Asbestos and shipbuilding: fatal consequences

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Medical History

Asbestos and Ship-Building: Fatal Consequences

John Hedley-Whyte, Debra R Milamed

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SUMMARY

The severe bombing of Belfast in 1941 had far-reaching consequences. Harland and Wolff was crippled. The British Merchant Ship-Building Mission to the USA was being constrained by the UK treasury. On being told of the Belfast destruction, the British Mission and the United States Maritime Commission were emboldened. The result was 2,710 Liberty Ships launched to a British design. The necessary asbestos use associated with this and other shipbuilding, after a quarter century or more latency, is a genesis of malignancy killing thousands. Reversal of studies on asbestos limitation of fire propagation was crucial to Allied strategic planning of mass-fires which resulted in the slaughter of one to two million civilians. Boston and Belfast institutions made seminal discoveries about asbestos use and its sequelae.

Key Words: Asbestos, Shipbuilding, Standards, Incendiary bombing

INTRODUCTION

Shipbuilding in World War II is a significant aetiology of the malignancies caused by asbestos. US incendiary bombs contained asbestos and possibly air-raids disseminated the risk. Certainly warfare critically influenced the trade and application of asbestos. Regulation and risk-analysis was thoughtful and based on the history of mass-fires which occur rarely. Hamburg (1943), Dresden (1945), Tokyo (1945) and a score of other Japanese cities (1945) were destroyed by mass-fires triggered by incendiary bombs. Kassel, Darmstadt, Heilbrun, Wuppertal, Wesar, Magdeburg, Wurzburg, and possibly Lübeck and Belfast (1941-45) also suffered the same fate. Most large fires are line-fires: for example London (1666), Chicago (1871), San Francisco after the 1906 earthquake and Los Alamos (1999). Mass-fires have a unique feature which consists of almost instantaneous combustion of many fires over a large area. Enormous volumes of air are heated, rise and suck in new air at hurricane speed. The terms “conflagration” and “fire-storm” are poorly defined and should be eschewed.

The roles of Queen’s University and Harvard in description, history and risk assessment of the diseases caused by asbestos - essentially all mesotheliomas, 3-5 percent of cancer of the lung and asbestosis - is long-standing and far-ranging.

LOGISTICS OF ASBESTOS

US asbestos use in the Depression year 1932 was 197 million pounds annually. By 1937, it was 633 million. During the World War II years it averaged 783 million pounds. During the early Cold War rearmament it exceeded 1,400 million pounds, which did not decrease until the middle 1970s. In 1990 it was 90 million pounds. Asbestos use in the United Kingdom follows a similar historical pattern (Tables I and II).

Asbestos is chiefly mined in South Africa (and Zimbabwe), and in the Province of Quebec especially near the towns of Thetford Mines, Asbestos and Black Lake. The use of asbestos was patented in the late 1820s: the price fell in the 1890s from £32 per ton to £7 ten shillings by 1904. The UK did not mine asbestos and the US imported 94% of its

Table I.

Historical trends in asbestos use in the USA and UK. “Use” is defined as production plus imports minus exports.

<table>
<thead>
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<th>Year</th>
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<th>UK</th>
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<tbody>
<tr>
<td>1930</td>
<td>423</td>
<td>51</td>
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<td>197</td>
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<td>1935</td>
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<tr>
<td>1985</td>
<td>357</td>
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needs during the years 1900 through to 2003, although twentieth century asbestos production has been reported, with the leading producers being Arizona, California, North Carolina, and Vermont. In the early Twentieth Century scientific methods of measuring fire-resistance of materials showed that asbestos was the best and most cost effective insulating material. The British Fire Prevention Committee reported testing of asbestos floors in 1898, and completed an assessment in 1899 of asbestos ceiling. Underwriters Laboratories (UL) was founded in 1894 in Chicago, IL, and the National Fire Protection Association (NFPA) was founded in 1896 in Boston, MA, USA. In 1917 UL issued its Standard Time-Temperature Curve for fire propagation and presented it to the NFPA, who incorporated it into the first edition of NFPA Standard 251, Standard Specification for Fire Tests of Building Materials and Construction in 1918, adopted as an American Standard in 1920. In 1922 Albert J Steiner of UL pioneered a test method to evaluate materials and their rate of fire spread, fuel contribution, and smoke production. The original apparatus - the Fire Hazard Classification Furnace - consisted of a trough about 20 feet long and eighteen inches deep made of yellow pine. The American Society for Testing and Materials (ASTM International founded in 1897) published the first consensus standard on the use of Asbestos, D299-29 in 1930, By World War II this technology had been refined with asbestos board as the standard of noncombustibility. The classification furnace became known as the Steiner Tunnel. These British, UL, NFPA and ASTM standards were used in planning Allied bombing of Japan and Germany.

