy."

A few years later a new warning was heard when engineer Abel Wolman, Hon. M.ASCE, testified in 1960 before a Congressional Committee [7]:

> It is only with research for criteria for radiation limits that one finds that it should be permissible to kill people to attain benefits to society. This has undoubtedly been in the minds of all criteria makers, but rarely has it reached the frank and stark pronouncements of recent years. . . . An agreed acceptance of a number of consequent disabilities is not an appealing basis for the development, say, of nuclear power. *Industry will do better than rest upon such an affront to man.*
>
> (Emphasis added)

These words should have touched everyone's conscience. But, unfortunately, this responsible warning has remained unheeded to this day.

Only on rare occasions were appeals heard for a more deliberate approach in developing "engineered factors of safety" and economic principles of application. Reports and professional papers were difficult to find on operating problems and on deficiencies or failures experienced in the first group of atomic power plants, although the art of engineering is advanced through the lessons learned from failures. However, over the years, and generally under special circumstances, a few significant statements saw the light of day, such as "We Are Being *Misled* on Nuclear Power" by a former member of the AEC's General Advisory Committee [8] and my own paper [3].

Furthermore, with Hiroshima and Nagasaki still very much in the public mind, some local groups of citizens banded together and registered violent opposition to the building of atomic power plants in populated areas. This resulted in several important projects being canceled as, for example, in Queens, N. Y., and Bodega Bay, Calif.

Despite all the deficiencies and confusing concepts that inevitably appeared during the first decades of this new technology, the engineering profession (through its official societies) has made very little effort to oppose unsound policy trends or to bring about a sound reorientation in professional responsibility.

The Problem of Public Safety is Taken to Court

The first court action in defense of public health and safety was filed in 1956, not by the engineering profession, but by a labor union, which opposed the construction of the Enrico Fermi Atomic Power Plant near Detroit. After this case reached the U. S. Court of Appeals it handed down a decision in June 1960 [9]:

> In our opinion the [Atomic Energy] Commission's findings regarding safety of operation are not sufficient. . . . We think it clear from the Congressional concern for safety that Congress intended no reactor should, without compelling reasons, be located where it will expose so large a population to the possibility of a nuclear disaster. . . . Because we think the safety findings insufficient, we must set aside the Commission's grant of a construction permit. . . .

The case was carried to the Supreme Court of the United States on appeal in the fall of 1960 [10]. This provided an opportunity for contributing an *amicus curiae* brief to the Court [11], in which the professional and legal responsibilities of engineers were defined and recommendations were offered for returning to the traditional practices of engineering and construction under the rule of law.

Unfortunately, the Court held that since only a *construction* permit had been granted there could be no legal issue over *operating* safety until the plant had been constructed and an *operating* permit was under considera-

tion. Against this the minority opinion of the Court declared [3]:

> The legislative history makes clear that the time when the issue of "safety" must be resolved is before the Commission issues a construction permit. The construction given the Act by the Commission (and today approved) is, with all deference, a lighthearted approach to the most awesome, the most deadly, the most dangerous process that man has ever conceived.

The net effect of the Court's decision on atomic power development has been to disrupt a traditional safeguard for prospective investors and to weaken the ethical disciplines of the engineering profession in the areas of economics, finance, and public safety.

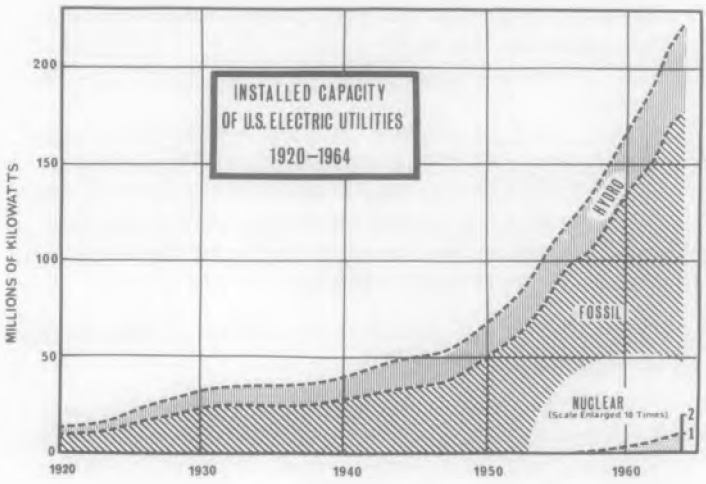


Fig. 1. Installed capacity and annual energy production by U. S. electric utilities, 1920–1964 [12, p. 740]. (Note that the scale for nuclear power generation is enlarged 10 times for visibility.)

II. Responsibilities of Management

The problems of corporate liability in the event of a catastrophic failure of an atomic power plant continued to plague a number of responsible utility managements and their Boards of Directors. The chief reasons for their concern were 1) the continuing refusal by the insurance companies to write the same kind of comprehensive Third Party Liability Insurance as is available for fossil-fueled steam plants; 2) the absence of an adequate record of successful operating experience from which sound judgment could be drawn for major commitments into the future; 3) a high degree of public concern about the peril of radioactive fallout, as reflected in the active opposition to several atomic power projects; and 4) the fact that the Price-Anderson Act was operable for only a limited period of ten years and was due to expire in 1967.

As recent as June, 1967, there were only four public utility atomic power plants in operation in the U. S. with capacities exceeding 75 000 kW, and only one of these had a rating as high as 265 000 kW. All of them, including seven smaller plants, were considered largely experimental. The total capacity of nuclear generation, including the smaller units, came to about 1 000 000 kW, or less than half a percent of the total electrical capacity in the United States of about 230 000 000 kW (Fig. 1). (The deficiencies in these atomic power developments, and the unsatisfactory operating experiences, have been critically reviewed elsewhere [12], [13].

Responsibilities of Boards of Directors

Our great American system of free enterprise is founded on the *integrity* of each company or corporation, and on their *willingness to assume full responsibility* for their acts. At that level, obviously, only the Board of Directors can supply the answers to questions of corporate policy. Granted that there are many fine directors of high integrity serving on the Boards of the great power and manufacturing companies, it is, nevertheless, distressing to see how few have publicly challenged the revolutionary changes of policy in the power industry, and the ethical issues inherent in the application of nuclear science. The majority appear to be unaware of the new and subtle influences that are undermining the welfare of their own companies, as well as the public safety. Some of them seem to rely on someone else's opinion, or on the fact that "everybody's doing it." A more cynical comment is sometimes heard that "Directors don't direct."

At a recent hearing before an Atomic Safety and Licensing Board these deficiencies in corporate management were identified in the following testimony [14]:

> The introduction of a major peril, with a potentiality for destruction greater than was experienced at Hiroshima, is a tremendous responsibility. *This is, first of all, a responsibility resting on the individual Directors of the power company*—and on the Directors of the participating power companies. Commissioner James T. Ramey of the U. S. Atomic Energy Commission has declared: "It must never be forgotten, however, that responsibility for safety of the plant rests with the owner or operator. The regulatory groups, no matter how thoroughly they carry out their function, cannot provide complete assurance that public health and safety will be adequately protected in a power reactor project. . . ." (AEC Authorizing Legislation—1968, p. 1288.)
>
> The proposed atomic power plant represents a revolutionary departure from traditional corporate responsibility and from the traditional confidence reposed in utility Directors by an uninformed public. There is little indication that utility Directors have examined the personal and ethical responsibilities involved in introducing such a peril. It is respectfully suggested that each Director be given an opportunity to re-examine his responsibilities and publicly declare his position as part of this hearing record.

Very few utility directors apparently have been given the opportunity to balance their judgment through a careful study of the *failures* and *adverse experiences* in atomic power development, and the lessons to be learned from them. These experiences include the public protests which led to calling off plans for the 1 000 000-kW Ravenswood plant in New York and the 325 000-kW Bodega Bay plant near San Francisco in 1964; the deferment of the 462 000-kW Malibu plant near Los Angeles in 1966; the abandonment of the 150 000-kW Enrico Fermi reactor near Detroit in 1965 and the decision of the Detroit Edison Company directors to enlarge their system until 1972 with a coal-burning steam plant; the closing down of the Oak Ridge plant in 1966 after $57 000 000 had been spent on it; the dismantling of the Hallam, Neb., plant in 1966 after an expenditure of $55 000 000; the interminable operating difficulties with smaller plants in La Crosse, Wis., Elk River, Minn., and Puerto Rico; the discovery late in 1967 of more than a hundred cracks in the Oyster Creek pressure vessel; and the disapproval by the AEC in 1967 of the 2 000 000-kW plant in Burlington, N. J., "because of its proximity to major population centers."

Furthermore, Directors could to advantage examine the complete lack of operating experiences in large-sized reactors, the lack of integrity in the massive promotional campaigns, the efforts to brainwash the public, the problem of radioactive waste disposal, and several other technical problems of equal importance.

There are some fundamental defects also in basic economics in comparing the cost of electricity produced from atomic reactors with the cost of electricity produced from fossil fuels. Comparative costs in terms of "mills per kWh" are being relied upon by Directors for making huge financial and long-range policy commitments, despite the fallacies to be found on the subject of "cost of atomic energy." We would do well to remind ourselves of the notable opinion expressed by a former AEC Director of Reactor Development who declared [15]:

> Figures in the literature on estimated cost of atomic energy vary by at least a factor of 10. I am not going to try at this time to give you more accurate cost figures for three very good reasons:
>
> 1) They do not exist even with the Atomic Energy Commission.
> 2) If they did exist, they could not be released for security reasons.
> 3) If they did exist and if they could be released, I wouldn't believe them anyway.

III. New Congressional Hearings

In June 1965 the Joint Committee on Atomic Energy held new hearings in the nation's Capitol on the question of extending the Price-Anderson Act for another ten years. A total of 35 witnesses were heard, of which 30 advocated extension of the Act and 5 opposed such extension (4 from the coal industry and 1 independent consulting engineer) [16].

The promotional efforts and "emotional engineering" in support of this legislation were something remarkable to behold. The preparatory work by most witnesses was extensive, and a solid front was presented by the spokesmen for the electrical industry.

These hearings brought forth some strange testimony. For example, two witnesses who advocated the extension of the Price-Anderson Act inadvertently exposed some important factors that impinge directly on business ethics.

The first one, a reactor manufacturer, was asked what effect it would have on his company's activities in the nuclear field if the Price-Anderson Act were not extended. He replied [16, p. 95], " . . . Of course, my opinion would be that that probably would deter us from taking on further work—a conservative approach by the Board of Directors. . . ."

The second one, a spokesman for the Nuclear Energy Liability Insurance Association, was asked what the impact would be on the insurance industry and the nuclear liability policies they issue if Price-Anderson were allowed to expire. He responded [16, p. 196], "It would be my guess that the system of economic channeling that Price-Anderson more or less stimulates might very well break down . . . and it would depend largely *on the financial responsibility and integrity of each nuclear operator*" (emphasis added).

Testimony by Concerned Citizens

Such hearings also provide an opportunity for interested citizens to contribute important information; and when the official reports on such hearings are published, they are available to all citizens for detailed study. Obviously, anyone who speaks out in dissent against popular ideas assumes a special burden in volunteering to testify. And, depending on the adequacy or inadequacy of the judgment developed from these hearings, the future of our nation and its people is committed accordingly.

The fact remains, however, that the public is confronted with a highly sophisticated new technology, and the controversial issues (such as the "safety factors" in atomic power plants) despite their importance are understood by very few people. This was confirmed by the general lack of public interest and concern in the announcement of August 31, 1965: "The Senate proceeded to consider bill (S. 2042), 'Extending and Amending the Price-Anderson Indemnity Provisions of the Atomic Energy Act of 1954' and passed it"—without a record of the voting [17].

JCAE Hearings of September 1967

The most recent opportunity for reexamining basic issues was at the JCAE Hearings in the U. S. Capitol on September 12–14, 1967. The hearings provided a review of current procedures [18] and comments were invited on

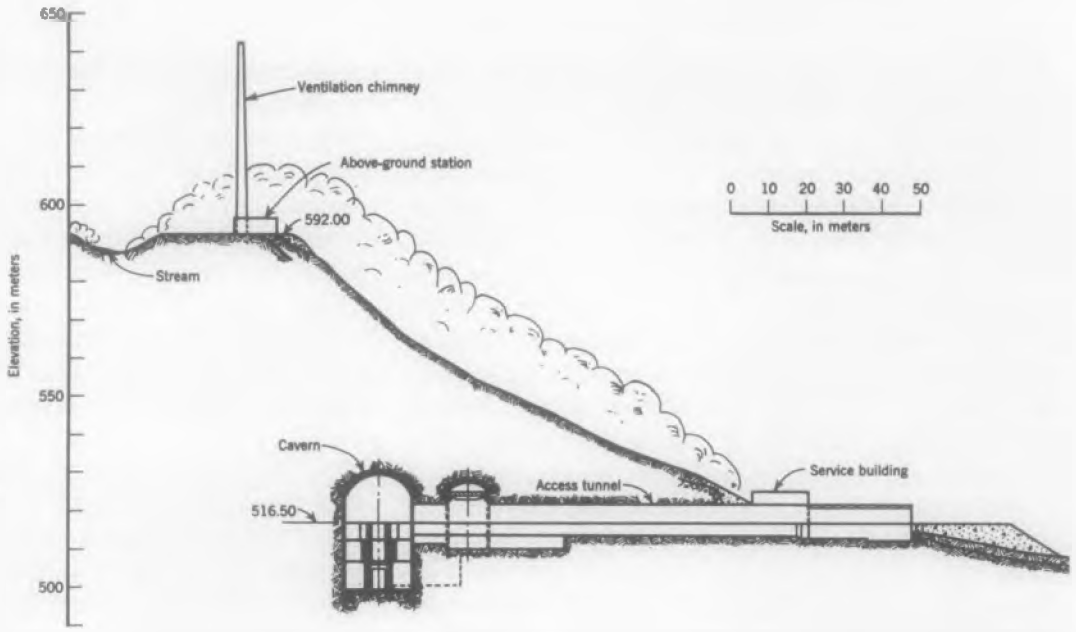
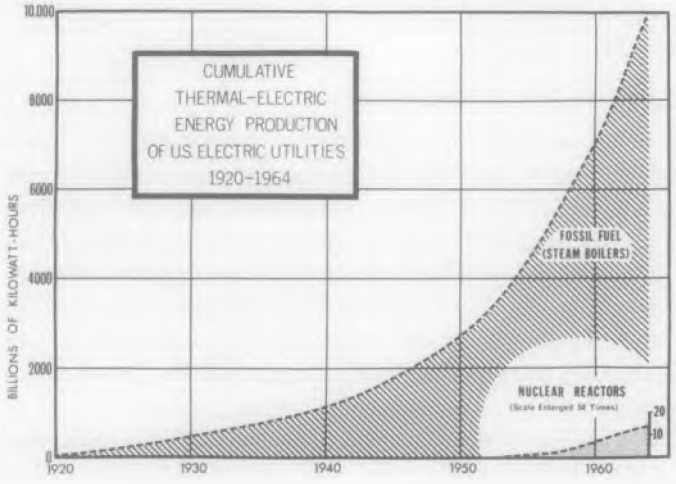


Fig. 3. Underground setting for atomic power plant, Lucens, Switzerland [3, p. 68]. In this design the atomic power plant is located completely underground in solid rock, a well-recognized technique employed for the economic development of hydroelectric power in many parts of the world.

Fig. 2. Cumulative thermal-electric energy production of U. S. electric utilities, 1920–1964 [12, p. 747]. (Note that the scale for nuclear power generation is enlarged 50 times for visibility.)



twelve questions. The proponents of atomic power were there en masse and painted a rosy picture for the future. By contrast, the author's testimony, in essence, covered the following points [18].

1) The AEC's regulatory program (at this stage) cannot be expected to provide reasonable assurance that the public health and safety is not endangered by the operation of nuclear reactors. In this new technology the operating experience is exceedingly small (Fig. 2) in relationship to the magnitude of the peril to the public; in the half-dozen small reactors currently in utility service, the operations have been under constant surveillance by scientists and physicists who have had superior training. However, as in the case of the historical development of steam boilers, *major failures in atomic power plants* eventually will provide important lessons and serve as a guide for future developments.

2) The nuclear industry undoubtedly is taking many important steps in the development of this new technology. But it has not adopted the design and siting criteria which would guarantee complete safety to the public living in the surrounding region. (The feasibility of such siting has been demonstrated by the underground testing of atomic bombs.)

3) A further separation of the AEC's regulatory responsibilities is called for at this time, provided it leaves the ultimate responsibility for public safety with the utility companies, their Chief Engineers, and their insurance companies.

4) The regulatory process would become more efficient if the Price-Anderson Act were repealed and if regulation were based on placing *full* responsibility for public safety on the Directors of the utilities, and on their designated Chief Engineers of the projects.

5) A change is definitely called for in the AEC's policies on siting of nuclear reactors for all regions, whether heavily or sparsely inhabited. It is recommended that the AEC require all atomic power plants to be located "underground." This means, in caverns excavated in solid rock hillsides, as in the case of many hydroelectric projects (Fig. 3). (Such plants could be designed to justify 100 percent commercial insurance protection for third parties, without reliance on the Price-Anderson Act.)

6) It is not feasible to evaluate the . . . reactor safety systems . . . as long as sabotage can release a major radioactive fallout with widespread destruction.

7) Members of the public . . . have very little opportunity to become aware of the problems of public safety. For example, where has an owner of an atomic power plant explained to homeowners that under their insurance policies on their homes they are not covered against nuclear reactions or fallout. . . .

8) In summary, the following recommendations for Congressional consideration were offered:

a) that Congress repeal the Price-Anderson Act;
b) that the insurance companies remove the nuclear exclusion provisions from all homeowners' insurance policies;
c) that full responsibility for public safety be placed on the Directors of the utility company or power agency operating an atomic power plant;
d) that the power company's own Chief Engineer for the project be publicly identified as having the full responsibility for directing the design and construction of an atomic power plant—with the overriding duty to protect the public interest and safety;
e) that atomic power plants be located underground in solid rock.

Lack of Responsible Criticism in JCAE Hearings

The author's testimony reviewed in particular "The Duty to Dissent" and his concern that the Joint Committee, while dealing with one of the most important responsibilities in the history of the world, is being denied the full benefits of "the loyal opposition." In a supplementary communication to the Committee this issue was identified in greater detail, from which the following is summarized [18, pp. 791–794].

The former editor of the official journal of the IEEE has recently reviewed the obstacles confronting an engineer when his conscience dictates that he must record a dissenting opinion where the public interest is at stake. He declared editorially [19]:

> Is it true . . . that editorial space for presentation of an unpopular viewpoint is virtually impossible to obtain in a reputable technical journal? Alas, it is true—. . . . Dissenting opinions are likely to be unpopular. . . . Many claim that it is disloyal to protest. Sometimes the penalty—disapproval, loss of status, even vilification—can be severe. The penalty for neglect of this duty, however, can be much more severe. . . .

The responsibilities resting on the Joint Committee on Atomic Energy are tremendous, and the Committee has shown a willingness to hear a diversity of ideas, including forthright criticism and opposition. However, there was a notable lack of critical testimony as may be illustrated by several incidents.

1) A spokesman, claiming to represent "178 investor-owned electric power companies serving more than three-quarters of our nation's users of electricity," introduced a statement bearing the names of 17 utility executives. Unfortunately, however, some of their declarations were contrary to the disciplines and ethical commitments of the engineering and legal professions. The long-term effect of such high-level initiative is to silence all engineers and lawyers in the private utility industry unless they are prepared to jeopardize their future by challenging the policy commitments introduced by these few but influential executives. As a consequence the process of critical analysis is suppressed on the most important and controversial issue ever to confront that industry.

2) A representative of one of the nation's leading manufacturers of nuclear reactors testified: "We simply could not afford to jeopardize our very substantial investment in this industry, and perhaps in other businesses, by assuming safety risks. I have no doubt at all that the entire industry holds this view." In a matter as important and as controversial as the question of public safety this declaration tends to silence professional engineers and lawyers employed in that industry who should be speaking out against such an "affront to man." This testimony was reminiscent of the notable opinion handed down by Federal District Judge J. Cullen Ganey in 1961 in the Price-Fixing Case [20]:

> What is really at stake here is the survival of the kind of economy under which this country has grown great, the free enterprise system. . . . The conduct of these corporations and individuals has flagrantly mocked the image of the economic system of free enterprise which we profess to the country, and it has destroyed the model which we offer today as a free world alternative to state control, to socialism, and eventual dictatorship.

3) The Chairman of JCAE referred to the fact that "in the Turkey Point licensing proceedings there was considerable discussion of the need for an applicant to make specific provision in design for sabotage or other enemy action." He asked a leading public utility executive [18, p. 779]: "Do you believe consideration should be given in such matters of design of nuclear power plants?" There was no open and forthright answer to this question, although it is one of the most important questions on public safety ever posed in the history of our country. Furthermore, no proposal was offered by this executive to consult the engineering profession which has the ultimate responsibility for public safety.

4) The Chairman also remarked that the Atomic Energy Commission had decided that protection against sabotage was not to be an issue in the Turkey Point licensing procedure. It is interesting to note that this particular rule, applicable to all atomic power plants, was published earlier in 1967 in the Federal Register where it apparently attracted very little attention (February 11 and April 5, 1967). This terrifying rule did not have the benefit of open analysis and debate within the engineering and legal professions. According to the AEC's public document file, only three comments were received, one from a reactor manufacturer concurring in the order, and two in opposi-

tion—one from an independent consulting engineer [21] and one from an independent attorney [22]. (The current rule on the sabotage peril, as an open invitation to catastrophe, is of such great importance that it calls for a separate story.)

IV. New Program of Atomic Power Development

Extending the Price-Anderson Act for another ten years has had the net effect of greatly enlarging the "fourth dimension" in atomic power development—*the perversion of responsibility* and the *abandonment of primary concern for public safety* by various Boards of Directors who decided to join the bandwagon rush into atomic power.

Furthermore, it has opened the door for a new campaign of emotional engineering at all levels. For example, in an effort to brainwash a worried public the management of a national magazine of the "family type" was persuaded to publish a propaganda article on the "New Age" of atomic power, authored by a free-lance writer—a type of article no responsible executive or independent engineer would write. To give the article more "character," it was first "planted" in the official magazine of an international service club of business and professional men, and then "reprinted" for the nation's families.

The latest effort to brainwash the public was a so-called "public opinion" poll in California which reported, "Seventy-three percent agreed that nuclear plants are necessary for additional electricity for California's growth . . . and 64 percent agreed that opponents of nuclear plants spread false rumors and try to scare people." However, apparently none of those interviewed were told that the insurance companies (under a standard "nuclear exclusion clause" in the fine print) specifically deny homeowners compensation in the event of damage from the failure of a nearby nuclear plant.

The more aggressive reactor manufacturers stepped up their sales initiative with offerings of "turn-key contracts" for atomic power plants of unprecedented size; this included all costs of engineering, construction and installation of equipment under an AEC *construction permit*, without knowing in advance whether AEC would ever grant an *operating permit* when the plant is completed. The engineering firms on these projects, in effect, became subcontractors or drafting services and gave up their professional independence and freedom to challenge the merits of such projects. The net effect of all this has been a breakdown in professional disciplines and ethics in this new technology, and a voluntary retreat from the obligation to serve the public safety and interest above all others.

Claims that prospective generating costs from atomic power plants in the years ahead will be lower than from coal- or oil-fired steam plants were disseminated with an abandon reminiscent of the "30-inch yardstick costs" of earlier days. It is nothing short of frightening that in the brief period of 18 months of 1966–1967 a total of 97 large atomic generating units, aggregating 78 000 000 kW, were ordered or projected for installation during the period 1969–1975. Most of these units have ratings of 800 000 to 1 000 000 kW, far beyond any reactor in commercial operation today [23].

This situation has become so serious that the JCAE issued House of Representatives Report 1266 on April 1, 1968, in which it expressed concern about "the bandwagon rush" into atomic power, and warned a portion of the utility industry that it "lacks a full appreciation of the job confronting the utilities at this time."

Need for Return to Fundamentals

In this overpowering new science the experiences of the past decade have demonstrated that the traditional structure of corporate and professional responsibilities has been undermined by revolutionary changes in insurance philosophy and engineering philosophy. Today atomic power technology is in the hands of a small but influential group whose members have convinced themselves that "all is well." Responsible protests are dismissed as being "beyond human credibility"—a kind of dismissal reminiscent of the few desperate protests against the operation of the gas chambers in 1942–1945.

There is a crying need for vigorous and open debate and for freedom of communication to clearly identify the monstrous gamble with human lives which has grown out of the current perversions of responsibility. A reappraisal of these responsibilities is inevitable—the choice being only whether to undertake it now or in the aftermath of a catastrophe.

It would be a sad day if an iron curtain eventually were to descend and keep independent engineers from exercising their judicial professional responsibilities in the areas of public safety. If this were to happen it would mark another step in the relentless trend towards the *technocratic petrification of our nation's freedom.*

V. The Importance of Maintaining Perspective

A New Event in Human History

Today we are confronted with the terrible responsibility of controlling a scientific power great enough to destroy all life. But this power of total destruction is also a power that can be made to serve mankind if it is applied according to the will of the Creator.

The tremendous responsibility of interpreting this power to all the world, along with the duty of determining what is to be done with it in the coming centuries, is presently in the hands of the Joint Committee on Atomic Energy of the U. S. Congress. But it is also a responsibility of the American engineering profession, and this responsibility is of a unique type which no governmental agency or politically constituted body can fulfill. It is the responsibility at the level of professional ethics.

The Overriding Importance of Professional Ethics

Ethics are a product of conscience—on the same level with faith and trust and integrity—and founded on intellectual honesty. Ethics are the dominating influence on the truly responsible engineer. In the past, for example, ethics have provided the self-disciplined guidelines for thousands of engineers in creating the miracle of safe drinking water in the communities throughout America. The people take this standard of service for granted and place their complete trust in the integrity of the engineers. It is a trust which every professional engineer must respect. Knowing more than the people do about the effect his work will have, his first duty is to *serve the public interest above all others*, no matter what his employer may want or what some governmental regulation may permit.

