From Stockholm, with love

It's Nobel Prize season in Sweden

Josephson *Giaever* *Esaki*

Physics: Tunneling where classical theory says no

Work on the quantum-mechanical tunneling effect has brought the 1973 Nobel Prize in Physics to two scientists in America, Ivar Giaever of General Electric and Leo Esaki of IBM, and one Briton, Brian Josephson of Cambridge University.

The tunneling effect is a phenomenon that permits particles to go where classical physics says they cannot; they tunnel through potential barriers instead of going over them. A potential barrier is a kind of energy fence, a region of space where the balance of forces would force an impinging particle to go back in the direction it came from unless it had enough energy to sail over the barrier. That is the classical definition. In quantum mechanics, a particle doesn't always need enough energy to clear the barrier; there is a certain probability that a particle with less energy will get through by "tunneling" the barrier.

A potential barrier can be set up simply by a field of force in the space concerned or it can be due to a material element. In electronic circuitry potential barriers result from the insertion of an insulating layer between two conductors. It is in work of this sort, tunneling junctions as they are called, that the three Nobelists are distinguished.

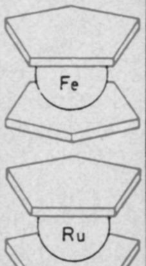
Esaki's work comes first in time. It began in 1957 when he was with the Sony Corporation of Tokyo. He started to work with germanium p-n junctions in the hope of finding tunneling currents in them. A germanium junction is a small piece of germanium between two metal electrodes. Germanium is a semiconductor, and will pass a current in one direction only. In the normal operation of such a junction, the current flows by means of motion of electrons and holes in the semiconductor. Esaki wanted to find a tunneling of electrons from one electrode to the other through the germanium. He found that by making the germanium extremely thin and by doping it heavily with impurities, a tunneling current did flow and in the same direction (the "forward" direction) as the semiconductor's own current would flow. From this work Esaki produced a diode that had polarity reversed from that of other diodes and contained a negative resistance region, a region where an increase in voltage results in a decrease in current instead of an increase. Thus he invented the Esaki tunnel diode, which has many applications in circuitry as a fast-switching or high-frequency amplifying element.

In his own words Giaever says: "What I have done is marrying tunneling to superconductivity." Giaever worked with junctions in which one metal electrode was superconducting and one was not. In the case where two electrodes are normal conductors, the current rises linearly with the rise of voltage across the junction. In the case where one electrode is superconducting, the current change is not linear, and in cases where both electrodes are superconducting, the negative resistance phenomenon can also appear. The way the current changes with voltage depends on the density of electron energy states in the superconductor, and so Giaever's work can be used to study the spectroscopy of superconducting electron energy states and to test theories of superconductivity.

In 1962 Josephson predicted a new kind of tunneling, that of electron pairs, in cases where both electrodes of a junction were superconducting. The theory of superconductivity says that superconductivity appears when the conduction electrons of a metal bind themselves in pairs, the so-called Cooper pairs. Josephson's prediction was that in suitable cases of a junction with two superconducting electrodes, Cooper pairs would tunnel rather than a single electron. The idea has been confirmed experimentally, and the Josephson junction thus produced has a number of unusual qualities. One of these is that it will emit electromagnetic radiation when an alternating voltage is applied to it. The Josephson junction shows much promise of practical application in many areas of electronics.

Esaki was born in Osaka and educated in Tokyo, receiving his Ph.D. from the University of Tokyo in 1959. He came to the United States in 1960 to join IBM's Thomas J. Watson Research Center. Giaever was born in Bergen, Norway. He graduated as a mechanical engineer at the Norwegian Institute of Technology in Trondheim. In 1954 he emigrated to Canada and in 1956 to the United States. He earned his Ph.D. at Rensselaer Polytechnic Institute in 1964. Josephson, a native of Wales, was educated at Cambridge University and continues to work there.

Esaki and Giaever will share half the $122,000 prize; Josephson will get the other half.



Fischer *Wilkinson*

Chemistry: 'Sandwiches' of metals and carbon

For the first time in many years, the Swedish Royal Academy has awarded the Nobel Prize in Chemistry for basic chemistry research, not for methods or discoveries that border both the biological and physical fields. The recipients are Geoffrey Wilkinson of the Imperial College of Science and Technology of the University of London and Ernst Otto Fischer of the Technical University in Munich.

