University of Queensland’s 100th Anniversary

The University of Queensland and its engineering school are celebrating their 100th anniversary this year. Naming the members of the first Senate in the Government Gazette of 16 April 1910 marked the foundation of the University. It was Australia’s fifth university.

The University’s foundation professor of engineering was Alexander James Gibson. Born in London in 1876, he was educated at Dulwich College and served an apprenticeship with the Thames Ironworks, Shipbuilding and Engineering Company. He became an Associate Member of the Institution of Civil Engineers in 1899. He migrated to Shanghai in that year, and came to Sydney in 1900, where he became a fitter at Mort’s Dock. He received encouragement from Professor Warren, and was appointed as an assistant lecturer in engineering, building and design at the University of Sydney in 1903. Following his appointment in 1910 to the University of Queensland as foundation professor of engineering he designed and built the engineering laboratories, then the finest in Australia.

In January 1919 Gibson resigned his chair at the University of Queensland to become superintendent of construction at the Broken Hill Proprietary Co. Ltd’s steelworks at Newcastle, New South Wales. In 1922 he went into partnership with Sir George Julius and William Poole, to form the consulting engineering firm of Julius, Poole & Gibson. He was senior partner for many years. He died in 1960.

Warragamba Dam: 50 years old

Sydney’s Warragamba Dam, the largest city water supply dam in Australia, was completed in 1960. A formal 50th anniversary celebration will be held at the dam site on Sunday 17 October. The dam has an interesting history.

Before the dam

The dam is located 65 west of Sydney in a narrow gorge on the Warragamba River, a tributary of the Nepean. The explorer de Strzelecki identified the site as suitable for a water supply dam in 1845 and engineer Lieutenant Thomas Woore proposed a 170 foot high earth fill dam with a masonry core. A Royal Commission in 1867-69 considered flooding problems were too great to build a dam on the site.

The Upper Nepean scheme, commenced in 1880 and completed in 1888, was a lower cost alternative for augmenting Sydney’s water supply without the need to build dams. During a severe drought in 1901-1902 Sydney suffered stringent water restrictions and a Royal Commission recommended building dams in the Upper Nepean catchment. Work began on Cataract Dam in 1903 and was completed in 1907. It was followed by Cordeaux Dam, completed in 1926, Avon Dam, completed in 1927 and Nepean Dam completed in 1935. Woronora Dam, outside the Nepean catchment, was completed in 1941. These were all concrete faced masonry structures.

In 1927 an Expert Committee approved a proposal for a dam on the Warragamba, to be constructed on completion of the Nepean Dam. The depression delayed progress with the Nepean and Woronora Dams, and with a drought between 1934 and 1942, Sydney’s water supply came close to failure. As an emergency measure, building a 15 metre high weir on the Warragamba River with pumps to deliver water to Prospect Reservoir, was approved in 1938 and completed in 1940. Preliminary geological work for a dam on the Warragamba finally commenced in 1942. A dam site was selected in 1946.

Building the dam

Excavation work on the Warragamba Dam started in 1948 and actual construction of the dam began in 1950. It was completed in 1960. It was built as a conventional mass concrete dam, 142 metres high and 104 metres thick at the base. For the first time in Australia, special measures were taken to reduce the effects of heat generated during setting of the concrete; special low-heat cement was used, ice was added to the concrete during mixing, and chilled water was circulated through embedded pipes during setting of the concrete.

The dam was designed to pass a maximum flow of 10,000 cubic meters per second, with the water level 1.8 metres below the crest of the dam. This was the maximum flow estimated to result from a flood having an annual probability of occurrence of 1:500. This corresponds to a 10 per cent chance of a flood larger than the design flood occurring in the following 50 years. During the 1950s, there were new developments in hydrology and the design of dams to withstand large floods, and new calculations were made.

Continued on page 3
ASHET events

Thursday 23 September, 2010
Talk by John Brock
Edward Albin Amphlett: Surveyor of the Bridge

Not only was E. A. Amphlett the principal surveyor of the Sydney Harbour Bridge, he was also one of the main men who set out the underground railway system which winds its way through the underworld of the Sydney Business District, itself another marvel of engineering and technology.

