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Dr. Philip H. Abelson,

I'll try now to give you some facts instead of stories.

1. The oldest known written record that mentions the word diamond is found in the Old Testament: Exodus 28:18 and Jeremiah 17:1.

2. In 1772, Antoine Lavoisier burned diamond in oxygen and discovered that the only combustion product was carbon dioxide. An equal weight of graphite when burned in oxygen gave him the same quantitative result. Therefore, graphite and diamond were polymorphs and man began to speculate on the possibility that soft, black graphite might be transformed into the worlds hardest known material; namely, diamond.

3. C. Cagniard de la Tour was the first person to claim that he had made diamond. Nothing resulted from his claim.

Others who pursued the problem included rank amateurs, downright charlatans and some of the worlds most honored scientists including Boyle, Bragg, Bridgman, Crookes, Davey, Despretz, Friedel, Liebig, Ludwig, Moisson, Parsons, Tamman and Wohler.

4. British encyclopedias credit J. B. Hannay as being the first to make diamond. Fifty years ago, his obviously natural diamonds were still on display in the British Museum. I don't know if they are still on display today.

Henry Moisson laid claim to being the first to make diamond. However, some of his associates said that they slipped in some natural diamonds because he was getting old and needed to feel that he had obtained his goal. To Moisson's credit, however, he invented the Electric Arc Furnace wherein he produced many previously unknown metal carbides and other refractory substances.

5. Percy W. Bridgman worked in the field of high pressures at room temperature from 1905 to 1955 and was awarded the Nobel Prize in 1948 for his prodigious efforts.

6. Great secrecy has been companion to most of those who have attacked the diamond problem. David T. Griggs was one of the few graduate students to work with Bridgman at Harvard.

In a 1954 article Griggs stated the following: "...when working pressures were being increased from 20,000 bars to 100, 000 ...I noticed that Bridgman would become secretive and brusque, during the first run, visitors were not welcome.. I subsequently learned that in each case, graphite was the first substance tried."

Bridgman never was able to design an apparatus that would combine the two extreme requirements; namely, very high pressure simultaneously with very high temperature.

7. In 1951, GE Research Laboratory managers called twenty of its chemists to a meeting and announced that they were going to tackle the diamond synthesis problem. Volunteers were asked for. Tracy Hall was the only chemist interested and got the job.

It was revealed that two physicists were already at work on the problem. Within a month a second chemist was hired and two laboratory assistants for the physicists were hired.

8. A 1,000 ton, three stories tall, double acting press was ordered for the physicists at a cost of \$25,000.00. Special permission had to be obtained from corporate headquarters to obtain that amount of money. The money need not have been spent. Hall was busy utilizing a 200 ton press that was already available for use with his Belt apparatus.

9. Hall designs the Belt press in 1953 and puts it into operation. It was found to be capable of a temperature of 29 hundred degrees fahrenheit simultaneously with a pressure of one million pounds per square inch.

10. Hall makes diamond on December 16, 1954 and continues to make diamond in twelve

additional runs.

11. GE wants verification of Hall's work. Two corporate GE lawyers witness the tests. Richard Oriani, from metallurgy and Hugh Woodbury from physics were selected to make three runs each according to Hall's procedures. Diamond was made in all six runs.

12. One of the physicists claimed that he had made diamond exactly one week before Hall. Most of the scientists in the lab were highly skeptical of this claim because it looked like a chip off of a natural diamond. Almost forty years later an interested geologist brought up the subject of testing this diamond. GE's own laboratory did the work. As suspected the diamond was a natural diamond of type 2a.

13. A massive GE press release, planned well in advance, occurred on February 15th of 1955. Media persons were specially invited from the U.S. and some foreign countries to hear GE's great news, although they were not going to tell the invites that diamond had been synthesized until the media people were seated in the Research Lab auditorium

GE stock price jumps several points when the news arrives.

14. Hall becomes dissatisfied with GE and visits a few other research labs. Brigham Young University became aware that Hall might be interested in a university appointment. Although the salary offered was low he accepted and became a full professor and Director of Research and Creative Endeavor.

Hall invents the Tetrahedral Anvil high temperature, high pressure research apparatus that frees him from the Belt that GE would not let him use. Later on he invents the Cubic Press and the Anvil Guide. The anvil guide is a mechanical device that synchronizes the advance and retraction of the anvils. All of Hall's devices are covered with U.S. and foreign patents.