SHIPBUILDING

In 1922 the US Navy specified asbestos use in new submarines. South African chrysotile asbestos was specified for gaskets, insulation, packing and tape. Transvaal amosite asbestos was essential for light-weight and high insulation. In 1939 the US classified asbestos as a critical material and stockpiling began as world-wide demand exceeded supply.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>USA</th>
<th>UK</th>
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<tr>
<td>1990</td>
<td>90</td>
<td>35</td>
</tr>
<tr>
<td>1995</td>
<td>48</td>
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<td>2000</td>
<td>32</td>
<td>&lt;1</td>
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<tr>
<td>2003</td>
<td>10</td>
<td>&lt;0.05</td>
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In World War II as in World War I shipping was essential. At the outset of World War II the British Admiralty took over control of merchant ship-building and the allocation of asbestos. British Empire new construction of merchant shipping in 1940 was 780,000 gross tons, in the US it was 439,000. In 1943 the British Empire launched 2,201,000 tons and the US 12,400,000 tons.

THE DESTRUCTION OF BELFAST

In late 1940 and early 1941, the second phase of the German Blitz included “The Luftwaffe’s tour of the Ports” and shipyards. Belfast was heavily bombed on the night of April 7 to 8, 1941, on Easter Tuesday, April 15 into16, and on May 4, 1941. On these nights John Hedley-Whyte was out on his family’s lawn off the Dummerry Lane not far from the Lagan River. On the night of April 7, thirteen Belfast inhabitants were killed and twenty-three seriously injured. Water mains were fractured and a timber yard and grain and tar storage facilities were set ablaze. At 3:00 a.m. on April 8th, Rank’s Flour Mill by Pollock Basin was hit, trapping many in the steel and asbestos. The Newtonwards Road, Shore Road and Northern Road were heavily damaged as was McCue Dick’s Works in Duncrue Street and St. Patrick’s Church, Ballymacarett.

The night of Tuesday, April 15th was generally fine. A light wind was blowing and there were some low cumulus clouds until midnight. The German bombers split over Cardigan Bay with 180 flying to Belfast and arriving at 10:40 p.m. They dropped 203 metric tons of bombs on Belfast. Flares were dropped slowly floating to Jordanstown and Whiteabbey. Eleven year-old Mary Wallace described the sky as “red, pure red.” Hedley-Whyte recollects that it was brighter than noon in summertime on his family’s lawn. Within three hours all telephone service was destroyed. The guns of aircraft carrier HMS Furious (Fig. 1) sounded different than the regular anti-aircraft guns. At 1:45 a.m. the task was declared “beyond capacity of fire services.” By 4:30 a.m. four large line-fires raged out of control. Nineteen serious fires burned uncontrollably as did over a hundred less serious fires. Dawn came at 5:00 a.m. Possible mass-fires ranged through York Street and Road, Antrim Road up to Cavehill and the Shankill Road. A large shelter at the corner of Percy Street collapsed. Hogarth Street and Veyan Gardens were obliterated as were Sussex and Verner Streets. A Hudson Street margarine factory was destroyed. “Wiltons, Belfast’s smartest undertaker, was hit and dozens of the black Belgian horses” were killed.

The boiler shop of Harland and Wolff was destroyed as were copper and bolt processing factories. A six-story brick wall of a flax spinning company collapsed. The Ulster Hospital for Children and Women in Templemore Avenue was severely damaged. Eire sent thirteen fire engines: ten large pumps came from Glasgow. Firefighters complained of lack of oxygen in the air. Seven hundred and eighty persons died, many unwounded but asphyxiated by the possible mass-fire. There were also 420 seriously wounded that night. Five German bomber-planes were destroyed.

