

Asbestos and Ship-Building: Fatal Consequences

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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^{1,2}. 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 eschewed¹.

TABLE I.

Historical trends in asbestos use in the USA and UK. “Use” is defined as production plus imports minus exports^{16,17}.

TABLE I: ASBESTOS USE, MILLION POUNDS

Year	USA	UK
1930	423	51
1932	197	51
1935	348	116
1937	633	187
1940	525	225
AVERAGE, WW II (1940-45)	783	158
1945	756	147
COLD WAR		
1950	1,455	237
1955	1,563	343
1960	1,417	359
1965	1,589	457
1970	1,466	330
1975	1,217	303
1980	785	206
1985	357	82

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-ranging³⁻¹⁴.

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 pounds¹⁵. Asbestos use in the United Kingdom follows a similar historical pattern (Tables I and II)^{16,17}.

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 Lake¹⁸. 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^{16,17} and the US imported 94% of its

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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 Vermont¹⁶.

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 1898¹⁹, and completed an assessment in 1899 of asbestos ceiling²⁰. 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 1920²¹. 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 pine²². 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^{23,24}. By World War II this technology had been refined with asbestos board as the standard of noncombustibility²². The classification furnace became known as the Steiner Tunnel²⁵. These British, UL, NFPA and ASTM standards were used in planning Allied bombing of Japan and Germany¹⁹⁻²⁵.

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 supply²⁶.

TABLE II

The Anglo-American reduction in asbestos use should be contrasted with the 1,000 million pounds per annum use during World War II and the 1,800 million used annually during the Cold War. "Use" is defined as production plus imports minus exports¹⁶.

TABLE II: ASBESTOS USE, POST-COLD WAR MILLION POUNDS

YEAR	USA	UK
1990	90	35
1995	48	22
2000	32	< 1
2003	10	<0.05



Fig 1. The HMS Furious whose guns defended Belfast in the spring of 1941. HMS Furious had been laid down as a battle-cruiser but became operational as an aircraft carrier in 1917 by removal of her forward gun-turret. In the period from the Belfast air-raids of 1941 until a year later, Royal Navy carrier strength was reduced from six to three. Harland and Wolff's Formidable (launched October 31, 1940, gross tonnage 28,095)³⁴ Furious, and Victorious were still active³⁵. In 1941-1942 HMS Furious played a crucial role in the defence of Malta and in battles near the North Cape supporting convoys to Murmansk³⁶. HMS Furious was in Belfast Lough undergoing repairs following her role in destroying 10 German destroyers and one cruiser prior to the Battle of Britain³⁷. Oil on Canvas by Charles Pears, 1919, Courtesy Imperial War Museum.



Fig 2. R Cyril Thompson's only daughter-in-law, Sarah Hedley-Whyte, holds her mother's coat at the November 15, 1941 christening of her brother Michael at St Patrick's Church, Drumbeg, Diocese of Down and Dromore. Colonel Angus Hedley-Whyte, DSO, MS, FRCS, was then commanding officer of the 31st British Military Hospital at Musgrave Park³⁸. God-parents, 31st General Hospital chaplains, nurse from Sligo and the defender of the bantam cockerel are also present.

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 asbestos²⁷. 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 tons²⁸.

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 ship-yards. Belfast was heavily bombed on the night of April 7 to 8, 1941, on Easter Tuesday, April 15 into 16, and on May 4, 1941²⁹⁻³⁴. On these nights John Hedley-Whyte was out on his family's lawn off the Dunmurry 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 Newtownards Road, Shore Road and Northern Road were heavily damaged as was McCue Dick's Works in Duncrue Street and St. Patrick's Church, Ballymacarett³⁰.

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"³³. Hedley-Whyte recalls 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)³⁵⁻³⁷ sounded different than the regular anti-aircraft guns. At 1:45 a.m. the task was declared "beyond capacity of fire services."³⁰ 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 killed³⁰. 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 with four hundred firefighters by destroyer and ferries from bombed Liverpool and Preston. Five heavy and twenty-seven 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 destroyed³⁰.

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"³³. 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"³⁰. 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 east³³. Food became almost unobtainable and for many the water supply was unreliable for ten days.



Fig 3. King George VI and Queen Elizabeth accompany RC (next to Her Majesty) on their visit to JL Thompson's North Sands Shipyard, Sunderland, 1943. R Cyril Thompson, CBE (RC) (1907-69) joined Joseph L Thompson and Company in 1930. In 1935 RC won the Gold Medal of the Institute of Engineers and Shipbuilders. On September 11, 1940, RC was appointed head of the Merchant Shipbuilding Mission to USA. Mr and Mrs R Cyril Thompson entertained the A and J Hedley-Whytes at East Boldon, Co. Durham (1957-59). It was there that reminiscences of the interplay of Belfast and the 1940-41 emboldment of RC in the US took place (Photograph copyright *Northern Echo* and reproduced with their permission).

