collector, in the negative or high-resistance direction. A third contact, the base electrode, makes a low-resistance contact to the block. A large part of the forward current consists of holes flowing into the block. Current from the collector consists in part of electrons flowing from the contact and in part of holes flowing toward the contact. The collector current produces an electric field in the block which is in such a direction as to attract holes introduced at the emitter. A large part of the emitter current, introduced at low impedance, flows in the collector circuit. When it is biased in the reverse direction, the collector has high impedance and can be matched to a high-impedance load. There is thus a large voltage amplification of an input signal. It is found (*17*) that there is some current amplification as well, giving an over-all power gain of 20 decibels or more. An increase in hole current at the collector affects the barrier there in such a way as to enhance the current of electrons from the contact.

The collector current must be sufficiently large to provide an electric field to attract the holes from the emitter. The optimum impedance of the collector is considerably less than that of a good germanium diode in the reverse direction. In the first experiments, it was attempted to achieve this by treating the surface so as to produce a large inversion layer of *p*-type conductivity on the surface. In this case, a large fraction of the hole current may be in the inversion layer. Later, it was found that better results could be obtained by electrically forming the collector by passing large current pulses through it. In this case, the surface treatment is less critical, and most of the emitter current flows through the bulk.

Studies of the nature of the forward and reverse currents to a point contact to germanium were made by making probe measurements of the variation of potential in the vicinity of the contact (*18*). These measurements showed a large increase in conductivity when the contact was biased in the forward direction and, in some cases, evidence for a conducting inversion layer near the surface when the contact was biased in the reverse direction.

Before it was established whether the useful emitter current was confined to an inversion layer or could flow through the bulk, Shockley (*19*) proposed a radically different design for a transistor based on the latter possibility. This is the junction transistor design in which added minority carriers from the emitter diffuse through a thin base layer to the collector. Independently of this suggestion, Shive (*20*) made a point-contact transistor in which the emitter and collector were on opposite faces of a thin slab of germanium. This showed definitely that injected minority carriers could flow for small distances through bulk material. While transistors can be made to operate either way, designs which make use of flow through bulk material have been most successful. Junction transistors have superseded point-contact transistors for most applications.

Following the discovery of the transistor effect, a large part of the research at Bell Laboratories was devoted to a study of flow of injected minority carriers in bulk material. Much of this research was instigated by Shockley, and it was described by him (*1*).

Research on the surface properties of germanium and silicon, suspended for some time after 1948 because of the pressure of other work, was resumed later on by Brattain and others and is now a flourishing field of activity with implications in a number of scientific fields other than semiconductors, such as adsorption, catalysis, and photoconductivity. This research program is described by Brattain (*2*).

It is evident that many years of research by a great many people both before and after the discovery of the transistor effect have been required to bring our knowledge of semiconductors to its present development. We were fortunate enough to be involved at a particularly opportune time and to add another small step in the control of nature for the benefit of mankind (*21*).

References and Notes

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21. In addition to my colleagues and others mentioned in the article, I should like to express my gratitude to M. J. Kelley and Ralph Bown for their inspired leadership of Bell Telephone Laboratories when this work was done.

C. V. Weller, Pathologist and Editor

The sudden and untimely death of Carl Vernon Weller, professor and chairman of the department of pathology at the University of Michigan Medical School, on 10 December 1956, prematurely closed the career of a great medical teacher, tissue pathologist, medical writer, and editor.

Dr. Weller was born in St. Johns, Michigan, on 17 February 1887. He received his A.B. degree from Albion College in 1908, his M.D. degree from the University of Michigan in 1913, and his M.S. degree in pathology from the University of Michigan in 1916. In June 1956 he was awarded the honorary degree of Sc.D. by Albion College.

Beginning as an instructor in 1911, Weller served on the staff of the department of pathology of the University of Michigan Medical School for 45 years. On the death of Aldred Scott Warthin, in 1931, he was appointed chairman of the department and served in that capacity until his retirement, 1 July 1956. In 1913 Weller married Elsie Huckle, of St. Clair, Michigan.

Weller was editor of the *Annals of Internal Medicine* from 1931 to 1933 and, from 1941 until his death, served as editor of *The American Journal of Pathology*. He was acting president of the American Association of Pathologists and Bacteriologists in 1938 and president in 1939. He was a founder of the Michigan Pathological Society and served as its first president in 1931; he was president of the American Society for Experimental Pathology in 1933 and of the International Association of Medical Museums in 1938. At the time of his death he was chairman of the Scientific Advisory Board of the Armed Forces Institute of Pathology.

