# CHARLES STARK DRAPER PRIZE

CANDIDATE(S) NAME S):
(Include all candidates' names for joint nominations)

H. Tracy Hall

SUMMARY OF ACCOMPLISHMENTS:

Scientists have recognized since early in the 20th century that graphite and diamond are different forms of the same element, carbon. Many experimenters worked intensely to find a way to convert carbon from its inexpensive graphite form to its valuable diamond form. Prominent among investigators of this problem was Percy W. Bridgman, 1946 Nobel Prize winner for his studies in high-pressure physics. All the attempts to synthesize diamond failed, primarily because the necessary condition of simultaneous high pressure and high temperature could not be achieved.

H. Tracy Hall became interested in the diamond synthesis problem while an employee of General Electric Company. His assignment was to discover the proper chemical environment for diamond synthesis. He soon realized, however, that the real problem was the lack of equipment that could produce high temperature simultaneously with the necessary high pressure. Dr. Hall had an idea for a device to produce these conditions. With the help of a friendly machinist at GE, he took it upon himself to build his "belt" apparatus. The belt proved capable of producing about one million pounds per square inch pressure while simultaneously generating temperatures up to 1800 °C. With the belt in operation, the synthesis of diamond swiftly followed.

Shortly after developing his process to synthesize diamond, Dr. Hall left GE to become the Director of Research at Brigham Young University in Provo, Utah. Because of proprietary concerns, GE was unwilling to let Dr. Hall use his belt apparatus in an open university setting. Not wanting to give up his interests in high-pressure research, Dr. Hall set about to invent a second device that would duplicate the achievements of the belt. He soon developed the concept of a multi-anvil high-pressure apparatus. Based on this concept, he built first, the "tetrahedral-anvilpress", and later, the "cubic press". These devices matched or exceeded the belt apparatus in producing the high pressure-high temperature environment Dr. Hall needed to synthesize diamond and to investigate other new materials. Both of these new presses rivalled the belt in capacity and in convenience. The inventive genius demonstrated by H. Tracy Hall in developing these three independent high pressure-high temperature devices is truly remarkable. The processes for diamond synthesis developed by H. Tracy Hall has been used to produce what is conservatively estimated to be at least $30 billion worth of industrial diamond products!

The following four patents, of the eighteen U.S. patents received by H. Tracy Hall, are for the work mentioned above. Dr. Hall also has 58 foreign patents to his credit for his work.

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| U.S. 2,918,699 | (the Tetrahedral Anvil Press) |
| U.S. 2,941,242 | (the Belt) |
| U.S. 2,947,608 | (Diamond Synthesis) |
| U.S. 3,829,544 | (Polycrystalline Synthetic Diamonds) |

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SUMMARY OF ACCOMPLISHMENTS (continued - page 2):

The major scientific achievements of H. Tracy Hall in high pressure-high temperature research and engineering are summarized in more detail below.

1. The invention of the "Belt" high pressure/high temperature apparatus, U.S. Patent No. 2,941,242 issued 21 June 1960. Two foreign patents were also granted. Conception and reduction to practice occurred in 1953 but issuance of the patent was delayed by a U.S. Government secrecy order based on the invention's importance. This device can simultaneously maintain a pressure of one millions pounds per square inch and a temperature of 2000 degrees Celcius. It is used throughout the world in the commercial manufacture of industrial diamond. An estimated one billion carats (about 200 tons) of diamond has been made since the Belt was invented. This invention is the most highly cited invention in the field of high pressure and was so recognized in "This Week's Citation Classic", Current Contents, ISI Press, 41, 14, 1980.

2. The first synthesis of diamonds, a feat that had eluded scientists for at least 150 years. The Belt made this possible. U.S. Patent Nos. 2,947,608 and 2,947,610, 20 August 1960. Twenty one foreign patents were also granted for this process.

3. The invention of the tetrahedral press, U.S. Patent No. 2,918,699, 29 December 1959. Two foreign patents were also granted. This invention circumvented the proprietary interest of the General Electric Company which prevented H. Tracy Hall from using the Belt for scientific research after leaving that company in 1955. It has the same pressure-temperature capabilities as the Belt. Note that the patent on this was granted before that on the Belt. This device also became subject to a U.S. Government secrecy order.

4. Sintered diamond, a synthetic carbonado first introduced to the world by Megadiamond Industries 24 September 1970. This type of material is rapidly revolutionizing the industrial diamond industry. U.S. Patent Nos. 3,816,085; 3,829,544; and 3,913,280. Eleven foreign patents were also granted. See Science, 169, 868-69 (1970).

5. The determination of the first melting curve under high pressure, high temperature conditions. The material studied was germanium. See J. Phys. Chem. 59, 1144-1146 (1955).

6. The first high pressure, high temperature X-ray diffraction apparatus (with J. Dean Barnett) U.S. Patent No. 3,249,753. Also see Rev. Sci. Instrum. 35, 175-182 (1964).

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SUMMARY OF ACCOMPLISHMENTS (continued - page 3):

7. Discovery of the first pressure induced phase change from a close-packed to a non-close-packed structure (FCC to BCC in ytterbium at 40 kbar) with J. Dean Barnett and Leo Merrill. Such a change was thought to be impossible before this discovery. The article disclosing this transformation appeared in Science 139, 111-112 (1963) and was featured on the front cover of that issue.
8. The determination of the nature of the "resistance cusp" in cesium. This intriguing problem had remained unsolved since the discovery of the cusp by P.W. Bridgman, See Science, 146, 1297-1299 (1964).
9. The synthesis of over 100 rare earth compounds and polymorphs that are impossible to synthesize by conventional means. These were prepared by the application of high pressure and high temperature techniques. The syntheses and properties are described in a series of 20 papers beginning with an article by Norman L. Eatough and H. Tracy Hall entitled "High Pressure Synthesis of Rare Earth Diantimonides", Inorg. Chem. 8, 1439 (1969).

H. Tracy Hall has received many awards, some of the more prestigious of which are noted below.

1959 - Alfred P. Sloan Foundation Research Fellow
1960 - Fellow, American Association for the Advancement of Science
1961 - Member of the editorial board of "Inorganic Chemistry"
1962 - Research Medal from the American Society of Tool and Manufacturing Engineering
1962 - Featured in a Man-Made Diamond Exhibit at the Seattle World's Fair
1964 - First Annual Distinguished Faculty Lecturer at Brigham Young University
1964 - Third Annual Olin Matheson Lecturer at Yale University
1965 - James E. Talmage Scientific Achievement Award from Brigham Young University
1965 - Utah Award from the American Chemical Society
1965 - Modern Pioneers in Creative Industry Award, National Association of Manufacturers
1966 - Member of the editorial board of the "Review of Scientific Instruments"
1967 - Robert A. Welch Foundation "Lecturer in Chemistry"
1970 - Chemical Pioneer Award from the American Institute of Chemists
1971 - Honorary Doctor of Science Degree from Brigham Young University
1972 - Creative Invention Award from the American Chemical Society
1972 - Fellow, American Institute of Chemists
1973 - The American Society for Metals "Engineering Materials Achievement Award"
1975 - Distinguished Alumni Award from Weber State University
1977 - The American Physical Society "International Prize for New Materials"
1977 - The Willard Gardner Prize from the Utah Academy of Sciences, Arts and Letters
1978 - Karl G. Maeser Research Award from Brigham Young University
1987 - Honorary Doctorate of Humanities, Weber State University
1994 - Utah State Governor's Medal for Science And Technology

Dell K. Allen
NOMINATOR'S SIGNATURE

2/14/97
DATE