Symposium to mark 50 years of diamond synthesis

On December 16, 2004 the leaders in the industrial diamond industry were invited to Provo Utah, USA by Novatek and the Tracy Hall foundation to attend a one-day symposium to recognize Dr. H. Tracy Hall and the original diamond team on the 50th Anniversary of the first reproducible diamond synthesis back in December of 1954. Leaders from throughout the industry, representing major diamond associations, suppliers, toolmakers and academia, attended the event. This report by **Terry Kane**.

Terry Kane (Industrial Diamond Association of America), Tracy Hall Jr. (Novatek), Redd Smith (Hughes-Christensen), Louis Pope (US Synthetic), Caoimhin Armstrong (Boart Longyear), Richard Hall (Saint-Gobain Abrasives), Terry Matthias (ReedHycalog), Ricky Flak (Smith MegaDiamond), Bill Pope (US Synthetic), Tracy Hall (Novatek), Tanya Fratto (Diamond Innovations), Jim Cheney (GE retired), Christian Hultner (Element Six), Jim Shigley (GIA), David Shin (Iljin Diamond Ltd), David Hall (Novatek)

The Symposium at Provo featured presentations from dignitaries honouring Dr. Hall and the original team and highlighting the developments and products springing from that first diamond process. Displays from a number of local companies were available for viewing as well as a display of the memorabilia of Tracy Hall related to the first diamond team and their accomplishment.

David Hall started the symposium off by welcoming everyone and giving some personal insights to the accomplishment and his father.

Terry Kane, the Executive Director of The Industrial Diamond Association of America spoke on the wide uses of diamond and the growth of the industry. He noted in 1946 when the IDA was formed all diamond used was natural with limited areas of applications such as grinding of carbide, wire dies, gage stones for drilling, single crystal machining tools and polishing powder. The mid 50s saw synthetic diamond commercially available and product lines expanded to larger, tougher diamond and then cubic boron nitride and polycrystallines

Mr. Kane also showed charts reflecting examples of the growth of diamond consumption from a few thousand carats to over a billion a year today and a chart showing all superabrasive finished tools valued today at around 4 billion dollars. He also touched on the new products of tomorrow with scientists working on high pressure/high temperature substances harder than diamond and CVD diamond being grown under low pressure, high temperature.

Tanya Fratto, CEO of Diamond Innovations (previously known as GE Superabrasives, the GE business formed as a result of the first synthesis of diamond), pointed out the successes and failures that led to this achievement. She talked about the character of those scientists and the many opportunities and businesses that came about through the years, along with the tremendous improvements and new technology. Ms. Fratto also spoke of the global impact of diamond and how countries around the world have reacted to changing technology both in the diamond and other industries using diamond. Tanya spoke of the integrity in the diamond industry and the leadership of the profitable companies that become the growth engines to society.

Christian Hultner, Managing Director of Element Six recognized the achievement by presenting Dr. H. Tracy Hall with a diamond filled hourglass to commemorate the first reproducible diamond process.

Mr. Hultner said the anniversary was a significant achievement and means more challenges will follow. He stated that all technology stemmed from the belt apparatus and that Element Six has

dedicated today more investment and R&D for even larger presses. Scalable high pressure high temperature presses are evolving to meet or beat demands of industry and keep a competitive advantage. The new larger presses are designated Mark 12, but the same concepts are going into planned Mark 13 & 14 which are on the way.

Christian also challenged the diamond industry to move away from referring to industrial diamond production in terms of carats (an old gem diamond term) and switch to tons or kilograms.

The audience was then privileged to hear from Jim Cheney one of the scientists on the first diamond project. Jim spoke of how the team was formed and the bonding that took place between its members. The team was shrouded in secrecy and no one outside the team was privileged to its purpose.

He spoke of the first press of 20 ton, which is dwarfed by today's behemoth standards and the problems with keeping it working for experiments. Jim said there were many buildups and failures over the many months and how scientist Bob Wentorf said their goal was "to make mistakes as fast as possible, but not to make the same mistake twice."

Mr. Cheney went into detail on the contributions of each team member and how each brought a special talent and expertise to the team. Guy Suits was their leader, Francis Bundy, was a man of pure science and worked on the carbon phases, Herb Strong developed the diamond phase and temperature diagrams, Tracy Hall worked on the belt designs and Hal Bovenkerk was the process and equipment expert.

Of course the team also came up with cubic boron nitride in the 50s but its application and use would not be refined until the late 60s. Jim Cheney summed up those times by saying it was a sinfully satisfactory experience and he could not wait to come to work everyday.

The attendees were treated to many other presentations from industry leaders speaking of how that first diamond process had been the springboard for today's businesses, applications and new products.

Ricky Flack of Smith Megadiamond gave a provocative demonstration on the use of polycrystalline cubic boron nitride as a plug/thermocouple (at 900° C) on a patented machine to weld joints of pipeline steel. Many in attendance had never seen this type of application.

Tracey Hall's role in synthesis

Tracy Hall was born in Ogden, Utah in 1919 and raised on a farm in Marriott, a rural town in northern Utah. He completed his education in Utah, finally graduating with a doctorate degree in 1948, at which point he fulfilled his childhood ambition by going to work for General Electric Research labs in Schenectady, NY.

In 1951 GE began a program to attempt to synthesise diamonds from carbon and assigned Drs. Bundy and Strong, physicists from the Mechanical Investigations Section, with that task. GE management assembled the chemists at the lab and asked for volunteers and Dr. Hall was quick to step forward to be followed shortly afterwards by another physical chemist, Dr R. H. Wentorf.

