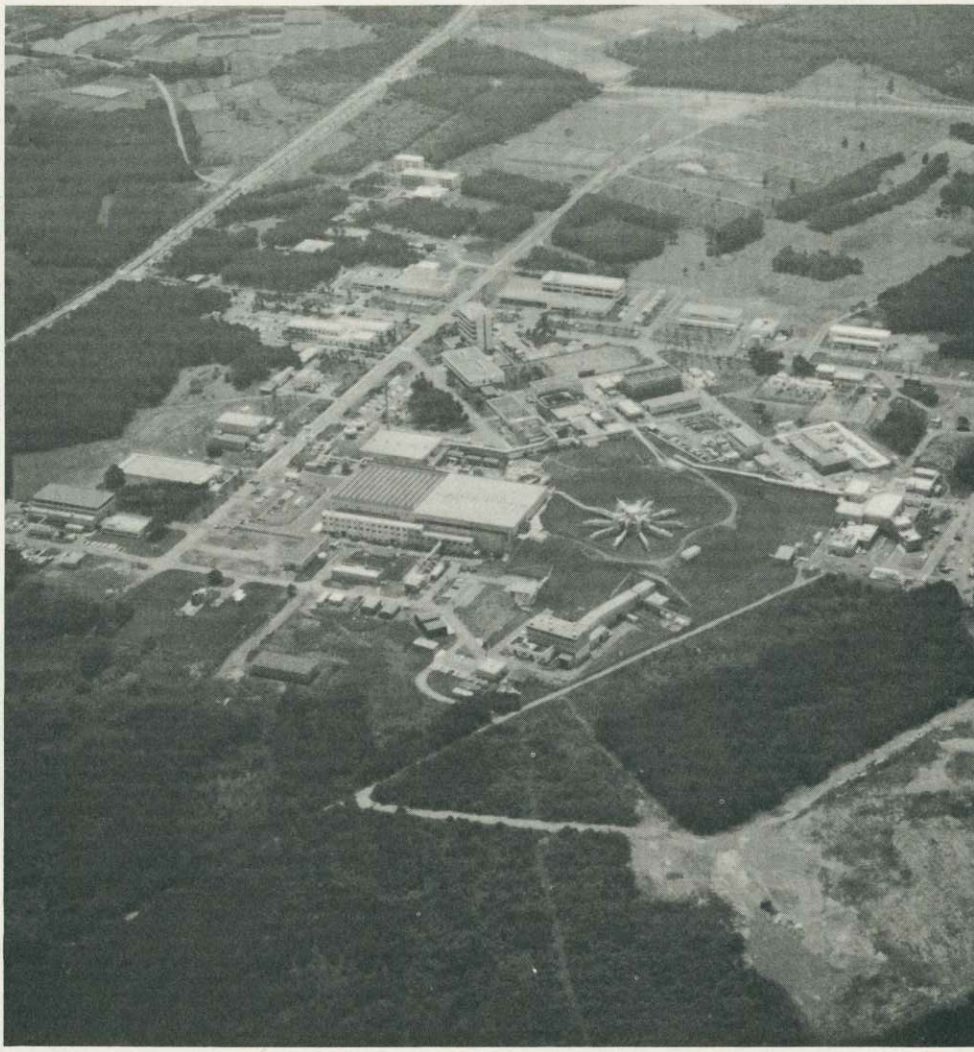
Scientific Research Vigorously U

Is Japan's science and technology development aimed only at industrial applications, with no real depth? Do Japanese scientists and technical engineers think that they can get by cheaply on improvements to imported foreign technology, making slightly better products to flood the world market, rather than conducting their own research and development? Or are they really making efforts to gain for Japan a top rank among the world countries not only in the industrial field but in scientific research as well?

In order to find answers to these questions, I visited three research institutes. One of them is state-owned, another is jointly used by universities, while the third is a private research institute.

From my visits I learned that Japan is vigorously promoting not only research on industrial technology, but also basic research which forms the root of industrial technology. Moreover, I found that Japan, whose technology has reached one of the world's highest levels, is now being urged to display some originality.