In his talk, surveyor and historian John Brock will focus upon the singular excellence of Surveyor Amphlett’s triangulation and control for the positioning of the mighty “Coathanger” which straddles the harbour. His talk will also look at Amphlett’s interaction with the legendary designer of the Bridge, J. J. C. Bradfield, and the various proposals for harbour crossings which were put forward during the seventy five years before the official opening of our monumental landmark.

This is a joint activity of ASHET and the Royal Australian Historical Society.

Venue: History House, 133 Macquarie Street, Sydney
Time: 5.30 for 6 pm
Cost: $8.00 Includes light refreshments on arrival
Bookings: phone RAHS on (02) 9247 8001 or email history@rahs.org.au

Thursday 14 October, 2010
Night tour of Sydney Observatory

The tour is guided by an experienced astronomy educator and includes a 3-D flight through the solar system, a look at the night sky, a view of the moon, the planets, double stars, star clusters and nebulae using the Observatory’s large refractory (lens) telescope and topics will cover solar exploration, site history of the Sydney Observatory and the history of Australian astronomy.

This is a joint activity of ASHET and the Royal Australian Historical Society.

Time: 8.00pm for 8.15pm start. Tour ends 9.45pm.
Meet: Sydney Observatory, Watson Road, Observatory Hill, The Rocks
Cost: $15.00 members
Bookings: phone RAHS on (02) 9247 8001 or email history@rahs.org.au

Numbers are strictly limited so please book early.

Tuesday 26 October 2010
Talk by Chris Middleton
History of Whisky Distillation in Australia

Australia’s favourite spirit since the 1880s has been whisky and it still hold a 46% volume share of the Australian spirit market today, over 4 million 9 litre cases. Since Robert Webb’s first distillation of wheat into potable spirit in 1792, Australia has produced over 140 million litres of whisky from about 50 legal distilleries across the country. Victoria’s Federal Distillery (1884), later Corio (1928) and Gilbey’s Moorabbin (1946) produced 85% of Australia’s whisky using both pot stills (malt whisky) and continuous stills (grain whisky).

Chris Middleton is writing a book on this subject and will explore the development of still technology, the reasons why whisky came to dominate Australia’s spirit preferences and rediscover some of the lost whisky distilleries of Sydney, Melbourne and Adelaide. Chris has worked in the industry for 20 years and since returning from the US is chairman of Victoria Valley Distillery in Melbourne, a large malt whisky distillery which started production in January this year.

This is a joint activity of ASHET and the Royal Australian Historical Society.

Venue: History House, 133 Macquarie Street, Sydney
Time: 5.30 for 6 pm
Cost: $8.00 Includes light refreshments on arrival
Bookings: phone RAHS on (02) 9247 8001 or email history@rahs.org.au

Tuesday 30 November, 2010
Talk by John Jeremy
Cockatoo Island Dockyard, 1857–1991

One of the treasures of Sydney Harbour, Cockatoo Island, has a remarkable history, starting as a penal establishment and becoming a major shipbuilding and ship repair facility which made a considerable contribution to Australia’s maritime affairs for 134 years.

Naval architect John Jeremy worked at Cockatoo Island for 32 years, the last ten years as the last Chief Executive of the Dockyard. In his presentation he will outline the history of the dockyard and, in particular, the work done there in peace and war.

This is a joint activity of ASHET and the Royal Australian Historical Society.

Venue: History House, 133 Macquarie Street, Sydney
Time: 5.30 for 6 pm
Cost: $8.00 Includes light refreshments on arrival
Bookings: phone RAHS on (02) 9247 8001 or email history@rahs.org.au
Visiting Warragamba Dam

Warragamba Dam grounds reopened in November 1999, after being closed to the public for ten years during the construction of the auxiliary spillway and other works at the dam. There is now a new visitor centre, viewing platforms and picnic areas.


To reduce the risk of the dam overtopping in a large flood and possibly failing catastrophically, the dam the spillway was modified, by eliminating the 1.8 metre freeboard and placing additional concrete on the upper section of the dam wall, to allow passage a flow of 12,000 cubic metres per second before the dam overtopped. It was estimated that such a flood flow had a 1:700 probability of occurring in any year.

**Dam safety**

These estimates were criticised in an article by G. N. Alexander published in the Journal of the Institution of Engineers Australia in 1966. He estimated that the dam could safely withstand only a 1:200 flood, well below the then current standards for safety of large dams.