This is particularly important in the revolutionary new technology of atomic power where we are confronted with new responsibilities of unprecedented magnitude, and where there has been no opportunity to develop the requisite rules of law. Chief Justice Earl Warren of the U. S. Supreme Court has alerted us to such responsibilities in these words (forming part of an address delivered on November 12, 1962):

> Society would come to grief without Ethics, which is unenforceable in the Courts, and cannot be made part of Law. . . .
>
> Not only does Law in civilized society presuppose ethical commitment; it presupposes the existence of a broad area of human conduct controlled only by ethical norms and not subject to Law at all. . . .
>
> The individual citizen may engage in practices which, on the advice of counsel, he believes strictly within the letter of the Law, but which he also knows from his own conscience are outside the bounds of propriety and the right. Thus, when he engages in such practices, he does so not at his own peril—as when he violates the Law—but at peril to the structure of civilization, involving greater stakes than any possible peril to himself.
>
> This Law beyond the Law, as distinct from Law, is the creation of civilization and is indispensable to it. . . .
>
> A person able to discern the right in the midst of great confusion and to pursue it, is a person of character. A person may be learned or ignorant; he may be old or young, rich or poor, well or sick; whatever his condition he has to act, and his actions have their effect on himself and generally also on his fellow men.
>
> The education of both ministers of religion and of lay specialists, qualified to help the confused find himself in the maze of ethical problems is, in my opinion, one of the urgent needs of Western democracy, as it attempts to preserve its tradition of freedom in competition with rival systems of life. . . .

Modern science has put in the hands of policy-makers a tremendous new leverage in which the mistakes can now be exceedingly large; and the importance of the *ethical* question has escalated accordingly. From this perspective engineers working in the new technology of atomic power owe it to themselves to search their consciences in terms of the following specific guidelines which may be derived directly from our Code of Ethics.

1) It shall be deemed unethical for an engineer to apply his talents and responsibilities to the location, design and construction of an atomic power plant with such a low factor of safety that, in the event of accidental failure or sabotage, catastrophic damage will result to the surrounding region and its people. (Under current official regulations the peril of sabotage may be disregarded in the design and location of an atomic power plant.)

2) It shall be deemed unethical for an engineer to apply his talents and responsibilities to the location, design and construction of a low-cost atomic power plant, with a low factor of safety, on the assumption that, in the event of a major accident or sabotage, the nation's taxpayers will compensate the survivors for damages. (Such compensation is present-day official governmental policy.)

VI. Summary

Today we are struggling with the controversial question of how to apply this revolutionary discovery of atomic energy for the benefit of man. In particular, we are groping for the right answer to the ultimate question of how to convert the energy of the atom into electricity without peril to the public—and without violating the rights of the citizens under our constitutional system of government.

Measured in these terms, our progress, if any, has been feeble, indeed; and the question "*Who* is responsible in the event of a major failure?" is passed around in a vicious circle.

Certainly, all mankind has a right to expect something better than to acknowledge the possibility of a catastrophe and to provide for covering 10 000 graves with a blanket of greenbacks! If the eager prophets who are proclaiming the blessings of atomic power were to examine the other side of their coin, they might see that such a catastrophe (from the failure or sabotaging of an atomic power plant) would precipitate a violent public revulsion against our most important industry and its directors—and ultimately against our entire system of free enterprise for having condoned such an appalling irresponsibility in the application of this new science.

The time has arrived for a thorough review of the disillusioning collapse of integrity and for facing up to the ominous challenge advanced eight years ago:

> An agreed acceptance of a number of consequent disabilities is not an appealing basis for the development, say, of nuclear power. Industry will do better than rest upon such an affront to man.

Our free enterprise system *must* provide a better answer. Atomic power stations as currently designed present a unique and incredible hazard to human life. Where in industry is the leader with the requisite courage and integrity to promote 1) the repeal of the Price-Anderson

Act, and 2) the repeal of the AEC's regulation 10 CFR Part 115 which authorizes the design and location of atomic power plants without complete protection of the public against the perils of sabotage of all types? These two steps alone would go far towards reestablishing engineering and corporate responsibility founded on integrity and on primary concern for the public interest and safety.

REFERENCES

[1] T. Merriman, "Naught but the best," *Civil Engrg.*, pp. 701–702, December 1939.
[2] H. G. Rickover, testimony, "Radiation safety and regulation," *JCAE Hearings* (June 15, 1961).
[3] A. J. Ackerman, "Atomic power, a failure in engineering responsibility," *Trans. ASCE*, vol. 128, pt. 5, 1963.
[4] *Congressional Record* (Senate), pp. 9606–7, June 19, 1957.
[5] *Congressional Record* (House), p. 10716, July 1, 1957.
[6] Brief for the Petitioners, United States and Atomic Energy Commission before the U. S. Supreme Court, no. 454, p. 45, October 10, 1960.
[7] "Radiation protection criteria and standards: their basis and use," *JCAE Hearings*, pp. 34–35, 1960.
[8] R. E. Wilson, "We are being *misled* on nuclear power," *Power Industry*, pp. 14–15, January 1959.
[9] 280 F-2d. 645, 1960.
[10] Power Reactor Development Company and AEC, Petitioners, v. International Union of Electrical Workers, AFL-CIO *et al.*, October Term, 1960, no. 315 and 454.
[11] A. J. Ackerman, *Amicus Curiae*, brief for the case of [10]. Also see [3].
[12] ——, "Atomic power plants—what's wrong with them?" *Proc. Am. Power Conf.*, vol. 27, pp. 737–755, 1965.
[13] H. Matheson, "Atomic power and the problems of public safety," *Rotarian* (Evanston, Ill.), pp. 32–35, December 1966; also Reader Comments, *ibid.*, April 1967.
[14] A. J. Ackerman, testimony given at hearings on Vermont Nuclear Power Station (514 000 kW), Brattleboro, Vt., August 1, 1967.
[15] "Atomic power and private enterprise," *JCAE Hearings*, p. 132, 1952.
[16] A. J. Ackerman, testimony, "Proposed extension of AEC indemnity legislation," *JCAE Hearings* (June 22–24, 1965), pp. 155–176.
[17] *Congressional Record* (Senate), p. 21461, August 31, 1965.
[18] "Licensing and regulation of nuclear reactors," *JCAE Hearings* (September 12–14, 1967), pp. 783–801.
[19] C. C. Cutler, "Duty to dissent," *IEEE Spectrum*, vol. 4, p. 47, June 1967.
[20] J. G. Fuller, *The Gentlemen Conspirators.* New York: Grove, 1962, pp. 101–102.
[21] A. J. Ackerman, letter to Atomic Energy Commission, March 13, 1967. See also [18, p. 796].
[22] P. Siegel, letter to Atomic Energy Commission, March 10, 1967. See also [18, p. 796].
[23] M. Shaw, "Nuclear power—the next decade of development," *IEEE Spectrum*, vol. 4, pp. 73–80, October 1967.

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His experience in the planning and construction of power plants includes a six-year assignment in Brazil, where he was in charge of designing and building a million-kilowatt power program including the first large underground hydropower plants in the Western Hemisphere. For a number of years he served the World Bank, making feasibility reports on power developments located chiefly in South America and India. With the advent of the new technology of atomic power he has paid particular attention to the planning and design of underground atomic power plants, and during the past ten years has maintained a comprehensive review of atomic power developments in the U. S. Since 1952, he has been an independent consulting engineer on electric power and water resource development.

Mr. Ackerman is a member of the American Institute of Consulting Engineers, American Society of Civil Engineers, American Society for Mechanical Engineers, Eta Kappa Nu, Tau Beta Pi, and Chi Epsilon. He is a Registered Professional Engineer in the states of Pennsylvania, New York, Tennessee, California, and Wisconsin.

Discussion

Frederic A. Lang (Good Hope Road, Landenberg, Pa. 19530): Engineers have need to know each of the seldom-told stories of public safety problems that are concurrent with great strides forward in technology. Too often the safety aspects of such conquests are hidden by company policy because full public knowledge of potential safety problems would result in precautionary slackening of the rush forward. The author is commended for his personal effort in behalf of public safety and professional ethics.

We should keep forever before us the author's key statement which I quote, "Knowing more than the people do about the effect his work will have, his (the engineer's) first duty is to *serve* the public interest above all others, no matter what his employer may want or what some governmental regulation will permit." Such ethical conduct is our only hope of solving the public safety problems in the absence of specific laws and government regulation.

Corporations by definition are not able to make ethical decisions. Industrial corporations exist for the sole purpose of making a profit. Only humans, including engineers, make the needed ethical decisions. Of course, corporate interest in maximizing the profit from power generation and other business endeavors is under some control by individual engineers who can use their own ethical standards to prevent a mad rush for profits and potential catastrophe. The author properly appeals to these engineers to undertake their professional duty on safety matters.

If members of our profession fail to heed this appeal, they may expect that public safety will thereafter be derived from government regulations designed to protect the public from the dangers of otherwise uncontrolled engineering projects of great consequence. The need for professional societies will be reduced if engineers choose to abdicate their responsibilities to the public on safety problems.

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Alfred Ogram (201 East Copland Drive, Orlando, Fla. 32806): The author has clearly identified the area of professional responsibility under the violently changing conditions that have been precipitated by the advent of atomic power. Heretofore, moral function within the profession has been largely taken for granted under intuitive application of postulates that worked reasonably well under normal conditions. The arrival, however, of this spectacular but insufficiently understood and highly dangerous source of power brings with it the urgent need for a thorough reappraisal of the engineer's overall moral obligation if he is to retain professional status.

The problem is rendered especially acute because of the complications and difficulties resulting from an expansion of the central government. Any realistic analysis, therefore, must take into consideration the many facets of this form of government while reviewing the relationship of the engineer to his profession, to his client, and to the public—the third party to every contract, even though that contract may be only an employer–employee association.

Manuscript received November 25, 1968.

The prescription for successful voluntary individual conduct has been thoroughly covered by the great religious teachers of history. Engineers are, after all, individuals, and, as such, are subject to personal responsibility for decisions that affect the lives and safety of many other people. Thus they become their "brothers' keeper" by reason of their superior knowledge of the materials and forces with which they deal.

The application of this overriding principle of successful human conduct specifically to the engineer has been well established in its fundamental aspects by Merriman [1], Hoover [24], Ackerman [25], and others. Further development for adjustment to current problems will depend on the degree of courage displayed in answer to the question of how much weight shall be given expediency in view of an increase of central government and its effect on the decision of engineers. Is compromise with principle possible for engineers? Can intellectual honesty be right on some occasions and wrong on others?

We are confronted here with a matter of extreme importance in the development of civilization—of even more importance than the profession itself. For without a fertile political, moral and economic climate, the profession, per se, would cease to exist, and the progress of society would come to a halt—perhaps even ebb—plunging the world into a new dark age.

I refer particularly to the current trend in this country away from the principles of individual freedom, moral responsibility, and personal independence on the basis of which we, as Americans, have been able to acquire the highest standard of living the world has ever known. In place of these bright tenets of progress, we are substituting the dogma of a debilitating collectivism which, if not stoutly resisted, will engulf all the professions, reducing their members to mere technicians and puppets of ignorant or unscrupulous politicians and bureaucrats—who are even now forming a new elite to which all the rest of us will be subservient.

The engineering profession occupies a critically important position in this situation for two reasons. First, without its supporting knowledge and skills, the bureaucracy would be helpless in many areas of prime importance to the furtherance of its aims. Second, the profession, with its very existence at stake, can easily lose by default unless it maintains an aggressively moral and ethical attitude of unswerving integrity in "serving the public interest above all others."

Let us be sure we understand the issue before us. It is *not* whether atomic power should, or should not, be developed. It will be, as the need arises. The timely and vitally important questions are how and where.

The public is constantly being bombarded by massive claims and deliberate propaganda that the "how" is all settled by the offerings of the reactor manufacturers. I am not so sure! The "how" should include due regard for safety of the public, particularly when the basic material is known to be fraught with danger greater than ever before experienced by man. And as long as human beings design and build and operate, there will be mistakes and accidents. Furthermore, any engineer or other person of professional status who lends himself to the planning and building of an atomic power plant without primary dedication to the safety of the public has abrogated his professional responsibility and betrayed his trust to himself, to his profession, and to his fellow man.

The "where" is answered in conjunction with the "how." Why take undue risks when they can be avoided by underground installations as recommended by Ackerman? The

AEC's underground testing of bombs is helping to demonstrate the feasibility of confining atomic fallout under the most extreme conditions, and thus avoid exposing the public to an unprecedented peril.

From the halls of Congress [26] we have been warned that "at any point in history the 'state of the art' imposes definite limits on what is technologically feasible. Failure to probe, define, and recognize these limits leads to the choice of unrealistic and generally overly expensive goals which in turn lead to technical failures." To this Ackerman, on another occasion [26], has added that "the silence of the engineering profession (or the suppression of competent engineering analysis) on these controversial issues has allowed the nation to drift into the present perilous situation. It adds up to an arrogant exploitation of public confidence in traditional professional excellence."

So far as I am aware, this paper by Adolph J. Ackerman is the first on this momentous subject which has been presented to the members of the American Society of Mechanical Engineers. There should be much more discussion of this subject and the time is very late.

REFERENCES

[24] H. C. Hoover, *The Challenge to Liberty*. New York: Scribners, 1934.

[25] A. J. Ackerman, "The engineer's obligation to disclose all the facts," *Civil Engrg.*, March 1960.

[26] "Apollo and excellence . . . ," *Am. Engineer* (Letters), March 1968.

Harold P. Green (National Law Center, George Washington University, Washington, D.C.): As an attorney, I feel no little trepidation in commenting on questions of the professional responsibility and ethics of engineers. I do so, however, because Ackerman's paper deals essentially with a problem which impinges upon a matter of fundamental concern to lawyers as well as engineers: to what societal institutions does the public look for assurance that technology will be practiced in a manner consistent with protection of the health and safety of the public?

At the threshold, it must be recognized that a serious accident in an atomic power plant could result in injury to the lives, health, and property of the public many orders of magnitude greater than might result from any previously known technology. Present national policy encourages and supports development and practice of nuclear power technology because of the enormous benefits which are expected to result. The public is required to assume the risk of a catastrophic accident cheerfully, just as it pays taxes, to support national objectives.

In a normal industry, corporate executives would think twice (at least) before they invested in a technology with such destructive potential because of the enormous public liability which might arise in the event of an accident. From the lawyer's standpoint, one of the functions of legal liability is to discourage extra-hazardous activities. Indeed, it is clear that American industry was unwilling to invest in nuclear power without firm assurance that it would be relieved of all possible liability which was not insurable on an economic basis. Since the insurance companies were unable or unwilling to provide insurance against all but a small portion of the potential risk, the Government stepped in with the Price-Anderson Act which provides positive assurance that no one who might be liable in the event of a nuclear power plant accident will have to bear one cent of liability out of his own pocket. For this assurance, industry pays a nominal annual indemnity fee to the Atomic Energy Commission which is in no way related to the actual risk. In other words, the public is required to assume the very risk which industry refused to assume.

With elimination of the deterrent effect of potential liability, the public's protection must rest with 1) "engineered safeguards" designed to minimize both the possibility and the consequences of an accident, and 2) stringent government regulation to assure adequate safety precautions. But the government regulation is admittedly designed to provide for safety without placing any crippling obstacles in the path of development of this new technology; and because nuclear power technology leapfrogs experience, the "engineered safeguards" find their validity in the predictive judgment of scientists and engineers and not in wisdom derived from experience.

Oliver Wendell Holmes wrote "the life of the law is experience." Although I am no expert in engineering, I suspect that engineering ethics are based, implicitly at least, on the principle that "there is no substitute for experience." The fundamental question which Ackerman raises when he discusses "responsibility" is whether it is right—as a matter of law, of policy, and of ethics—for the public to be required to assume a risk of unprecedently catastrophic proportions on the basis of predictive judgments by experts—who are, after all, fallible humans—where these judgments are not rooted in experience.

Manuscript received November 25, 1968.

Robert L. Whitelaw (Virginia Polytechnic Institute, Blacksburg, Va.): I wish to endorse fully the principal argument advanced by A. J. Ackerman in his paper and, perhaps, strengthen the impact of his paper with this brief discussion.

His principal argument has been confirmed by my own experience of the past fifteen years on nuclear projects and problems of various kinds. This experience included preparing proposals and nuclear hazards evaluations on a variety of nuclear power plants, both commercial and military.[1]

It has been my observation that, despite the enormous amount of meticulous detail which the ACRS regularly requires on every projected power plant to satisfy itself that there is no "credible accident" that can threaten the public (or even the operators)—and despite the volumes of paper and hours of presentations consumed on this topic, and no doubt well-intentioned—there is still by common consent an unwritten agreement to treat as "incredible" the most fearful of all nuclear accidents that can occur in any plant with a highly pressurized primary system. Such an accident is, of course, the explosive rupture of the primary vessel itself, which is ruled out of the list of credible accidents for the simple reason that there is no adequate answer short of putting the plant underground or inside a mountain, as Ackerman has pointed out.

Manuscript received February 7, 1969.

[1] Prof. Whitelaw was formerly Project Engineer for the design and construction of the power plant of the N. S. Savannah.

The Blind Road to the New Despotism[1]

ADOLPH J. ACKERMAN
Consulting Engineer
Madison, WI

Comments from the Editor-in-Chief Emeritus

Previous argumentation papers by A.J. Ackerman have been published by the IEEE, and in particular by the AES. We are remote from the financial and contractual turmoil of the nuclear field, though thoroughly involved in the attempted understanding of "corpuscular physics" and its most recent applications.

We have consistently backed Mr. Ackerman's right to be heard as a dissenting voice in today's forest of automatons and shall continue to do so. If you wish to comment, (and we *invite* commentary) please do so in writing for our correspondence section.

—H.R. Mimno

P.S.

This paper is the first half of Ackerman's manuscript as originally submitted. Shortly before these *Transactions* went to press he re-wrote the second half because of what he considers an event of historical importance:

On March 31, A Federal Judge in Charlotte, North Carolina, declared the Price-Anderson Act unconstitutional, thereby lending support to Ackerman's chief criticism of current national policy in the new technology of atomic power.

Ackerman's revised paper, with a summary of the Court's decision, appears as Part II in later pages of this issues. —H.R.M.

Manuscript received December 10, 1976; revised January 31, 1977.

This paper was originally presented under the title "Obstacles to Responsible Dissent" at the 97th Annual Winter Meeting of the American Society of Mechanical Engineers, New York, N.Y., December 7, 1976.

Author's address: 1250 Sherman Ave., Madison, WI 53703.

[1] "The New Despotism" by England's renowned Chief Justice, Hewart of Bury, records the Fabian process of destroying the Rule of Law (Ernest Benn, Ltd., London, 1929).

This message is directed to the founders of today's "legal and moral chaos" in America—to our lawmakers and to the leaders in the elite professions—engineers, lawyers, educators, and journalists. They have failed, during the past two-score years of the Scientific Revolution, to heed the warning of our nation's Founding Fathers that "where law ends, tyranny begins;" they have failed to defend our Constitution against the "new despotism" founded on modern science and technology.

All mankind is now committed to a revolutionary upheaval generally called the Scientific Revolution—the most violent ordeal in the history of the world. Many years ago we were warned [1]:

> This revolution will decide for generations whether all mankind and the whole world is to become free, or whether, in the struggle, civilization as we know it is to be completely destroyed or completely changed. It is our fate to live upon that turning point in history. It is in fact a total crisis. In part, the crisis results from the impact of science and technology upon mankind which, neither socially nor morally, has caught up with the problems posed by that impact. In part it is caused by men's efforts to solve those problems. It is not a revolution of violence. It is a revolution by bookkeeping and lawmaking.

I. The Rise of a Legal and Moral Chaos

Part of the revolutionary change in our nation was introduced in the early 1930's when the United States went off the gold standard. This opened the door to widespread governmental and political planning, including vast science-based programs, without regard to the traditional fiscal disciplines and controls. Today we can all see the consequences of massive deficitory spending with printing-press money and the buildup of national debt and uncontrollable inflation.

In 1935 when the constitutionality of abandoning the gold standard was challenged in the Supreme Court of the United States, it was upheld by only five Justices. We would do well to study the dissenting opinion of Justices McReynolds, Van Devanter, Sutherland, and Butler who declared [2]

> Acquiescence in the decisions just announced is impossible; the circomstances demand statement of our views. To let oneself slide down the easy slope offered by the course of events and to dull one's mind against the extent of the danger, ... that is precisely to fail in one's obligation of responsibility. ... Loss of reputation for honorable dealing will bring us unending humiliation; *the impending legal and moral chaos is appalling.* (emphasis added)

This remarkable dissenting opinion may now be reviewed in retrospect as a statement of exceptional wisdom and historic perception. Unfortunately, however, it has been displaced by the Court's majority opinion. Today the American nation is in a position to review the events of the past four decades and to recognize "the legal and moral chaos" to which our great country now stands committed.

Exploitation of Engineering Disciplines

In particular, our engineering profession has witnessed at first hand how the Scientific Revolution of the twentieth

century has been exploited and subverted by the "political-scientific" complex. This complex has discarded our traditional system under which the planning and organizing of productive scientific ventures has been in the hands of responsible professional engineers whose first duty is to serve the best interests of the public. Instead, this complex originates and administers highly sophisticated science-based programs, whose open-ended deficit financing is rapidly undermining our American economic system. By this means America is gradually being committed to a system of centralized authority and to the eventual disappearance of human liberty and justice under law. This marks an historic turning point for the world and for all mankind. The scientific term for this obscure process is "technocratic petrification of freedom" which ends in "scientific despotism" [3].

In terms of basic philosophy, this revolutionary process has been identified by Nicolas Murray Butler of Columbia University in these words [4]:

> The world is made up of three groups of people: the first group, a very small one, who make things happen; a somewhat larger group, who watch things happen; and the great multitudes, who don't know what happens.

In this contest the warning by the noted scientist James Clerk Maxwell nearly 100 years ago has acquired a new meaning for the present age and especially for the engineering profession [3]:

> Such indeed is the respect paid to science that the most absurd opinions may become current provided they are expressed in language the sound of which recalls some well-known scientific phrase. If society is thus prepared to receive all kinds of scientific doctrines, it is our part to provide for the diffusion and cultivation not only of true scientific principles but of a spirit of sound criticism.

The Uncontrolled Scientific and Managerial Revolutions

The "great multitudes who don't know what happens" have been shocked into comprehension of the realities of the Scientific Revolution by such unspeakable horrors as the atomic bomb, the gas chambers, and similar "inventions of the devil." On the other hand, through wise and responsible management, the Scientific Revolution has also brought into our lives great benefits in the forms of mass communication, radio and television, mass travel by land and air, massive supplies of electricity under human control, the miracles of chemistry, and other great scientific and engineering achievements.

The "very small group who *make* things happen" has been perpetuated in our postwar economic system in the form of two radically different groups. In the one group are the traditionally "rightist" or conservative managers or leaders. In the other group are the "leftist" strategists who have launched a revolutionary type of *mis*management. This is a new but obscure technique of management founded on "freedom *from* responsibility" and on "mismanagement without accountability."

On closer examination of these obscure but revolutionary changes in our economic and political systems, it can readily be shown that the mismanagement of science and technology (or the subversive management of falsely applied technology) offers the easiest course for secretly guiding America down the road to national suicide. It is a terrifying fact that such mismanagement of the *new* sciences, no matter how dangerous they may be, has become an accepted way of life at the elite levels not only of government but also in corporate directorates, higher education, public communication, journalism and, most regrettably also, in the engineering profession.

A former Justice of the Supreme Court of the United States, Robert Jackson, has summarized the origin of these destructive influences in these words [5]:

> It is one of the paradoxes of our times that modern society needs to fear only the educated men. The primitive peoples of the earth constitute no menace. The most serious crimes against civilization can be committed only by educated and technically competent people ... .

And Herbert Hoover has given us this profound warning [6]:

> Our greatest danger is not from invasion by foreign armies. Our dangers are that we may commit suicide from within by complaisance with evil. Or by public tolerance of scandalous behavior. Or by cynical acceptance of dishonor. These evils have defeated nations many times in human history. The redemption of mankind by America will depend upon our ability to cope with these evils here at home.

The foregoing review and pronouncements by some of our great American leaders and statesmen serve to bring into focus the great challenge confronting the responsible engineer in meeting his overriding commitments to the public interest and safety, especially in the application of the new and revolutionary sciences and technologies. The fulfilling of such commitments demands of the individual engineer a fearless and courageous response to the dictates of his conscience and his ethical obligations.

The Importance of Ethics

Ethics has been defined as the Science of Morality. The importance—even the indispensability—to society of those who will identify their ethical obligations in a time of confusion, and act on them, was pointed out by Earl Warren, former Chief Justice of the United States, in a notable address delivered on November 12, 1962 [7]:

> Society would come to grief without Ethics, which is unenforceable in the Courts, and cannot be made part of Law. ...
>
> Not only does Law in civilized society presuppose ethical commitment; it presupposes the existence of a broad area of human conduct controlled by ethical norms and not subject to Law at all. ...
>
> The individual citizen may engage in practices which, on the advice of counsel, he believes strictly within the letter of the Law, but which he also knows from his own conscience are outside the bounds of propriety and the right. Thus when he engages in such practices, he does so not at his own peril—as when he violates the law—but at peril to the structure of

civilization, involving greater stakes than any possible peril to himself.

This Law beyond the Law, as distinct from Law, is the creation of civilization and is indispensable to it. ...

A person able to discern the right in the midst of confusion and to pursue it, is a person of character. A person may be learned or ignorant; he may be old or young, rich or poor, well or sick; whatever his condition he has to act, and his actions have their effect on himself and generally also on his fellow men.

The education of both ministers of religion and of lay specialists, qualified to help the confused find himself in the maze of ethical problems is, in my opinion, one of the urgent needs of Western democracy, as it attempts to preserve its tradition of freedom in competition with rival systems of life. ...

II. Examples of Historic Mismanagement

In terms of current events our nation has only recently witnessed the experiences of Watergate as the top horror story of the "mismangaement revolution. Other examples of destructive mismanagements may be seen in 1) the nuclear power technology as promoted by many great corporations; 2) the numerous scandals with great financial losses in insurance companies and real estate ventures; 3) some of our "great" professional societies; 4) the displacement of the Rule of Law by Administrative Law; 5) the wasteful spending of the public's funds; and 6) the predictable crisis due to uncontrolled inflation.

Fortunately, the Watergate case has demonstrated that in the minds of the American people the sense of what is moral and right has prevailed; it has culminated in the historic tragedy of a President of the United States being compelled to resign. Furthermore, in other matters our nation is experiencing a reassuring sense of revulsion against mismanagement and against exploitation of public confidence on the part of those in high levels of leadership.