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 22nd—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 Ulster³⁸.

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 Company³⁹. 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 superheating³⁹.

According to RC's wife Doreen's diary, "Cyril up to London to see about this America idea. Two (London) raids"³⁹. 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 Naval Attaché in London in the early 1920s when Winston S Churchill (WSC) was Chancellor of the Exchequer³⁹. Land was a football star and a pithy public speaker. "If you want fast-ships, fast shipbuilding, fast women or fast horses, you pay through the nose for them"⁴⁰. Possibly Land's testimony was influenced by Harvard Professor of Economics and war-time colleague Joseph A Schumpeter's testimony: "I intend to be the World's best economist, best lover of women and best rider. I am having trouble with the horses"⁴¹.

The remit given RC in London was firstly as head of Merchant Ship Building Mission to the USA, to "Ascertain the types, sizes and numbers of merchant ships that can be built in USA shipyards for delivery by: 30th June 1941, 31st December 1941 and 30th June 1942". Point 4,v was to agree plans and specifications with shipbuilder. Point 4,vi was that "total amount to be paid in the form of 'signing' or subsequent instalments is not to exceed £5,000,000 up to 28th February 1941"⁴².

Harry Hunter, OBE (Technical Director, Messrs. North Eastern Marine Engineering Co. Ltd, Wallsend-on-Tyne)

was instructed together with RC "as early as possible to contact the United States Maritime Commission". "It will be desirable to keep the Maritime Commission fully acquainted with all movement and actions", they were ordered by the British Admiralty Instruction. RC did not take the design specifications of *Embassage*, nor *Dorington Court* nor a third modification which was to become *Empire Liberty*. He took designs for hull 607 *Empire Wave* launched on March 28, 1941. 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 knots³⁹⁻⁴².

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"⁴⁰.

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"⁴⁰. 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"⁴⁰. 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 flash-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"⁴⁰. 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

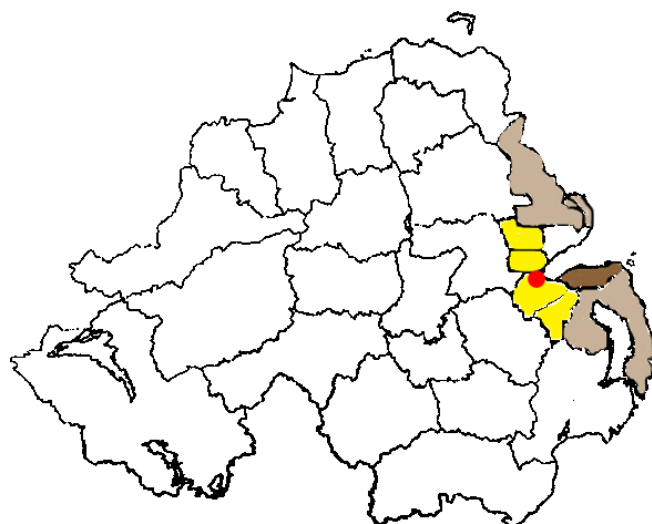


Fig 4A. Male Pleural Cancer Standardized Mortality Rate per 100,000 Males by District Council, 1985-1994



In Northern Ireland (4A) the death rate from pleural cancer generally mesothelioma, is highest in close proximity to Belfast, the most populous Local Government District. During World War II, Harland and Wolff (location designated by red dot), was the UK's largest ship-building firm. Standardized mortality rates (SMR) are shown for ICD-9 codes 158, 163 and 501 for the period between 1985 and 1994 inclusive. Modified from O'Reilly D, Reid J, Middleton, R, Gavin AT, by permission of Oxford University Press¹⁴.