A series of catastrophic dam failures in the USA in the 1970s led to a heightened interest in dam safety. The Sydney Water Board responded by commissioning further studies to determine an appropriate design flood for the Warragamba Dam and eventually an acceptance that the dam should be capable of withstanding a flood, designated the Maximum Probable Flood, which had an annual probability of occurrence of 1:100,000.

Work commenced in 1985 on interim measures to increase the safety of the dam by raising the height by 5 metres, installing prestressing cables to strengthen the dam structure, and modifying the spillway. This work was completed in 1989. It resulted in the dam being capable of withstanding a flood with an annual probability of 1:1,500.

Various possibilities for further increasing the capability of the dam to withstand severe floods were studied. They included constructing an auxiliary spillway, strengthening the dam so that it could safely withstand overtopping, increasing the height of the dam and constructing upstream works to limit the flow into the dam in the event of large floods in the catchment.

**Flood mitigation dam proposal**

In 1989 the state government established an Interdepartmental Committee to address the issues of dam safety and downstream flooding and to make recommendations. The committee recommended increasing the dam height of the dam wall by 23 metres and strengthening it by increasing the thickness of the concrete wall. The cost was estimated to be $279 million. The dam’s water supply storage was not to be increased and the increase in the height of the dam wall would provide ‘air space’ that would fill during flood events and be released in a controlled manner afterwards to restore the dam’s capability to retain a flood flow. Even in the most extreme flood event the water level would remain elevated for no more than two weeks. The result would be that the dam would have the capability to withstand the Maximum Probable flood and in addition the Nepean Valley would be protected from serious flooding.

An Environmental Impact Statement for the Project was prepared but never released for public comment. In 1994 the Fahey government announced that the project was to proceed. Environmentalists formed a coalition, the Kowmung Committee, to oppose the project, on the grounds that it would be detrimental to the environment upstream of the dam, and that by making the in the Nepean Valley downstream of the dam less flood-prone would encourage increased urban development.

**Auxiliary spillway**

There was a change in government in 1995 and the new Carr government cancelled the project and directed that a proposal be developed to provide an auxiliary spillway beside the existing dam, with a capacity to pass the flow that would result from the Maximum Probable Flood. The spillway would under normal conditions be closed by a ‘fusible plug’, which would be removed by the water pressure behind it as the dam water level increased during a major flood. An Environmental Impact Statement for the proposal was released by Sydney Water for public comment in November 1996.

The EIS showed that the fusible plug was designed to break in the event of a 1:200 probability flood, and this would cause greater flooding downstream than would occur with the existing dam to an extent that many considered to be unacceptable. As a result Sydney Water modified the design by increasing the capacity of the auxiliary spillway and designing the fusible plug to break only in a flood of probability 1:750 or greater. The Department of Urban Affairs and Planning, as determining authority for the EIS, accepted this modified design, on the grounds that a 1:750 event would be rare, and the extent of the increased downstream flooding in this event would be modest compared with the natural flooding that was already occurring, and reasonable considering that the dam would be protected from catastrophic failure. It noted that the issue of flood mitigation in the Nepean Valley was being managed separately and did not need to be considered in assessing the EIS for the auxiliary spillway.

Work on the auxiliary spillway commenced in 1999 and was completed in 2002.

**The Deep Water Recovery Project**

In 2006 work was completed on a further project that has resulted in an increase of around 8 per cent in the amount of stored water that can be drawn from the dam. The 62 million Deep Water Recovery Project consisted of reactivating a low level outlet that had been installed during the original dam construction, to allow water to be extracted from the dam and pumped to the Prospect Reservoir while construction of the dam continued. The low level outlet was blocked off later when the permanent outlets at higher levels were completed, allowing water to flow to Prospect by gravity. The temporary scheme made use of a pumping station that had been installed as part of the 1940 emergency scheme. For the Deep
Water Recovery Project a new underground pumping station near the base of the dam was provided to pump water up into the existing pipeline to Prospect.