Tsukuba Science City in Ibaraki Prefecture is a newly developed city located about 60 kilometers to the northeast of Tokyo. Many state and public research institutes and laboratories have been relocated there from other parts of Japan. At the core of these facilities is Tsukuba University. Among the group of laboratories in the northern section of the city stands the National Laboratory for High Energy Physics, popularly known as KEK (*Ko Enerugi-butsuri Kenkyusho*). Ten years after its establishment, construction work is still going on there. Created by the Ministry of Education as the first laboratory for joint use by state universities, KEK is engaged in research in elementary particle physics. Standing on a tract of land covering 2,020,000 square meters, the laboratory buildings occupy a total floor space of 55,000 square meters. Under KEK Director-General Tetsuharu Nishikawa, 349 personnel, including 34 professors and administrative staff, are engaged in research. KEK's budget in fiscal 1981, ended March 31, 1982, was about ¥18.4 billion ($80 million). Its budget for fiscal 1982 is about ¥23 billion ($100 million).



An overall view of KEK

Despite its short history, KEK has earned worldwide fame for its success in December 1976 in speeding up the proton to 120 MeV (mega electron volts) or 99.7% of the speed of light. KEK's proton synchrotron has a diameter of 108 meters. It is made up of 48 deflection electromagnets and 56 focusing electromagnets. This is not a big synchrotron by world standards. How did KEK earn worldwide fame with such modest equipment? The answer is that KEK was able to control time up to one-millionth of a second and to conduct the experiment without any serious trouble.

Once the synchrotron is put into operation, experiments have to be conducted continuously for about 10 straight days. The incidence of breakdown or mechanical trouble is extremely low in the case of KEK's synchrotron, with an operation rate always averaging more than 90%. Three elements—high reliability of the apparatus, reliability of control technology and high quality of staff—are vital in operating a synchrotron. In the laboratories of other countries, the average operation rate of synchrotrons is below 70%.

I asked Dr. Kikuchi, chief research professor at the Engineering Research and Scientific Support Department of KEK, the secret behind this high operating rate. He explained the biggest reason is that Japan has many manufacturers who are able to assemble synchrotrons exactly to the specifications required by the labora-

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By Masaaki Aoki
Kyodo News Service

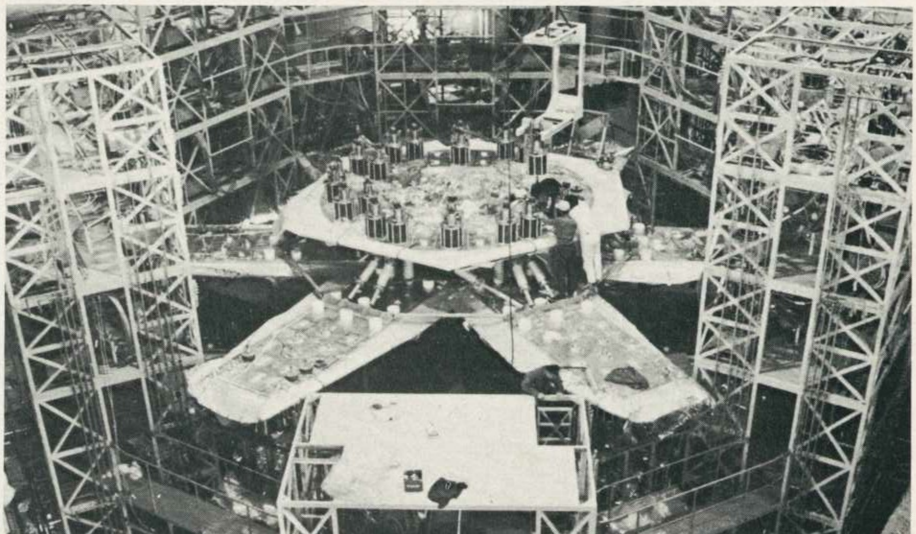
tories. Synchrotrons are made to order. So, in many cases, researchers are involved in the construction of a synchrotron from the stage of designing to trial-manufacture. All components and apparatuses employed are manufactured by commercial firms on their own responsibility. It is no exaggeration to say that every component of apparatus delivered to the laboratory by commercial manufacturers undergoes laboratory inspection. Professor Kikuchi said that KEK has so far ordered about 100 special electromagnets, and none failed to pass KEK's inspection. "I have heard that in an extreme case in a foreign country, all the electromagnets that were delivered to a laboratory did not come up to the required standard," he went on. "When we place an order for an electromagnet with accuracy of up to 0.5 millimeter, the maker tries to produce one with accuracy of up to 0.3 millimeter so they will be able to meet our requirements without fail." Thus Professor Kikuchi expressed complete confidence in the reliability of Japanese manufacturers.

