HURRICANES, FLOODS

The second major type of disaster to be considered concerns tropical circular winds and the floods often caused by them. The worst in recent history, the East Pakistan near-catastrophe, has already been mentioned. A potentially equally dangerous situation exists along the whole east coast of the United States, and although many separate analyses have been made, there appears to be as yet no interdisciplinary assessment of what might lie ahead. During this century many tropical storms have hit the east and south coasts of the United States, including the worst disaster in US history, the drowning of over 6,000 people after a hurricane struck Galveston on 8 September 1900. Since then windspeeds of up to 135 m.p.h. and tides 15 to 20 feet above normal have occurred in the same area ten times, yet the death toll has steadily decreased and thus brought a feeling of false security to the 300,000 people now living permanently below the 20 foot elevation in that area. During the holiday season, this number may double and similar dangers exist the whole way along the Gulf Coast and the eastern areas of the United States.

In addition, large demands for ground water, both industrial and residential, have lowered the ground level, and erosion of sand dunes and beaches has increased the danger. Much has been written, yet little can be done to reduce the real danger if a major hurricane should strike again. Advance warning, from satellites and computer forecasting, has been responsible for lowering the death toll, yet the maximum prediction time which can be broadcast is 10-12 hours, leaving a 50 mile error on either side. Evacuation is beginning to be countered by forecasts of massive jamming of traffic, even if roads are not flooded or otherwise damaged.

Protection against hurricanes along exposed coastal areas has cost Miami $64 million, recreating a 300 foot wide strip of new sand, 12 miles long. In other areas further north the building codes are not strict enough and timber houses replace those destroyed during the previous tropical storm. Galveston after the storm of 1900 constructed a huge sea wall facing outwards to the Gulf, but has failed to protect its shores facing inwards. When on 2 September 1981 nearly a foot of rain fell during 24 hours and four small tornados hit the town, the damage was estimated at nearly $ 5 million, but not a single person was hurt. Yet it is doubtful if Galveston can survive another 1900 hurricane without a death toll in the tens of thousands. It is simply called the irreducible residue of risk, shrugged off by saying "it may not happen to me".

In comparison with the east coast of the United States, Australia may perhaps call herself fortunate that Cyclone Tracy has given Australian Disaster Planners a lesson which will be remembered for decades. Hardly had the Natural Disaster Organisation been set up in Canberra and Major-

General Alan B. Stretton been appointed its Director-General, than Cyclone Tracy devastated Darwin on 25 December 1974. During the following seven days Stretton was appointed by the Australian Government to act in complete command of all relief operations, being himself stationed in Darwin. After the historical evacuation of three-quarters of the inhabitants and restoring major faciities in the town, General Stretton summed up the following lessons to be learnt: Apathy syndrome, communications breakdown, failure of local radio stations, convergence of visitors to disaster area, legislation needed, lack of co-ordination of relief stores, registration and tracing of disaster victims, first aid instruction at secondaty school level in disaster-prone areas, the requirement for centralised control of all disaster areas.

"Disasters caused by enemy attacks are possible, but disasters caused by natural phenomena are certain", Stretton concluded. It does happen in the history of science that one exceptional individual can combine knowledge of one or more disciplines and can thus greatly contribute to interdisciplinary progress. In the history of disaster research General Stretton deserves such a place.

LONDON FLOOD BARRIER

Like Darwin, the story of the London Flood Barrier is equally instructive. Had any interdisciplinary research been carried out in connection with the real danger of a London disaster, the preventative measure of building the largest movable flood barrier in the world could have been avoided. London, like many other towns situated on rivers and near their estuaries, has been flooded many times in its history. But only research in recent decades has determined the particular dangers threatening London. There was the gradual sinking of the southeast of England, about 2.5 cm per century, as an after-effect of the last ice-age. Then the existence of the North Sea storm surges was recognised when a meteorological anti-cyclone to the east and a cyclonic depression to the west of England combined to rush masses of oceanic water around Scotland into the funnel between Denmark and England. A further factor was the dredging of the sandbanks lying in the estuary to allow bigger ships to enter the Port of London. Thus in January 1953 a storm surge coincided with high spring tides and more than 300 people were drowned along the East coast; in the Netherlands the same floods killed 1,400 people. Fortunately the flood of 1953 did not coincide precisely with the Thames high tide, and London itself was spared. London was not so lucky in January 1928 when tides and storm coincided and 14 people died. It was then that the proposals for a flood barrier were first considered and the 1953 events strengthened the demand. However it took precisely 30 years before the barrage was completed at Woolwich and was first used in earnest on 1 February 1983. In those 30 years there had been innumerable reports, warning of the catastrophic consequences if 45 square miles of London had been flooded, with 50 underground railway stations, 35 hospitals as well as the heart of Government in Whitehall inundated. Damage was estimated at thousands of millions of pounds sterling, casualty figures in the tens of thousands.