On the night of May 4th, 204 German bombers dropped 219 metric tons of bombs on Belfast and 96,000 incendiary bombs. Ernst von Kuhren, a German war reporter flying with the Luftwaffe reported: “When we approached the target at 2:30 we stared silently into a sea of flames such as no one had seen before. Then, after a time, our squadron leader, who had already made over one hundred flights said: ‘No one would believe it’. In Belfast there was not a large number of conflagrations, but one enormous conflagration which spread over the entire harbour and industrial area…within the target area there is not one black spot. In the district of the docks and wharfs, factories and storehouses, an area of about one and a half square kilometres, everything was on fire.” Chater Street, part of City Hall and a police station on Glenravel Street were destroyed. From the hills surrounding Belfast this apocalypse appeared “a great ring of fire, an inferno as if the whole city was ablaze.” The whole sky was pink. Pulsating fire could be clearly seen from forty-five miles to the west and the smoke plume from Liverpool to the east. Food became almost unobtainable and for many the water supply was unreliable for ten days.

Harland and Wolff was again very severely damaged. Production went to zero increasing thereafter by ten percent of capacity each successive month. Dublin and other Eire fire brigades once more helped despite scores of delayed action bombs and mines. Water mains again failed and there was difficulty tapping the Farset River and Connswater especially after the tide turned. The Eire units tapped the Lagan.

The Hedley-Whytes’ one hectare lawn was covered with blown burnt debris for three weeks from April 16th. Until the start of Barbarossa, on June 22—the German invasion of the Soviet Union - Belfast refugees streamed past the Hedley-Whytes’ drive night after night (Fig. 2). Some returned each morning to work in the city. One group threatened to eat John Hedley-Whyte’s pet live bantam cockerel, and thereafter he
slept with it in his bedroom. He was forbidden to take his pony and trap near the refugees. The total Belfast deaths in these three raids were approximately one thousand. German aircrew casualties were about twenty-five. The severe destruction of Harland and Wolff and of other British ship-building capacity had far-ranging effects. So did the Belfast fires of April and May 1941. What burned and why was studied and shared with US fire prevention experts. By now, eight months before Pearl Harbour, the US War Department had issued Rainbow 5 which detailed the deployment of 30,000 US personnel to Ulster.

THE BRITISH MISSION TO THE USA

On the night of April 8, 1941, approximately six hours after the end of the first serious Belfast bombing, R Cyril Thompson (RC), a Sunderland ship-builder, landed in the United States. He was there for the second time. On the previous September 2nd he had been summoned to a committee by the fourth Sea-Lord of the Admiralty. RC, born in 1907, was managing director of Joseph L Thompson (Fig. 3). Founded in 1846 in Sunderland, Thompson’s had built Embassage for £95,000 in 1935. With a full cargo she could average ten knots using economical reheated triple expansion engines. On March 7, 1939, after six months construction, Dorington Court was launched. She was ten feet longer and eighteen inches wider than Embassage and powered by a 2,500 horse power engine developed by North-Eastern Marine Engineering Company.

The engine used reheating to raise steam temperature as it passed from high pressure to intermediate pressure cylinders via a system of poppet-valves, through a chamber heated by steam coming directly from the boilers, thus maintaining superheating.

According to RC’s wife Doreen’s diary, “Cyril up to London to see about this America idea. Two (London) raids”.

RC’s meeting was chaired by Sir James Lithgow, the controller of merchant shipbuilding and repairs - a post he had also held during World War I, when Franklin Delano Roosevelt (FDR) was US Secretary of the Navy. FDR had replaced Joseph Kennedy, father of President Kennedy, as head of the United States Maritime Commission, with Rear-Admiral Emory Scott Land, an old FDR friend of World War I. Land had worked as US Secretary of the Navy. FDR had replaced Joseph Kennedy, as head of the United States Maritime Commission, with Rear-Admiral Emory Scott Land, an old FDR friend of World War I. Land had worked as US Naval Attaché in London in the early 1920s when Winston S Churchill (WSC) was Chancellor of the Exchequer. RC left New York on the Western Prince on December 6, 1940, his draft contract documents and rush orders for Hull 607 to allow Hull 611 to eventually become Empire Liberty. RC was allowed £3, five shillings per day for food and accommodation, drawable from the British Purchasing Commission, 15 Broad Street, New York, NY. No mention in RC’s instructions were made as to British design. The main objective was to obtain sixty tramp-type ships averaging 10,000 tons and capable of 10.5 knots.

The British Mission met with Richard Powell who provided the main continuity until the end of the Mission’s remit in late 1943. Powell had been a Cambridge contemporary of RC. On their first meeting with Land it was confirmed that most of the present shipbuilding capacity in the US was already allocated. Land stated “RC’s mission would be completely free to conduct negotiations with US shipbuilding firms…but US Government clearance [must be] obtained. If capital expenditure is required…the British Government would probably have to meet it”. The UK Treasury objected to even this expenditure, but in a UK cabinet instruction on September 16, 1940, RC received a letter stating “The Chancellor of the Exchequer has agreed with the First Lord that our efforts to obtain the construction of new ships in the USA can proceed to the extent of ten million pounds expenditure, the sum to be expended in the next six months limited to five million pounds”.