15. Hall and his university colleagues publish 150 peer reviewed papers utilizing his various presses over a span of about sixteen years.

16. GE establishes a diamond plant in Detroit, Michigan in 1957 just two years after the first synthesis, Price for diamond crystals about the size of fine sand was set at five dollars per carat, Friable diamond was the first industrial product.. Such crystals were very useful when used in resin bonded grinding wheels. Many variations of diamond products eventually filled a host of applications on up to the manufacture of gem quality diamonds. The latter products were manufactured in a new plant located in Worthington, Ohio. Very large additional facilities were subsequently placed in Ireland. DeBeers has also constructed a comparably large installation in Ireland.

17. Hall's Belt and Cubic presses are the work horses of the diamond synthesis industry. There are 750 Cubic Presses in China and 200 Belts in Ireland and an unknown number of both types of presses are scattered around the world.

18. Randy P. Oates of GE Superabrasives has an article in Volume 7, No. 4, 1995 of "Finer Points", the organ of the Industrial Diamond Association of America, Inc.

The information that he gives therein calculates that manufactured diamond consumption since 1960 is 351 million carats but he gives no figure for the dollar value of this material. It undoubtedly amounts to several billion dollars.

19. The number of uses for industrial diamond products are almost innumerable.

On the small end there are diamond coated finger nail files that may cost five dollars. On the large end there are 36-inch diameter rock drilling bits studded with hundreds of diamond coated tungsten carbide drill bit inserts. Each rock bit is worth as much as ten thousands dollars.

20. Just a few examples follow that employ diamonds: diamond surgical knives, diamond saws, diamond cutting tools for lathes and milling machines, drills and boring tools, diamond grinding wheels of many types and sizes, some of which are 10 feet in diameter, single point dressers, wire drawing dies, diamond wear guides, diamond heat sinks for semiconductors, diamond scaifs, surface grinders, loose grits of various sizes for wet polishing machines, gem stones, and diamond abrasive cloth.

The importance of H. Tracy Hall's diamond making machine inventions have long been overlooked in the annals of engineering history.

His story began in 1948 when he was hired on at the General Electric Research Laboratory after graduating from the University of Utah with a Ph. D. Degree in physical chemistry and a minor in physics. However, his academic degrees did not channel his efforts in the direction of his most famous scientific contributions.

He had a natural bent for machinery and mechanical devices which led him to the drafting board. He studied drafting as a senior in the Ogden Utah High School and followed this with two years of drafting practice at Weber College, also in Ogden.

Little did he realize that drafting ability would later on serve him so well.

Hall's most famous invention at the GE Laboratory was his Belt apparatus in which he became the first person to transform graphite into diamond. This occurred on a wintry, sunny day on December 16, 1954. Black and white pictures of the first synthetic crystals are shown on the cover page.

Hall's Belt apparatus is capable of sustaining pressures of one million pounds per square inch at simultaneous temperatures of twenty-five hundred degrees Fahrenheit. These conditions inside of the reaction cell which is composed of a refractory material called pyrophyllite or Wonderstone can be maintained for days. This material comes from a mountain of the material mined in South Africa.

Hall's Belt, for patent purposes was named "High Temperature high Pressure Apparatus" and granted as U.S. Patent No. 2,941,248 on June 21, 1960, with additional patents issued in ten foreign countries. This patent was delayed for almost seven years before it was allowed to issue because of a Secrecy Order that was placed upon it by the federal government because of the importance of the invention!

When the patent finally issued, it was assigned to General Electric.

It would seem important to preserve all of the details concerning the original Belt apparatus as it came off Hall's drafting table. They are provided by the seven sheets that follow this page.

As of this date, it is impossible to determine the sales or quantities of diamonds that General Electric has produced.

However, in 1977, which is now twenty years ago, GE published a small paper called "GE Monogram" that said it had manufactured more than fifty tons of diamond. It is entirely possible that the total Belt output can now be measured in hundreds of tons.

General Electric now has competition from DeBeers. This company has Belt plants in South Africa and, also, in Ireland. Additionally, GE's Worthington, Ohio facility also has a Belt plant in Ireland. Each company has 100 very large Belts with individual investments of many millions of dollars. Belt presses are actuated by a double acting hydraulic ram.

Hall's Belt should take an honored place <u>among the historic inventions of all time!</u>