Elaborate rescue plans code-named "Operation Giraffe" had been formulated by the Armed Services, with forward and rear command posts, with hundreds of assault boats and helicopters on standby. Fortunately these often rehearsed plans have never had to be implemented. But the most extraordinary aspects of the London Flood was the barrier itself. From bank to bank, over half a kilometer long, the barrage consists of four main navigation spans, each 61 m wide. These can be closed in 30 minutes by vertically rising steel sectors, which normally lie below the river bed to allow free navigation. This macro-engineering project cost more than five hundred million pounds and was demanded by the influential shipping interests of the City of London. It will be the biggest movable flood barrier in the world until the Delta Plan of the Netherlands is completed.

What nobody had foreseen, inspite of years of engineering research on the Thames Flood Barrier, was the complete change in social and economic forces during the 30 years from 1953 to 1983. Shipborn container traffic had concentrated at the Tilbury Docks, 20 km downstream from the barrier, and the docks above the barrier, for which navigational access had been requested, had become derelict and abandoned. A much simpler dam with one or two standard locks would now seem perfectly adequate for the few small ships steaming up to the higher reaches of the Thames. Was this totally unforeseeable?

MAN-MADE DISASTERS

Let us now turn to man-made accidents and disasters. By definition, accidents are unforeseen contingencies, and unpredictable. But that they are also inevitable, is only now slowly being realized. Nothing, but absolutely nothing, made by man is perfect and therefore everything will have inherent faults, be they in design, materials or manufacture. All that the best of engineers can aspire to achieve is to reduce the number of accidents, to accumulate sufficient experience, allow a large enough safety factor and include one or more back-up systems to continue operations when a component fails. And most important of all, where humans are involved, provide for their utmost training by the simulation of all kinds of accidents and supply the operators with instruments of simplicity, clarity and reliability.

TANKER DISASTERS

Accident statistics for the operation of large tankers make unhappy reading, not only for the owners and operators, but for all concerned with past and potential future disasters. So for example in 1978, the Amoco Cadiz spilled 220,000 tons of oil onto the coast of Brittany in Northern France; but the number of dead during that year was only 29. In the following year, the total spillage of oil during all accidents was only 105,000 tons, but 177 died, and four tankers exploded. In a wide-ranging interdisciplinary review of tanker safety Captain R. Maybourne (J. Roy. Soc. Arts, July 1980) admitted that accidents occurred because of human error, slackness in obeying operating procedures, and because of the irreducible residue of risk; better training was the most promising answer in his opinion.

However, Captain Maybourne only dealt with the transportation of oil, not of liquefied gases, either natural gases LNG, or refined petroleum gases LPG. Their flammability and the necessity to carry them in highly compressed and liquified state at -175°C makes them certainly the most dangerous cargo carried at sea. On 16 December 1980, the LNG tanker Taurus, capacity 125,000 cubic metres ran aground off the west coast of Japan while carrying its cargo from Indonesia to Japan. Fortunately no serious consequences arose unlike the fictional story of the LPG Tanker Prometheus, whose fate was described a year earlier by Terence Moan in his disaster fiction book The Deadly Frost (Ballantine Books). Prometheus struck a submerged but uncharted obstacle inside New York harbour, ripped her hull and part of her cargo escaped onto the surface of the water; her capacity was 123,000 m^3. A weather inversion at first prevented dispersion of the gases, later they penetrated the New York subway, finally they ignited and the ship exploded. Damage and loss of life were great, as can be expected if such a scenario should ever become reality. Meticulous research had been carried out by the author to describe the disaster and the tale is highly recommended to any port authority contemplating the dangers arising from the transport of liquified gases.

So far the worst accident caused by an LPG explosion occurred on 11 July 1978 when a road tanker carrying 23.5 tons propylene exploded near a holiday camp on a road running parallel to the north east coast of Spain; 200 people were killed instantly, over 150 suffered severe burns. The causes for the explosion were variously attributed to overloading, lack of a pressure relief valve, corrosion, as the tanker had been occasionally used to transport ammonia. and the high summer temperature of 28°C; most likely it was a combination of several factors that led to this accident.