RC chartered a Dakota plane (DC3), visited thirty-five shipyards and a large number of engineering works and in RC’s words, “innumerable mud-fields and stretches of coast where shipyards might be built”. They worked by day and flew by night and obtained aviation fuel by charm. On October 29th, RC told the Admiralty in London “No large existing yards can undertake work for us. [But] Todd Shipyard Corporation has been practically allocated to us by US Maritime Commission - provided we act quickly”. The British Admiralty then insisted on enlargement of the plans for Hull 607 to allow Hull 611 to eventually become Empire Liberty. The change in ship specification did not alter the building of the new yards. The proposed deal made a mockery of the UK Treasury. RC left New York on the Western Prince on December 6, 1940, his draft contract documents and provisional deals with potential suppliers in his briefcase. When alone some 250 miles south of Iceland the Western Prince was torpedoed and sunk by U-96 whose crew flashes photographed the sinking. Captain Reid, nine crew and six passengers were drowned. RC was asleep when the torpedo struck. “The vessel shuddered and seemed to stop. I threw on more clothes, grabbed my dispatch-case in which were the Mission’s documents and rushed up on deck…I scrambled into one of the lifeboats…We were alone in a waste of sea that was dark grey and menacing. A heavy sea was running and there was a cutting Arctic wind. The temperature was below freezing…Thirty people were huddled in the bottom and the spray froze as it hit them”. For nine hours RC kept pulling at his oar. Suddenly just as a dreadful night loomed, the British Baron Kinnard was sighted westbound. After the
Asbestos and Ship-Building: Fatal Consequences

rescue the Admiralty provided as escort destroyer *HMS Active* and together they made Gourock at 10:00 a.m. on December 18th. RC arrived at Admiralty two days late and Britain signed the preliminary accord on December 20th. The Canadian government joined with financing and extra orders. William Gibbs, a US attorney and engineer of 21 West Street, New York, New York was brought in as chief expediter of mass production of RC’s plans.

RC left England again on April 4, 1941, arriving in New York by air on April 8th. He was told of the latest instalment of the Luftwaffe port tour and the attack on Belfast. In New York, RC met again with Harry Hunter and Richard Powell. There followed a marathon of yard visits and negotiations with top people in the American and Canadian shipbuilding industries. In Washington DC, he met with the US Maritime Commission. On June 10th, RC took a Liberator bomber via Gander back to Prestwick.

On the Atlantic Coast, yards were built for the Liberty ships' standardised mass-production near Baltimore (Maryland), Brunswick (Georgia), Jacksonville (Florida), Savannah (Georgia) and Providence (Rhode Island). On the Gulf Coast yards were built at Mobile (Alabama), New Orleans (Louisiana), Panama City (Florida) and Houston (Texas). On the Pacific Coast, yards were built near Los Angeles (California), Vancouver (Washington), and Sausalito (near San Francisco, California), Portland (Oregon) and the Permanente Yards at Richmond (California) (Fig. 4). Two thousand seven hundred and ten Liberty ships took part in World War II, of which Henry Kaiser’s companies built 43%.

These 2,710 Liberty ships total weight was almost 20 million tons, almost the same weight as Allied and neutral World War II losses. American yards produced 5,000 merchant vessels in World War II. In 1943 the US Navy launched 30,000 warships and in 1944, 45,000. On January 20, 1942, in preparation for this massive expansion of ship-building, the first Asbestos Conservation order was issued. FDR’s presidential order essentially banned the use of asbestos for non-military purposes; priority was given to merchant and US and Royal Navy ship-building. In December 1942, with an acute asbestos shortage, these regulations were further tightened and not relaxed until December 1944. All asbestos conservation orders were revoked by August 31, 1945.