He was an active writer on medical subjects and was the author of approximately 100 publications, which deal chiefly with mustard gas poisoning, neoplasms, tuberculosis, lead and alcoholic blastophthoria, and the history of medicine. His last major contribution was a monograph on *Causal Factors in Cancer of the Lung* (Thomas, Springfield, Ill., 1955).

Weller was noted as a great teacher. In 1956 he was honored, by the Galens Medical Society of the University of Michigan, by the establishment of the Weller award for scholarship in pathology.

Other honors included the Mellon lectureship at the University of Pittsburgh in 1941 ("The inheritance of retinoblastoma and its relationship to practical eugenics"); the Macgregor memorial lecture at the University of Western Ontario, London, in 1951 ("The causes of cancer"); and the Beaumont lecture before the Wayne County Medical Society, Detroit, in 1955 ("Causal factors in cancer of the lung").

A recent honor came to Weller with the establishment, in 1956, of the annual Carl V. Weller lecture by the Michigan Pathological Society. Howard T. Karsner delivered the first of these lectures on 8 December 1956; his subject was "The place of pathology in biomedical research."

Weller was respected by medical students, by his departmental staff members, and by his colleagues in the medical school and university and, throughout the nation, as a leader devoted to duty and to the highest ideals of ethics in medicine and in life. The profession of medicine and the field of pathology have lost a truly great teacher, diagnostician, writer, and editor.

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K. Shiga, Bacteriologist

When the American occupation forces landed in Japan in 1945 and their Medical Corps officers began to inquire into the state of microbiology in that country, they were surprised to hear that Dr. Kiyoshi Shiga, discoverer of *Shigella dysenteriae* 1 (Shiga), which was formerly considered the most important cause of bacillary dysentery, was still alive. A visit to Dr. Shiga, who was then living in retirement on his estate near Sendai, was rather easy to arrange at that time. He was very anxious to meet and talk with American physicians, whose respectful attention he enjoyed.

Shiga was a pleasant, polite, and dignified man. A chat with him, spiced with reminiscences, was always a treat, especially for us old-timers. He liked to dwell on his youth, on his studies in Germany, and on his trials, tribulations, and triumphs in that country.

Shiga attained world fame at a relatively early age. Born in 1870, he was graduated from Tokyo University in 1886, immediately started working under Shibasaburo Kitasato at the Japan Institute for Infectious Diseases and, as early as 1897, published his paper on the dysentery bacillus in the *Japanese Journal of Bacteriology*. Four years later he went to Germany to study, an experience which deeply influenced the rest of his life.

In Germany, Shiga worked under Ehrlich, discovered trypan red, and picked up a slogan, which he attributed to Ehrlich, as the motto of his life: *Geld, Geduld, Geschick, und Glück* (money, patience, fate, and luck). He kept repeating this saying of Ehrlich's and insisted that it governed all his decisions. Shiga, however, was not a money hunter.

In Germany he acquired an interest in immunology and chemotherapy and continued to work in these fields after his return to Japan. He was a delightful raconteur, especially when telling of his debate with Kruse, who, 3 years after Shiga's article was printed, published a paper on the same dysentery bacillus that Shiga had described. Although Shiga considered his bacterium to be motile, Kruse found it nonmotile, and for this reason Kruse, supported by various workers, claimed priority for the discovery of the dysentery bacillus. According to Shiga, Kruse was a big, tall man, with an apparently dominating personality, while Shiga had a complex about his short, slight build, for which he tried to compensate by his dignity. Kruse did not pay much attention to Shiga in the beginning, but later he had to concede his importance. The organism was called the Shiga-Kruse bacillus until the genus *Shigella* became established; this acknowledged, with finality, Shiga's priority.

Shiga was loyal to his teacher Kitasato. When the Japanese Government tried to transfer the Institute for Infectious Diseases to the Ministry of Education, in 1914, Kitasato seceded from it and founded his own independent research institute, now known as the Kitasato Institute. Shiga declared his allegiance to Kitasato and, together with other staff members, followed him into an uncertain future. The Kitasato Institute, however, later became the most famous research institute of Asia.

Shiga received numerous honors, including the highest civilian medal of the Japanese Government, but when he retired to his native village, during the first part of World War II, literature and painting became his main interests. He was an accomplished water-color painter, a follower of the Japanese style in this art. His textbook on bacteriology and immunology was still in great demand when he died, early this year, on 25 January.

Shiga lived a full life; he had an active youth, a sedate middle age, and a serene retirement. Although he was a distinguished scientist, he appreciated the fine arts and had an immense number of cultural interests. He believed in the Japanese philosophy of life, which teaches that neither joy nor sorrow shall ever be overwhelming. One wonders whether adherence to Dr. Shiga's principles might not save many a candidate from a coronary attack.

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