The prize this year is in "chemistry for chemists," said Gunnar Brusewitz of the Swedish Royal Academy. "A very essential part of scientific discipline is its structure and its concepts. Fischer and Wilkinson widened the basic concepts of chemistry by their work and therefore also changed the structure of chemistry."

Wilkinson and Fischer share the Nobel Prize for their independent contributions to the field of organometallics, specifically to the elucidation of "sandwich" molecules. In sandwich bonding, two symmetrical rings of hydrocarbon molecules make a sandwich around a metal. One symmetrical ring forms the top slice of bread. The other symmetrical ring forms the bottom slice. The metal sits between the rings like the meat in a sandwich. The rings may lie parallel to each other, or in staggered or eclipsed configurations.

The first sandwich molecule was discovered in 1951, partly by Wilkinson. It is called ferrocene. Because ferrocene is exceedingly heat-stable, it had long been thought to consist of two symmetrical carbon rings joined together by iron. But then by a combination of chemical and physical studies, culminating with X-ray confirmation, its true structure was determined. Its symmetrical five-sided rings form a sandwich around iron, in a staggered configuration.

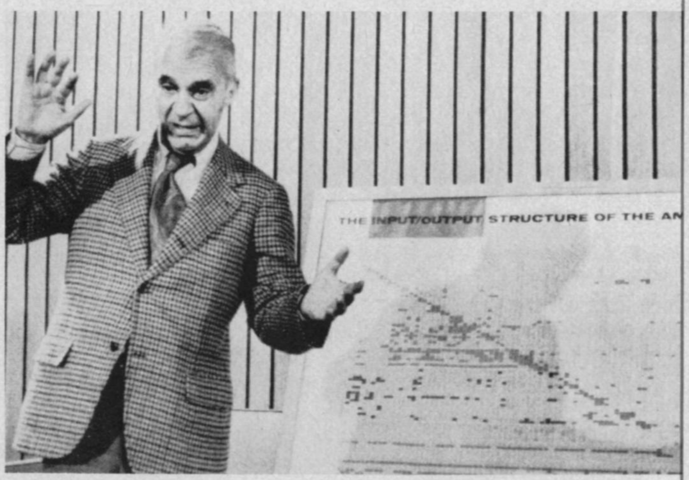
Work on metal complexes, specifically sandwich compounds, is still experimental, but there has been a "tremendous increase in the importance of this type of complex for scientific and industrial purposes," Fischer says. For example, sandwich molecules may mean that the present lead in gasoline can be replaced with less dangerous metallic ingredients, creating less risks of exhaust pollution in large cities.

Fischer was born in 1918, Wilkinson in 1921. They head the inorganic chemistry laboratories of their respective universities. Wilkinson has also researched and taught at the University of California at Berkeley, the Massachusetts Institute of Technology and Harvard University.

Economics: Charting the economy's in's and out's

In a trailblazing paper in 1936, a young Russian-born Harvard University economist named Wassily W. Leontief set forth and defined the input-output theory of economic analysis, which, as he puts it, "can view the economy of a country as an organism, in which each part plays its role and they are all interrelated; so if one is sick it affects the operation of the others."

Basically, input-output analysis is an analytical tool to explain inter-industry economic relationships. It views the whole economy of a region or country as a single system. Information is reduced to a table in which all industries are listed down the left side of a grid and across the top in the same order. Inputs, the goods and and services that each industry buys from the others, and outputs, the products that each industry turns out and sells to the others, are represented by numbers on the grid. Each number is a simultaneous representation of input and output. From the standpoint of the industry at the left of each row, each number represents that part of its ouptut which is sold to the industries listed across the top of the table. From the standpoint of the industries along the top, each number below



Photos: Wide World

Leontief explains input-output chart of the economy.

represents an input that it uses in making its own products.

Using Leontief's technique, the Commerce Department has produced detailed models of the nation's economy listing up to 370 different sections of the economy. Such models are used to project the future structure of the economy as a result of growth, giving economic planners insights into industries that will expand or contract. The input-output model was used, for instance, to predict the effects of disarmament on the economy.

The Leontief system of analysis has been adapted for use by the governments of 50 countries to meet various economic challenges, and is now being used by economic planners in socialist countries and by market analysts in private-enterprise countries. These input-output tables, says Leontief, "give the discipline of economics the 200-inch telscope it requires for its work today." The Nobel committee obviously agrees with him. Last week it awarded Leontief, the "sole and unchallenged creator of the input-output technique," the 1973 Nobel Memorial Prize in Economic Science.