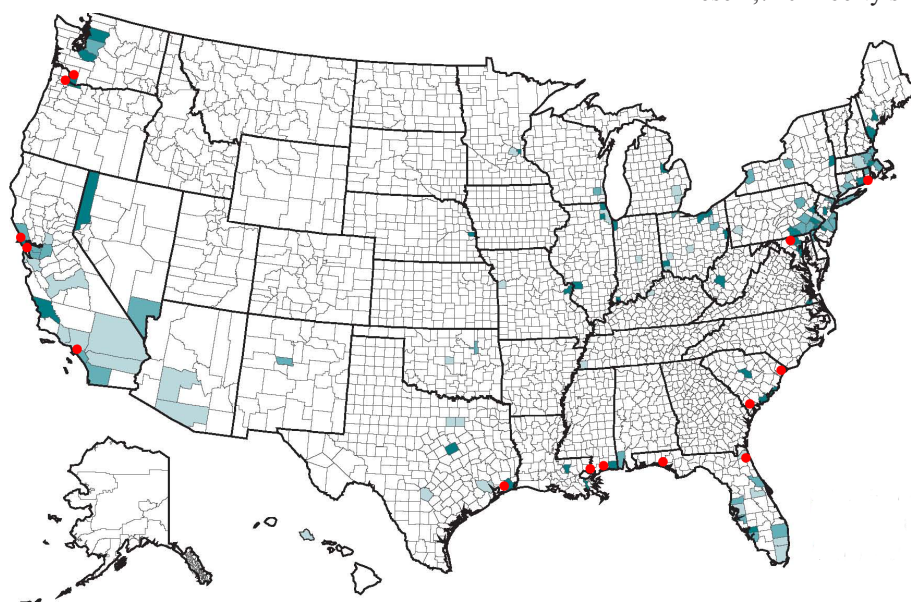


Fig. 4B Malignant mesothelioma: Age-adjusted mortality rates by county, US residents age 15 and over, 1999, with locations of the fourteen Liberty ship construction yards in the USA (red dots)⁴⁴.

Deaths/Million/Year



Note the high incidence of asbestos-related disease in areas surrounding the 1941-45 major Liberty ship-building efforts, and the long latency, often over half a century⁴⁵. The majority of sites of Liberty Ship building were either closed or curtailed in 1945. The proportional rate of asbestos-induced death in former shipyard workers is sixteen times that of the average of other occupations.

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 20th⁴⁰. 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 expeditor of mass production of RC's plans⁴³.

RC left England again on April 4, 1941, arriving in New York by air on April 8th⁴³. 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 Prestwick⁴³.

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 Permanent Yards at Richmond (California) (Fig. 4)⁴⁴. Two thousand seven hundred and ten Liberty ships took part in World War II, of which Henry Kaiser's companies built 43%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^{43,46}.

On January 20, 1942, in preparation for this massive expansion of ship-building, the first Asbestos Conservation order was issued⁴⁷. 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 1944⁴⁶. All asbestos conservation orders were revoked by August 31, 1945⁴⁶.

REVERSE FIRE SAFETY; REVENGE

Forest J Sanborn of Factory Mutual Laboratories and Improved Risk Materials, in 1942

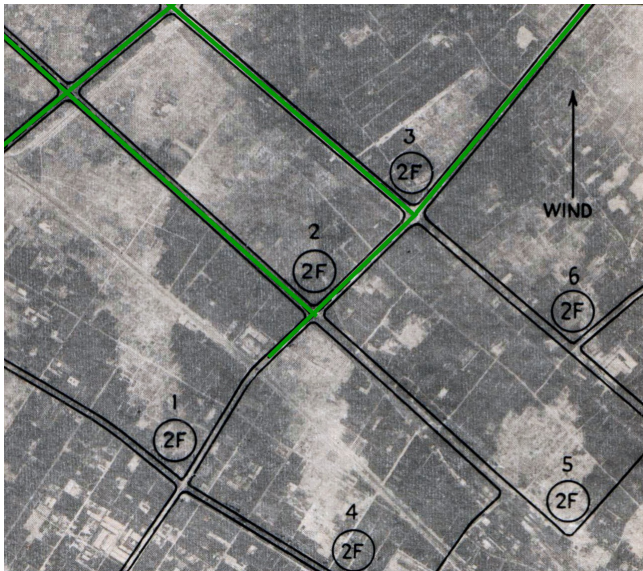


Fig 5. The planning protocol to Allied bombing generated mass-fire. This photo and its overlay constitute a fire susceptibility plan—a reverse fire protection plan, therefore known as a reverse Sanborn map. This fire susceptibility plan was constructed from photographic reconnaissance by professional fire experts.

Incendiary Attack and defence of a Japanese urban area

□ 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 G JB *Incendiary Bombing*⁵². Reproduced with permission of McGraw-Hill). Figure and text of legend in public domain.