The second reason for the high operation rate of KEK's synchrotron, according to Professor Kikuchi, is that the level of technical staff engaged in the operation of synchrotrons in Japan is high, although there are fewer than in comparable foreign institutions. He meant that if the technical level of the operating staff is low, the operation of a synchrotron does not go smoothly. However, because the technical level of the Japanese staff is high, unnecessary troubles can be avoided. It is possible in Japan, therefore, for professors, assistants and technical staff to work in shifts to keep the synchrotron operating 24 hours a day. "I think Japan is the only country in the world where professors and the technical staff are able to alternate in shifts," Professor Kikuchi said proudly.

A new page was added to the history of KEK in March 1982. The world's largest synchrotron radiation research facility was completed as scheduled, and KEK succeeded in speeding electrons up to the targeted 2.5 gigavolts. This facility is made up of an electron lineac, measuring 400 meters in total length, and a ring housing an oval electron beam measuring 68 meters in large diameter and 50 meters in small diameter. (This electron lineac is the world's second longest, following the one at Stanford University in the United States, which measures 3.2 kilometers.) The facility is called a photon factory, because ultra-high-speed electrons emit, within the entire range of wave lengths from visible light to X-ray, radiation more than 1,000 times stronger than that from a conventional light source and superior to a laser beam in directional characteristics. Research being conducted at present at the photon factory is expected to produce results applicable not only to physics but also to biology and medicine. If applied to the industrial field, it will make possible the ultra-minute lithography needed to manufacture an ultra-LSI. Similar research is being conducted in many countries. A synchrotron radiation research facility (2.5 GeV) is now under construction at the Brookhaven National Laboratory in the suburbs of New York and another at the Kuruchatov Atomic Energy Research Institute in the Soviet Union. The only photon factory that has already been completed abroad is the one (1.8 GeV) at the Dirthberry Research Institute in Britain. In terms of capacity, the photon factory at KEK is the largest in the world.

KEK has another grand-scale project called TRISTAN (Transposable Ring Intersecting Storage Accelerators in Nippon). A ring about 900 meters in diameter has been constructed to confirm the existence of the Top quark, the sixth quark particle yet to be identified. Five of the different kinds of quark particles, said to comprise a proton or a neutron, have already been identified. As far as the length of diameter of the ring is concerned, the ring at the Fermi National Accelerators Research Institute measuring 2 kilometers in diameter, is the largest in the world. If this TRISTAN project should materialize, the ring at KEK should become the world's largest electron collision-type synchrotron. Special note must be taken of the fact that the TRISTAN project uses super-conductive electromagnets. Super conductivity is a phenomenon in which electric resistance completely disappears in metals when they are cooled down to a temperature close to absolute zero. If electromagnets are produced by means of super conductivity, power consumption can be cut down enormously. The TRISTAN project plans to employ 400 to 500 super-conductive electromagnets, each about 6 meters long. Research on super-conductive electromagnets is now underway not only at KEK but also at the Japanese National Railways (JNR)

Nuclear fusion system used in ETL



Dr. Ken Kikuchi, KEK research chief

for use in a proposed highspeed linear motor car.

KEK is also actively engaged in exchange of research on an international scale. When I visited KEK, a research group from UCLA was busy making preparations for an experiment. According to a KEK spokesman, about 60 KEK staff members go to different laboratories in the United States and other countries annually to promote joint research. These exchanges are carried out under the Japan-U.S. Science and Technology Cooperation Agreement concluded in 1979 as a fruit of the Japan-U.S. Summit held that year. Professor Kikuchi said he thinks that of all fields for international corperation, high energy physics is the field where cooperation in research has been most successful.

Japan, which has produced such Nobel Prize winners in physics as Dr. Hideki Yukawa and Dr. Shinichiro Tomonaga, is advanced in theoretical study of elementary particles, but is seriously lagging behind in experimental research. However, the fact that KEK has been operating the accelerator exactly according to plan and maintaining a high operational rate is proof that Japanese research in science has already reached international level.