CHEMICALS AND OIL INDUSTRY

Some of the worst man-made accidents have occurred in the chemical industry. In Ludwigshafen, West Germany, 550 people were killed in 1921 during an explosion and subsequent fires, and in 1948 a similar accident in the same town killed 184, 70 were missing and 6,000 were injured. When two cargo ships carrying ammonium nitrate collided in the port of Texas City, Texas, in 1947, exploding and setting on fire an oil refinery plant, 561 people were killed and 3,000 injured. Much less severe was the explosion of cyclo-hexane at Flixborough, England, in June 1974; 28 people died. Then in the 1970s a new industrial risk arose, the production of oil from the sea. It had of course been carried out in the offshore regions of the Gulfs of Arabia and of Mexico for some time, but never before in such dangerous waters as the North Sea.

OIL RIGS

By 1981, more than 100 divers and workers on offshore oil rigs in the North Sea had lost their lives, a loss registered by the oil industry as nothing more than a statistic in oil production economics. Only when on 27 March 1980 the Keilland platform sank in the Ekofisk oil field with the loss of 123 men aboard was there a major investigation. It was concluded that serious flaws in both design and construction were responsible. A 70 mm long crack in one of the welds had existed since the rig was manufactured; this led to the development of a fatigue crack in one of the bracing columns which failed in a North Sea storm. A similar disaster overtook the Ocean Ranger off the east coast of Canada in February 1982 with the loss of 84 men during a fierce storm; structural failure was considered the reason for the disaster. These were by no means the only disasters which occurred on oil rigs. In November 1979 an oil rig off China collapsed and 79 men died; others, fortunately with a much smaller loss of life had occurred in January of the same year when a new rig sank while being towed from Scotland to Brazil; in May 1979 another rig collapsed in the Mexican Gulf, off Galveston. Deadly accidents to divers operating from oil rigs and their attending control ships are too numerous to be considered here and unfortunately little research has been undertaken to improve their working conditions.

The safety of oil rigs and their crews became a highly political question, with human lives balanced against the profits of operators and their many sub-contractors. A highly critical book, The Other Price of Britain's Oil was published in 1981 by W. G. Carson of the University of Edinburgh; his main argument was that the Government Agency responsible for production of oil was also responsible for safety, two objectives fundamentally contradictory. Disaster research is powerless when such conflicts are involved.

COMPUTER AIRSAFETY

The situation is even worse for disaster research when relevant facts are deliberately hidden. Such is the case for certain investigations of air crashes demanding disaster research of a very special nature; this is particularly so nowadays when flight path control is computer predetermined. Two examples might be briefly considered. The Air New Zealand DC-10 which crashed into Mount Erebus, Antarctica, in November 1979, with the total loss of 257 passengers and crew, the third fatal disaster of a DC-10 that year. And secondly the total loss of the Korean airliner, KAL-007 a Boeing 747 in September 1983 with the deaths of 269 passengers and crew, when it was shot down by a Russian fighter. In both cases the position of the aircraft was not the one intended and both had their flight paths computer predetermined. Subsequent official and unofficial enquiries into both disasters left many doubts and it is unlikely that the full facts will ever be known. What research can answer these questions where facts remain secret and when the pilots are dead?

ATOMIC ACCIDENTS

The last type of man-made disasters to be considered is also the worst, the possibility of a malfunction at an atomic reactor leading to the release of very large amounts of radioactivity. Much of the debate about the safety of nuclear power focusses on the large number of fatalities that could be caused by an extremely unlikely, but imaginable, reactor accident. Sir Walter Marshall, FRS, until recently chairman of the UK Atomic Energy Authority, discussed in October 1982 (Atom 312 p.210) the vocabulary used by the media - for example 104,000 killed - compared to the technical description of such an accident. He did not specify what such an accident might involve, for example a melt-down of the core, nor did he mention the direct number of people killed by lethal radiation received in the neighbourhood of the disaster. He did, however, state the increased average probability of cancer for people exposed to 1 rem: a loss of 20 hours in their life expectancy of 70 years. If such a gigantic hypothetical accident should occur in London, with an assumed population of 10 million, it would result in a potential long-term death toll of 1,250 persons. It is doubtful if such figures would assuage public concern, particularly when films like The China Syndrome with their horrific, but not impossible scenario, are given such wide publicity.

WINDSCALE

The first accident to an atomic reactor which received world-wide attention occurred on Friday 11 October 1957, when the graphite moderator in the air-cooled nuclear reactor at Windscale in Cumbria caught fire. It had been built to produce plutonium for British bombs. No-one had ever seen or experienced such a fire or anything like it, and the only solution to the emergency was to put out the fire by drowning the reactor in water. A small quantity of radioactive iodine escaped, and found its way from the surrounding fields, through grass eaten by cows, into milk, which was declared unsafe and was confiscated.