A Warning from History

The obscure and little-understood technique of "mismanagement," or creating a "new despotism" through the political domination of technology, and thereby subverting human liberty, has been identified by the highest living authority, Albert Speer, the former Minister of Armaments and War Production under Hitler. In his memoirs *Inside the Third Reich* [8] he has becorded this severe warning:

> Dazzled by the possibilities of technology, I devoted crucial years of my life to serving it. ... This was the first dictatorship of an industrial state in this age of modern technology, a dictatorship which employed to perfection the instruments of technology to dominate its own people and to keep criminal operations shrouded in a high degree of secrecy. ... Some day the nations of the world may be dominated by technology. ... Every country in the world today faces the danger of being terrorized by technology. ... Therefore, the more technological the world becomes, the more essential will be the demand for individual freedom and the self-awareness of the individual human being as a counterpoise to technology.

In Albert Speer's recent interview with Greg Wegner [9] he responded to a question about developments in the world today:

> Many traits of Hitler's time are continuing in a dangerous way. One of these traits I see is Hitler's organization. ... Everything is geared toward presenting an idea which in time becomes so powerful that it even changes the minds of strong people. This is continuing, and it is not Hitler or a dictator who is doing it but the influence of technology. This causes great depersonalization and even more so in the highly civilized countries. ... I am warning about the danger in which we are living now. ... I can see the danger, that we are coming into a new dictatorship. This new dictatorship is not the dictatorship of a human being but of technology.

Albert Speer's warning is especially applicable to the revolutionary technology of nuclear energy. In this area we also have the notable challenge from Winston Churchill [10] with his unique perspective on human history:

> This revelation of the secrets of nature, long mercifully withheld from man, should arouse the most solemn reflections in the mind and conscience of every human being capable of comprehension.

These voices of warning from recent history have identified a sophisticated type of subversion. Our nation is in peril of losing our heritage of liberty and leaving behind for the coming generations a continuing legal and moral chaos—and eventual surrender in the current Cold War.

III. The Duty to Dissent

"Is it possible to transmit the experience of those who have suffered to those who have yet to suffer? ... Is it possible to warn someone of danger?" These questions were recently advanced by *Reader's Digest* [11] in a notable review of our nation's peril. Is it possible to awaken the public to the realities of modern scientific dangers or to get our national leaders to stop, look, and listen? Most of them seem to find it easier to glibly respond: "That's beyond credibility!"

Engineers have a responsibility that goes far beyond the building of machines and systems. We cannot leave it to the technical illiterates, or even to literate and overloaded technical administrators, to decide what is safe and for the public good. We must tell what we know, first through normal administrative channels, but when these fail, through whatever avenues we can find. Many claim that it is disloyal to protest. Sometimes the penalty—disapproval, loss of status, even vilification—can be severe [12].

IV. What Can We Do Today?

"Can it happen again here in America?" In 1972 this was the question addressed to Dr. Raul Hilberg, the noted author about Hitler's Holocaust and the gas chambers. He responded [13]:

> How does one answer that? How does one identify a major peril? The Holocaust is a unique event in human history. The entire configuration grew out of a continuing sequence of ordinary events. ... The Holocaust demonstrated that a deterrent capability was lacking and there seems to be no way of building up such a capability in advance of such a Holocaust ... or of a well-planned process of destruction.

This is, indeed, a profound observation on the question: How does one identify a major peril? And who will stop to listen to competent warnings and responsible dissent involving unprecedented events? It is much easier to dismiss such warnings as "incredible" and to vilify the dissenters. This has been confirmed by the horrible experiences of the German chemical engineer, Kurt Gerstein, who tried to expose the horrors of the gas chambers and failed [14].

Today, by the grace of God, we still have in America freedom of speech and the right to persevere in building up a "deterrent capability." But at this critical stage in our nation's history, much more is needed. There is a great need for effective public enlightenment. Where in our nation is just one industrial statesman who will dedicate himself to restating those American principles which must prevail if we are to maintain our system of free enterprise and human liberty for all our citizens? Furthermore, there is a great need for a new and exceptional type of journalistic confrontation. Watergate has demonstrated that in our open adversary system of two-party government it takes only one courageous publisher, a superior editor, and two dedicated reporters to alert our nation to an incredible type of disservice in high places.

The time has arrived for a similar journalistic service to interpret to the American people the new "dictatorship of technology." But this will be a much more difficult task. The Watergate case called for applying the tests of decency and honesty in public office and then reporting the shocking facts to a nation of deeply concerned citizens. In contrast, the intellectual crimes and treason in modern technology call for applying the tests of integrity and ethics in business, in engineering, and in government, and then translating the criminal exploitations of the public into nationwide public understanding.

Can this be done?

References

[1] W. Chambers, *Witness.* New York: Random House, 1952, p. 7.
[2] U.S. Supreme Court, numbers 270, 471, Feb. 18, 1935.
[3] A.J. Ackerman, "Slow death of a free profession," *IEEE Trans. Aerosp. Electron. Syst.*, pp. 418-428, May 1971.
[4] A.J. Ackerman, "Using engineering to enslave you," *Civil Engineering*, pp. 67-70, July 1964.
[5] Address to American Bar Association, 1968. See also "The new czars versus the Rule of Law," American Bar Association, Chicago, Ill., 1964.
[6] E. Lyons, *Herbert Hoover.* New York: Doubleday, 1964.
[7] Address to the Louis Marshall Award Dinner of the Jewish Theological Seminary of America, New York, N.Y., Nov. 12, 1962.
[8] A. Speer, *Inside the Third Reich.* New York: Macmillan, 1970.
[9] _____, "Looking ahead," *Wisconsin State J.*, sect. 5, Oct. 17, 1976.
[10] Winston Churchill's memoirs, "Thoughts and adventures."
[11] *Reader's Digest*, pp. 69-74, Dec. 1975.
[12] C.C. Cutler, "Duty to dissent," *IEEE Spectrum*, editorial, p. 16, June 1967.
[13] R. Hilberglecture, University of Vermont, March 1972.
[14] P. Joffroy, *A Spy for God: The Ordeal of Kurt Gerstein.* New York: Harcourt, Brace, Jovanovich, 1972; and S. Friedlander, *Kurt Gerstein, The Ambiguity of Good.* New York: Knopf, 1969.

Adolph J. Ackerman (SM'49) was born in New Ulm, Minn., on April 21, 1901. He attended Martin Luther College, and received the B.S.E.E. and C.E. degrees from the University of Wisconsin, Madison, in 1926 and 1933, respectively.

His experience in the planning and construction of power plants includes a six-year assignment in Brazil, where he was in charge of designing and building a million-kilowatt power program, including the first large underground hydropower plants in the Western Hemisphere. For a number of years he served the World Bank, making feasibility reports on power developments located chiefly in South America and India. With the advent of the new technology of atomic power he has paid particular attention to the planning and design of underground atomic power plants, and during the past thirteen years has maintained a comprehensive review of atomic power developments in the United States. Since 1952 he has been an independent consulting engineer on electric power and water resources development.

Mr. Ackerman is a member of the American Institute of Consulting Engineers, American Society of Civil Engineers, American Society for Mechanical Engineers, Eta Kappa Nu, Tau Beta Pi, and Chi Epsilon. He is a registered Professional Engineer in Pennsylvania, New York, Tennessee, California, and Wisconsin.

The Blind Road to the New Despotism: Part II

Example: The Atomic Power Insurance Act Violates the Constitution of the United States

"Therefore we are always confident ... for we walk in faith. ..."

Every engineer is a witness to such faith as he experiences the profound reward of seeing his plans and ideas translated into a successful project.

Almost as a miracle, I have again experienced the reward for that faith, this time in our American Judiciary System. On March 31, 1977, in Charlotte, North Carolina, United States District Judge James B. McMillan, in response to a local citizen initiative, handed down a decision declaring the Price-Anderson Indemnity Act in violation of the Constitution of the United States.

This decision fully confirms the basic philosophy and engineering principles for the revolutionary new technology of atomic power as I have advanced them in my Amicus Curiae Brief to the Supreme Court of the United States in April 1961. This Brief subsequently was published by the American Society of Civil Engineers in its ***TRANSACTIONS*** *of 1963 (vol. 128, part V, Paper 3497) and received generous approval and commendation from many civil engineers.*

I believe my 1961 brief merits careful reading by all who are engaged in this new field of atomic power engineering. In addition, it takes knowledgeable and persistent action by engineers to defend their ethical commitments and the Constitution of the United States at this critical but obscure level of our nation's intellectual resources.

I continue to regard our prevailing nuclear power policies as a major peril to our country's security and one that can only be rectified if the engineering profession faces up to its responsibilities.

However, this calls for sharing the results of my 25 years of research on this subject with my colleagues, and for this we need Freedom of Communication. Unfortunately, such freedom has become severely restricted. The editor of IEEE SPECTRUM acknowledged this editorially ten years ago (June 1967) in these words:

> "Is it true, as he states, that editorial space for presentation of an unpopular viewpoint is virtually impossible to obtain in a reputable technical journal? Alas, it is true . . ."

Obviously, it is much easier for critics, instead of studying the facts, to respond to the voice of dissent by distorting the facts, or even engaging in name-calling and disparagement, or glibly responding: "That's beyond credibility!" (When reason fails, men become personal).

Basically, I am firmly opposed to political domination and perversion of our engineering disciplines and ethics. I am firmly for maintaining high professional standards in engineering for public safety, for defending our national security, and for preserving our Constitutional system of government under the Rule of Law.

To gain a better understanding of the obstacles which engineers must overcome in warning the public of a major peril, I traveled to Germany in October 1966 to study the world's biggest scientific and engineering crime–The Holocaust–and particularly the part played be engineers in the design and operation of the gas chambers. I inquired: Were there any engineers who refused to take part in the operations?" To this the standard response from German engineers and scientists was: "We never knew that these chambers existed."

It is from this perspective on today's engineering journalism that I feel impelled to pay a special tribute to the editor of these Transactions, *for having upheld the God-given right of Freedom of Communication.*

ADOLPH J. ACKERMAN

Editor's Notes: Part I will be found on page 329 of this issue. Read Ackerman's 1961 brief–you will get a different perspective on his entire argument. –H.R. Mimno

The profound concern, as expressed in Part I, summarizes a 25-year review of the Scientific Revolution, particularly as it has revealed itself in the unprecedented new technology of atomic power. In the course of this public service effort (an effort our great universities have failed to undertake), a hideous fact has loomed constantly larger: *A terrible but obscure peril to the public is being created through the undisciplined practices under which the American atomic power industry is currently growing up*; and this includes the related professions in engineering, law, insurrance, public regulation, and accounting.

As this profound fact has gradually gained recognition in competent circles, it became evident that a new and major effort in communication was called for in the form of a "dissenting voice" (despite all the perils that this implied for the dissenter).

I. The Engineers's Duty To Dissent

The Duty to Dissent has been defined with exceptional clarity by C.C. Cutler, the fomer editor of IEEE SPECTRUM in his notable editorial of June 1967:

> "As an engineer, you have a responsibility to decide what is safe and for the public good. You must tell what you know through whatever avenues you can find."

The first effort was directed towards alerting our country's engineering leaders and the profession at large to the fact that we are confronted with two new challenges of critical importance to the public and to our national security: 1) educating ourselves to the realities of the Scientific Revolution in all of its facets; and 2) facing up to our new obligations and overriding responsibilities for public safety in the new technology of atomic power.

During the past two decades a series of papers have been published in our leading engineering journals, along with testimony at public hearings, under the authorship of Adolph J. Ackerman, including;

1. "Amicus Curiae" Brief in the United States Supreme Court, 1961 [1]
2. "Atomic Power, A Failure in Engineering Responsibility," 1963 [2]
3. Opposition Testimony to the Proposed Extension of the Price-Anderson Indemnity Legislation, 1965 [3]
4. "Atomic Power Plants–What's Wrong With Them?" 1968 [4]
5. Testimony on Licensing and Regulation of Nuclear Reactors, 1967 [5]
6. "Atomic Power–Who Looks After Public Safety?" 1969 [6]
7. The Unresolved Engineering Problems in the New Technology of Atomic Power" 1970 [7]
8. "Slow Death of a Free Profession" 1971 [8]
9. "Atomic Power–Fallacies and Facts" 1972 [9]
10. Opposition Testimony on Legislation to Amend the Price-Anderson Indemnity Act 1974 [10]
11. "Atomic Power is Undermining the ASME Boiler Code for Public Safety," with Amicus Curiae Brief to the United States District Court, Southern District of New York 1974 [11]
12. "Atomic Power Engineering Under Falsified Safety Standards" 1974 [12]
13. "ASCE and Nuclear Power Plants"–A critical Discussion, 1977 [13]

These efforts to communicate obscure but critically important facts by one small voice have produced only limited results. However, as has been clearly set forth in the professional paper "Slow Death of a Free Profession," the engineering profession is suffering severely from the abdication of its responsibilities and from widespread apathy in the face of the rapidly growing powers of the new political despotism in science and technology.

Nevertheless, over the years it has been rewarding to receive generous responses and encouragement from competent sources, such as the comment from a Justice of the Supreme Court of the United States (1966):

> "You write with refreshing concern and I am sure many will heed your words. Thank you for letting me have them. It is indeed good to know that an engineer is taking up the cudgels for dissent."

From one of our most distinguished American leaders (1969);

> "I believe you are performing a vitally essential public service in keeping up your attacks on prevailing nuclear power policies. Some day the record will be exposed for all to see. The electric power companies will then have much to answer for."

Editorial commendation in the official journal of the Institute of Electrical and Electronic Engineers (June 1967):

"The main reason that we don't hear much of the unpopular viewpoint is that dissent is seldom available in publishable form. Few will make the effort that Mr. Ackerman has made to warn, publicly, of what is believed to be dangerous practice. What is required is clear, logical exposition, loaded with *facts* and backed by character. What we need most is the individual motivation to take the personal responsibility, as does Mr. Ackerman, to 'record a dissenting opinion where the public interest is at stake.' ..."

From a distinguished professor in engineering at one of our great universities (1971):

"As I am no longer paid by the AEC [Atomic Energy Commission] I feel free to write that I have long greatly admired your position on nuclear power. I feel that your arguments are much more convincing than those of the AEC. I took a position similar to yours several years ago after a long process of change .... (I was forbidden at Oak Ridge [a verbal order] to refer to you or your work in *any* way.)"

A Dissenting Voice from the U.S. Navy

The most important voice and leader in the application of the revolutionary new science of atomic energy to practical purposes has been, and still is, Vice Admiral H.G. Rickover, U.S. Navy. He is one of the very few engineers in our country who has educated himself to a comprehensive understanding of the scientific fundamentals of atomic energy and of the tremendous responsibilities involved in the development of adequate safeguards for employing the power in the atom.

In addition, Admiral Rickover has rendered a notable service in recording his experiences and publishing them so that all may read and learn. His testimony of March 1970 on the naval nuclear propulsion program before the Joint Committee on Atomic Energy of the Congress of the United States is especially noteworthy on the need for higher standards, along with his criticism of the ASME Boiler and Pressure Vessel Code. From his extensive testimony the following warnings are of highest importance: [14]

"For anyone to take full advantage of modern technology, he must raise his standards of knowledge and performance–there is need for utmost care in design, manufacture, installation, and operation of complex systems and equipment inherent in this technology. No carelessness can be tolerated anywhere in the entire chain or the results may prove disastrous.

"Unfortunately there are many who are not aware of the necessity of this approach. The difficulties in connection with the fabrication of civilian nuclear central station power plants are, I believe, largely due to failure to specify and enforce the required high standards for systems and equipment. ... I believe those involved in the civilian nuclear power industry are now becoming convinced that much improved standards are needed. Some progress is being made; much more needs to be done.

"... It is widely–but erroneously–believed that industry through its codes and standards fully meets this responsibility. It does not ... There is much confusion regarding the role of technical societies in formulating these industry codes and standards. For example, the American Society of Mechanical Engineers (ASME) is much involved in this area. ... In a subtle way, the use of industry codes or standards tends to create a false sense of security."

Other Voices of Dissent are Emerging

A notable demonstration of the duty to dissent and to follow the dictates of conscience, integrity, and ethical commitment to protect the public safety was the announcement on February 3, 1976, that three veteran nuclear engineering managers at General Electric Company's plant in California had resigned from their employment–men who had helped design, build, and oversee the safety of a number of atomic power plants–because they had become convinced that nuclear energy is too dangerous to continue developing. All three engineers–Richard Hubbard, Gregory Minor, and Dale Bridenbaugh–are acknowledged experts in atomic technology and each one has an experience record of more than 15 years.

Shortly after their resignation they were called upon to testify before the Joint Committee on Atomic Energy of the United States Congress on February 18, 1976; their testimony on nuclear design defects was also reprinted in the Congressional Records of February 25 and March 2. However, it is a regrettable fact that instead of being duly recognized for their integrity, courage and personal sacrifices, they have been subjected to disparagement and ill treatment which stands very much to the discredit of the engineering profession.

There are other dissenting engineers of specialized competence who felt obliged to sacrifice their carreers as a means of expressing their concern for public safety. But none of them have been accorded the normal respect for their high standards of integrity–engineers such as welding inspector Carl W. Houston, M. ASME of Jefferson, Tennessee, Robert D. Pollard, former project manager for the U.S. Nuclear Regulatory Commission (NRC); Ronald M. Fluegge, former nuclear engineer for NRC, and others.

Furthermore, various committees in the United States Congress are holding hearings and building up published records of competent warnings regarding the deficiencies and failures being experienced by American industry in the new technology of atomic power at its present embryonic stage of development.

II. Serious "Trouble" at the Industry Level

Today the atomic power industry in America is in serious trouble and rapidly heading into a crisis. This is true at the manufacturing level as well as in the public utility and power generating areas.

During the past year various business publications [15] have reported on a variety of setbacks, such as financial losses in the billions, deficiencies and failures of equipment, years of delays in manufacturing and construction schedules, breaches of contracts in the supply of nuclear fuels and reprocessing, and major lawsuits in the courts.

It is difficult to visualize the grotesque spectacle of some of our nation's biggest industrialists and corporate Directors

engaging in such public combat with little understanding of their earlier management defiences and failures which have made such confrontations inevitable.

But!!! Will adequate safeguards be adopted against a catastrophe and massive human casualties—before it is too late?

The Breakdown of Engineering Responsibility

It is a regrettable fact that since World War II a major change in traditional engineering practice has taken place, especially in the new technology of atomic power: We can no longer point to a Chief Engineer who is willing to assume the ultimate professional responsibility of designing and building an atomic power plant with first consideration for public safety. We are obliterating the fact that "responsibility" is a unique concept—it can only reside and inhere in a single individual. In today's engineering of an atomic power plant the main feature—and the most serious one—is the obliteration of individual professional responsibility.

This brings us to the fundamental reason for raising a dissenting voice. We, the people, the investors, the managements, our public officials and the generations yet unborn all have a right to know who is "the responsible engineer" and what engineering measures has he provided for the public's safety? How has he evaluated the *human costs* for his atomic power plant?

III. Evaluation of the Human Costs in Atomic Power

The crucial issue of *human costs* was identified by this author in some detail in a letter published in SCIENCE of 18 May 1973 [16]. From this letter the following is quoted; today it holds special significance because of a recent court decision, as will be noted later:

> "An attempt to identify and evaluate the 'human costs' of producing and utilizing nuclear fuel to generate electricity ... must, of necessity, include the consequences of an operational failure or a catastrophic accident at an attomic power plant. However, some revolutionary new problems have arisen concerning both property insurance and third-party liability insurance for these power plants.
>
> "The best guidelines for evaluating the human cost of power generation are found in the historical records of oil or coal burning steam plants. Following the development of the American Society of Mechanical Engineers (ASME) Boiler Code, with its high standards for engineered safety in design and operation, a notable record of safety was achieved through the voluntary initiatives and the ethical commitments of individual engineers. They have carried out their professional responsibilities of designing and building such steam plants with an overriding obligation to protect the public health and safety.
>
> "An influence of equal importance has been the ethical commitment of the engineers employed by private insurance companies, and their constant surveillance over the fabrication, testing, installation, and operation of every steam boiler and its related pressurized equipment. It has been their responsibility to certify that the installation conforms to all of the requirements of the ASME Boiler Code and qualifies for full insurance coverage, or for good cause to deny such certification and thereby prevent the issuance of an insurance policy to the owner of the steam plant.
>
> "By these procedures the insurance companies have protected the public health and safety while maintaining their financial stability. In the past the private insurance companies have constantly evaluated the risks and human costs of the power generation technology, and no one else is in a better position to perform this function.
>
> "By contrast, this traditional course of professional and financial responsibility has been repudiated in the case of the revolutionary new technology of atomic power. In 1957, a small group of manufacturing and utility executives persuaded the U.S. Congress to enact the Price-Anderson Indemnity Act. This act authorizes the U.S. Treasury, in the event of a serious failure in an atomic power plant, to pay $500 million to the victims and survivors or approximately 10 percent of the estimated cost of a major disaster [as evaluated by the Atomic Energy Commission in its Brookhaven report of March 1957 [17], which indicated the possibility of 3.500 fatalities and 35,000 radiation injuries from a major failure of a moderate-sized atomic power plant].
>
> "It is regrettable that private insurance companies have quietly compromised the confidence extended to them by a trusting public by lending their good names to 'token' insurance policies on atomic power plants that cover only 1 percent of the estimated damage. By this means, the evaluation of risk (and human cost) has been discarded for atomic power plants. The Price-Anderson Indemnity Act releases the power companies and public power agencies, along with their insurance companies, of any major financial risk. As a consequence, the traditional influence of the insurance companies on the engineering and design standards for fossil-fuel power plants have not been carried over to atomic power plants. The application of these standards to atomic power plants, and the resulting high safety factors, could make these plants 100 percent insurable.
>
> "Instead, today's atomic power plants are being designed and located with unjustifiably low factors of safety and their deficiencies will become apparent only in the aftermath of a catastrophe. Unfortunately, our national policy for atomic power plants is the product of deficient engineering and regulating practices and of an obscure type of 'pollution of responsibility and integrity' at the board-of-director levels of public and private utilities and reactor manufacturers.
>
> "Before a competent evaluation of the human costs of atomic power can be undertaken, the responsibility for public safety must be defined, as it has been for fossil-fuel power plants. This can be achieved only by having the Price-Anderson Act declared unconstitutional, or by having it repealed by congressmen who understand the importance of the word 'responsibility.'"

IV. The Price-Anderson Act is Judged Unconstitutional

On March 31, 1977, a remarkable piece of news appeared from Charlotte, North Carolina [18]:

> "A Federal district judge declared unconstitutional today the law that limits the financial liability of power companies for nuclear accidents.
>
> "If allowed to stand, the ruling would leave nuclear power companies open to unlimited liability claims, a situation that would raise major doubts about the future of atomic energy in the United States.
>
> "Judge James B. McMillan struck down the Price-Anderson Act as an unconstitutional deprivation of property without due process of law."

In the face of the highly complex and technical issues, Judge McMillan has presented a 43-page Decision which is

truly a remarkable document. His clear perspective, sound and consistent analysis and forthright conclusions are bound to prevail as of historical importance for all future time. However, it may take some time before the full significance of his services to our nation become generally understood and recognized as a major event in the history of our country.

Judge McMillan rules that the act was unconstitutional because it violated the rights of due process and equal protection under the law. He declared:

> "The Act violates the Due Process Clause because it allows the destruction of the property or the lives of those affected by nuclear catastrophe without reasonable certainty that the victims will be justly compensated."
>
> "The Act violates the equal protection provision ... because it provides for what Congress deemed to be a benefit to the whole society (the encouragement of the generation of nuclear power), but places the cost of that benefit on an arbitrarily chosen segment of society, those injured by nuclear catastrophe."

A condensed version of Judge McMillan's decision is presented in Appendix A.

Some Warnings from the Past

In 1957, when the Price-Anderson legislation was being considered by the Joint Committee on Atomic Energy (JCAE), and in the United States Congress, Rep. Chet Holifield, as the lone dissenting member of this 18-member Committee, declared himself opposed to this Act in these words:

> "This bill was put forth by its proponents as a bill for the protection of the public. This amounts to making a virtue out of a subsidy. This bill is protective of large utilities, industrial companies, and insurance companies which are not willing to adhere to the tenets of free enterprise. ...
>
> "This bill is not a minor technical amendment to the Atomic Energy Act. It is a major piece of legislation. It goes far beyond anything I know in committing the federal government to future liabilities without any clear understanding or basis in experience as to the nature or the magnitude of those liabilities."

Unfortunately, this historic warning was ignored. The lobbying for this bill apparently had been managed so skillfully that the Act was passed by both Houses of Congress without even recording the voting.

Today Mr. Holifield's warning is being recognized far and wide as an exceptionally accurate appraisal of the terrifying dangers which are now inherent in every atomic power plant in this country.

We are also reminded of another notable pronouncement made by Professor Abel Wolman of Johns Hopkins University before the Joint Committee on Atomic Energy in 1960 [19].

> "It is only with research for criteria for radiation limits that one finds suggestions that it should be permissible to kill people to attain benefits to society. This has undoubtedly been in the minds of all criteria makers, but rarely has it reached the frank and stark pronouncements of recent years.
>
> "Fear has been expressed that the establishment of too rigid criteria for the radiation activity may stifle progress because of excessive costs of attainment. One may view this fear with some cynicism in the light of the whole history of health and safety endeavor. This fear has always been expressed, but the historical realities consistently belie it. Criteria must rest upon health protection and not cost. ...
>
> "The day of handbook rule for measuring the hazards of radiation is a long way off. In the meantime one acts upon limited knowledge. In such action the guiding principle must be the maximum protection of the people, not because of sentiment but because society demands it. An agreed acceptance of a number of consequent disabilities is not an appealing basis for the development, say, of nuclear power. Industry will do better than rest upon such an affront to man. ..."