Often in the news
Largely as a consequence of the widely variable rainfall in the catchment, Warragamba dam has often been in the news. During its construction there were large floods and this led to concerns that the spillway might not have sufficient capacity to pass a large flood. The greatest flow recorded over the spillway occurred in 1961, the year after the dam’s completion, when it reached around 75 per cent of the dam’s original designed spillway capacity. But in the drought year of 1987 the water level in the dam was down to 45 per cent of capacity. Even lower levels occurred during the drought years from 1998, with an all time low level of 32.5 per cent of capacity being reached in 2007, while stringent water

Australia’s first materials testing machine
by Ian Bowie

Historical background
The Greenwood and Batley testing machine, currently housed in the School of Civil Engineering of the University of Sydney, has a pedigree extending from the early part of the nineteenth century.

In this phase of the Industrial Revolution, the early and cheap advantages of steam power, canal and railway transport and larger scale metal production had delivered spectacular benefits to society but matters had now entered a more competitive stage. It became necessary to match one bridge design against another, one machine against another and to compare the increasing variety of available building structures.

Of the yardsticks available, cost was dominant and this logically led to the determination of the various strength limits of the materials available. In addition to the well-known names of engineers such as Telford, the Stephensons and the Brunels, the literature of the time started to include contributions from researchers such as Fairbairn and Hodgkinson whose specialisation was in the laboratory testing of samples of wrought iron, cast iron, masonry and eventually the cheaper steels that would become available.

The main problem facing these early workers was to provide large forces, capable of taking materials to failure, with control combined with precision. Some of the testing devices consisted of arrangements of levers and loading by weights which did not inspire confidence in accuracy or convenience of operation.

David Kirkaldy (1820-97) of Dundee was at first a draughtsman of considerable skill in an age when clarity in presentation of engineering concepts was of particular importance. In employment at Napier’s Vulcan Foundry Works in Glasgow, he won awards in exhibitions for his drawings. His interest in the properties of engineering materials caused him to seek improved methods of testing. The earlier work of Bramah on the transmission of force by hydraulic means, later taken up by W. G. Armstrong, offered promise of application to the testing field.

At Kirkaldy’s own expense he designed and commissioned an ambitious machine capable of exerting a force of one million pounds. This resulted in a device weighing 116 tonnes and 14.5 metres in length. The manufacturer selected was Greenwood and Batley of Leeds, England, but production of this one-off and unusual device was extremely slow to the extent that Kirkaldy completed the work himself. A machine of this size required specially built premises and these were constructed at 99 Southwark Street, London.

From 1866, the machine fulfilled all of Kirkaldy’s hopes for its performance in that it carried out a range of tests including tensile, compressive, short-column, torsion and transverse types of testing. It was well patronised by industry including forensic work on the remains of the Tay Bridge disaster of 1879 and the Comet aircraft crashes of 1954. This success continued until the family closed down the business in 1965. (After a lapse of twenty years, a volunteer society restored the machine to full operation in the Southwark Street building.)

The success of Kirkaldy did not escape the notice of Greenwood and Batley and they proceeded to manufacture versions of the apparatus based on Kirkaldy’s principles but substantially smaller to suit the finances and space of other organisations interested in materials testing such as universities and monitoring laboratories in industry. In 1884 “The Engineer” journal published a large illustration of a G & B testing machine acquired by University College of the University of London which appears to be about two-thirds the size of the original Kirkaldy machine. The hand-operated hydraulic pump is clearly visible. Soon afterwards the journal published a side elevation of a G & B machine purchased by nearby King’s College but which had a short base which would have restricted the range of tests.

Professor Warren

The University of Sydney started offering degree courses in Engineering from the beginning of 1883 with the appointment of William Henry Warren (1852-1926) as Lecturer in this field. His status was raised to that of Professor of Engineering the following year.

Warren’s training in England and Ireland included experience in what would be seen in later times as both civil and mechanical engineering but it was much more within the former branch – along with engineering materials – that he carried out most of his career’s work and for which he is mostly remembered.

An important period in Warren’s career is the two years after
his arrival in Australia in 1881 which he spent in the Department of Public Works of the colony of New South Wales. Working in this large government organisation, he would have had his first encounter with the impressive range of hardwood timbers native to eastern Australia. Once the settlers and their descendants had overcome the problems of cutting these materials, the strengths available were far greater than for typical timbers from Europe. It would have been noted by Warren that data on the properties of this resource was difficult to find in that no Australian testing facility of any reliability was available. Another widely used local material for which much the same could be said was Sydney sandstone. Local iron was now being produced and its quality needed to be monitored. There was a clear information gap for engineers seeking to use up-to-date design calculation methods as distinct from earlier “rule of thumb” approaches and guesswork based on experience.