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REVERSE FIRE SAFETY; REVENGE

Forest J Sanborn of Factory Mutual Laboratories and Improved Risk Materials, in 1942...
became a Major in the US Army Chemical Warfare Service, a service whose responsibilities included fire propagation. He was seconded to the UK Government Laboratories at Princes Risborough, where John F Baker (later Lord Baker of Windrush FRS) was in charge of the Design and Development Section of the UK Ministry of Home Security. There the Anglo-American team Stradling RE8 soon co-opted NFP's chief engineer, James K McElroy and his NFP colleague Horatio Bond. RE8 prepared fire vulnerability maps and target analyses which were reversed images of fire-risk maps prepared by the Sanborn Map Company. McElroy states, “We were asked to go into General Lauris Norstadt’s office in the Pentagon with our first Japanese industrial target map. We had the map hand coloured. The reinforced concrete structures were shown in brown, the combustible roof part of the target in red, and so on. We went in and laid it on his desk… [As] Deputy to General Arnold in command of the

boundary of target sectors | natural firebrake

“The plan evidently contemplated starting six secondary fires at points marked (2F) with expectation that they would join to produce a mass-fire that would sweep the entire area. It will be noted that the boundaries of target sectors follow existing firebrakes wherever possible.

Fire No. 1 was kept from spreading laterally and was driven into pocket formed by firebrakes in the upper corner of the sector, about half of which was destroyed.

Fire No. 2 was stopped along the line of rail trackage, although the remainder of the sector was burned out. This was the most destructive fire, yet it did not spread into the next sector.

Stopping of fire No. 3 along an air gap was no doubt facilitated by the diagonal direction of the wind. Six blocks of houses were destroyed, but the remainder of the sector was saved.

For fire No. 4 the same tactics were used as for fire No. 1; lateral spread was stopped and the fire died out against firebrakes without spreading to adjoining sectors.

Fire No. 5 was pinched out along a fairly wide diagonal street in what appears to have been a good example of fire fighting.

Fire No. 6 was actually a series of primary fires in a sector where fire susceptibility was only fair. The stopping of fire No. 5 probably saved this sector from more serious damage.

Obviously the attack was handicapped in this situation by the direction of the wind. On the other hand, the fire defence took full advantage of this fact. In subsequent attacks of this area, the chances of starting a mass-fire would be slight.” (From Fisher GB Incendiary Bombing). Reproduced with permission of McGraw-Hill). Figure and text of legend in public domain.

Incendiary Attack and defence of a Japanese urban area

Fig 5. The planning protocol to Allied bombing generated mass-fire. This photo and its overlay constitute a fire susceptibility plan—a reverse fire protection plan, therefore known as a reverse Sanborn map. This fire susceptibility plan was constructed from photographic reconnaissance by professional fire experts.
Twentieth Airforce, later combined with the Twenty-First, [Norstadt] wanted to send our only hand-coloured sheet of paper right out to General [Curtis] LeMay that afternoon49. So was focused the overwhelming onslaught on each of sixty-nine cities, almost every Japanese city with a population greater than Belfast: sixty percent of Japanese urban areas were destroyed50–51. Nineteen million incendiary devices were dropped on Japan in the first eight months of 1945 (Fig. 5). Two hundred and fifty million incendiary devices were produced by the US Chemical Warfare Service of which 65 million were supplied to the RAF52,53.

The US fire-bombing of Japan from B29 Superfortresses commenced on November 24, 1944 and continued until August 15, 1945, after the second atomic bomb had been detonated above Nagasaki on August 9th. Single raid totals of more than one hundred thousand Japanese civilian fatalities in one mission were achieved several times, overwhelmingly by fire4. For instance, on March 9, 1945, Curtis Le May and his bombers destroyed 15 square miles of Tokyo and killed by recent estimate 130,000 persons55. The mass-fire rushed through Tokyo at 50 miles per hour. From November 1944 to mid-August 1945, Japanese civilian casualties by fire bombing were twice Japanese military casualties of the previous thirty-five months of war, probably 2.3 million versus 1.5 million46. The 2.3 million total is a contemporary estimate of the Canadian War Museum in Ottawa56. Sir Max Hastings writes that mass-fire fatalities are a ‘guesstimate’ and that this fatality figure is closer to one million of which approximately an eighth were the combined result of the uranium and of the plutonium bomb57. Captain Professor Sir Michael Howard OM has written poignantly and incisively on the ethics and shades of justification for and against the causation of mass-fire in World War II19–21. In mid-August 1945, at cease-fire, although 2,550 kamikaze planes had been expended there were still 5,500 left: 5,000 young men were in training to deliver them from dispersed grass strips and caves to cause further untold damage20. Japan had an undefeated and well-munitioned army of over one million soldiers on its home islands. Six thousand Japanese planes were furthermore available for orthodox fighting52,63. Final figures for Japanese deaths due to Allied World War II actions are difficult to ascertain: there exist, in reverse order of magnitude, Japanese official figures, US bombing survey figures, and more recent estimates, a total of 3,553,000 Japanese women, men and children56–58,61,62.