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References

[1] Brief on case No. 315 and 454, October Term, U.S. Supreme Court, April 1961.
[2] A.J. Ackerman, *Trans. Am. Soc. of Civil Engineers,* vol. 128, paper 3097, 1963.
[3] *JCAE Hearings,* June 22-24, 1965, pp. 155-176, 269-294, 335-338.
[4] *Wisconsin Professional Engineer,* Feb. 1968.
[5] *JCAE Hearings,* Sept. 12-14, 1967, pp. 781-801.
[6] *IEEE Trans on AES,* vol. 5, May 1969, pp. 369-375; *Mechanical Engineering,* June 1969, pp. 38-43.
[7] Hearings, Atomic Safety and Licensing Board, Saint Paul, Minn., April 29, 1970.
[8] *IEEE Trans. on AES,* vol. 7, May 1971, pp. 418-428.
[9] *IEEE Trans. on AES,* vol. 8, Sept 1972, pp. 576-582.
[10] *JCAE Hearings,* May 23, 1974.
[11] ASME preprint 74-WA/TS-3, Nov. 17, 1974.
[12] *IEEE Trans. on AES,* Nov. 1974, pp. 754-764.
[13] *ASCE Journal of Prof. Activities,* Proceedings Paper 12259, vol. 103, Jan. 1977.
[14] *JCAE Hearings,* March 19-20, 1970, "Nuclear Propulsion Program-1970," pp. 96-101, 260-273.
[15] *BARRON'S,* Sept. 15, 1975; *Electrical World,* July 16, 1976; *Fortune,* August, 1976; *Wall Street Journal,* Sept. 30 and Nov. 18, 1976.
[16] A.J. Ackerman, Letter in *SCIENCE,* 18 May 1973, Amer. Assoc. for the Advancement of Science.
[17] *Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants* (WASH Report No. 740, Atomic Energy Commission, Washington, D.C. 1957).
[18] *The New York Times,* April 1, 1977, p. 4.
[19] Hearings on Radiation Protection Criteria and Standards: Their Basis and Use, Joint Committee on Atomic Energy, 86th Congress, 2nd session, pp. 29-45, 1960.

Appendix A

Highlights of the Decision by JUDGE JAMES B. McMILLIAN in the District Court of the United States for the Western District of North Carolina C-C-73-139

Plaintiffs: Thirty-six local citizens plus a local Labor Union and a local Study Group.

Defendants: The United States Atomic Energy Commission; Dr. Dixy Lee Ray; James T. Ramey; Dr. Clarence E. Larson, and William O. Doub, Commissioners of the United States Atomic Energy Commission; and Duke Power Company.

Preliminary Statement

Plaintiffs brought this action to obtain a declaration of the unconstitutionality of those portions of the Price-Anderson Act, 42 U.S.C. Par, 2210(c) and Par. 2210(e), which place a limitation of $560,000,000 on the maximum amount of libability of a power company or a contractor for damages resulting from a nuclear accident involving an atomic power plant.

Defendants in their pleadings denied the merits of the claims of the plaintiffs and asserted that the plaintiffs lack standing and that the claims are not ripe for decision.

On the 21st day of May, 1975, at a hearing on the motion to dismiss, it appeared that full dress consideration was desired on the issues of standing and ripeness. Time was allotted, therefore, to develop evidence, and a hearing, four days in leangth, was conducted on September 27, 29 and 30 and October 1, 1976, on these subjects. Briefs were subsequently filed and the case is ready for decision.

The Plaintiffs

Plaintiffs are a group of people with a common interest in protecting themselves, and other present day citizens and their children, against what they see as the deterioration and destruction of their property and the world they live in. Some of them have fought against nuclear power at numerous administrative and legal levels. ... They have not slept on their rights. They are vigorously represented by able and experienced counsel. Their claims are seriously advanced. ... They include people who have moved away from homes near the nuclear plants ... people who have legitimate fears that nuclear power plants are dangerous, and who contend that but for the Price-Anderson Act such dangers would not exist.

The Price-Anderson Act

The Price-Anderson Act was adopted in 1957. In pertinent part, 42 U.S.C. Par. 2210(e), it provides:

> "(e) Aggregate liability for a single nuclear incident ... such aggregate liability shall not exceed the sum of $560,000,000. ..."

In other words, $560,000,000 is the maximum amount that all persons injured could recover for injury, death or property damage in the event that a domestic nuclear power plant got out of control.

The Nuclear Power Plants in Question

Defendant Duke Power Company has harnessed many miles of the Catawba River, in Western North Carolina and South Carolina, with numerous dams to supply water for a number of coal fired and water powered and atomic powered electric generating plants. ... Part of the hearing was a guided tour of the McGuire Nuclear Station. ... This tour left the writer thoroughly impressed by two things: The first is the complexity and monumental nature of the task of handling a beast (or genie) of such tremendous power as an atomic reactor capable of generating one and a quarter million net kilowatts. The second is the obvious competence and discipline and engineering know-how and determination with which the people of Duke Power Company are pursuing the construction of the plant and the taming of this Promethean power. If and to the extent that the job can be safely and efficiently done, in the present state of the art, I am satisified that it is their purpose to do it. ...

What a Nuclear Power Plant Does to Plaintiffs and the Environment

Operation of the nuclear power plants will have immediate or present effects and potential or future possible effects on plaintiffs and their environment. ...

Any of these forms of accidents can produce radiation of temporary or longer duration and varying intensiity, and can require evacuation of the areas affected for substantial periods of time. They can produce cancers, thyroid illnesses, genetic effects adverse to later generations, and deaths. The costs of such accidents also include the cost of evacuation and relocation of human beings and industries and farming activity, and the property damage which results.

The Likelihood that a Bad Accident May Occur, and the Likelihood of Bad Results from such an Accident

Most of the evidence at the hearing dealt with the likelihood of a major accident and the extent of injury and damage likely to follow from such an accident.

... Defendants and their witnesses say further that the likelihood of a major nuclear accident is much less than the likelihood of numerous others of the "thousand jolts and shocks the flesh is heir to" ... and suggest that it is actually so small that as a practical matter it may be disregarded.

The plaintiffs present a grimmer picture. Their experts say that the Reactor Safety Study was made in part to promote and sell the development of nuclear power and does not provide a realistic estimate of its dangers. They say, among other things, that: (a) True evaluation of the likelihood of component failure and human failure is impossible; (b) Not all the causes of malfunctions are known; (c) ... (d) ... (e) Possibilities of sabotage have not been adequately recognized and evaluated; (f) ... (g) ... (h) Unforeseen accidents do occur. ... (i) ...

The Reactor Safety Study was prepared for the Nuclear Regulatory Commission and under its supervision. ... The tenor of the study is more that of a lawyer's brief than of a

detached scientific analysis of risks. It is not signed by any responsible person. ...

Conclusions as to the Likelihood and Consequences of a Major Nuclear Accident

The court finds as a fact that the probability of a major nuclear accident producing damages exceeding the $560,000,000 limit of the Price-Anderson Act is not fanciful but real. It is the kind of risk againtst which prudent business people guard, by trying to design and build safely *and* by reserves of insurance against possible losses and liability to others.

It is not the kind of risk which responsible government or business places upon bystanders.

Plaintiffs have no source from which they can get insurance against loss or damage from atomic radiation; insurance companies, regardless of the odds, won't write policies to cover such losses.

The court is not a bookie. ... The significant conclusion is that under the odds quoted by either side, a nuclear catastrophe is a real, not fanciful, possibility.

The court finds ... that a core melt at McGuire or Catawba can reasonably be expected to produce hundreds or thousands of fatalities, numerous illnesses, genetic effects of unpredictable degree and nature for succeeding generations, thyroid ailments and cancers in numerous people, damage to other life and widespread damage to property. Areas as large as several thousand square miles might be contaminated and require evacuation. ... Radioactive pollution of a few hundred square miles of heavily populated piedmont North Carolina or South Carolina could well produce property damage vastly exceeding the Price-Anderson ceiling.

But for the Price-Anderson Act, The Nuclear Plants Would not be Built Nor Operated

Testimony before the 1956-57 hearings of the Joint Committee on Atomic Energy, United States Congress, indicates that the Price-Anderson Act's limitation on liability, or its equivalent, was a condition precedent to atomic power plants.

Sober corporate managers were unwilling to equip or operate nuclear plants without assurance that someone besides their stockholders would run the major risks. ... Without the protection of the Price-Anderson Act, regardless of the desires of the nuclear power industry, power companies would probably not be able to obtain the necessary financing, supplies, and architectural skills to build nuclear power plants and to maintain them once construction was complete. [In this chapter the court cited in five pages statements from the pertinent 1956-57 testimony from officials of power companies and public agencies.]

Plaintiffs Have Standing to Sue

Defendants assert that plaintiffs have no standing to bring this action to test the constitutionality of the Price-Anderson Act. They also assert that there is no live "case" or "controversy" to support federal jurisdiction. ...

Standing is dependent of the facts. Facts of this particular case bearing on standing include these: (a) The nuclear reactor-turbine plants would not be under construction and are not likely to operate without the guaranty of limited liability provided by the Price-Anderson Act. ... (b) Operation of the plants will cause *present* and *certain* injury to the plaintiffs. It will release a small but regular amount of radioactive energy at all times following the start-up of the nuclear reactor. ... The long term results of adding radiation in these quantities are estimated to be slight; however, since nuclear physics is a relatively recent science and the experimental data is scanty, there is no way to tell short of a few generations what this unwanted and unintended radioactive invasion of the air, ground and water will do to human and other beings. ... (d) The threat and present fear of future catastrophic accidents is real and objectively reasonable. ... (h) Recoveries in cases of injury to and death of a human being have been known in recent years to exceed a million dollars and more. Without even considering property damage, it appears that death or major injuries to 500 or 1,000 people could produce legitimate losses vastly exceeding $560,000,000.

This is a Live Controversy Ripe for Decision

Plaintiffs in this action suffer two kinds of injuries. First is the present everyday injury through heat and radiation of living in proximity to an operating nuclear power plant. The second is the reasonable possibility that there will be a nuclear accident that will cause them injury for which they will not be fully compensated as a result of the liability limit of the Price-Anderson Act. ...

Not only is plaintiffs' action ripe, but also, if plaintiffs did not bring the suit within three years after the injury began, their action might be barred.

Plaintiffs' exposure to injury from a nuclear accident for which the Price-Anderson Act will prevent full compensation is not a certainty but it is much greater than a fanciful possibility. ...

There is a distinct possibility in this case, as in the *Regional Rail Reorganization Act Cases,* that plaintiffs will suffer a taking without assurance that compensation will be provided.

The plaintiffs are directly, immediately and personally interested in the event; they allege and have shown that they will be immediately injured when the plant starts operating; there is a real possibility that the injury may become catastrophic; ... they are entitled to challenge the Price-Anderson Act on its merits.

The Price-Anderson Act is Unconstitutional

.... For a number of reasons, the Prince-Anderson Act violates the Equal Protection and Due Process provisions of the Fifth Amendment to the United States Constitution.

Due Process

The Act violates the Due Process Clause because it allows the destruction of the property or the lives of those affected by nuclear catastrophe without reasonable certainty that the victims will be justly compensated. Considerations that lead to this conclusion include the following:

1. The amount of recovery is not rationally related to the potential losses. ... Damage to life and property for this and future generations could well be many, many times the limit which the law places on liability.

2. The Act tends to encourage irresponsibility in matters of safety and environmental protection rather than to encourage responsibility on the part of builders and owners.... when a low ceiling is placed on accountability to the public, the *tendency* of such low ceiling is to diminish rather than to heighten steps necessary to protect the public and the environment.

3. There is no *quid pro quo*. ... Those who operate nuclear reactors give up nothing of consequence when they waive defenses of negligence, contributory negligence, assumption of risk and governmental or charitable immunity. ... Power companies don't have governmental or charitable immunity. ... The courts of North Carolina ... hold those who engage in ultrahazardous activities to a standard of strict liability. ... The philosophy behind the imposition of strict liability is that "the law casts the risk of the venture on the person who introduces peril into the community. ..."

(h) A further problem with Price-Anderson is that the limit is absolute and applies to nuclear catastrophe even though it may be the result of wilful conduct or gross negligence.

Equal Protection

The Act violates the equal protection provision that is included within the Due Process Clause of the Fifth Amendment because it provides for what Congress deemed to be a benefit to the whole society (the encouragement of the generation of nuclear power), but places the cost of that benefit on an arbitrarily chosen segment of society, those injured by nuclear catastrophe.

Conclusion (unabridged)

Plaintiffs are threatened with certain injury of relatively minor nature, and with the reasonable likelihood of major and perhaps catastrophic injury, without assurance of adequate compensation if that should occur. But for the limitation of the Price-Anderson Act, the nuclear power plants would not be being built and those threats would not exist. Plaintiffs are actively pursuing the case. They have a live stake in the controversy and are sufficiently aroused that their position has been well and adequately presented. A live case or controversy exists; they have standing; the issue is ripe for deciding the case. The time to put on the roof is before it starts raining. The question of the constitutionality of the Price-Anderson Act should be decided now.

Injunctive relief is not sought and is not contemplated; at the time this action was filed one federal district judge had no authority without the concurrence of one of two other judges to issue an injunction based upon the unconstitutionality of an Act of Congress.

The question is, however, whether or not to declare the constitutional rights of the parties.

Granting declaratory relief in this case is not likely to interrupt the operation of the statutory scheme before the parties can seek to have the Supreme Court finally adjudicate the issue. Kennedy V. Mendoza-Martinez, 372 U.S. 144, 154-55 (1963). A direct appeal lies should the parties choose that route. 28 U.S.C. Par. 1252.

This court like other courts has a duty to "faithfully and impartially discharge and perform all the duties incumbent upon [a] United States District Judge ... agreeable to the Constitution and laws of the United States. ..." The Constitution is the "supreme law of the land." Only by forthright recognition of rights reserved to the people by the Constitution and laws can those rights be made real to the people whom government officials are chosen to serve.

I therefore hold and declare that the provisions of 42 U.S.C. Par. 2210(e) and any other provisions necessary to implement the $560,000,000 limitation of liability are unconstitutional and unenforceable insofar as they apply to nuclear incidents occurring inside the United States.

Counsel may tender any further order or judgment appropriate under the foregoing memorandum of decision.

This 31 day of March, 1977.

/s/ James B. McMillan
United States District Judge

AMERICAN SOCIETY OF CIVIL ENGINEERS

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TRANSACTIONS

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ATOMIC POWER, A FAILURE IN ENGINEERING RESPONSIBILITY

By Adolph J. Ackerman,[1] F. ASCE

With discussion by Messrs. D. P. Barnes; Karl Terzaghi; Jacob Feld; C. Ken Weidner; A. Bernard Drought; Albert S. Fry; Alfred Ogram; Morton I. Goldman and C. Rogers McCullough; Jakob Kaegi; Weston S. Evans; A. C. Ingersoll; Paul E. Gisiger; L. A. Elsener; John W. Forster; and Adolph J. Ackerman

SYNOPSIS

This paper discusses the application of the new scientific development of atomic power for public service, which has appeared on the national scene following the end of World War II. In this short span of 15 yr, the spectacular new energy resource of the atom has attained a stature which to some people is exciting, to others fearsome, and to most everyone highly mystifying.

A brief historical review is presented, with an outline of basic legislation, governmental controls of policy, a demonstration program of power reactors, and the hazardous features of the new science. Of primary interest to all engineers, and particularly to independent consulting engineers, is the question of public safety and the overriding responsibility of professional engineers to protect the public against the unprecedented hazards which are involved in the operation of an atomic power plant.

Reference is made to the private insurance industry's inability to write adequate third-party liability insurance. As a consequence, most of the burden of paying indemnities, following a major disaster, has been shifted to the taxpayers. This, in turn, has created incentives for the selection of sites for atomic power plants which tend to increase the hazard to the public and which violate the basic responsibilities of the engineering profession. An example is presented where a new atomic power plant has been constructed near a large population center. Court action was initiated to halt construction of this plant. When these proceedings reached the United States Supreme Court, the writer

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was nearing the end of a ten-year research effort for a book on "Facts and Fallacies in Atomic Power." Because it appeared that the court would be confronted with some highly complex technical questions and unprecedented responsibilities which should be of primary concern to professional engineers, the writer was granted the privilege, by the Court, of presenting part of his findings in the form of an "amicus curiae" brief. The brief is included as an appendix to this paper. It provides an example of the privileges and obligations which a professional engineer may exercise under our judicial system in an effort to protect the public interest.

POSTWAR TRANSITION IN BASIC RESPONSIBILITIES

The vast complex of facilities required for the production of the first atomic bombs was constructed at Hanford, Washington, and Oak Ridge, Tenn., in the remarkably short period of three years, from 1942 to 1945. This tremendous performance in simultaneous research, design, and construction had demonstrated what can be achieved (in time of war) by taking a new technology and developing it under a combination of unrestricted governmental authority and unlimited supply of governmental funds. Such a policy of direct governmental action, as a temporary but essential wartime measure, is generally accepted by the American people to assure the preservation of their republican form of government. But, by the same token, a primary objective (with the end of war) is the return, as rapidly as possible, to the constitutional processes of government and the normal forms of commercial enterprise.

In retrospect, for most industrial enterprises, the postwar transition to a normal commercial activity took place under the traditional system of free enterprise, economics, localized responsibility, and the Rule of Law. However, no such combination of traditional guidelines existed for the commercial applications of the hazardous new science of atomic fission. Furthermore, at this stage, all of the government-owned facilities for the production of fissionable materials were considered, primarily, as of continuing great military importance, and were confined behind a vast wall of secrecy. These facts contributed to the decision to maintain basic control of the new science in the form of a continuing governmental monopoly.

Ever since the first sustaining chain reaction was accomplished in 1942, there was no doubt about the technical feasibility of producing electricity from heat generated by the fission process. In time, various proposals were advanced to utilize the heat from a controlled atomic reaction for the production of steam to drive a conventional steam-electric generating unit. (In terms of a conventional fuel-burning steam plant, the steam boiler unit would, in effect, be replaced by an atomic reactor.) The practical problems, however, were quite obvious even at that time; in fact, it seems that as more knowledge was acquired, the practical problems loomed constantly larger. In particular, there was no early prospect of bringing down the cost of atomic power to a level of costs which prevail for conventional thermal or hydro power.

LEGISLATION OF 1946 - ATOMIC ENERGY COMMISSION

The "Atomic Energy Act of 1946" created the Atomic Energy Commission and established a first stage of legislation for the development of electric power

from atomic fission. It was recognized at that time, as stated in the "Declaration of Policy" of the Act, that "the effect of the use of atomic energy for civilian purposes upon the social economic and political structures of today cannot now be determined. It is a field in which unknown factors are involved. Therefore, any legislation will necessarily be subject to revision from time to time. It is reasonable to anticipate, however, that tapping this new source of energy will cause profound changes in our present way of life."

Unfortunately, the effect of the "Atomic Energy Act of 1946" was to make it practically impossible for the private power industry to participate in the development of atomic power for commercial purposes.

During the late 1940's the Atomic Energy Commission (AEC) undertook the development and construction of four atomic reactors that were intended to provide experience in the construction and operation of such devices. In 1950 the AEC received expressions of interest from various industrial groups who wanted to explore the possibilities of developing the commercial aspects of atomic power; this interest was further stimulated during the period of 1950 to 1953.

ATOMIC ENERGY ACT OF 1954

In February, 1954 Congress began consideration of major revisions in the Atomic Energy Act which finally culminated in the "Atomic Energy Act of 1954." The new Act introduced the following principal changes:

(a) It relaxed statutory restrictions against ownership or lease of fissionable material and of facilities capable of producing fissionable material.

(b) It permitted private manufacture, ownership, and operation of atomic reactors and related activities, subject to necessary safeguards under licensing systems administered by the AEC.

(c) It authorized the AEC to establish minimum safety and security regulations to govern the use and possession of fissionable materials.

(d) It permitted the AEC to supply special fissionable materials and services to licensees for the operation of reactors, at prices to be established by the AEC.

(e) It liberalized the patent provisions of the Atomic Energy Act to a limited degree.

Since the time the "Atomic Energy Act of 1954" became law, there have been a number of amendments, some of them relatively minor and others of considerable importance.

The legislative history of the "Atomic Energy Act of 1954" shows quite clearly that Congress favored an active industrial program of participation in the development of atomic power. For example, when the Joint Committee on Atomic Energy reported the proposed legislation for consideration by Congress the majority stated: "We do not believe that any developmental program carried out solely under government auspices, no matter how efficient it may be, can substitute for the cost-cutting and other incentives of free and competitive industry."[2]

However, responsibility for the development of atomic power was not turned over to industry by the Act of 1954. The Act authorized and directed the AEC

[2] House Report No. 2181, Senate Report No. 1699, 83rd Congress, 2nd Session, 1954.

to arrange for the performance of research and development relating to the use of atomic energy, for the "generation of atomic energy, and a demonstration of the practical value of reactors for industrial and commercial purposes, either through its own facilities or by private or public institutions or persons."

Under the Act of 1954, the government retains ownership, through the AEC, of all rights, title and interest in the special materials, such as uranium or plutonium, which are capable of releasing substantial quantities of atomic energy. A private company owning an atomic power plant is prohibited from owning the special atomic materials, or "fuel rods," which are the basic source of the heat energy. Such materials must be borrowed or leased from the AEC, subject to what the Atomic Energy Act defines as a "reasonable charge."

DEMONSTRATION PROGRAM OF POWER REACTORS

In January, 1955 the AEC announced its demonstration reactor program, in which it offered to underwrite a part of the cost of certain atomic power projects. In January, 1957 the AEC expanded this program by inviting proposals to design, construct, and operate atomic power plants. No limitations were placed on the types or sizes of plants which could be proposed, other than that they should make significant contributions toward the achievement of commercial atomic power and that construction should be completed by June, 1962.

During the past six years the AEC has issued licenses to nine private utility groups for the construction of atomic power plants ranging in capacity from a small one of 17,000 kw to the largest one of 150,000 kw. Available cost estimates for six of these projects indicate a total of $280,900,000. Of this total the AEC has committed itself to the payment of subsidy contributions in the total amount of $57,200,000.

The AEC has also licensed four public power groups for the construction of somewhat smaller plants ranging in size from 10,000 kw to 75,000 kw. The available cost estimates indicate a total of $131,400,000 for these four plants, and the AEC has committed itself to subsidy contributions amounting to a total of $96,800,000.

RADIATION AND ITS EFFECT ON HUMAN BEINGS

Prior to the development and use of the atomic bomb in World War II, radiation injury was a relatively rare occurrence and, when it did occur, it was usually confined to scientists or other specialists working directly with such early developments as x-rays. As a consequence the general public has almost no knowledge, and very little concern, about the possible harmful effects of radiation. Even the vast amounts of medical information and other statistical records which were accumulated in Hiroshima and Nagasaki have been studied by relatively few people. However, there is no question about the importance of radiation as a significant factor which must be taken into consideration when atomic power and its uses are discussed.

Unfortunately it is not feasible to enlarge on this extremely important subject in the present paper. However, it may be stated briefly that the harmful consequences of radiation fall into "short term effects" and "long term effects." The short term effects (other than immediate death) involve radiation sickness and burns, including injury to the blood cells from which recovery can generally

be achieved by competent treatment within 6 months to 1 yr. The long term effects of radiation on human beings consist of general reduction of the life span, the induction of cancer, and the propagation of harmful effects to the next generations of offspring.

NEW AREAS OF PROFESSIONAL RESPONSIBILITY

The introduction of the new science of atomic power has brought with it two new areas of responsibility which should be of particular concern to the engineering profession. The first relates to the safety of operating personnel in atomic power plants and to the safety of the public living in the vicinity of such plants. This area of responsibility is of primary concern in the present paper.

A second and very important area of responsibility relates to the disposal and storage of radioactive wastes from atomic power plants. The following brief quotation will suffice to identify the importance of this new responsibility:

> "In the current wave of enthusiasm for nuclear power, the management of wastes has the position of a step child. One risks being branded a Casandra if he points out, as I am doing, that waste problems may make or break the nuclear power business. A lawyer active in the atomic power field has pointed out that improper disposal of reactor wastes may involve as large a sum for public liability as one of the reactor accidents now receiving so much attention. It may not be fashionable to ponder these problems, but it is nonetheless important to do so while there is still time to avoid serious mistakes."[3]

It has also been pointed out that "the problem of keeping millions of tons of dangerous nuclear waste out of circulation for centuries will become prodigious as more and more atomic furnaces come into use. AEC officials term it 'one of the major challenges of the industry.' "[4]

With respect to the responsibilities of operating a reactor, an acceptable appraisal of the potential hazards can be made only after actual operating experiences, under a variety of circumstances, have produced a significant record of failures. This severe discipline in the advancement of the art of engineering, commonly known as "learning from failures," is well exemplified in the slow and laborious development which has taken place in the design and metallurgy of high pressure steam boiler units.

PROBLEMS OF INSURANCE

One of the noteworthy influences in the development of steam boiler units has been the private insurance industry. This industry has at all times collaborated closely with designers, manufacturers, and operating companies through its own resources of engineering and inspection service. This important resource of professional and business responsibility has made it possible for the insurance industry to provide full insurance protection against the

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[3] Presented by G. Hoyt Whipple, Health Physicist, Univ. of Rochester, Atomic Energy Proj., at the Amer. Industrial Hygiene Assn. meeting, in Philadelphia, Pa., on April 26, 1956.

[4] "The Development of Nuclear Power for Peaceful Purposes," Electrical Engineering, June 1954, p. 498.

consequences of any type of boiler failure, involving not only the physical and personal damage to the power plant and its operators but also to the public living in the vicinity of the plant. The latter protection is provided through "third party liability insurance."

This sense of localized responsibility is a feature of our national economy which deserves special recognition. It represents a unique combination of legal and ethical standards in serving the public interest. In the atomic power field, on the other hand, the insurance companies were confronted with a new and unprecedented peril. After considerable study they were obliged to announce that they would be unable to offer satisfactory public liability insurance on atomic power installations.

A FAILURE IN ENGINEERING RESPONSIBILITY

In March, 1957 the AEC published a report, "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants," which is generally known as the Brookhaven Report. The results of these studies indicated that, depending on local conditions, the property damage alone could range between $2,300,000,000 and $4,000,000,000, and possibly higher. Damage to health and life could be on the order of 43,000 injuries and 3,400 fatalities, without taking into account the probability of harmful long term effects on several hundred thousand people. The financial liability for human casualties was not evaluated and is, obviously, beyond comprehension.

There are, of course, various alternatives available with respect to site selection to minimize the potential damage in the event of a reactor failure. As a matter of fact, remote locations and long transmission lines have been adopted for many hydroelectric developments. The traditional practice has been to rely on the free interplay of professional engineering and corporate responsibilities to produce an optimum solution of design and site selection for a new power plant. However, instead of relying on such practices for atomic power plants, a proposal was advanced which must be regarded as a great historical tragedy, particularly as it relates to exploitation of public confidence in the engineering profession. In 1957 Congress was persuaded to enact legislation under which the public liability, except for the relatively small coverage offered by the private insurance industry, was transferred to the taxpayers of the nation.