Another significant encounter by Warren at the DPW was with John A. McDonald, Engineer for Bridges, best known for the McDonald Truss type of bridge of which 91 were built in NSW for roads and others built for railways.

On arrival at the University, Warren was faced with the facts that there was at first no engineering building, no laboratory equipment and that he was originally supposed to effect the purchase of the latter from his academic remuneration – although this problem was eased by a grant for equipment and books in 1883.

Once the urgent work of organising and teaching the engineering courses was under way, contact was made with Greenwood and Batley for the supply of one of their Kirkaldy-type machines, similar in size to the University College London model referred to above.

In October 1884 an order was placed for a G & B machine capable of applying a force of 100,000 pounds. Unlike the case of Kirkaldy, delivery was prompt to the extent that the new building for engineering was not ready when the machine arrived the following year. The installation in its home for twenty-three years between Science Road within the University and Parramatta Road took place in February 1886.

The machine was an immediate source of income to the University for reasons already apparent. Although fees were charged to industry in general, charges to NSW government bodies appear to have been minimal in view of various forms of support received.

Testing certainly started quickly after the machine’s installation because on 1st December 1886 Warren was able to report to the Royal Society of New South Wales the results of strength and elasticity of ironbark timber obtained on “the testing machine”. McDonald had been a collaborator in the tests and Warren gives him credit for the invention of an autographic strain recording device for the tests. Early access to the results is evidenced by the fact that the Roads and Traffic Authority records indicate that the first of the McDonald-type bridges appeared in 1886. The finest example of these was the 1893 bridge over the Lachlan River at Cowra which lasted 93 years and which had three timber truss spans, each of 48.8 metres. From an engineering point of view, to design such a structure without accurate properties of the main material is unthinkable.

But more impressive work was to follow. Percy Allan, at the time Chief Draftsman of the DPW, used the Howe truss principle that had originated in the USA to produce an even more economic design in which timber was the dominant material, aided by wrought iron rods for some tension members and cast iron shoes to minimise problems at the joints. The Allan-type bridges, of which 105 were built for the roads in NSW, displaced the McDonald designs from 1893 and continued to be built until 1929. The twelve approach spans of Pyrmont Bridge (1902), each consisting of multiple trusses, are of Allan’s design and the large ironbark sections are clearly visible. DPW engineer E. M. de Burgh was responsible for the design of 20 road bridges applying the American Pratt truss principle in a similar way to Allan’s use of the Howe truss. Colleague Harvey Dare contributed designs for 40 road bridges between 1905 and 1936 in which some of the timber elements in the Allan type were replaced by steel which was beginning to be more affordable.

Hundreds of simple timber beam bridges, familiar to users of local roads, were also constructed. Whilst the sophistication of the design of such structures is not great, it is impossible to produce economical results without being able to put numbers for strength into the equations -- and this could be done from 1886.

Thus, with respect to bridges alone, the results from the testing machine can be said to have a massive effect on the NSW economy. One of the factors to be remembered was the severe depression that afflicted Australia in the 1890s. In this period, steel was beginning to be used by most developed parts of the world but NSW had great difficulty in affording this imported material. A consequence was that Allan’s design for the bridge over the Murrumbidgee at Wagga Wagga (1895), with three spans of 33.6 metres, was much cheaper than the rival steel truss design that matched overseas practice. Likewise, only the double swing span of the Pyrmont Bridge is of steel after a comparative steel design for the bridge over the Murrumbidgee at Wagga Wagga (1895), with three spans of 33.6 metres, was much cheaper than the rival steel truss design that matched overseas practice. Likewise, only the double swing span of the Pyrmont Bridge is of steel after a comparative steel design for all spans had been rejected on the grounds of cost.

In addition to bridges, the results from the testing machine provided an impetus for building construction. The fire-resistant properties of local hardwoods, especially of ironbark, had already been established and this timber had for some time been used for columns of multi-storied buildings as well as for beams. But again, this had been done without complete quantitative knowledge of compressive strength and without a thorough investigation of whatever peculiarities there may be for ironbark in buckling.
The length of the G & B machine is such that it is possible to accommodate specimens of up to 72 inches (1.83m) in length. On 13th June 1889, Warren announced to the Engineering Association of New South Wales that he was carrying out compressive tests on this length combined with a cross-section of three inches (76mm) square. Whilst this length is only about half a typical building storey height, these dimensions correspond in engineering terms to a length/radius of gyration of 83 which allows some scope for confident interpolation for thicker columns in relation to storey height, closer to half this figure being normal.