The circumstances and analysis of this horrendous slaughter proved the efficacy and ability of asbestosis to save lives, and its absence to highlight vulnerabilities.

TRUMAN, BAKER AND THE LIBERTY SHIPS

During World War II the Liberty ships suffered structural problems. John Baker was called to Cambridge from Princes Risborough in 1943 (Fig. 6)63. The Cambridge University Engineering Department of which he had become head was commissioned to undertake investigation of the Liberty ship accidents64. Drs Frank B Bull, John Heyman, Michael R Horne and Constance F Tipper co-authored scientific and technical papers with their chief63–65. Frank Bull met with RC who lent a Liberty ship, Empire Duke which RC’s yard had built in 194366. Meanwhile Senator Harry S Truman headed the Special Committee Investigating the [US] National Defense Program. Truman and his committee determined that the steel plate manufactured by United States Steel Corporation for Liberty Ships “was defective and that the physical tests to which the finished steel plate was subjected to determine its tensile strength were faked and falsified”67. Dr Constance Tipper (1894–1995) in her investigations showed some of the steels with the incorrect manganese content to be notch-sensitive68. The Cambridge research on the plasticity of steel laid the foundation for successful replacement of human joints with specialized steels. British-produced steel was more trustworthy69. Truman was selected to be FDR’s Vice-President in 1944.

The other lead investigator to Harry S. Truman, John Baker, had been a popular Clare undergraduate scholar and from 1943 a Fellow. “Baker’s door was always open”63. He and his wife Fiona entertained frequently, and well, sometimes with food from his Brown University collaborators63. As a Clare freshman, John Hedley-Whyte was fed the canard that the Baker’s food came from Harry and Bess’ still in the White House. Margaret, the Trumans’ only child, and later well-known author, died in 2008.

After the experimental physicist Sir Henry Thirkill, Master of Clare since 1939, retired, John Baker was thought to be sometimes tactless,63 especially to his new Master Sir Eric Ashby, a former Vice Chancellor of Queen’s Belfast, a botanist70. The Ashbys’ eldest son Michael was educated at Campbell College, Belfast and subsequently in Baker’s Department where he became in 1989 Royal Society Professor. The other Ashby child, Peter, after Campbell’s
went to medical school at Queen's and from Belfast to a Professorship at the University of Toronto. 

**ASBESTOS POST WORLD WAR II**

By 1955, less than a hundred cases of asbestos-related disease were known to have occurred anywhere in the world. On average, in the United States alone 10,000 persons per year were killed by fire in the first half of the Twentieth Century. Almost forty percent of these fire deaths were children. All of the asbestos-related diseases occurred in adults. The reasons physicians and fire-safety experts were slow to realise the onset of the epidemic of asbestos-related diseases have been well-reviewed. They range from failure to diagnose to unwillingness to read German. One of the most cogent strictures was made by JS Logan, H Bharucha and J Sloan who complained that the Queen’s University pathology report on thirteen cases of mesothelioma in 1958 would have improved industrial health if the occupation of the deceased had been told to the pathologist.

**A FATAL SEQUEL**

Currently 60-92 persons in Northern Ireland die each year from the effects of asbestos inhalation (Fig 7). In the rest of Great Britain, each year in this first decade of the Twenty-First Century, about 1,600 die. In the United States each year, there are approximately 4,000 deaths, attributed at least in part to asbestos. The median age of these fatalities is 73 years. In 1999, 2,485 persons in the US died of malignant mesothelioma and 1,265 of asbestosis without apparent malignancy. The balance of about 300 deaths is attributed to asbestos causing cancer of the lung. The proportional mortality rate for asbestosis of former shipyard workers is sixteen times that of the average of other occupations. These deaths are disproportionately concentrated in areas where, as President Franklin Delano Roosevelt put it, “The bridge across the Atlantic” was built.

![Fig 4](http://www.ums.ac.uk)

(Fig 4) with “Liberty, the ship that won the war”. The timing of the destruction of Belfast -proportionally the most seriously damaged of UK cities, was not to German or Japanese advantage. Parsimony of the UK Treasury was rendered moot and the Allied response overwhelming.

Authors’ conflict of interest: None. J Hedley-Whyte is a Fellow and Award of Merit holder of ASTM International. DR Milamed is honorary secretary of ASTM technical subcommittees.

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