The net result of this action has been to disrupt the traditional system of disciplines and responsibility of the engineering profession. The public has great confidence in the engineering profession to protect the public health and safety, and professional engineers are expected to serve under the highest standards of ethics and intellectual honesty. However, these standards cannot prevail under a system of monetary indemnity which displaces such responsibilities.

THE LAGOONA BEACH PLANT - AN EXAMPLE

Although the issues of public safety apply equally to all atomic power plants, whether publicly or privately owned, a specific case may help to identify the conflicting issues which are currently growing up in the field of atomic power.

Under the Act of 1954, which authorized industrial ownership and operation of an atomic reactor, a group of power companies formed the Power Reactor Development Company (PRDC) and offered to participate in the AEC's "Power Demonstration Reactor Program." This company proposed to develop a "breeder" reactor for the generation of steam, and applied for an AEC construction permit in January, 1956. In June, 1956 the AEC's Advisory Committee on Reactor Safeguards reported on the PRDC proposal and stated in part:

> "The proposed PRDC reactor represents a greater step beyond the existing state of knowledge of the art than any other reactor of comparable power level which has been proposed by an industrial group . . . . The Committee believes there is insufficient information available at this time to give assurance that the PRDC reactor can be operated at this site without public hazard."

Despite this adverse report, the AEC issued a provisional construction permit in August, 1956. Since then, the construction of the plant has been substantially completed and it is now known as the Enrico Fermi Atomic Power Plant. The site, on the shores of Lake Erie, is about 35 miles from the center of Detroit and about 30 miles from the center of Toledo, Ohio. Important municipal and industrial water intakes lie within 30 miles of the site. Many of the site conditions correspond to the setting which was assumed for the study in the Brookhaven Report. Ultimate capacity is estimated to be 430,000 kw of heat, or 150,000 kw of electricity.

LEGAL ACTION TO STOP CONSTRUCTION

The action of the AEC in granting the PRDC construction permit was strongly criticized in Congressional circles and other groups concerned with safety aspects. In August, 1956, after public release of the adverse report of the Safeguards Committee, representatives of organized labor filed a petition requesting the AEC to order suspension of the construction permit. They alleged that the permit would result in construction of a reactor which had not been found safe, and that operation of such a reactor would create hazards which would imperil lives, health and property. Following hearings held in 1957, the AEC issued its "Opinion and Final Decision" on May 26, 1959. It concluded:

> "We believe the public interest in the development of the fast breeder reactor, the time to be saved in proceeding with construction while the remaining technical and safety problems are being solved, and our responsibilities under the Atomic Energy Act of 1954 are better served by continuing the permit."

Dissatisfied with the AEC's decision, the labor unions petitioned the United States Court of Appeals to review the case. The decision of this Court, issued June, 10, 1960, included the following significant statements:

> "In our opinion the Commission's findings regarding safety of operation are not sufficient.
>
> "The economy cannot afford to invest enormous sums in the construction of an atomic reactor that will not be operated. If enormous sums are invested without assurance that the reactor can be operated with rea-

sonable safety, pressure to permit operation without adequate assurance will be great and may be irresistible.

"We think it clear from the Congressional concern for safety that Congress intended no reactor should, without compelling reasons, be located where it will expose so large a population to the possibility of a nuclear disaster. It does not appear that the Commission found compelling reasons or saw that such reasons were necessary.

"Because we think the safety findings insufficient, we must set aside the Commission's grant of a construction permit. . . ."[5]

In November, 1960, the PRDC and AEC appealed this decision to the United States Supreme Court. On June 12, 1961, the Supreme Court reversed the judgment of the Court of Appeals.[6] It ruled that issuance of the construction permit had complied with the statute and regulations. Unfortunately, the Supreme Court chose to limit its decision to the legality of the construction permit, and to isolate it from the further procedures of applying for an operating permit. The Court stated:

"PRDC has been on notice long since that it proceeds with construction at its own risk, and that all its funds may go for naught. With its eyes open, PRDC has willingly accepted that risk, however great."[6]

Thus, the basic question of operating the atomic power plant remains unresolved. The Court's decision declares:

"It may be that an operating license will never be issued. If one is, that will not be the end of the matter. The respondents may have judicial review."[6]

The minority opinion of the Court declared:

"This legislative history makes clear that the time when the issue of 'safety' must be resolved is before the Commission issues a construction permit. The construction given the Act by the Commission (and today approved) is, with all deference, a lighthearted approach to the most awesome, the most deadly, the most dangerous process that man has ever conceived."

AMICUS CURIAE BRIEF

An extensive research in the field of atomic power had brought the writer to the conclusion that the selection of a site for an atomic power plant is not governed by rules of law, but calls for the application of expert judgment by professional engineers. It is a problem involving great responsibility and technical complexity on which the available knowledge is relatively limited.

It appeared advisable to make the results of this research available to the Supreme Court by exercising the privilege of filing an "Amicus Curiae" Brief. It was hoped that this would contribute to serving the public interest. However, the majority of the Court chose to limit its decision to the legal interpretation of the case.

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5 280 F. 2d 645, 1960.

6 U. S. Supreme Court No. 315 and 454, October Term 1960, June 12, 1961.

The "Amicus Curiae" Brief contains much which is believed to have continuing reference value; it is included here as an appendix. It provides a summary of basic philosophy in a new area of engineering responsibility which demands the attention and critical appraisal of all professional engineers.

The task of attempting to communicate the basic concepts of professional responsibility in non-technical language was not a simple one and, undoubtedly, the present result is not the best. However, it serves to identify the great responsibilities and the duty which confront the professional engineer in this technological age. His failure to meet these responsibilities is bound to add to our national peril.

SUMMARY

Unfortunately, limitations of space have prevented a more detailed exposition of various important matters. To clarify the issues, emphasis has been directed to the factors which relate to engineering responsibilities. It is clear that the basic problem as outlined in this paper remains unresolved. Hence there is much to challenge the resources of the engineering profession, and particularly the independent consulting engineer.

APPENDIX*

In The

Supreme Court of the United States

October Term, 1960

No. 315 and 454

Power Reactor Development Company, *Petitioner,*

v.

International Union of Electrical, Radio and Machine Workers, AFL-CIO, et al., *Respondents.*

United States of America and Atomic Energy Commission, *Petitioners,*

v.

International Union of Electrical, Radio and Machine Workers, AFL-CIO, et al., *Respondents.*

On Writs of Certiorari to the United States Court of Appeals For the District of Columbia Circuit

BRIEF OF ADOLPH J. ACKERMAN, AMICUS CURIAE

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April 1961

* Index and statement of position have been omitted.

REASONS PROMPTING THE SUBMISSION OF AMICUS CURIAE BRIEF

The issues before the Court in this proceeding are of grave importance in the application of the new science of atomic energy for the generation of electricity, and involve heavy responsibilities concerning the health and safety of the general public. Beyond the questions which have been defined in terms of embryonic law and emerging regulatory principles, is the fundamental question whether a potential hazard of unprecedented magnitude shall be introduced in an area where a large population would be exposed to it. The Court's decision in this case is bound to have direct and far-reaching influence on the progress and application of atomic power and on the related questions of public health and safety.

The selection of a site for an atomic power plant is not governed by rules of law, but calls for the application of expert judgment by professional engineers. It is a problem involving great responsibility and technical complexity on which the available knowledge is relatively limited.

Although the criteria for the selection of a site for a conventional type of power plant correspond to well established principles based on the operating experiences of many similar power plants in all parts of the country, the introduction of atomic energy for the generation of electricity has brought with it new criteria for site selection. It will be shown that some of the criteria employed in the selection of the site for the atomic power plant in the case before this Court violate the traditional principles of responsibility which the engineering profession is expected to observe. The basic issue, therefore, although it here concerns specific parties, is of deep concern—now and for all future time—to professional engineers.

It is the belief of amicus curiae that an exposition on the responsibilities of the professional engineer in relationship to the tremendous perils involved in the application of a new science will help to clarify the fundamental questions before this Court. This brief, therefore, represents an effort on the part of a professional engineer to meet his obligations in serving the public interest.

Questions Relating to the Project

The questions before this Court relate to an atomic power plant (Enrico Fermi) currently under construction by the petitioner, Power Reactor Development Company (PRDC), at a site known as Lagoona Beach, some 29 miles southwest of the city of Detroit, Michigan. Although a specific project is here involved, the issues are of overriding importance and applicable to all atomic power developments, whether owned privately or by public bodies.

Why is there a conflict? This question is discussed in considerable detail in the present brief, but the following basic factors are elements in the conflict:

1. In the selection of this power plant site, the normal influences of professional engineering responsibility for the protection of the public—and the ethical obligations of the engineering profession—have been denied their normal freedom of action.

2. Once the atomic power plant goes into operation, the surrounding population (although generally unaware of its position) would be living in the shadow

of a potential disaster of unprecedented magnitude. For this reason part of the population in the vicinity is seeking relief from the Court to prevent this project becoming an operating hazard.

3. In the event of a major accident or failure of the atomic energy unit, most of the resulting cost of the disaster would fall on the taxpayers of the country. At present they are generally unaware of this potential new burden.

4. In applying for a license for this new power plant (which was approved by the Atomic Energy Commission) some unusual procedures were introduced.

a. A first license has authorized only the financing and construction of the power plant, on the strength that this involves no atomic operating hazards; however, the magnitude of such potential hazards was recognized.

b. A second license for the operation of the power plant is to be considered some years later, after the large capital investment has been made. This sequence may create an element of pressure for gaining approval from those who must finally pass on questions of safety in the operation of this plant.

QUESTIONS BEFORE THE COURT

1. Does the Atomic Energy Act of 1954 require the Commission to withhold approval of a site for an atomic power reactor near a populous area, unless the Commission finds that there are "compelling reasons" for approving such location?

2. Before granting a permit for the construction of a developmental atomic power reactor, is the Commission required, under the Atomic Energy Act of 1954, to determine that the proposed reactor can also be operated at a proposed location without undue risk to the health and safety of the public?

SUMMARY OF ARGUMENT

1. The fundamental question is this: In the experimental or commercial application of a new scientific discovery of an extremely dangerous type, is adequate protection being provided for the health and safety of the public?

2. In the normal course of our historical development the health and safety of the public have been safeguarded by two basic influences which have grown up as intrinsic features of our social and economic system and of our Constitutional form of government. The first influence is a broad structure of law which has been enacted at the local, state and national levels of government; this is administered by selected public officials and is upheld by a distinguished profession in law, as well as by an independent judiciary at each of these levels. The second influence is an equally broad structure (at the local, state and national levels) of trained specialists in the professions of medicine and engineering; these carry out their responsibilities within the law, but with the added obligation of observing the self-imposed disciplines and ethical standards of their professions. Both of these influences are the product of centuries of experience in human relations and mutual confidence.

3. The new scientific discovery of atomic energy is of fundamental importance and far-reaching influence throughout the world. However, its complexities are understood by an extremely small number of scientists; further-

more its application in the useful service of man (for the production of electricity) is generally regarded as being only in the experimental stage.

4. The case before the Court raises some basic questions regarding the application of atomic science under a very limited structure of new law and in conflict with the established disciplines and ethical standards of the engineering profession. This is the first case of its kind before this Court concerning the administration of such law and the final decision will have an important bearing on the future trend in the application of this new science.

5. An objective of this brief is to demonstrate that the present issues before the Court have developed out of various current deficiencies in our social and economic system, and out of the abandonment of the normal sense of responsibility in the application of a hazardous new science.

6. The application of atomic science for the production of electricity ("atomic power") has developed under unique circumstances as a result of an historical coincidence. Scientists succeeded in making the first experimental demonstration of nuclear fission in the same year that World War II began. The destructive potentials of nuclear fission were soon recognized, and this led to the rapid development of the atomic bomb. All of this work was done under governmental control and in strictest wartime secrecy. With the end of the war came a strong desire to apply atomic energy to beneficial uses and, as a first step, Congress passed the Atomic Energy Act of 1946. However, this Act established atomic energy as a government monopoly and subjected the research and development work on such applications to full governmental control. Some eight years later new legislation was enacted (in 1954) which relaxed the governmental monopoly features—but did not eliminate them.

7. In general, the development of atomic power has taken place in a direction opposite to that which has occurred in the production of electric power from coal, oil or falling water. These conventional power sources have grown up step by step through a multi-centered process of development, and under exacting standards of design which carry the approval of the engineering profession. Governmental controls have been devised as the need developed. In contrast, the current development of atomic power is taking place in reverse sequence, starting with the status of a government monopoly. This is interfering with the application of the established disciplines and responsibilities of the engineering profession for safeguarding the public health and safety.

8. In the case of the atomic power project before this Court, if the location of the project had been established within the normal disciplines and responsibilities of the engineering profession, the present site could not have been approved. When an Advisory Committee originally reviewed the proposal, it found the available information insufficient to give assurance that the reactor could be operated at this site without public hazard. Unfortunately, the opinion of this Committee did not prevail.

9. The historical development of law at the state and local levels which, in essence, holds individuals and companies responsible for any damage which their activities might inflict on the public, has produced nationwide standards of public safety. As a concurrent influence, the insurance industry has demanded high standards of safety and the application of sound engineering practices as a prerequisite to writing insurance against any liability which might arise. In the new and startling developments of atomic power the insurance industry was confronted with many new problems and potential hazards of un-

known magnitude. Estimates released by the Atomic Energy Commission revealed that property damage from the failure of an atomic power plant could amount to more than $2,000,000,000, that fatalities could number in the thousands, and injuries in the tens of thousands. The insurance industry sought to serve this new area of risk-taking, but found it beyond its capabilities. The various companies finally pooled their resources and agreed to provide up to $60,000,000 in public liability insurance for an atomic power plant. Although this was an unprecedented amount for the American insurance industry, it fell far short of protecting the manufacturers and the agencies which might engage in the production of atomic power.

10. It must be viewed with regret that this problem was resolved by placing on the Federal Government and, thus, on the nation's taypavers, the liability for any damages (in excess of the amounts covered by the insurance companies) which might result from an atomic power plant disaster. This did not, of course, eliminate the hazard; it only relieved the agencies which might engage in the development or production of atomic power of the great financial responsibilities in the event of a disaster. This is the situation which applies today to all large atomic power projects.

11. The developmental and design programs of the past 15 years, together with operating failures which have occurred on small scale "pilot" atomic power plants, have confirmed the terrifying potentials of disaster which may be associated with such power plants.

12. It is generally recognized that the conventional energy resources of coal, oil and falling water are more than adequate to meet the foreseeable power needs for the remainder of this century. This removes the concept of urgency for generating electricity from "atomic fuels," or of taking chances which involve potentially disastrous consequences (no matter how remote they may be "believed" to be) on the grounds that by so doing the development of atomic power would be "accelerated."

13. The idea that history tends to repeat itself may find some confirmation in the present case. In 1929 the late Lord Chief Justice of England, Hewart of Bury, wrote in eloquent terms about the emergence of a new system of law. He called attention to the trend (in this age of technology) of transferring great responsibilities, by legislation, to new administrative agencies; these, in turn, are given wide range of authority to establish administrative controls and regulations which eventually become "administrative laws." This, he warned, may eventually lead to "administrative lawlessness." Such a trend, obviously, would contain hidden dangers to our Constitutional system of government and to the Rule of Law, as well as to the independence of our established system of justice.

14. The factors and relevant issues involved in the present care are much broader and far-reaching than the simple question whether a specific atomic power reactor should or should not have been constructed at a particular site. The Court's decision in this case could have a far-reaching influence in preventing the abandonment of principle for expediency.

ARGUMENT

I. OBJECTIVE OF THIS BRIEF

The objective of this brief is to demonstrate that:

I. The present issues before the Court have developed out of one or more of the following deficiencies:

(a) Circumvention of the responsibilities of the independent professional engineer;

(b) harmful exploitation of engineering responsibilities;

(c) harmful exploitation of public confidence in the engineering profession;

(d) failure of leaders in the engineering societies to defend the position and responsibilities of the profession;

(e) failure of leaders in higher education and in scientific societies to provide effective interpretation of this new science to public authorities and to the professions;

(f) overzealousness and uncontrolled pressures to manufacture and sell new types of atomic equipment;

(g) undisciplined efforts to excel in new technological achievements;

(h) abandonment of management and corporate responsibilities (as a consequence of special legislation), and transfer of such responsibilities to the Federal Government;

(i) unwillingness or failure on the part of those in high governmental authority to seek or accept responsible engineering advice;

(j) a combination of these deficiencies which may be summarized as "a situation peculiar to these times of declining self-discipline and morality."

II. These deficiencies have led to a situation which is harmful to the public interest and the national welfare. The various areas of responsibility which are involved in the development and practical application of the new science of atomic energy will be reviewed in greater detail.

II. A CONFLICT OF RESPONSIBILITIES

A factor contributing to the present case is the lack of common understanding regarding the basic difference in responsibilities as between scientists and engineers. As a matter of fact, in recent decades there has emerged such a confusing concept of these two professions that the terms "scientist" and "engineer" are at times used interchangeably or in combination as "engineer-scientist." Such a confused use of these designations is harmful to public safety as well as to national policy.

Technology During World War II

World War II was largely a terrifying struggle in the application of modern engineering and science; in the course of this struggle, our nation mobilized its resources of engineering and of science into a single collective "force of technology."

The end of the war left the world disrupted at all levels of civilized endeavor. From this chaos new levels of authority and responsibility had to be established

either through the exercise of dictatorial powers or by the slower processes of democracy.

In this historical transition from war to peace the normal areas of responsibility as between the scientist and the engineer have not been re-established on a basis which would best serve the national welfare. As a matter of fact, the traditional concepts in such matters have become obscured within both of these great professions, and there is little evidence that their members have the resources or the will to redefine their respective areas of responsibility. This must be regarded as a basic defect in our national posture. Furthermore, it can be shown to be a factor in the conflict which this Court has been asked to resolve.

The Decisive Powers of Modern Science

Modern science has demonstrated that it can open the way to a golden age if it is developed in freedom for the benefit of mankind. However, as some of the basic forces of science are becoming all-powerful, modern science is also providing the means for a "reign of terror" under the threat of "total destruction" if these forces are concentrated in the hands of the few and directed toward selfish or ruthless ends. The history of mankind has been a story of being buffetted by the forces of good and evil. Today, more than ever, the choice of direction for the future of man depends upon the wisdom of great decisions involving the application of scientific principles.

One of the great truths of our technological age has been stated in these words: "Modern science is the blessing and curse of our age; it holds decisive powers for good and for evil." Today the ability of man to govern himself—to control his own destiny—has been seriously challenged.

Professional engineers, working in freedom, have a primary responsibility of making plain to their governments, their fellow citizens, indeed to all mankind, the true nature of this situation and of the awesome choices it presents. In meeting this obligation it is their duty to give overriding consideration to the public safety and to the national welfare. This is a moral responsibility—a moral responsibility for the direction taken by our civilization and for the sort of lives our children's children shall inherit.

Definitions of "Scientist" and "Engineer"

There is as much difference between the roles of the scientist and of the engineer as there is between night and day. Specifically, the scientist makes things known and the engineer makes things work. A world-renowned scientist has identified the fundamental characteristic of a scientist by saying that "the most common activity in which a scientist finds himself is to make mistakes, recognize them and correct them."[1] In other words, out of the repeated failures in a research project the skilled scientist eventually brings forth a new discovery. This is the ultimate objective of a scientist. His training has prepared him to become an expert in experimenting; however, no matter how great the public esteem may become as a result of his discovery, he has not become vested, overnight, with any peculiar authority to decide on its use.

Too many scientists, if they succumb in later years to the temptation of assuming administrative or governmental authority, are prone to experiment also in public affairs and to commit monumental errors.

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1 "What Is Scientific Education?" (Dr. Edward Teller) Address presented at Marquette University, Milwaukee, Wisconsin, May 20, 1959. Unpublished transcript from Marquette University.

In contrast, the engineer is trained and disciplined not to make mistakes. He commits himself to the severe discipline and moral obligation of applying scientific principles within established rules of public safety and with due regard to economy and the national welfare. Within these severe demands on personal integrity the professional engineer undertakes to synthesize a wide range of technical, legal, financial and social requirements and to function as a planner, designer, builder or administrator. However, it must be remembered that the application of scientific discoveries remains the task of fallible men and, once the engineer has made a serious mistake, his professional standing may be damaged or permanently ended.

The engineer's conservatism and sense of responsibility in the practical application of scientific discoveries has, in the past, taxed the patience of many a scientist. If left to his own devices and to his "privilege of making mistakes," the scientist is inclined to adopt "short-cuts" in approaching his objectives, and to by-pass the moderating influence and professional disciplines of the engineer. A statement by a noted scientist regarding the post-war development of atomic energy is an example of this philosophy: "This simultaneous pursuit of programs of research, development and construction has become standard in the fast-moving field of atomic energy."[2]

In recent decades the distinctive functions and responsibilities of the professional engineer have become so obscured that a detailed exposition is needed here to identify some of the important elements, particularly as they apply to the conflict before this Court.

The Role of the Professional Engineer

The purpose of engineering is to serve mankind; this service is achieved through the individual and personal responsibility of the professional engineer. His professional services demand every bit as much personal attention and responsibility as that of a surgeon performing a highly critical operation.

Although a professional engineer may rise to a high position of success and public recognition for his achievements, there is, unfortunately, a general lack of understanding and appreciation of the great risks and personal responsibilities which he assumes in his work. Too often this part of the engineer's function comes to public attention only in the event of a failure. Numerous failures have occurred in the past, generally with tragic consequences to the engineer.

As an example, a disastrous failure in engineering occurred on the night of March 12, 1928 when the St. Francis Dam in California broke, resulting in 700 houses being swept away and a loss of 450 lives. The Chief Engineer who was responsible for the design and construction of this dam, Mr. William Mulholland, after 40 years of leadership in his profession, declared: "Don't blame anybody else. Whatever fault there was in this job, put it on me. If there were any errors in judgment—and it's human to make mistakes—the error was mine. I envy only those who are dead."[3]

There is no substitute for such a concept of responsibility in engineering. This sense of personal responsibility on the part of each engineer is particularly important in areas of general public service, such as electric power supply or municipal water supply. Adequate protection of the public health and

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[2] Brief For the Petitioners. United States and Atomic Energy Commission. No. 454, This Term. p. 45.

[3] Western Construction News. Quoted in editorial. San Francisco, California. Vol. III, Number 7, p. 223. April 10, 1928.

safety calls for a nationwide resource of engineers who are dedicated to the practice of their profession in accordance with established disciplines and ethics. Such engineers have the obligation of building and operating public and private facilities of all types which conform to approved standards of design and economy and which contribute to the advancement of the nation within our Constitutional form of government and within the established rules of law.

It is in these terms that the engineering profession is a vital national asset whose members are skilled in applying scientific discoveries for the benefit and well-being of the public. Unwarranted political influence or encroachment on their responsibilities and authority would clearly be a violation of public trust.

Thaddeus Merriman, the former Chief Engineer of the Board of Water Supply for the City of New York has summarized the professional engineer's obligations as follows:

> ". . . [The engineer's] duty does not lie only in saving a maximum of his client's money. It demands absolutely that the public be afforded a maximum of safety. If the client is unwilling or unable to pay for that maximum then he should not have [his project]. And what is true in the case of a private client is just as importantly true when the engineer acts for public authority—he must still protect the public—no one else can perform that function."[4]

The sense of responsibility of professional engineers, together with the confidence of the public in the engineering profession, comprise a rich heritage which stands as the primary bulwark for the protection of the public in the application of science and technology. This confidence must be maintained and merited in the future as an essential feature of a free society. The public has a right to expect absolute intellectual honesty. Herbert Hoover has stated most precisely that "technology without intellectual honesty will not work."

The Importance of Freedom in Engineering

It has been well stated that: "Without engineering, freedom could bring you a happier but not an easier life. Without freedom, dictators could use engineering to enslave you."[5]

Without freedom the professional engineer is unable to meet his ethical obligations in the practice of his technical skills, and without freedom, he is unable to serve his client's and the public's interest to best advantage.

A noted engineer has described the obligations of the professional engineer in these terms:

> "Since engineering is a profession which affects the material basis of everyone's life, there is almost always an unconsulted third party involved in any contract between the engineer and those who employ him, and that is the country, the people as a whole. These, too, are the engineer's clients, albeit involuntarily. Engineering ethics ought, therefore, to safeguard those interests most carefully. Knowing more than the public about the effects his work will have, the engineer ought to consider himself an officer of the court and keep the general interest always in mind.

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4 "Naught But the Best," by Thaddeus Merriman, Civil Engineering, December 1939, pp. 701-702.

5 Inscription on Museum of Science and Industry, Chicago, Illinois.

"Service ceases to be professional if it has in any way been dictated by the client or employer. Professional independence is not a special privilege but rather an inner necessity for the true professional man and a safeguard for his employers and the general public. Without it he negates everything that makes him a professional person and he becomes at best a routine technician or a hired hand, at worst, a hack."[6]

In recent years decisions have been made in areas of science—areas in which even the well educated man is often a stranger—which affect the lives and welfare of many people and of entire nations. However, if a free society is to remain free, it must demand the application of scientific discoveries under the dedicated responsibility of professional engineers working in freedom.

Responsibilities and Limitations in Engineering Design

The predominant influences of science and of engineering have appeared on the world's scene within the past century, which, in terms of history, is a relatively short time. The turn of the century marks the beginning of the revolutionary period of modern science, and it is still within the span of our lifetimes that engineers have become a vital factor in the American industrial scene. Not long ago industrial development depended largely upon mechanical inventiveness. With the advent of modern science have come discoveries and explanations which are more fundamental. Yet, such fundamentals do not explain what is engineeringly sound.

With the advent of a new science the engineer cannot minimize or ignore a potential hazard on the grounds that all of the scientific data necessary for a complete understanding of the hazard are not available. In fact, it is precisely in such areas where the professional skills and judgment of the engineer take on added importance as a moderating influence.

Recognizing that error is an inherent factor in all human activity, the professional engineer applies his technical knowledge and professional disciplines preponderantly on the side of safety. One of his most important tools is the "factor of safety." For example, the stability of a dam may have a factor of safety of 2; this means that before such a structure would fail, the supported load would have to be twice the assumed or predictable load for which the structure was designed. Thus the factor of safety compensates for unexpected or unpredictable greater loads in the coming decades, as well as for possible deterioration with time.