Fig 6. John Fleetwood Baker (1901-85), Professor of Mechanical Sciences and Head of Department of Engineering, Cambridge University, 1943-68. Scholar and 1943-85 Fellow of Clare College. At the outbreak of World War II, Baker left his chair at Bristol to become Scientific Advisor to the Ministry of Home Security at Princes Risborough to which NFPA experts were recruited from Boston, Massachusetts. Later at Cambridge, lead investigator, UK, opposite Senator Harry S Truman, US, of structural failures in Liberty ships. In 1943 the Department was staffed by twenty-four lecturers and one other professor. In 1968 there were 111 teaching staff. Twenty-six junior colleagues of Baker had been called to Chairs elsewhere. Created Baron Baker of Windrush, 1977⁶³. Oil on Canvas, 1953, by Eric Kennington. Note the Clare College Crest. Reproduced by permission of the Master and Fellows of Clare College, and by the Department of Engineering of Cambridge University, solely for this medical history.

became a Major in the US Army Chemical Warfare Service, a service whose responsibilities included fire propagation⁴⁸. 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 NFPA chief engineer, James K McElroy and his NFPA 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 [the General’s] desk... [As] Deputy to General Arnold in command of the

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 destroyed^{50,51}. 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 RAF^{52,53}.

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 fire⁵⁴. 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 1.15 million⁵⁶. 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 II⁵⁸. 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 damage⁶¹. 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 fighting^{62,63}. 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 children^{56-58,61,62}. The circumstances and analysis of this horrendous slaughter proved the efficacy and ability of asbestos 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

* Louis Fieser, the Sheldon Emory Professor of Organic Chemistry, Harvard University, together with Standard Oil had developed new and improved incendiary weapons.^{59,60} Later, after Fieser had been a patient at the Massachusetts General Hospital, John Hedley-Whyte asked him to certify Hedley-Whyte's suitability to oversee theses of chemistry PhD candidates. Fieser certified that the Cambridge Natural Science Tripos was a satisfactory and adequate preparation. Hedley-Whyte's fellow examiners at the Université Libre de Bruxelles (Free University of Brussels) unsuccessfully challenged this academic strategy: London and Boston Universities did not. Candidates EL Strosberg, HK Darrah and GC du Moulin were successful.

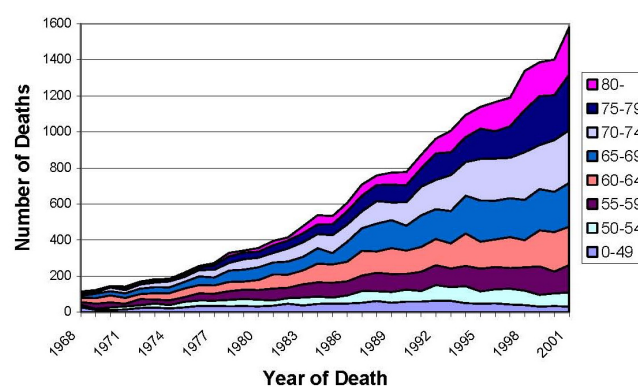


Fig 7. Number of mesothelioma deaths among males 1968-2001⁷⁹. Thirteen cases of mesothelioma were described from Belfast in 1958⁴. Currently 60-92 patients die each year from mesothelioma in Northern Ireland⁷⁸. Figures shown here, for men by decade of age of death, are for the rest of the United Kingdom for the years 1968 to 2001. Fifteen percent of deaths were in women (not shown), but the age distribution for females is essentially the same. Note the small number of deaths in men (and women) under 50 years of age, reflecting the long latency of the effects of inhalation of asbestos⁷⁹.

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 chief⁶⁵⁻⁶⁸. Frank Bull met with RC who lent a Liberty ship, *Empire Duke* which RC's yard had built in 1943⁶⁹. 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"⁷⁰. 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"⁷⁶³. 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 botanist⁷¹. 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^{71,72}.

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^{3,73}. On average, in the United States alone 10,000 persons per year were killed by fire in the first half of the Twentieth Century⁷⁴. Almost forty percent of these fire deaths were children. All of the asbestos-related diseases occurred in adults⁷⁵. 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 German⁷⁶. 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 1958⁷⁷ would have improved industrial health if the occupation of the deceased had been told to the pathologist⁴.

A FATAL SEQUEL

Currently 60-92 persons in Northern Ireland die each year from the effects of asbestos inhalation (Fig 7)⁷⁸. In the rest of Great Britain, each year in this first decade of the Twenty-First Century, about 1,600 die⁷⁹. 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 years⁸⁰. In 1999, 2485 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 lung⁸⁰. The proportional mortality rate for asbestosis of former shipyard workers is sixteen times that of the average of other occupations⁸⁰. These deaths are disproportionately concentrated in areas where, as President Franklin Delano Roosevelt put it, "The bridge across the Atlantic" was built. (Fig 4)⁸¹ 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.

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