No lasting disaster occurred and no-one was nurt, yet the effect of the accident was widespread, the first ever to be made public. A sister reactor was also shut down for good and the two giant concrete structures with their huge overhanging chimneys stand today, after a quarter of a century, as "monuments to our ignorance" as Lord Hinton described them. The full details of the fire were described 25 years later by Roy Herbert, present at the accident, in New Scientist of 14 October 1982, page 84.

URAL ACCIDENT

Much worse, but not revealed to the west until 20 years after its occurrence, was the accident in the USSR, described in a most interesting piece of disaster research. Dr. Z. Medvedev proved that a large explosion of nuclear waste in the South Ural mountains had occurred in late 1957 or early 1958 (New Scientist 30 June 1977, p. 761). He made a systematic search of the Russian biological literature and found a large number of scientific research reports describing amongst many other facts the behaviour of many different species, from single cell algae to carp, living in highly radioactive contaminated areas. In only one of the papers he found was a location given, obviously a slip in censorship. From the number of generations, up to 30, who had lived in contaminated areas, it was easy to calculate the date of the accident. No loss of human life has ever been revealed.

THREE MILE ISLAND

So far the most serious potential disaster occurred at Three Mile Island. Let me quote the official report:

"On Wednesday, 28 March 1979, 36 seconds after the hour of 4.00 am several water pumps stopped working in the Unit 2 nuclear power plant on Three Mile Island, 10 miles south-east of Harrisburg, Pennsylvania, USA. Thus began the accident at Three Mile Island. In the minutes, hours and days that followed, a series of events - compounded by equipment failures, inappropriate procedures and human errors and ignorance - escalated into the worst crisis yet experienced by the nation's nuclear power industry." (The President's Commission on the Accident at TMI, John G. Kemeny Chairman, published Washington, DC, 31 October 1979.) That such an accident was to occur sooner or later, was brilliantly forecast by Thomas N. Scortia and Frank M. Robinson in their disaster fiction book The Prometheus Crisis, published in 1976; it was made into the film The China Syndrome two years later.

One reads in the Kemeny report "that training did not adequately prepare them (the operators) to cope with the accident at TMI-2" (p. 91) and "the fact that they failed to realize that these conditions resulted from a LOCA (Loss of Coolant Accident) indicates a severe deficiency in their training to identify the symptoms of such an accident" (p.96). Also on page 91:

"Frederick and Faust (two reactor operators) were in the Control Room when the first alarm sounded, followed by a cascade of alarms that numbered 100 within minutes. The operators reacted quickly as trained to counter the turbine trip and reactor scram. Later Faust would recall for the Commission his reaction to the incessant alarms: "I would have liked to have thrown away the alarm panel. It wasn't giving us any useful information".

These must be the interdisciplinary lessons of the Three Mile Island accident:

* Accidents will inevitably happen at nuclear power stations as anywhere else and they will always be unpredictable.

* To keep accidents to minor inconveniences, it will be essential to have in the control rooms operators trained to astronaut standards, and to accord to the best of them salaries and status equivalent to captains of a jet aircraft.

* Only the most modern electronic computer aided instruments and executive controls can find a place in the high technology operation rooms of nuclear power stations.

* And finally, when the inevitable and unpredictable has happened, as unfortunately it must, a highly efficient aid and rescue service should be available; they will have had frequent rehearsals and thus have become near perfect.

DISASTER REHEARSALS

Apparently once a year, each British nuclear power station holds an emergency exercise. Little of these exercises is made public and the general population is never involved; thus little can be said about the effectiveness of such emergency drills. However, one of these was described in full in The Sunday Times of London on 18 May 1980, but giving little detail of what would have happened in the case of a real disaster. All actions and reactions within the atomic power station, Dungeness, went according to plan: the incident assessment team donned protective gear, the local fire brigade extinguished a fire, and a much delayed damage control team finally cleared the way to an emergency valve which was closed and thus brought the "incident" to a close. The exercise was considered successful by those who had planned it and who had prepared the 50 page document setting it out.