The factor of safety has also been called the "factor of ignorance"—as an acknowledgment of the inability to predict all of the events which a structure may experience in the future. Similar criteria apply in all engineering but, in spite of all the applied skill and precautions, failures continue to occur for many reasons which could not be anticipated in the original design.

There is no such thing as foolproof design or operation of a power plant. The possibility of an accident or disaster is ever present and the biggest disasters have been the most incredible. Generally, out of a painstaking investigation of a disaster a complex chain of "incredible" circumstances has emerged to explain the cause.

Modern history records numerous disasters in engineering and technology, with tragic loss of life, such as the sinking of the "unsinkable" Titanic, the conflagration in the "fireproof" Iroquois Theater, the explosion of gas in the new school of New London, Texas, the collision of two large passenger air-

[6] The Meaning of Your Profession." 104 Cong. Rec. 18349, 18351.

planes over the vast expanse of the Grand Canyon region. Many others could be cited. In every case there was a great loss of life and property. And in every case the odds against the occurrence were undoubtedly considered to be fantastically large. Nonetheless, they did occur and there is no reason to believe that others will not occur in the future.

Separation of Responsibilities of Engineers

The personal responsibilities of a professional engineer are at times so great that it is in the best interest of all concerned to subdivide and isolate the main areas of engineering responsibility, and to adopt a system of checks and balances similar to the system of our republican form of government.

For example, a project may be undertaken by a corporation whose chief engineer has the primary responsibility of interpreting the particular objectives as laid down by his directors. (This would correspond to the legislative branch of our government.)

A second area of responsibility is undertaken by a separate consulting engineer and his firm which create the designs within economic limits and under approved factors of safety; this firm would also supervise the interpretation of its designs during the period of construction and during the manufacture of the required machinery and materials. (This would correspond to the administrative branch of our government.)

A third area of engineering responsibility rests on the shoulders of the chief engineer for the contractor who undertakes the construction of the project for a specific price. His primary obligation is to devise the most efficient and economical construction techniques in full compliance with the plans and specifications. (This would correspond to a second area within the administrative branch of government.)

A fourth area of engineering responsibility is assigned to an independent consulting engineer (or to an independent board of consulting engineers), with the overriding duty of looking after the owner's and the public's best interests, by acting as an observer or technical auditor during the planning, design, financing and construction of the project, and in reviewing issues which may run into conflict. (This would correspond to the judicial branch of the government.)

Such a system of coordinated professional controls, functioning freely, but, without compromise on important professional responsibilities in each of the four areas has, in the past, produced notable engineering achievements; more importantly, it has effectively minimized the occurrence of serious mistakes or failures in the administration and execution of the work.

Unfortunately, in recent years this system of control of engineering responsibilities has been displaced all too often by political domination of such controls. In other cases the so-called "more efficient package deal" system of contracting has been offered in which the constructor or even the manufacturer of power plant equipment undertakes to provide all of the services, not only of construction and manufacture of the equipment, but also the engineering planning and design, with the engineers appearing in direct partnership or as sub-contractors. It is inevitable that in such cases the independent professional control of major engineering responsibilities (in the best interest of the client and the public) is obliterated and displaced by the motivations of easier profits for the constructor or the manufacturer. In some cases this has led to very faulty engineering planning and construction, or in other cases to

scandalous performances in diverting and wasting public funds even though the design and construction may have been of good quality.

III. UNIQUE HISTORICAL FACTORS IN ATOMIC POWER DEVELOPMENT

The unique circumstances under which atomic power has been developed appear to be largely the result of an historical coincidence. In 1939 experimental demonstration had been made of the phenomenon known as nuclear fission. This same year also saw the outbreak of World War II. When it became evident that this newly discovered phenomenon might be applied to the fabrication of a weapon with unprecedented destructive power, the subject of nuclear fission (atomic energy) became a "top secret" high priority program under strict military control. This program was almost totally concerned with the development of a new type of bomb. Destruction was the primary objective; cost was of secondary concern. The terrifying demonstration of the atomic bomb's power in 1945 removed all doubts regarding the outcome of this wartime project.

With the advent of the fearfully destructive power of the atom has come a universal hope that eventually this power would be harnessed for equally impressive purposes, in the service of mankind. Unfortunately, however, this hope has been permitted to grow, through excessive publicity and false propaganda, to a point where the practical realities have become obscured. Once a new scientific concept with revolutionary potentialities has been demonstrated to have a certain "technical feasibility," it is still far removed from economic application.

After the end of World War II the high priority program of atomic energy for military use was modified. This led to the passage of the Atomic Energy Act of 1946 (60 Stat. 755), which established atomic energy as a Government monopoly. A basic factor in this decision (as acknowledged by the Congress in the Act itself) was the inability to predict how, or when, atomic energy could be used for civilian purposes. Accordingly, research and development of atomic power reactors for the production of electricity grew up as a monopoly venture under the control of the Atomic Energy Commission.

As in the case of the atomic bomb, the atomic power reactor also employs the principle of nuclear fission but, instead of suddenly releasing an enormous body of heat by explosion, the power reactor[7] is designed to maintain a controlled release of a limited amount of heat over a long period of time. This controlled heat is delivered to a heat exchanger where water is converted to steam; the steam, in turn, drives a conventional turbine generator for the production of electricity.

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[7] The special type of reactor to be employed by PRDC is called a "breeder reactor." The energy source will be fuel rods of enriched uranium. As these are consumed by fission at high temperature for the production of steam and the generation of electricity, a transformation occurs within the fuel rods and surrounding "blanket": this results in a phenomenon called "breeding" in which some of the uranium (U-238) is converted into plutonium (Pu-239). Since this plutonium is not expected to be used in this reactor, it will be sold back to the Atomic Energy Commission for other uses.

The term "breeding" applies only to this transformation of materials. It does not infer some kind of "reproductive process" of creating new energy for prolonging the operation of this reactor. The total energy resource which entered the reactor at the beginning of the cycle is, of course, reduced by the amount of heat energy which is consumed for the generation of electricity.

The appropriation of great sums of federal funds provided a major impetus for the atomic power program. Any question regarding soundness of the program was swept aside by a variety of considerations, including: willingness to accept unsupportable claims regarding the great potentialities in the new science; and desire for prestige by being first among the scientists of the various nations with any new developments.

It was not until 1951 that private groups were permitted to undertake limited studies in the application of atomic energy for the production of electricity. Even then, however, such studies were essentially under the complete control of the Commission, and were subject to all of the then prevailing regulations of secrecy and other restrictions.

Continuation of Governmental Controls

Interest continued to develop in the application of atomic energy for civilian purposes, and this led to the passage of the Atomic Energy Act of 1954 (68 Stat. 919). The Act of 1954 was designed, as were subsequent amendments, to permit private industry to employ the new technology in the construction of a limited number of atomic power plants. Despite the relaxation in the governmental monopoly of atomic energy, however, the Government still retains the following functions:

(a) It is the sole producer of enriched material for fuels to be used in power reactors.

(b) It sets the price of nuclear fuel and is empowered to guarantee prices or waive its charges.

(c) It owns and controls many of the basic research centers concerned with atomic energy and the information released therefrom.

(d) It has the power to pre-empt ownership of all patents which pertain to atomic developments.

(e) It is a leading developer of various types of atomic power reactors.

(f) It subsidizes, or has some form of financial stake in virtually all of the atomic power plants, publicly or privately owned, now in operation or under construction.

Limitations in Application of Engineering Responsibility

In retrospect it is quite apparent that the origin and growth of atomic power has followed a reverse sequence to that which has taken place in the development of the conventional sources of power—coal, oil, gas and water. In these compulsive circumstances, the engineering profession is confronted with the question of how to apply its traditional disciplines and responsibilities for public safety to the production of electricity under the following new conditions:

(1) The scientific principles of the atomic power reactor are understood by relatively few scientists, and by very few engineers.

(2) Only limited knowledge is available regarding the reactor's heat-producing characteristics in large quantities and over prolonged periods of time.

(3) An atomic power reactor is known to be a highly dangerous device, and its design and application must be developed with extreme care.

(4) No adequate record of operating experiences is available which might serve as a significant guide for the design of large power reactors.

(5) It is known that a major failure of a power reactor could do tremendous damage to life and property.

(6) The insurance companies are unwilling, in fact unable, to assume the full liability for any major reactor failure, or to protect the owners and operators of the power reactor from damage and death claims following a reactor failure.

(7) The consequences of sabotage or deliberate inducement of a major failure in a power reactor could lead to tremendous damage to life and property; there is no clear prospect of developing a simple design which would protect the public against this contingency.

(8) The ultimate cost of a reactor power plant cannot be satisfactorily predicted and could, conceivably, overrun an estimate two or three times.

(9) It is known that the cost of producing electricity from an atomic power plant is several times greater than the cost of electricity from conventional steam plants. Furthermore, the cost of various items, such as nuclear fuel rods and the disposal of waste, contain government subsidies of unknown magnitude.

(10) From an engineering standpoint there is no economic justification for an atomic power plant.

(11) At best, if investment cost and operating cost were to be disregarded, an atomic power plant may be considered an experimental facility.

(12) The development and control of this new science is in the hands of the Federal Government, and anyone wishing to engage in it may be obliged to work under restrictive regulations and rules of secrecy. This is an unprecedented situation. The conventional and traditional atmosphere of freedom of exchange of knowledge among engineers does not prevail.

(13) There is no indication that a system of checks and balances in engineering responsibilities prevails in this new field.

(14) No legal structure within the accepted principles of the "rule of law" and the Constitution of the United States has been established with respect to this new area of science. (See comments on Rule of Law, infra pp. 53-54.)

IV. BASIC PROBLEMS IN POWER PLANT LOCATION

Electric energy is produced for the benefit of the consumer. It has the unique characteristic of portability by means of transmission lines, and where it originates is of no direct concern to the consumer. Hence, there is considerable freedom of choice in the location of generating (or power) plants. As a first step, and for comparative purposes, the criteria which generally govern the location of the conventional types of power plants are presented.

Choice of Location of a Thermal Power Plant

A coal-burning steam power plant may be located either at the mouth of a coal mine or adjacent to an industrial load center, the choice depending on whether it is more economical to transmit the electricity or to transport the coal between the mine and the load center. An oil-burning steam plant is usually located near the load center, because of the ease and economy of transporting oil in pipelines.

The detailed choice of location of the power plant and related fuel storage, and the detailed design of the high-pressure steam boilers and all other components, is dependent upon well established engineering criteria which, in turn, are based on long records of experience in the operation of similar power plants throughout the country. Such engineering decisions must also meet the ap-

proval of the insurance underwriters. This system of control of the safety features in design and location of thermal power plants has evolved from the free interplay of opportunity and responsibility brought about by private or local initiative, tested by experience, generally governed by sound economic considerations in their application and, as the need arose, subject to regulatory controls by public utility commissions.

Another basic influence in this process of engineering development has been the record of failures and disasters in earlier power plants. It is part of the history of engineering that many of the most important advancements in the art have been developed from the lessons learned through the occurrence of major failures or disasters. Such failures obviously were not expected to occur. However, whenever they have occurred, the resources of the engineering profession have been mobilized to identify their cause and to establish modifications in engineering practice which have helped to prevent their recurrence. This is part of the slow and difficult process by which the art of engineering advances step by step and with due regard for the public's safety.

Choice of Location of a Hydroelectric Power Plant

There is less freedom of choice with respect to the location of a hydroelectric power plant. It must be located where a river has a site which is favorable to economic development. Such a location may be hundreds of miles distant from the load centers, and the electric energy must be conveyed over long transmission lines to the consuming areas.

Choice of Location of an Atomic Power Plant

The possibility of a serious reactor failure introduces some overriding considerations in any decision involving the location of an atomic power plant. The failure of a reactor, which involves the release of radioactive material to the atmosphere, can inflict terrifying damage on the property and on the population which may be located in the vicinity. The magnitude and extent of such destruction will be discussed later in greater detail.

Furthermore, the operation of an atomic power reactor introduces some new problems with respect to waste disposal. Reactor waste products are highly radioactive and so dangerous that they must be permanently stored in inaccessible places. These problems have been solved only to a limited degree. At present there are no economical solutions available, and, or course, no experience to guide the engineering profession in this new area of responsibility.

Under these circumstances a professional engineer might undertake the design of an experimental atomic power plant of limited size and cost and apply the highest degree of skill and judgment to the design of all its elements. However, there would still remain the overriding problem of locating this new power plant so it could not become an undue hazard to public life or property.

The solution which could be regarded as most acceptable by responsible engineers would be to construct such a power plant at a remote location and within a cavern excavated far back in a solid rock formation; as in the case of many hydroelectric developments, the electrical output would be delivered over long transmission lines to the load center. This concept of design was actually developed by some of the world's most competent engineers and has been adopted as a requirement in some other parts of the world. It was assumed that, in the event of any major failure of the nuclear reactor, the passageway to the cavern would be permanently sealed off and the project could be abandoned, without having exposed life or property in the vicinity to harmful radioactivity.

A Failure in Professional Engineering Responsibilities

In the case before this Court, as will be indicated in greater detail, it is a regrettable fact that the conventional responsibilities of the professional engineer, and his overriding obligations to the public safety, have not been fully respected. Furthermore, the essentials of professional freedom and moral duty to serve the best interests of the public and of the country did not prevail. If professional freedom had prevailed, it is most probable that the project now being contested before this Court would not have been constructed at the present site.

Hence it must be said of this project that the choice of location is the result of a denial of professional freedom, and of a terrifying violation of engineering disciplines and ethics. To support such a broad declaration requires an examination of the circumstances which led to the choice of the present location, and of the evidence which was available at the time regarding the potential hazards to the public.

If a remote location actually was recommended (as representing the best judgment of an independent consulting engineer), there is no evidence that such an opinion was considered acceptable, or that such independent and responsible judgment was invited. Furthermore, there is no evidence that the engineering profession publicly protested this violation of its professional disciplines and its stature before the public. The net result was that those responsible for construction of this project made the deliberate choice of a site in the vicinity of two large cities. The apparent reasons for this choice are without precedent and must be regarded as historically incredible. These are the basic issues which have brought the present case before this Court.

V. CRITERIA FOR SAFETY AND PUBLIC HEALTH

It is noteworthy that in all engineering, the criteria for design, or for the protection of health and safety, have of necessity been established in advance of full understanding of the related scientific principles. Much remains to be learned in all areas of engineering; this applies particularly in the area of public health. In this area the factor of safety has always been large and in favor of the public.

To cite a specific case, the supply of safe drinking water in every locality is an example, on a nationwide scale, of applied disciplines in engineering. The American system of water supply may truly be called a miracle. The continuity of such a standard of service demands constant vigilance and attention to many details on the part of thousands of engineers and employees in water works. Certainly, no one would advocate a lower standard of safety in water supply for the sole purpose of saving some money. It would be considered preposterous if a public official were to advocate a lower factor of safety and cheaper water supply, on the premise that the community would be financially ahead, even if this were to result in an occasional contamination of the water—or outbreak of typhoid—or a "slight" rise in the death rate.

Criteria for Radiation Limits for Human Beings

> "It is only with research for criteria for radiation limits that one finds suggestions that it should be permissible to kill people to attain benefits to society. This has undoubtedly been in the minds of all criteria makers.

but rarely has it reached the frank and stark pronouncements of recent years."

Thus testified one of the most competent living authorities in the field of sanitary engineering before the Joint Committee on Atomic Energy in 1960.[8] He continued:

"Fear has been expressed that the establishment of too rigid criteria for the radiation activity may stifle progress because of excessive costs of attainment. One may view this fear with some cynicism in the light of the whole history of health and safety endeavor. This fear has always been expressed, but the historical realities consistently belie it. Criteria must rest upon health protection and not cost.

"No one, of course, should advocate excessive and unnecessary restraints. Those restraints most logically suggested, however, within the framework of current scientific understanding should not be resisted solely because resulting costs may threaten to throttle application. This should be scrutinized with a great deal of care before it is accepted as a base line of decision.

"The radiation field is today confronted with similar problems and decisions, greatly complicated by the very nature of the biological effects to be considered. The effects of radiation are unclear and not fully predictable with assurance, perhaps for some years. Yet one cannot bide one's time in placing restraints upon the public and private producer. These latter do not have an unblemished record of self-policing. Hence society must look to scientific groups and public officials for providing criteria and guides, at times admittedly uncertain, and others admittedly tentative. As knowledge increases, reappraisals ensue, either for relaxation or for tightening of criteria. These supposedly fumbling steps have much historical validity and precedent in public health practice. . . .

"The day of handbook rule for measuring the hazards of radiation is a long way off. In the meantime one acts upon limited knowledge. In such action the guiding principle must be the maximum protection of the people, not because of sentiment but because society demands it. An agreed acceptance of a number of consequent disabilities is not an appealing basis for the development, say, of nuclear power. Industry will do better than rest upon such an affront to man. I know they will, and have."

VI. REPORT OF ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The problem of appraising the safety aspects of the Lagoona Beach project under "the guiding principles of maximum protection of the people" was assigned to an independent committee of scientists and engineers known as the Advisory Committee on Reactor Safeguards (ACRS). On June 6, 1956, this committee reported to the Atomic Energy Commission that it had reviewed the

8 Hearings on Radiation Protection Criteria and Standards: Their Basis and Use, before Joint Committee on Atomic Energy, 86th Cong., 2d Sess. pp. 29–45.

application of PRDC and had come to the conclusion that it could not approve the application.[9] Quoting from the report:

> "The proposed PRDC reactor represents a greater step beyond the existing state of the art than any other reactor of comparable power level which has been proposed by an industrial group."
>
> "From this review the following conclusions were derived:
>
> 1. "Even though there are no facts or calculations available to the committee that clearly indicate that the proposed reactor is not safe for this site, the committee believes there is insufficient information available at this time to give assurance that the PRDC reactor can be operated at this site without public hazard."
> 2. "It appears doubtful that sufficient experimental information will be available in time to give assurance of safe operation of this reactor unless the present fast reactor program of the AEC is amplified and accelerated as detailed below.
> 3. "It is impossible to say whether or not an accelerated program would give sufficient information to permit safe operation of this reactor at the Lagoona Beach site on the time schedule presently proposed."
>
> "The Committee considers it important that bold steps be taken to advance the development of the fast breeder reactor concept and commends the willingness of the Power Reactor Development Company to risk its capital and prestige in advancing the development of this reactor concept. But the Committee does not feel that the steps to be taken should be so bold as to risk the health and safety of the public. It is important for the AEC to provide sufficient development facilities and experimental information that the safety aspects of the PRDC reactor can be reliably appraised in advance of operation of the reactor itself."

Unfortunately, this report was withheld from publication and the conditional construction permit was authorized by the Commission on August 4, 1956. The report finally was released on October 9, 1956.

Questions Raised by Joint Committee on Atomic Energy

A major difference of opinion regarding this report developed between the Chairman of the Congressional Joint Committee on Atomic Energy and the Chairman of the Atomic Energy Commission.

On August 4, 1956, the Chairman of the Joint Committee issued a statement containing the following:[10]

> "AEC has informed the Joint Committee on Atomic Energy that it has issued a construction permit to PRDC of Detroit to construct a nuclear power plant near Monroe, Michigan. This is known as the Detroit Edison reactor.

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[9] "A Study of AEC Procedures and Organization in the Licensing of Reactor Facilities," Joint Committee on Atomic Energy, 85th Cong., 1st Sess. (Joint Committee Print 1957), p. 133.

[10] Joint Committee on Atomic Energy, Supra note 9, pp. 125–126.

"The issuance of this construction permit, in my opinion, sets a dangerous pattern in the early stages of AEC regulative and quasi-judicial activity for the following reasons:

"1. The AEC has issued this permit as a result of 'star chamber' proceedings in which the report of its Advisory Committee on Reactor Safeguards, which raised grave doubts as to the safety of the proposed reactor, has never been made public by AEC. It is my understanding that this important report, filed on June 6, 1956, which was prepared by a distinguished committee of experts, has not been retracted or modified by them.

"4. From a practical standpoint, AEC might feel obligated to go on through with a bad deal with respect to public safety because they will have permitted the expenditure of huge sums under the construction permit. It is my belief that decisions on safety should be made without any examination of dollars involved but only from the standpoint of human lives."

VII. PROBLEMS OF INSURABILITY

Traditionally the power industry has developed under laws which, in essence, hold the individual power companies responsible for any damages which their activities might inflict on the public. This concept of liability has proven to be a strong influence upon the industry in developing its high record of safety. As a result, new scientific and technological developments have been adopted only after undergoing severe tests, and after adequate proof that the adoption of any new equipment would be consistent with the prevailing standards of safety.

A vital factor in this process has been the private insurance industry. For example, as boilers for steam power plants have increased in size and output, it has taken many decades to develop the responsible criteria of design under the constantly increasing temperatures and steam pressures. In such details as the metallurgy of the steel, welding and fabricating procedures, installation, operating controls, and safety devices, the great traditions of responsibility in engineering and in manufacturing have served as a foundation for taking each progressively higher step. In all of this development the insurance industry has participated with clear understanding of its responsibilities, and has insisted on the application of sound engineering disciplines before it would assume the liability for public damage due to explosions or other accidents.

In the atomic power field, on the other hand, the insurance companies were confronted with a new peril in which experience is almost totally lacking. At the same time they were confronted with demands for coverage of unprecedented magnitude. After considerable study the private insurance industry was obliged to announce that it would be unable to offer satisfactory public liability insurance on atomic power installations. The position of the private insurance industry was summarized in a comprehensive report from which the following is quoted:[11]

11 Hearings on Governmental Indemnity before Joint Committee on Atomic Energy, 84th Cong., 2d Sess. pp. 248–250.

"The hazard is new. It differs from anything which our industry has previously been called upon to insure. Its potential is still unknown and must therefore be calculated currently in terms of a body of knowledge which is expanding from day to day.

"Very few insurance companies have had any opportunity to develop first-hand knowledge of the problems involved because of the present limited scope of operation. By the same token, very few insurance companies have developed trained technical personnel to assist their underwriting personnel in insurance evaluation of the hazards involved.

"The catastrophe hazard is apparently many times as great as anything previously known in industry and therefore poses a major challenge to insurance companies. . . . We have heard estimates of catastrophe potential under the worst possible circumstances running not merely into millions or tens of millions but into hundreds of millions and billions of dollars. It is a reasonable question of public policy as to whether a hazard of this magnitude should be permitted, if it actually exists. Obviously there is no principle of insurance that can be applied to a single location where the potential loss approaches such astronomical proportions. Even if insurance could be found, there is a serious question whether the amount of damage to persons and property would be worth the possible benefits accruing from atomic development."

Catastrophe Hazards

In addition to the damage to the power plant and operating personnel from a conceivable accident in an atomic reactor, the far greater hazard lies in the radiation exposure and contamination which could occur if the fission products should be released to the surrounding area. It is conceivable that accidental atomic or chemical reactions within the reactor or auxiliary systems could destroy equipment, break the containment structures, and release the accumulated fission products to the atmosphere in a highly divided state. Once airborne, these toxic products could be widely dispersed, threatening the health and safety of people over wide areas. The danger may be emphasized by noting that some radioactive materials are more than a million times as toxic as chlorine, the most potent common industrial poison.

Naturally, the Atomic Energy Commission, as well as the manufacturers and public utilities engaged in atomic power development, have been deeply concerned over the type and amount of damage to people and property which could occur in the event of a major catastrophe, and with the problems of settling the ensuing damage claims.

In March 1957, the Atomic Energy Commission published a report which is generally known as the Brookhaven Report: "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants."[12] This report contains the studies of an "assumed condition of accidental failure" of an atomic reactor with an electrical power capacity of 100,000 to 200,000 kw and located on a river about 30 miles from a major city. Various assumptions and conditions of the surrounding region were defined to provide some basis for computation. It must, of course, be kept in mind that some of the problems

12 "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants." ("Brookhaven Report"), R. 874–917.

involved are extremely difficult to analyze. However, the figures were intended to serve as an "order of magnitude" indication of the possible consequences of a major reactor failure. Such a failure could result in contamination of large areas from deposited fission products. Inhabitants of portions of the areas affected would have to be evacuated to avoid serious exposure. Standing crops would be lost. Agricultural use would be curtailed. Access to various areas would be restricted for considerable periods of time.

The results of these studies indicated that, depending upon the weather conditions and temperature of the released fission products for the assumed accident, the property damage alone could range between $2,300 million and $4,000 million and possibly higher. Damage to health and life could be in the order of 43,000 injuries and 3,400 fatalities, without taking into account the probability of harmful long-term effects on several hundred-thousand people. The financial liability for human casualties was not evaluated and obviously is beyond comprehension.

It might well be wondered, under these circumstances, how any agency engaged in the generation of electricity could afford to undertake the construction of an atomic power plant when faced with the possibility of becoming liable for such vast potential damages.

Government Acceptance of Liability

Eventually the private insurance industry, after pooling all its resources, committed itself to underwriting liability coverage on a single atomic power installation in the amount of $60 million. However, this represents only a small fraction of the potential damage to life and property from a major failure of an atomic reactor.

To resolve this impasse, a proposal was advanced which must be regarded as a great historical tragedy in the affairs of our government. The Atomic Energy Commission chose to recommend to the Congress—and the Congress saw fit to enact—legislation by which the liability, except for the comparatively small coverage provided by the private insurance industry, was transferred to the taxpayers of the nation. The 85th Congress adopted Public Law 85-256, known as the "Price-Anderson Act," which added Section 170 to the Atomic Energy Act of 1954. This Act was approved on September 2, 1957. (42 U. S. C. 2210)

Under this Act the United States Government has assumed a liability which is stated as a maximum of $500 million for each accident. However, in view of the commitment in principle, it is difficult to visualize how the Government could escape a much greater liability in the event of a larger disaster. The possibility of such a disaster occurring, obviously, has been acknowledged by the passage of this amendment. Representatives from the power and manufacturing industries had stated that without such assumption of liability by the government they would not be able to continue their participation in the atomic power program.

The enactment of these indemnity provisions into law, however, has not eliminated the hazard. It has served only to relieve the individual power companies and the manufacturers of the traditional system of financial liability by transferring such liability to the Federal Government. In this manner the way was paved for building so-called "low-cost atomic power plants" near the load centers. Following enactment of the Price-Anderson Act, a number of publicly and privately owned atomic power plants have been undertaken with governmental approval near populous areas, thus subjecting the people, without their

consent, to unnecessary and unprecedented hazards. The ultimate liability in the event of a disaster has been transferred, according to law, to the nation's taxpayers.