Also actively engaged in international exchange of research is the Electrotechnical Laboratory (ETL) of the Agency of Industrial Science and Technology attached to the Ministry of International Trade and Industry, also in Tsukuba Science City. According to Shigeru Maekawa, director of its Research Planning Office, ETL has had personnel exchanges with Stanford University, MIT (Massachusetts Institute of Technology), and the U.S. National Bureau of Standards. It also exchanges researchers with the Heinrich Hertz Laboratory of West Germany. ETL sends about 50 researchers abroad annually, while accepting more than 200 visitors, including many from overseas. The itinerary of French President François Mitterrand who came to Japan in April included a visit to ETL and also to KEK.

ETL is Japan's largest national research institute with seven laboratory buildings and 14 research departments covering a total floor space of 60,000 square meters. It has 569 researchers and a total budget in fiscal 1981 of ¥8,900 million ($36.3 million). ETL's research covers all fields from electricity and electronics to information technology, including development of energy alternatives to petroleum and energy-saving technology. ETL has already acquired a total of 694 patents.

The following episode shows the high standard of research programs being undertaken. ETL is also engaged in research into nuclear fusion reaction. Reading a report on the results of its studies, the Culham Laboratory in Britain sent two researchers to Japan with apparatus for follow-up experiments in February and March.

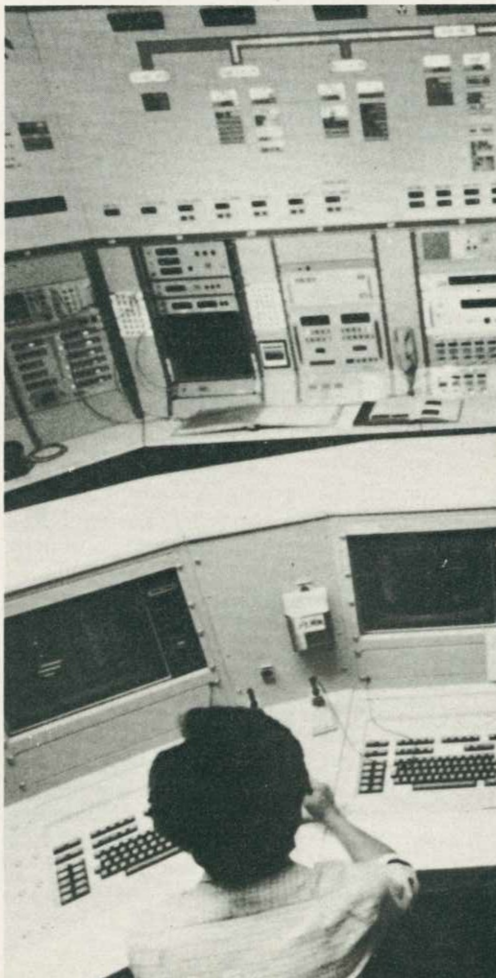
According to Maekawa, the Culham Laboratory is a top authority on nuclear fusion. The fact that it sent two researchers to ETL signifies ETL has achieved international recognition. Culham sent its researchers also to the Soviet Union for similar follow-up tests, and this served as a proof that research on nuclear fusion is advanced also in the Soviet Union.

ETL earned fame both at home and abroad for the originality it displayed in its research on a pattern information processing system. It conducted research under a 10-year program from 1971, in order to develop a system capable of directly inputting and processing information in characters, diagrams and voices which present computer systems cannot yet handle. Recognition of patterns is tantamount to human vision and hearing. ETL has now completed the prototype of this pattern information processing system, thus attaining the initial target of the research.

The significance of this research is paramount. The latest computer currently in use is a fourth-generation machine. The future fifth-generation computer will be one that will function like a human brain rather than one merely having deduction and learning functions. The research conducted by ETL is the first step towards developing such a fifth-generation computer. An international symposium on its development was held in Japan last October.

Research on materials and elementary particles is vital to the development of the next-generation computer. The newest laboratory in ETL is the Josephson Computer Technology Special Laboratory set up last summer. It has started research on a new computer on the basis of the Josephson effect. Japan has been developing computer technology in order to catch up with IBM of the U.S. But today, one can say that Japan is no longer imitating U.S. computer technology. "We have our eyes set on developing not only the fifth-generation computer, but even the sixth-generation," said Maekawa. "We are conducting research not only from a short-range standpoint but from a more far-sighted standpoint." He said that ETL is engaged not only in information technology but also in highly diversified research on various themes, such as the development of an amorphous cell for solar heat generators and an ultra-high-performance laser-applied compound production system. It is also helping other countries.