In the Federal Republic of Germany, two weeks earlier, a similar emergency drill had been held near the nuclear power station at Biblis. At least theoretically the population in the neighbourhood was to have been warned 30 minutes after the incident, but what would have happened if 60,000 people had been told of it and it was not rehearsed. Buses and trucks would have been made available, but what the private motorist would have done and whether he would have followed the emergency evacuation routes was much in dispute. (Hessische/Niedersachsische ALLGEMEINE 5 May 1980). A real evacuation of any modern large city is generally considered impossible, once panic has been created when a disaster has occurred. One may well doubt if soothing announcements over the radio and television from official sources would have any credence; they would only contribute to the general confusion, as the accident at Three Mile Island so clearly demonstrated.

DISASTER RELIEF

A few final words about disaster relief, a subject that should have the highest priority for interdisciplinary research, when the International Disaster Research Laboratory is established. Today, disaster relief is basically similar to what it has always been - a voluntary, highly uncoordinated affair. Disasters are still too often considered as Acts of God and are dealt with as local resources permit. If luck is on their side, victims receive medicines, food and blankets from their own government, if they are unlucky, their deaths are statistics. Foreign aid, although generously given, is probably the worst cost-effective operation ever mounted, and very rarely reaches the victims in time. Only an International Rescue Organisation with its own stockpiles and experts flown to the scene, can here offer a final and appropriate solution. I pleaded for it repeatedly during the last decade, but have been unsuccessful so far.

IDRL

Let me now sum up the need for interdisciplinary disaster research by giving some details of what an International Disaster Research Laboratory might do. The establishment might not prove as difficult as it appears, as during the last decade a considerable number of disaster fiction novels have been published. Apart from frightening people in general, especially in the nuclear field, this disaster literature has also informed the politicians of the Western world of what natural and man-made disasters might lie in store for us. As a concrete example, R. Doyle's Deluge (Arlington, London 1976), the story of the flooding of London, was considered an important factor in speeding up the completion of the barrage which now protects the metropolis. When politicians are frightened, action can be taken swiftly to prevent disasters, or at least minimise the irreducible residue of risk in man's affairs.

Here then are some of the research areas which might engage the attention of an I D R L, not necessarily in this order of priorities:

* Human behaviour, before, during and after a disaster, including the role of the media, unwelcome visitors and the needs of special groups.

* Pre-planning, warning systems, meteorological forecasting and apathy of populations.

* Demographic trends affecting disasters.

* State of art and science of disaster prediction.

* In-depth hindsight reviews of natural and man-made disasters, with laboratory staff members sent to site for direct observations.

* In-depth literature surveys with particular reference to lessons from historical research (Coates Survey and Ambraseys).

* Constant review of new technology and its possible effects, positive and negative, on disaster situations.

* Develop a simple disaster scale of magnitude.

* Disaster communications analysis, especially role of satellites, disposable radios air-dropped, emergency broadcasting facilities.

* World-wide co-operation with existing accident and terrorist investigation authorities, for example air and sea transportation.

* Training and education of people in disaster areas, rescue rehearsals and emphasis on First Aid teaching in schools.

* Investigate possibility of individual household in disaster areas holding emergency food and water supplies as was done in Switzerland.

* Triage and other medical aspects unique to disaster situations.

* Psychological and physiological endurance of workers and victims on disaster sites.

* Evaluation of satellite imagery before, during and after disasters.

* Relief priorities for various types of disasters, value of vaccination.

* Development of simple rescue gear, airdrop of inflatable lifebelts, gin poles.

* Investigate possibility of model experiments of disasters and their prevention, particularly by mathematical models using computers.

* Theoretical investigation of safety factor concept, comparison of its application in various industries.

* Co-operation with Insurance Companies, research and support.

* Best involvement of Armed Services in disaster relief in different countries, especially their Medical Services.

* Legislative aspects of state of emergency and Natural Disaster Acts in various countries.

  and above all develop better rehabilitation, physical and mental, for recovery of disaster victims, carried out by themselves.

Some of the above research areas are already being investigated by Australian and other universities and particularly by the Australian Counter Disaster College and co-ordinated by the Australian Natural Disaster Organisation. But are their resources sufficient to extend their pioneering work internationally and in an interdisciplinary manner to all the research programs outlined above?

TRIBUTE TO NOAH

I want to finish by once more going back in history, to the first recorded great disaster, the Great Flood described in Genesis. Noah was in fact the first search and rescue coordinator. He analysed the risk and trained his sons. Ignoring the ridicule of those whose visions were less keen than his, he constructed his rescue vehicle; gathered the family; searched out the animals to perpetuate all kinds; and when the flood came he set sail. While we may lack Noah's direct communication with the Lord, the lessons of the Ark - analysis, equipment and training - are as valid today as they were in Noah's time.