The net result of this action has been to circumvent and disrupt the traditional system of disciplines and responsibility of the engineering profession. As has been previously stated, the public has great confidence in the engineering profession to protect the public health and safety, and professional engineers are expected to assume their responsibilities and serve under the highest standards of ethics and intellectual honesty. However, these standards cannot prevail under a system of government indemnity which displaces such responsibilities.

Probability of An Atomic Disaster

It has been alleged that the location of an atomic power plant near a populated area is permissible on the grounds that the many safety precautions taken to avoid an accident render the possibilities of an atomic disaster "exceedingly improbable." However, as noted previously, such assurances in no way alter the fact that virtually every major accident or disaster which has occurred in past history has been "exceedingly improbable."

History has clearly demonstrated that man, with his imperfections, has never been able to foresee all future technical events. Despite his best efforts, failures have occurred; at the same time, he has used these failures to increase his knowledge and widen his range of confidence. In the face of this long-established historical fact, the atomic energy program is currently being promoted on the assumption that a major accident will not occur. However, despite the excellent technical efforts which have been applied to date, such an assumption, particularly in view of the completely new technology involved, must be regarded as utterly unrealistic.

Failures in the Field of Atomic Energy

Although the atomic energy industry is very young and has relatively few installations, it has achieved an impressive record of safety in its brief history. In fact, it seems doubtful that any other industry can show greater concern for safety in terms of time and effort, or money expenditures. However, reassuring as this fact may be, it is also significant that despite this safety effort, failures are still occurring. Such failures range from relatively minor ones to the more serious. In most cases the reactors which have failed have been relatively small. Some of the failures in the operation of atomic reactors have resulted in deaths, or have exposed considerable numbers of persons to radiation.

A failure occurred in December 1950 at the National Research Experiment (NRX), Chalk River, Canada, which resulted in a nuclear runaway and explosion. This accident is not widely known because the security regulations at the time of the incident were very strict; but it resulted in the death of one man and the serious radioactive contamination of five others.[13]

At Windscale, England, in 1957 a fire in an atomic reactor resulted in the widespread release of radioactive material over the surrounding countryside. It fell on the pasture lands of farms in a 200-square-mile area. The cows, while grazing, absorbed the fallout of iodine-131; it reappeared in the milk. Fortunately this was discovered almost immediately by scientific monitoring, and resulted in a ban on the use of all milk produced in this area. It was con-

13 "AEC Experience in Radiation Accidents," by D. F. Hayes. In A Compendium of Information for Use in Controlling Radiation Emergencies." U. S. Atomic Energy Commission. September 1960. pp. 2-3.

sidered advisable to dump all the milk for a period of two months to prevent its consumption by young children who might otherwise have accumulated significant quantities of radioactive iodine in their thyroid glands. The report of the board of investigation stated that the cause of the accident was due partly to inadequacies in the instrumentation provided for the control of operations, and partly to faulty judgment by the operating staff, these failures in judgment being themselves attributable to weaknesses of organization.[14]

Although both of these failures, among a number of others, have occurred outside the United States, published accounts have recorded 39 failures in reactors of various types in this country.

On January 3, 1961, about 9 p. m. a failure occurred near Arco, Idaho, in an AEC prototype power reactor rated at 200 kw. This resulted in the death of three persons who were working on the reactor at the time of the accident. Prior to this failure it was known that a variety of troubles had developed, some having their origin in the design and others in the operation of the reactor. Because of the high radiation levels inside the building, it has not been possible to enter and determine the cause of the failure.

The AEC report of January 27, 1961 states:

> "Because of the high radiation levels, it was not possible to remove the second crewman until January 5, and the third crewman until January 9."
>
> "At this time it is not possible to identify completely or with certainty the causes of the incident. The most likely immediate cause of the explosion appears to have been a nuclear excursion resulting from motion of the central control rod. As yet there is no evidence to support any of several other conceivable initiating mechanisms."[15]

These and other failures provide impressive evidence that no matter how great an effort may be made to prevent them, accidents will occur. This is particularly true in the development of a technology as new as atomic energy—much still remains to be learned.

Steel Containment Vessel

During the early 1950's there was considerable discussion on how to design an unprecedented type of power plant containing an atomic reactor. As a basic principle it was generally agreed that every effort should be made to minimize the hazard to the public as much as possible.

It had been determined that any release of fissionable material to the atmosphere could have a terrifying and disastrous result on public life and property in the vicinity. The possibility of such an occurrence, no matter how remote it might be, had to be admitted. These considerations eventually led to a proposal to construct a steel plate "containment shell" or dome completely surrounding the reactor unit. This dome presumably would confine whatever cloud of fissionable material might otherwise be released to the atmosphere. The dome at the PRDC (Enrico Fermi) atomic power plant at Lagoona Beach

14 "Accident at Windscale No. 1 Pile on 10th October, 1957." Presented to Parliament by the Prime Minister by Command of Her Majesty, November 1957. Cmnd. 302. London, HMSO.

15 "Interim Report on the SL-1 Incident." Report of the General Manager's Board of Investigation. U. S. Atomic Energy Commission. January 27, 1961. pp. 2, 11.

consists of a steel shell 72 ft. in diameter, 120 ft. high, and with varying thicknesses of steel plate from 0.52 to 1.25 inches.

Such a structure has become a highly controversial design concept and there is a considerable body of professional engineering judgment that it is of extremely limited value in safeguarding the public.

It could be claimed that the design of this dome has had the benefit of a careful review by the United States Naval Ordnance Laboratory in White Oak, Maryland. However, an examination of this report indicates that it does not claim to be a comprehensive treatise on the containment problem for this reactor power plant, and that many of the containment problems that are peculiar to this reactor have never been solved either experimentally or theoretically.

The limitations and reservations noted in this report reveal that the authors and the officers of the U. S. Naval Laboratory recognize the tremendous responsibilities involved in the over-all project. They have stressed the fact that their participation in a limited study area may not be regarded inferentially as approval of many other important areas which have not been studied. This sense of responsibility is in keeping with high professional engineering standards and is worthy of commendation. (It is regrettable that this report has not been given the degree of recognition commensurate with its importance.)

The following quotations from the Abstract of this report indicate the great care with which the U. S. Naval Laboratory approached this problem:

> "A study has been made on the ability of the Enrico Fermi fast breeder reactor plant to contain a nuclear excursion equivalent to the violence produced by 1,000 pounds of TNT. The results of the study indicate that the reactor plant can contain shock waves developed in the air and in the sodium and also fragments from the cylindrical covering materials surrounding the reactor core. The rotating shield plug, however, is a serious hazard when projected by the gun action of the internal blast pressure in the reactor compartment. This problem is analyzed and a recommendation has been made to lessen the danger.
>
> "This report is not claimed to be a comprehensive treatise on the containment problem for this reactor plant. To do so would go far beyond the intended scope of this study. Many of the containment problems that are peculiar to this reactor have never been solved experimentally or theoretically. Conclusions that have been made are based on concepts taken from applicable areas of explosions research.
>
> "It is emphasized that this entire report is based on information furnished by the Atomic Energy Commission that the most probable upper limit of energy release from a power excursion of this reactor is estimated to be 4.54 times 10^8 calories. Within this limitation and others noted here and elsewhere in the text, this report is presented for information purposes."[16]

The limited value of the containment shell or dome, from the standpoint of public safety, is particularly understood by those who have some appreciation of the consequences of sabotage or other possibilities of planned destruction.

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[16] "Containment Study of the Enrico Fermi Fast Breeder Reactor Plant." U. S. Naval Ordnance Laboratory, White Oak, Maryland. NAVORD Report 5747. 7 October 1957. pp. i–ii.

(Some descriptions of its protective value are reminiscent of the Middle Ages and indicative of the controversial nature of this design concept.)

"Compelling Reasons" Criterion is Sound and Desirable

One of the questions before this Court is whether the Commission must establish "compelling reasons" before it can approve the location of a reactor near a heavily populated area. However, the petitioners claim that this would "seriously impede and, in significant areas, might even block the programs and policies that the Atomic Energy Commission had carefully developed" with regard to atomic power development in this country.[17]

In view of the dangers in an atomic power plant, as acknowledged by the passage of the Indemnity Act, it is difficult to visualize any "compelling reasons" which could be cited in support of locating a reactor power plant near a populated area. It may be argued that to require the location of an atomic plant in a remote area would result in greater cost of such power to the consumer, and thus postpone the day when atomic power would be economically competitive with thermal or hydro power. However, such an argument lacks merit for three important reasons: (1) It tends to disregard the question of public health and safety; (2) references to atomic power becoming "economically competitive" with electricity produced by conventional means are meaningless because no acceptable basis for comparison of costs between the two methods is available;[18] and (3) it ignores the fact that hydroelectric plants, of necessity, frequently are located at great distances from the service areas.

While it may be argued that the possibilities of an atomic disaster are "believed" to be extremely remote, any effort to claim this as sufficient justification for locating an atomic power plant in the vicinity of a populated region must be regarded as a gross violation of professional engineering responsibilities. To ignore available alternatives and knowingly to expose a large population to a hazard of unprecedented magnitude, however remote its occurrence may seem, must be regarded as a gross violation of moral and ethical standards, not only in engineering but also in industry and in government. For a government or its agency to violate such standards and, in addition, to offer incentives which contribute to the violation of such standards, must be regarded as a revolutionary departure from the fundamental principles established by the Constitution of the United States.

VIII. A SILENT REVOLUTION IN OUR FORM OF GOVERNMENT

In this technological age the influence of the scientist and of the engineer (the experts) has assumed tremendous importance in governmental affairs. It may not be remiss at this point to call attention to the relatively simple device by which the highly complex field of science and technology, when dominated by governmental authority, can be applied over a period of years to the introduction of revolutionary changes in our form of government. This is particularly true where we find displacement of independent professional respon-

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17 Petition for a Writ of Certiorari filed by the Government and AEC, No. 454, This Term. p. 11.

18 All of the cost components of conventional power plants are determined through the competitive operations of a free market. On the other hand, many of the comparable costs of atomic power plants are established administratively by governmental authority.

sibilities, or where a commission is so constituted that it regulates its own acts. It is out of such procedures that a new system of "administrative law" is born. Over the years this tends to grow up to form a new legal structure in place of our conventional system of the "rule of law"—and generally beyond the reach of Constitutional controls and our judicial system. We have been warned that eventually such a legal structure can deteriorate into "administrative lawlessness."

The trend towards administrative procedures and law was clearly outlined by the late Lord Chief Justice of England in 1929:[19]

> "Two main obstacles hamper the beneficent work of the expert. One is the Sovereignty of Parliament, and the other is the Rule of Law.
>
> "A kind of fetish-worship, prevalent among an ignorant public, prevents the destruction of these obstacles. The expert, therefore, must make use of the first in order to frustrate the second.
>
> "To this end let him, under Parliamentary forms, clothe himself with despotic power, and then, because the forms are Parliamentary, defy the Law Courts.
>
> "This course will prove tolerably simple if he can: (a) get legislation passed in skeleton form; (b) fill up the gaps with his own rules, orders and regulations; (c) make it difficult or impossible for Parliament to check the said rules, orders and regulations; (d) secure for them the force of statute; (e) make his own decisions final; (f) arrange that the fact of his decision shall be conclusive proof of its legality: (g) take power to modify the provisions of statutes; and (h) prevent and avoid any sort of appeal to a Court of Law."

In the same essay the following warning has been sounded:

> "It is, or at any rate it was until quite recently, a commonplace to say that the 'Rule of Law' is one of the two leading features which distinguish our Constitution. So it has been ever since the eleventh century, and if this leading feature or essential characteristic is to be diminished or destroyed, it seems at least desirable that the work of diminution or demolition should be openly and frankly performed, with the British public standing by, fully instructed and deliberately consenting. Nothing could well be more unfortunate than that a change of so fundamental a character should be brought about piecemeal, by subterranean methods, which might escape general observation until the mischief had been carried to completion."

IX. ISSUES RELEVANT TO THE QUESTIONS BEFORE THE COURT

1. Technology has clearly emerged as a mighty shaper of human destiny. With the development of science and engineering to this dominant role, scientists and engineers have the responsibility of opposing the harmful exploitation of these powerful influences.

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[19] The New Despotism, by Hewart of Bury, Rt. Hon. Lord. Lord Chief Justice of England (dec). (Ernest Benn, Ltd., London), pp. 20, 23.

2. The two areas of responsibility, as between science and engineering must be clearly understood. Scientific truth is naked truth. A scientific principle is a naked principle. Engineering truth is fully clothed in ethics and morality. It is founded on the proposition of individual responsibility. In the application of scientific principles the engineer is expected to serve the public interest with due regard for the preservation of the Rule of Law and our Constitutional system of government. In developing new plans for the future, the engineer interprets the experiences of the past and adds the vital ingredients of imagination, sound judgment and integrity.

3. The atomic age has brought out a major biological factor in our world. The development of atomic power installations has brought with it the problem of radioactive hazards which is becoming an ever increasing danger to human life. In the application of this new science, safety of human beings is the most important consideration. Nuclear radiation not only endangers their immediate health, but also may harm or destroy their offspring.

4. The operation of a large atomic power plant involves many people; a failure in its control can occur at human hands by careless handling, lack of experience, by accident, or by criminal action such as theft or sabotage. Failure can also occur through errors in design of the complex and highly technical apparatus. A general release of radioactive materials, as has already happened, allows them to be spread over the countryside and into the rivers, ultimately reaching man through water and food of all types. "With all the inherent safeguards that can be put into a reactor, there is still no foolproof system. Any system can be defeated by a great enough fool. The real danger occurs when a false sense of security causes a relaxation of caution."[20]

5. The individual scientists and engineers, as well as the leaders in their professional societies have a traditional responsibility of presenting truthful information on both successes and failures in their work and to protest against efforts to misuse their services. Unfortunately the field of atomic power is suffering from lack of interest and concern on the part of most engineers, and from lack of responsible leadership. Furthermore, it is clouded by a variety of professional papers and publications, many of which are misleading or purely propaganda. The lessons of experience in this field are in their embryonic stage and, as the National Academy of Sciences has stated: "Present experiences give us only a shadow of a presentiment of what is yet to come."

6. The atomic power plants which for the most part are being undertaken by private industry at a loss are intended to develop technical knowledge and experience. "There was always a sort of threat, however, that if private industry did not do so the government would build the plants itself. What, if any, influence this had upon private industry's decision it is not possible to say."[21]

7. The threat of government competition to gain political objectives has been the subject of much discussion, as for example:

> "There can be little doubt, when government owns and operates a significant proportion of the capacity to produce electric power, that it gives

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20 "The Safety of Nuclear Reactors," by C. Rogers McCullough, Chairman of Advisory Committee on Reactor Safeguards, AEC. In 1955 Geneva Conference Proceedings (New York, United Nations, 1956) Vol. 13, p. 79.

21 "Atomic Energy in a Free Society." Paper presented to Mont Pelerin Society, September 7-12, 1959. In "Il Politico," University of Pavia (Italy), 1960, Vol. XXV, No. 2. p. 296.

to the government a greater ability to dominate and manage other economic activities. Those who favor centralized economic planning (or socialism in the sense of government ownership and operation of the basic industries), are naturally concerned about the role of government in the atomic industry. In the United States, the socialist voice seems to make itself heard by means of the public power advocates in our national legislature, who desire to retain nuclear produced electric power as a national monopoly. If this is possible, not only for electric power but for other aspects of atomic energy as well, the degree of central direction of all economic affairs would be increased and facilitated. . . ."[22]

8. The tendency of technicians to favor centralized planning was examined a few years ago, with great clarity and understanding.[23]

9. It is an ominous spectacle to see governmental authority taking charge of scientific discovery, and undertaking public developments without the benefit of an independent and responsible engineering profession to provide the moderating controls of ethics, morality and justice. This could eventually lead to the destruction of our form of government.

10. History has taught us that when political leaders and administrators in authoritative positions find themselves captivated by the premature application of scientific principles, and choose to take overriding control of them for the purpose of gaining high influence or domination over people and nations, without regard to the hazards or harmful consequences, they are practicing a system of usurpation and immorality in government, and are betraying a public trust.

11. The fundamental issue before this Court is not the simple question whether a specific atomic power plant should or should not have been constructed at a particular site. The basic issues are:

(a) Shall the Government of the United States, by legislation and administrative decision, engage in and foster the application of scientific principles under policies which violate the elementary codes of ethics, morality and justice which have been established by our founding fathers?

(b) Shall the Government of the United States, by the threat of direct competition with its citizens and under its own special rules, place in a defensive position those who are engaged in upholding our system of free and private enterprise under competent State regulatory controls?

(c) Shall the Government of the United States, without the full knowledge and understanding of all its citizens, provide special inducements and incentives for corporations and individuals to engage in the unsound application of scientific principles which contain the hazards of destruction of great numbers of human lives?

(d) What are the responsibilities of scientists and engineers who encourage or condone the enactment of laws for the building of atomic power plants where they will stand as constant threats of disaster to a large number of people at some unexpected time?

12. Whatever may be argued as having been the intent of Congress in the enactment of certain legislation, it must be assumed that Congress expected

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[22] "Atomic Energy in a Free Society," supra, note 21.

[23] "The Counter-Revolution of Science," by F. A. Hayek, Free Press, Glencoe, Illinois. 1952. See esp. Chapter 10, "Engineers and Planners."

the highest standards of professional engineering to be maintained for the health and safety of the public. Furthermore, it is evident that any legislation which creates a conflict with the essentials of professional freedom, or which invites a relaxation of professional standards, can be rectified.

13. It is high time we face up to the hypocrisy of our assumptions, and that we express an angry and solemn warning against varieties of intellectual corruption. We must learn to say "No" to both client and cash when the proposition turns out to be something less than the best. The abandonment of principle for expediency is an advanced symptom of the decay of popular institutions, and the plain fact is that the sickness of an acquisitive society has become so acute we must either redeem it or perish. We must take a moral and principled stand against sacrificing the future of our children and of our children's children and against depriving them of the freedom which is their birthright.

14. Science can provide the answer to many questions but beyond science is God who made both man and science. Man is only beginning to discover science but he is now learning that he can survive on this earth only if he applies science for the benefit of mankind according to the Will of the Creator of all things.

CONCLUSIONS

(1) This Court should find the Atomic Energy Act of 1954 precludes the Atomic Energy Commission from approving a site for an atomic power reactor near a populated area.

(2) The Commission, in granting a permit for the construction of an atomic power reactor, should be required to make adequate findings with respect to the safety of its operation.

(3) The general problems of public policy in the field of atomic power call for re-examination.

(4) Renewed emphasis is needed that our Constitutional form of Government must be respected and defended in the development of modern science.

GENERAL ACKNOWLEDGMENT

In addition to the specific references which have been cited in support of this brief, a comprehensive search has been made in a wide range of publications to gather basic facts in philosophy, engineering and human welfare. The synthesizing of this heritage of the past with the issues of today has, in essence, been a process of engineering design, similar to that employed in designing a bridge. Therefore, a general acknowledgment must be included to all who in the past have sought to show the way toward wisdom and understanding.

Respectfully submitted,

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Atomic Power: Fallacies and Facts

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Abstract

The first demonstration of atomic fission occurred in a laboratory thirty years ago (December 2, 1942). The first electricity from an experimental atomic power plant in the United States was produced fifteen years ago (December 18, 1957). Less than a dozen atomic power plants of significant size have been completed and started operating within the past five years; their brief record of operating experiences is grossly inadequate as a basis for responsible engineering (with absolute safety) and for committing large future investments in this new technology. However, in the utility industry, corporate wisdom and good judgment at the Board of Director level has been perverted by massive campaigns of overselling, irresponsible propaganda, and deliberate deception. This paper identifies some of the more common fallacies.

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Introduction

About a hundred years ago the noted scientist James Clerk Maxwell declared:

> Such indeed is the respect paid to science that the most absurd opinions may become current provided they are expressed in language the sound of which recalls some well-known scientific phrase. If society is thus prepared to receive all kinds of scientific doctrines, it is our part to provide for the diffusion and cultivation not only of *true* scientific principles but of a spirit of sound criticism.

Today we can all see that the explosive growth of science in this twentieth century has brought forth "The Scientific Revolution"–"the most violent ordeal in the history of the world"–with a variety of "super-events" such as:

Super-achievements

1) Mass communication by radio and television
2) Mass transportation by surface and air
3) Nationwide and efficient telephone service
4) Nationwide abundance of electricity.

Super-castastrophes

1) Nationwide propaganda techniques and dictatorships
2) World War I and World War II
3) German gas chambers
4) The atomic bomb.

Atomic power has been described in the U.S. Supreme Court as "the most awesome, the most deadly, the most dangerous process that man has ever conceived," and in this context a critical examination demands, first of all, some perspective on the historical position of this new technology.[1]

The revelation of God's power in the atom (and the means to destroy all life) occurred on December 2, 1942. (In terms of human history this ranks in importance with only two other events–the Creation of Adam and the Birth of Christ.) Three years later the tremendous energy in the atom, which had been identified mathematically by Albert Einstein in 1905, was suddenly translated into a "super-catastrophic" reality.

By contrast, the prospects of "super-achievement" remain to be demonstrated; today they exist largely as undisciplined claims, optimistic propaganda, or as a variety of self-delusions. The history of atomic power to date adds up to a very small record of operating experiences, along with a variety of deficiencies and failures. At this stage progress in this new technology has been handicapped by an unprecedented type of promotional effort, both at the governmental and industrial levels, and by a general breakdown in engineering responsibility and control of safety that could culminate in a national catastrophe.

[1] This paper is only concerned with the development of atomic power for civilian purposes under the traditional disciplines of our free enterprise economy and corporate responsibility. Atomic energy for military purposes is quite another matter.

Responsibility for Public Safety

In the past a fundamental factor in scientific and technical ventures has been the concept that the public health and safety are overriding responsibilities of professionally trained engineers, with all that this implies. This concept has been impressively identified by the noted engineer Thaddeus Merriman, who declared:

> The engineer's duty does not lie only in saving a maximum of his client's money. It demands absolutely that the public be afforded a maximum of safety. If a client is unwilling or unable to pay for that maximum then he should not have his project. And what is true in the case of a private client is just as importantly true when the engineer acts for public authority—he must still protect the public—no one else can perform that function.

And a clear definition of "responsibility" has been set forth in these words: "Responsibility is a unique concept: it can only reside and inhere in a single individual. . . . Unless you can point your finger at the man who was responsible when something goes wrong, then you have never had anyone really responsible."

By contrast, in the new postwar technologies we have seen many proposals for impressive science-based projects, but they are being promoted largely by scientists and bureaucrats under political domination, completely devoid of financial responsibility, and under deliberate censorship of any opposition.[2] As a consequence, we are seeing breakdowns in the areas of professional responsibilities, ethical standards, the Rule of Law, public safety, financial controls, and the accounting for public funds.

This situation is particularly serious in the postwar development of atomic power and has become a matter of public concern in all parts of the country. A full professional analysis and documentation of the pros and cons in this new technology could readily fill a book (and remains to be written). However, we can review here briefly some of the basic issues which are now becoming more generally recognized.

Fallacies Versus Facts in Atomic Power

Fallacy 1: The technology of atomic power for "peaceful" or commercial purposes has grown up in the American economy like any other of our basic technologies.

Fact: The controlled release of nuclear fission had its first demonstration as a top-secret governmental monopoly from which the Hiroshima and Nagasaki bombs were developed. After World War II the Atomic Energy Commission (AEC) was created to administer this monopoly and in due course certain ventures were launched for the civilian use of this new technology under the "Atoms for Peace" program. However, the AEC has perpetuated strict monopolistic control and policies of secrecy, along with the production of the uranium "fuel" for nuclear reactors.

Fallacy 2: In matters of "engineering responsibility" for the construction of atomic power plants, the profession's Founder Societies have established adequate guidelines and principles of planning and design to assure maximum public safety.

Fact: When Congress enacted legislation in 1954 authorizing the commercial development of atomic power, the Founder Societies appointed an ad hoc joint committee (of which the writer was a member) with the task of formulating a statement of policy and engineering principles which would serve as a "magna carta" for all engineers. Unfortunately, this committee effort gradually deteriorated to the point where "public safety" as the *first* criterion of design was brushed aside and "commercial feasibility" was given priority. This stands as a major historical tragedy for the profession and for the nation [2].

Fallacy 3: In matters of safety all responsibility for the design of an atomic power plant, and for the safety of the public in the surrounding region, is in the hands of the AEC.

Fact: This is a common misconception which is particularly prevalent among Boards of Directors who have committed their companies to the addition of atomic power plants to their systems. However, one of the AEC Commissioners has identified this fundamental fallacy in these words:

> It must never be forgotten, however, that responsibility for safety of the plant rests with the owner or operator. The regulatory groups, no matter how thoroughly they carry out their function, cannot provide complete assurance that public health and safety will be adequately protected in a power reactor project. . . .

Fallacy 4: Since the United States government, through the AEC, is looking after all problems of public safety, the American people may rest assured that all possible dangers in atomic power plants have been eliminated.

Fact: Through many decades of loyal and conscientious service in some of the older governmental agencies, the American public has developed a high sense of confidence and trust that it is being protected from a variety of dangers. A good example is the U.S. Bureau of Public Health and the notable services of Dr. Frances Kelsey in preventing the marketing of thalidomide pills in this country. However, in the new technology of atomic power the awesome spectacle—opportunists in and out of government first leaping in and then looking at the emerging facts—has created a situation which today can best be described as a "massive chaos."

Fallacy 5: In the licensing of nuclear power plants the AEC gives adequate concern to all factors which might adversely affect the surrounding environment.

Fact: In a recent decision the United States Court of

[2] Scientists have displaced the engineers in the public mind. But we should remember Dr. Edward Teller's definition of a scientist: "The most common activity in which a scientist is engaged is to make mistakes, to recognize them and correct them, and out of this comes discovery." By contrast, the engineer is trained *not* to make a mistake—one serious mistake can ruin his career [1].