Control center for the synchrotron



Under the ITIT (Institute for Transfer of Industrial Technology) program for example, ETL supplied Thailand with an industrial measuring standard. It is providing Brazil with cooperation in research on effective utilization of niobium, an ultraconductive metal.

Next, in order to see a private laboratory, I visited the Yokohama Plant of Sumitomo Electric Industries, Ltd., the top Japanese maker of optical fiber cable.

The optical communication system transmits signals on light instead of using electricity or radio waves. It can transmit nearly 1,000 times more information than conventional systems. It is often called a dream communication system because it is free from noise or image distortion. Optical communication is already being put to practical use in telephone circuits in the United States and some other countries. Optical communication recently came to the attention of the public in Japan and the United States when the Japanese company Fujitsu was denied a contract for building circuits linking Washington and Boston after it became the lowest bidder in an international tender. Fujitsu was turned down reportedly for "national security" reasons.

The nucleus of the optical communication system is a glass fiber only 0.1 millimeter in diameter through which laser rays are passed. The manufacture of optical fiber starts with the making of the preform, the parent material. Sumitomo's preform manufacturing process is called VAD (vapor phase axial deposition). According to Tadashi Watamizu, assistant manager of Administration and Planning in the Fiber Optics Division of Sumitomo Electric Industries, the VAD process produces preform much larger and of higher quality than the MCVD (modified chemical vapor deposition) process developed by Bell Laboratories of the U.S. and used widely in many countries other than Japan.

Dr. Shigeru Maekawa, Head of Research Planning Office, ETL.

Mr. Watamizu said the VAD process was developed jointly by Nippon Telegraph and Telephone Public Corporation (NTT) and Sumitomo. Sumitomo engineers say that an optical fiber mass production process superior to VAD is not expected to be developed within the next 20 years. About 15 kilometers of optical fiber can be produced from one preform made by the conventional process. But the VAD process produces 30 kilometers of optical fiber. In some cases, even 100 kilometers of optical fiber can be obtained from one VAD preform. Transmission loss is inevitable in communication. At the time Corning Glass Works of the United States began marketing optical fiber in 1970, the transmission loss was 20 decibels (rate of decay, 10%). Sumitomo's optical fiber has reduced transmission loss to 0.2 db.

Having been impressed by the superiority of Sumitomo's optical fiber, this reporter asked what were the respective shares of research expenses and how the research was divided with NTT.

"The VAD process was a product of joint research with NTT, but actually all research and development pertaining to optics was done by Sumitomo alone. Sumitomo received no research funds from outsiders," Mr. Watamizu said.

Sumitomo began studies in optical fiber communication at the end of 1960 and so far has invested ¥70 billion ($304 million) in research and development. Of the ¥10 billion ($43.5 million) which the company spent in 1981 for all research and development, ¥6 billion ($26 million) was spent on optics. At the same time, it is also a fact that NTT was involved in the research and development, and no one in the industry denies the contribution it has made to the development of optical fiber communication.

It also cannot be denied that the VAD process is an improved version of the MCVD process which was developed by the United States.

Now that optical communication has entered the phase of commercialization, an intense war is about to start on the world market in optical communication equipment and systems. It is projected that by the latter half of the 1980s, it will expand into a ¥1 trillion ($4.35 billion) industry in Japan alone. But a Sumitomo engineer said they are aware that before optical communication develops into a mammoth industry many technical barriers remain to be cleared. He explained, "Today, signals cannot be transmitted through optical fiber for more than 40-50 kilometers without booster connections. It is necessary to be able to transmit signals at least as far as 200 kilometers. Other problems that have to be solved include how to improve the structure of optical fiber cable and how to reduce transmission loss from connections."

Sumitomo boasts advanced technology which has succeeded in reducing transmission loss to 0.2 db. Now, the company is aiming to reduce this to zero.

The technology for optical fiber communication, unlike that for the automobile and color TV, is highly sophisticated. Yet, Sumitomo and other Japanese makers of optical fiber communication equipment have achieved the world's highest level. Japan has caught up with its teacher, the United States. The only target that remains for Japan is to display its originality and develop new technology of its own through research and development. This is a new challenge for Japanese industry. ●