The first experiments the team did were accomplished using a modified 20-ton automobile jack called a Carver press. The group designed a new, versatile press to achieve the never-before-realised goal of creating diamond from carbon. The press would cost around 125,000 1951 dollars and would take about two years to build. Meanwhile they modified an old water-operated Watson-Stillman press to continue their experiments. Although this was so leaky that rubber boots and squeegees were required to use it, it would – along with a small bench press – serve the entire group for much of the apparatus development phase.

The problem of creating high pressure is very simple in theory – a decrease in volume results in increased pressure. But even the strongest materials in the typical piston configuration break at the high pressures that were being investigated. Because of this obstacle, the team had to develop with variations of seals that had been tried in the past.

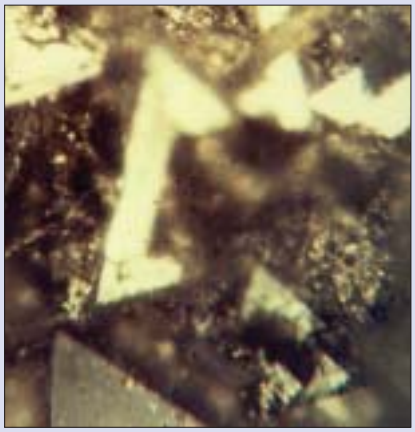
The team were experimenting with various piston and cylinder devices turned out by the group. While their gasketing and stroke capabilities were excellent they suffered from the common problem in piston and cylinder devices – failure at the junction of the side walls and bottom of the bore. Using lateral thinking, Dr Hall solved this problem by eliminating the bottom and using two tops "back to back." Thus the device called the 'belt' was born.

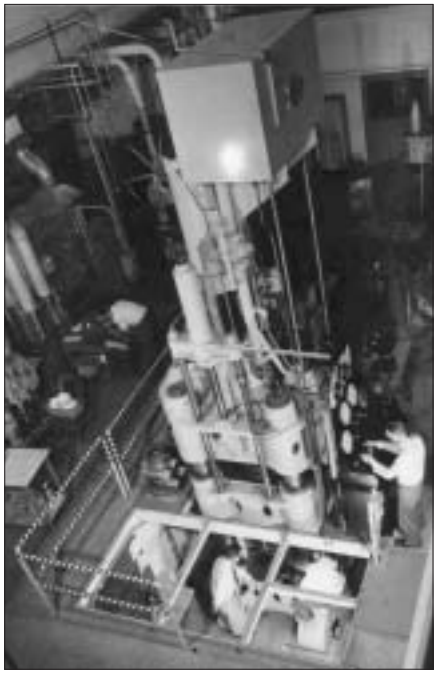
By fall of 1954, the new three-story tall double-acting press had been completed and assembled in the Knolls research laboratory. While experiments were being run on the new press Drs. Hall and Wentorf continued developing the geological chemistry of the cell on the leaky Watson-Stillman press.

On the morning of December 16th, 1954, Dr. Hall used his new carbide belt apparatus to run an experiment on the leaky, old press. A surprise awaited him upon breaking open the cell, as there in front of him he could see "the flashing light from dozens of tiny crystals." Subsequent tests and duplication runs convinced GE management that the team had indeed succeeded in transforming carbon to diamond. Run after run produced diamonds using Dr. Hall's belt device.

On February 15 1955, GE held a press conference and announced to the world that they had successfully synthesized diamonds. GE was granted a patent for Diamond Synthesis. Other patents were granted for other apparatus developed by the group, but the Hall Belt (US Patent No. 2,941,248) was the most practical and was later scaled up to become the first production apparatus and the model for diamond synthesis for the future.

Below Tracey Hall's belt device played a key role in the synthesis of diamond Right Photo of the diamond crystals produced in the first successful run in December 1955





The giant double-acting press that was built with the aim of synthesizing diamond took nearly two years to build – the Watson-Stillman press on which diamond was in fact first synthesised is visible in the lower left-hand side of the picture

Louis Pope of US Synthetic spoke of the many businesses (13 in total) in the Provo Utah area that were formed as a result of the work done with Tracy Hall and Brigham Young University and how this location had become a focus for research and development of new products and applications.

Terry Matthias of Reed Hycalog, Redd Smith of Hughes Christianson, David Shin of Iljin Diamond Ltd. and Caoimhin Armstrong of Boart Longyear all spoke of product advancements and how the first diamond synthesis impacted their own businesses gave other notable presentations.

Jim Shigley of the GIA spoke on the impact of synthesized gem diamonds to the jewelry industry and where future products may influence that market.

Richard Hall, R& D Manager of Saint Gobain, gave the attendees an in-depth overview of the abrasives industry today and the wide range of products and partners around the world.

Tracy Hall Jr. spent a few minutes wrapping up the day and gave everyone a very insightful view of the time he was growing up as H. Tracy Hall's son and the time his dad was working on the diamond team.

Many of the attendees took the opportunity to renew old friendships and begin new ones. The lengthy attendee list was filled with many companies and prominent figures from the industrial diamond and superabrasive industry. ◆

Terry M. Kane.
Executive Director of the Industrial Diamond Association of America and Editor of Finer Points Magazine.
P.O. Box 29460, Columbus, Ohio 43229
Tel: +1 614 797 2265
Fax: +1 614 797 2264
email: tkane-ida@insight.rr.com