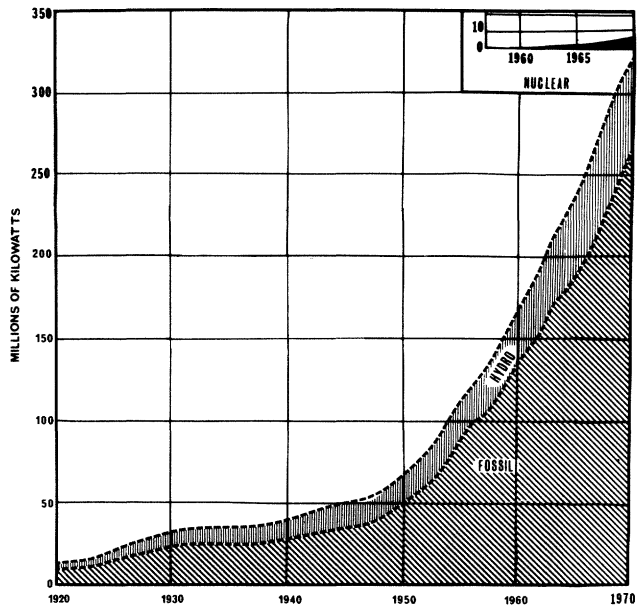

Fig. 1. Installed generating capacity of U.S. electric utilities, 1920 to 1970. In 1970 atomic power had grown to only 1.84 percent of the total.

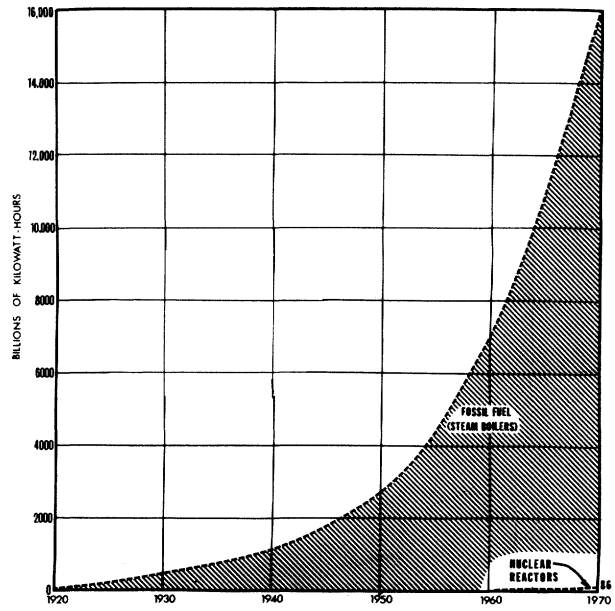

Fig. 2. Cumulative thermal-electric energy production of U.S. electric utilities, 1920 to 1970. Engineering and operating experience with nuclear reactors is insignificant by comparison.

Appeals has ruled that the AEC fails to provide "environmental" safeguards in certain nuclear power projects. The Court has ordered a temporary halt in construction of the $300 million Calvert Cliffs plant in Maryland, and the ruling is causing the AEC to reexamine the designs of more than 80 other projects. This has introduced a new tangle and serious delays in the whole atomic power program.

Fallacy 6: The Boards of Directors of public utilities are people of exceptional competence and judgment and would not allow their customers and their communities to be exposed to a catastrophic type of peril.

Fact: There are evidences that the Directors of certain utility companies and agencies are unaware of the deficiencies and failures in atomic power technology, and that they have failed to make their own analyses of the personal responsibilities they are assuming in authorizing an atomic power plant. This can be demonstrated by two graphical charts, Figs. 1 and 2, which show the historic experiences of the power industry in terms of installed generating capacity and in terms of energy production from fossil fuels. In both cases the position of atomic power is so small as to be barely visible on these charts. With respect to Fig. 2, it is especially important to recall the steam plants of the early decades and the great number of failures in steam boilers; from these failures have emerged the lessons of design and manufacture (and the sense of responsibility in engineering) to bring about the present-day achievements of safety in large high-pressure steam boilers. It is also important to remember that these safety standards have grown up through the constant collaboration and restrictions imposed by the insurance companies, so that today all steam boilers which comply with the approved codes of manufacture and installation are certified to be 100 percent insurable by commercial companies. (No Board of Directors would approve the installation of a steam boiler which fails to qualify for such certification. On the other hand, in the case of atomic power plants, some Boards of Directors are openly ignoring this disciplinary influence for the protection of public safety.)

Fallacy 7: The atomic power plants owned by the electric power companies and public agencies are fully insured just like their steam plants.

Fact: This simple statement sounds quite reassuring to an uninformed public which places its confidence in America's great industrial enterprises. However, a careful analysis of the facts identifies this declaration as a great hoax or a deliberate fraud on a trusting public. Briefly, when the first atomic power plant near Detroit was nearing completion in 1957, it was discovered that the American insurance companies were unwilling to write the conventional property and third party liability insurance for this plant. (The AEC's "Brookhaven Report" at that time had estimated that a major accident could result in great human casualties along with physical damage in excess of 5 billion dollars.) At this stage, apparently, the management of the power company gave little thought to the idea of shutting down this plant. Instead, a few so-called "pioneers in atomic power" ran to Washington and persuaded Congress to enact the Third-Party Liability (Price-Anderson) Act. In essence, this new law authorizes the payment of up to $500 million from the public treasury on any one failure of an atomic reactor, and relieves the utilities and insurance companies of a huge financial risk against damages. (The private insurance companies carry only a "token participation" which covers 1 percent of the peril, and have inserted a "nuclear exclusion clause" in every homeowner's insurance

policy.) At the Board of Directors level of the power industry the general attitude appears to be: "It can't happen here," or "This is none of our responsibility."

Fallacy 8: Congress was fully aware of the implications in the Price-Anderson Act but believed that the young industry in this new technology needed a special incentive.

Fact: When this legislation was being considered in 1957 only one dissenting voice was raised by Rep. Chet Holifield who declared his opposition in these words:

> It would provide another government subsidy to atomic power development without any commensurate benefits to taxpayers and power consumers. It would place upon the federal government an enormous potential liability that could reach several hundred billion dollars. This bill is put forth by its proponents as a bill for the protection of the public. . . . The bill is protective of large utilities, industrial companies, and insurance companies which are not willing to adhere to the tenets of free enterprise. . . . You members of Congress are taking upon your shoulders the personal responsibility for writing an indemnity bill which will give these people the coverage that they want *financially* and you will have upon your hearts and upon your minds and upon your souls the responsibility in case there is a blowup in this field.

Unfortunately, this historic warning was ignored. The lobbying for this bill apparently had been managed so skillfully that the Act was passed by both Houses of Congress without even recording the voting.

Fallacy 9: The public is well informed on the Price-Anderson Act and on the insurance coverage which it is intended to provide.

Fact: The public is confronted here with a highly sophisticated new technology, and the controversial issues, despite their importance, are understood by very few. The general lack of concern on the part of the public was reflected in the lack of response to the announcement in August 1965 when the Senate extended the Price-Anderson Act for another ten years (without even a record of the voting).

Fallacy 10: The big manufacturers wouldn't be in the atomic power game if it weren't good business from every angle.

Fact: In the first postwar decade the conservative utility companies were reluctant to take the risk of switching from fossil fuel to nuclear technology, and only a few small atomic power plants were built, chiefly for experimental purposes and to gain some experience. However, with the passage of the Price-Anderson Act in 1957, a revolutionary new concept came on the industrial scene—the perversion of responsibility and the abandonment of primary concern for public safety by engineers and by various Boards of Directors in the power business who decided to join the bandwagon rush into atomic power. Furthermore, the time apparently had arrived for *selling* atomic power plants commercially, and the spokesman for one of the big manufacturers declared:

> Our people understood this was a game of massive stakes, and that if we didn't *force the utility industry* to put those stations on line, we'd end up with nothing.

This manufacturing company even went so far as to brush aside the traditional engineering disciplines for public safety and undertook to sell complete "turnkey" atomic power plants, supplying not only the reactor, generating machinery, and electrical auxiliaries, but taking full responsibility also for building the entire plant—bricks, mortar, and all—at a fixed price [3]. No one could then foresee the turnkey fiasco until early in 1966 when this company quit offering turnkey bids after having lost well over $200 million on such contracts. Besides this financial loss, one of the reactor manufacturers also disclosed to a Congressional committee that "we simply could not afford to jeopardize our very substantial investment in this industry, and perhaps in other businesses, by assuming safety risks. I have no doubt at all that the entire industry holds this view."

Fallacy 11: No member of the public has been killed due to the operation of atomic power plants; hence, the Price-Anderson Act is of no great importance.

Fact: Proposals are currently being offered for Congress to repeal the Price-Anderson Act and, unquestionably, this could be one of the most salutary events in the development of safe atomic power plants. However, back in June 1965, when new committee hearings were held in the nation's capital on the question of extending this Act for another ten years, a total of 30 witnesses appeared and advocated extension. When one of the Congressmen asked what the effect would be if the Price-Anderson Act were *not* extended, one of the witnesses from the insurance industry replied: "It would be my guess that the system of economic channelling that Price-Anderson more or less stimulates might very well break down. . . . And it would depend largely *on the financial responsibility and integrity of each nuclear operator.*" (Emphasis added.)

Fallacy 12: Atomic power is the greatest development for the electric utility industry, for the general public, and for our country.

Fact: Once the bandwagon rush for atomic power got underway, even some of the better engineering companies went after the business, but without assuming the engineer's traditional responsibility for public safety. They were willing to leave these responsibilities to the AEC and to the Price-Anderson Act. Under AEC guidelines arbitrary standards for "postulated designs" were established which took account of a limited range of "credible" accidents. Design criteria of a more severe nature which might greatly increase the cost of an atomic power plant were placed in the category of "incredible accidents" and these could be dismissed from further consideration.

Fallacy 13: Even if a reactor should fail and release its highly radioactive fission products, none of this destructive contamination would reach the surrounding region because it would all be entrapped in a special containment structure built over the reactor and its auxiliaries.

Fact: This new design concept appeared in the earlier atomic power plants in the form of a relatively thin steel dome. This picturesque structure provided a certain amount of mental comfort for the designers who believed that they had provided special safety precautions, but in due course

confidence in such structures began to decline. In the more recently built plants the reactors are housed in heavily reinforced concrete silos, but these are still of doubtful value as protection for the surrounding regions.

Fallacy 14: Investors may safely commit their savings to the construction of an atomic power plant with full assurance of earning a fair return on the investment.

Fact: Under the licensing procedures established by the AEC, a utility company is only granted a construction license and may proceed with the three- to five-year program of design and construction without prior assurance that an operating license eventually will be granted by the AEC. In the meantime it is presumed that the necessary research will be undertaken during the construction period for resolving any design or safety problems. When the construction has been completed, a further hearing by the AEC will determine the adequacy of all safety features as a condition for granting an operating license. (Unfortunately, no clear and adequate warning appears in the financial prospectus of the borrower to alert the investors to this peril to their investment.)

Fallacy 15: Electricity generated in an atomic power plant is cheaper than the energy generated in coal- or oil-fired steam plants.

Fact: This claim is becoming recognized as a hoax. We would do well to remind ourselves of the notable comment by a former AEC Director of Reactor Development:

> Figures in the literature on estimated cost of atomic energy vary by at least a factor of 10, I am not going to try at this time to give you more accurate cost figures for three very good reasons:
>
> (a) They do not exist even within the Atomic Energy Commission.
>
> (b) If they did exist they could not be released for security reasons.
>
> (c) If they did exist and if they could be released I wouldn't believe them anyway.

This can be confirmed when we consider the complex processing involved in converting uranium ore to fuel rods for a reactor. Such processing consumes tremendous amounts of electricity and the AEC is generally regarded as the largest consumer of electricity in this country. Granted that the AEC is engaged in a variety of activities, it seems reasonable to assume that in the postwar era most of the AEC's electricity consumption has gone into the production of nuclear fuels. The facts presented in Fig. 3 bring out an impressive story. Since the end of World War II the AEC's cumulative total consumption of electricity amounts to 805.2 billion kWh. whereas the electricity generated by all of the U.S. atomic power plants currently in operation amounts to only 86.04 billion kWh. This helps to identify the basic fallacy that uranium is just a substitute for coal or oil.

Fallacy 16: Atomic power is the cheapest and most economical type of electric energy.

Fact: In view of the high subsidies inherent in the production of nuclear fuel, a factual demonstration of basic economics in comparison with coal- or oil-powered steam

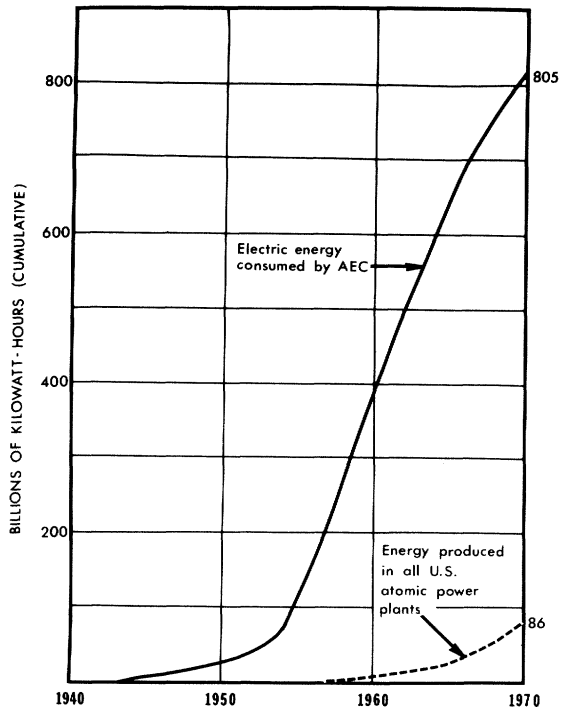

Fig. 3. Cumulative total of electricity *consumed* by the Atomic Energy Commission for the processing of uranium and other purposes, in comparison with the electricity *produced* to the end of 1970 by *all* U.S. atomic power plants (central stations).

plants has never been published and currently is not considered within the realm of feasibility.

Fallacy 17: A total of 128 civilian reactors are currently "operable," 53 large atomic power plants are under construction, and 34 additional plants are being planned.

Fact: The 128 "operable" reactors include 109 small test, research, and university reactors. This quickly brings the number of central station electric power reactors down to 19, according to official AEC statistics. Of the 19 plants declared "operable" at the end of 1970, 6 had less than 1 year of operating experience with the inevitable "startup" difficulties, and another 4 plants encountered a variety of shutdowns which brought their capacity factors to less than 50 percent for the year. This leaves only 9 plants, but these only have rated capacities between 200 and 575 MWe. Nevertheless, electric power Directors have committed their companies and agencies to some 85 large reactors with an aggregate capacity of over 79 000 MWe, and with many reactors rated at 750 to 1000 MWe—considerably greater than any reactor operating at the end of 1970. (See Fig. 4.)

Fallacy 18: Broad claims are being advertised that atomic power plants are being operated with such a high degree of safety that the public need not be concerned about radioactive exposures.

Fact: The sum total of experience to date with the few atomic power plants currently in operation is so small that it is quite impossible to draw reliable conclusions for the future on matters of long-term safety. The refusal of the

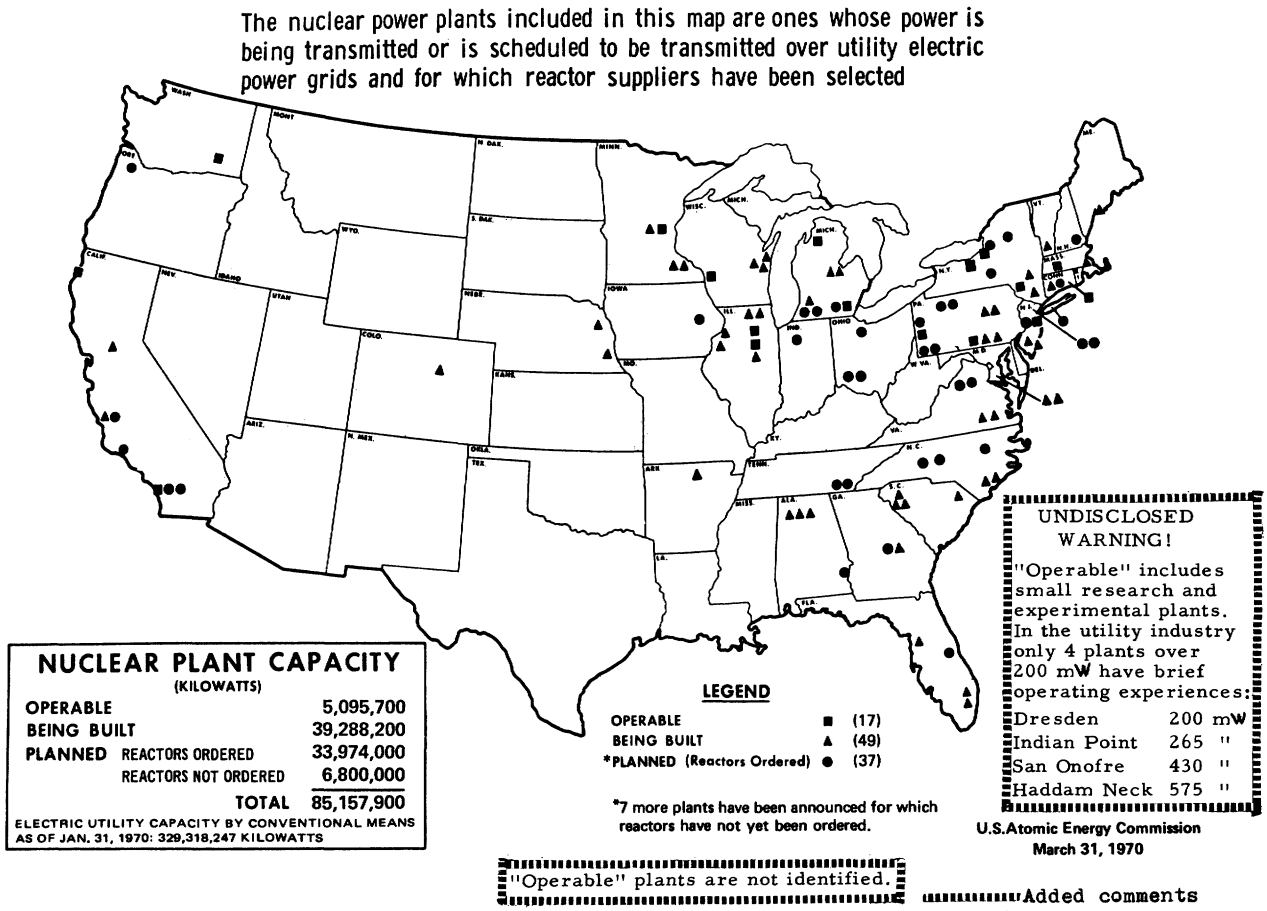

Fig. 4. Map published by the AEC showing U.S. atomic power plants under construction or planned by the utility industry without the benefit of extensive operating experience.

private insurance industry to write adequate financial protection speaks for itself [4]. The potentialities for massive catastrophe in the event of failure or sabotage of a large atomic power plant are beyond human comprehension.

Fallacy 19: In the design and location of an atomic power plant the AEC regulations provide adequate safeguards against all perils.

Fact: In April 1967 the AEC finally published regulation 10 CFR, Part 115, which authorizes the design and location of atomic power plants without complete protection of the public against the perils of sabotage of all types. Obviously, the elimination of this design requirement helps to reduce the cost of building an atomic power plant; but the net result is to create an open invitation for sabotage which could be every bit as catastrophic as the consequences of an atomic bomb. (This peril is particularly great since fissionable materials can be diverted for the making of atomic bombs.)

Fallacy 20: There is no problem in disposing of the radioactive waste products from an atomic power plant.

Fact: The general problem of disposing of highly radioactive waste products is looming constantly larger and a variety of studies are underway, including the storage of such products in abandoned salt mines and other disposal grounds where the residual radioactivity might be allowed to decay in a matter of many decades, if not centuries.

Fallacy 21: We are running out of oil and coal and must switch to atomic power to save the future.

Fact: This is purely a propaganda statement. No one knows the extent of useful resources hidden in the Earth's crust, nor what future generations will devise for locating and utilizing presently unknown fuel resources. On the other hand, in view of the presently limited knowledge of uranium deposits it would be easier to claim that these are totally inadequate for meeting the demands visualized by the promoters of atomic power.

Fallacy 22: The bright future in atomic power lies in the "breeder reactor" which produces more fuel than it consumes.

Fact: This propagandized claim is presumed to become a reality ten or more years from now. Propagandists have actually succeeded in writing speech material for national leaders who blandly assert: "Our best hope for meeting the nation's growing demand for economical clean energy lies with a fast breeder reactor. Because of its highly efficient use of nuclear fuel, the breeder reactor could extend the life of our natural uranium fuel supply from decades to centuries. . . ."

Fallacy 23: All basic research has been completed by the AEC and there are no major unknowns in the design of atomic power plants for maximum public safety.

Fact: Just in recent months responsible scientists have disclosed that some of the AEC's testing programs indicate that emergency safety systems might not function adequately in the event a reactor should lose its cooling water (loss-of-coolant accident). They declared: "In such circumstances the reactor core would be expected to melt down and breach all the containment structures, very likely releasing some appreciable fraction of its fission product inventory. The resulting catastrophe and loss of life might well exceed anything this nation has seen in time of peace." At this late stage the AEC is currently appealing to Congress for more money to support research on the safety of conventional, water-cooled nuclear reactors on the premise that significant "uncertainties" in the performance of reactors remain, and that "urgent" work is yet to be done to solve these uncertainties. Concurrent with efforts to speed up research on this hazard the AEC has released a statement declaring that "it is the engineering judgment of the regulatory staff that meltdown of the reactor core after a loss-of-coolant accident *is not credible,* and thus the consequences of meltdown are not considered in our evaluation of the safety of nuclear plants."

Fallacy 24: American engineering colleges are producing competent graduate engineers for this rapidly growing new technology.

Fact: Most universities offering courses in nuclear engineering have developed curricula which are primarily concerned with the science of nucleonics and with basic research, as contrasted with a thorough training in professional responsibilities and disciplines. No Chairman of a Nuclear Engineering Department has emerged and become recognized as the spokesman for the overriding ethical and professional disciplines, and this also applies to Deans of Engineering.

Summary

In summary, it may be stated that the "Scientific Revolution" of the twentieth century has been exploited and subverted in our country by the "political-scientific" complex. This complex, in developing the new technology of atomic power, has deliberately discarded our traditional system under which the planning and organizing of productive scientific ventures has been in the hands of responsible professional engineers whose first duties are to protect the public health and safety—and to serve the best interests of the public. Instead, this complex has established, among others, a revolutionary new policy for the production of atomic power by means of generating plants whose factors of safety are so low that they do not qualify for complete insurance coverage in the same way as has traditionally grown up with fossil-fueled steam plants. The full significance of this situation is likely to become understood only in the aftermath of a nuclear catastrophe.

The engineering profession, in particular, must be ever mindful of two profound warnings by Herbert Hoover:

1) Technology without intellectual honesty will not work.
2) Our greatest danger is not from invasion by foreign armies. Our dangers are that we may commit suicide from within by complaisance with evil. Or by public tolerance of scandalous behavior. Or by cynical acceptance of dishonor. These evils have defeated nations many times in human history.

References

[1] A.J. Ackerman, "Slow death of a free profession," *IEEE Trans. Aerospace and Electronic Systems,* vol. AES-7, pp. 418-428, May 1971.

[2] ——, "Atomic power—A failure in engineering responsibility," *Trans. ASCE,* vol. 128, pt. 5, 1963.

[3] "G.E.'s costly venture into the future," *Fortune,* p. 93, October 1970.

[4] A.J. Ackerman, "Atomic power—Who looks after public safety?," *IEEE Trans. Aerospace and Electronic Systems,* vol. AES-5, pp. 363-375, May 1969.

Adolph J. Ackerman (SM'49) was born in New Ulm, Minn., on April 21, 1901. He attended Martin Luther College, and received the B.S.E.E. and C.E. degrees from the University of Wisconsin, Madison, in 1926 and 1933, respectively.

His experience in the planning and construction of power plants includes a six-year assignment in Brazil, where he was in charge of designing and building a million-kilowatt power program, including the first large underground hydropower plants in the Western Hemisphere. For a number of years he served the World Bank, making feasibility reports on power developments located chiefly in South America and India. With the advent of the new technology of atomic power he has paid particular attention to the planning and design of underground atomic power plants, and during the past thirteen years has maintained a comprehensive review of atomic power developments in the United States. Since 1952 he has been an independent consulting engineer on electric power and water resource development.

Mr. Ackerman is a member of the American Institute of Consulting Engineers, American Society of Civil Engineers, American Society for Mechanical Engineers, Eta Kappa Nu, Tau Beta Pi, and Chi Epsilon. He is a registered Professional Engineer in Pennsylvania, New York, Tennessee, California, and Wisconsin.

It is true that the AEC requires every reactor builder to give every possible assurance of the integrity of the reactor vessel (not a "guarantee," however!), but much more than this is required to protect against possible failure of all other components and systems. Only the reactor is exempt from secondary protection against an explosive rupture whose hurtling fragments could easily open the reactor to the sky in many U. S. plants today! The question is whether this exemption is wise, especially in the light of the history of explosions in the steam pressure vessel business, despite the best of precautions; explosions that are happily rare, but nevertheless serious, and certainly not guaranteed never to happen by any responsible firm.

The further question, which Ackerman has wisely raised, is why such an issue should not be openly aired and discussed, and the public clearly appraised of its risks.

Finally, despite the current widespread concern (both national and local) over the pollution of our primary resources of air and water, there seems to be a curious silence on the part of government bodies over the long-range menace which the nuclear power industry may well be to both air and water.

On the one hand, we are insisting on long-range planning to restore the purity of our public streams and city air and ocean beaches. On the other hand, those who blithely project that electricity will be almost completely nuclear by the year 2000 —i.e., almost a 100-fold increase over present nuclear power generation—have yet to show any long-range plan by which the prodigious quantities of fuel reprocessing wastes, both gaseous and particulate, can be isolated with absolute assurance.

Is it possible that some of this unwillingness to face squarely *all* the hazards, and *all* the future problems of nuclear power generation, stems from the "atom-bomb guilt-complex," and the "Atoms-for-Peace" mania generated after the war, by which many feel compelled to promote the growth of nuclear power, no matter how great the ultimate cost, as a salve to the national conscience?

Finally, is it also possible that this obsession to see nothing but a nuclear future for the power business may well be blinding the eyes of both management and government, and deterring competent engineering from investigating better and more durable sources of power for the long-range future?