The era of ironbark column construction still had three more decades to run before domestically produced steel (1916) and properly designed concrete took over. Many buildings of the commercial and industrial type that have been conserved for alternative use therefore owe their existence to these tests by Warren and his associates.

At the 1889 EANSW meeting Warren produced results for timber specimens from the governments of Victoria, Western Australia and South Australia. The influence of results from the testing machine had therefore now become national. In fact “… the Senate of the University of Sydney has allowed all tests made on the Australian Timbers to be made without usual fees, as it was considered to be a matter of national importance.”

The culmination of Warren’s work on timber properties would have been the NSW government report: “The strength, elasticity and other properties of NSW hardwood timbers” that appeared in 1911. By this time, the G & B machine had been joined by a Buckton/Wicksteed machine and an Amssler 450-tonne capacity machine. Nevertheless, the report shows that the G & B carried out some of the tests that could be done more conveniently than with the newer machines. The timber properties used in this report were used in eastern Australia until general publication after World War 2 of the results obtained by the Commonwealth Scientific and Industrial Research Organisation.

The first Australian structures in reinforced concrete designed by recognisably modern engineering methods appeared in 1896. The consequence was a great interest by Warren to investigate the properties of concrete and cement mortars. In the early years these tests were carried out in the Greenwood and Batley machine and results reported in issues of the Journal and Proceedings of the Royal Society of NSW.

Warren’s main interest for most of his career, as may be deduced from all three editions of his book on construction engineering, was in iron and steel structures. The G & B machine was therefore used extensively for iron and steel specimens and artefacts as evidenced in the collection of Warren papers held in the University of Sydney archives.

The P. N. Russell School of Engineering building (now the John Woolley Building) on the south side of Science Road was completed in 1909 and all laboratory equipment was moved there. The G & B machine appears in its second location in the centre of photographs in the 1911 NSW timbers report.

The second forty years

After Warren’s retirement, Professor William Aitken Miller became the University’s first Professor of Civil Engineering in 1926. His interests were similarly inclined towards steel structures. With the arrival of testing machines with more sophisticated and convenient hydraulic operation, the use of the G & B machine was gradually reduced but it still played a role in the testing repertoire because it could take objects for testing that would not fit or would fit more awkwardly in the newer equipment. The length capacity of 1.83 metres was important in this respect.

In anticipation of the move of the Faculty of Engineering to Darlington, in 1960 the hydraulics of the machine were converted to an electric pump system with a modern control panel.

The materials and structures section of the School of Civil Engineering moved to Darlington in 1962 and the G & B machine installed in the later-named J. W. Roderick Materials and Structures Laboratory. Its occasional use for some testing continued but the consensus is that the last testing was carried out circa 1965.

The present

As described, Professor Warren set a formidable pace in the use of testing apparatus for research and investigation. This tradition – for it deserves the name, having been established over forty-three years – was continued by his successors, starting with the long-serving Professors Miller and Roderick and continued by those that have followed. The research record by the School of Civil Engineering has brought in very many grants from the Australian Research Council and other similar bodies in the face of national competition. In addition, the flow of work brought to the School of Civil Engineering by industry continues to grow. Much of this involves the testing of new products or investigating failures.

The result is that that the amount of equipment in the laboratories has continued to grow in quantity and complexity. In turn, a consequence is that there is now no space in the Materials and Structures Laboratory for the Greenwood and Batley machine.

The footprint that it occupies is about ten square metres in that the overall length is 8.2 metres and the width of the crosshead is 1.2 metres.

Until further space becomes available for the University, there is now extreme difficulty in finding space for the G & B machine. The University has some concept of expansion into areas where the machine could be housed in suitable surroundings relating to the heritage of the University and the community but this is not likely to happen for many years.

There is therefore an urgent need to find appropriate accommodation for the machine. If it could be housed in an environment appropriate to its contribution to the community, that would be excellent, but the need is immediate.

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