Of the grounds on which the founder of the Buchanan Medal desired the awards of it to be made, Sir Wilson Jameson's high claim to it is based on "administrative and constructive work" of outstanding merit in the service of hygienic science.

The Hughes Medal is awarded to Professor Enrico Fermi, now of New York. Professor Fermi has made most notable contributions both to theoretical and experimental physics. In the early days of the modern quantum theory he was one of the first theoretical physicists to appreciate the generality of the considerations put forward by Pauli and known as the exclusion principle. This led him to discuss the statistical theory of a perfect gas of particles in equilibrium, obeying this principle, with results which were obtained independently and almost simultaneously by Dirac by similar methods. These results of Fermi and Dirac are of the utmost importance in the modern theory of assemblies of similar particles, such as electrons, protons and neutrons. Following this outstanding personal contribution, Fermi played a great part in building up at Rome a distinguished school of theoretical physics, where he himself made one of the earliest successful attempts to construct a theory of radioactive β-ray change. This theory shows the most profound insight into the theoretical nature of the quantum theory.

His interest in the atomic nucleus led Fermi naturally on to his experimental studies in this field. Immediately after the discovery of the neutron he realized that it provided a new possibility of attack on the nucleus and of stimulating nuclear change by neutron bombardment. This work opened up the fruitful modern field of study concerned with the transformations of nuclei of medium and great atomic number, and led directly to the most exciting transformations of all, the nuclear fission of uranium and thorium.

Professor Fermi's work is characterized throughout by profound insight and great experimental skill. In the fields which he has made his own he is universally acclaimed a leader.

CRISIS IN RUBBER[1]

By JOHN L. COLLYER

PRESIDENT, THE B. F. GOODRICH COMPANY

It is a pleasure for me to meet with members of the Academy of Political Science. I feel honored and privileged to acquaint you with certain facts pertaining to the all-important question of rubber—natural and man-made.

America is in the grip of a rubber crisis. Our country, which normally uses more than half of all the rubber that is consumed throughout the world, has been shut off by decisive enemy action from sources which formerly produced 90 per cent. of the world's rubber. We are now engaged in a grim race against time. Several hundred thousand tons of new rubber will shortly be urgently needed to manufacture the wide range of war products required by the armed forces of the United Nations and to keep our vital industrial plants and essential transportation functioning.

The crisis that we face resolves itself into a question of whether we can bridge the gap until synthetic rubber manufacturing facilities now under construction within our country's borders are producing the huge quantities of this indispensable material that we will need to win the war.

It seems odd that we should be faced with a crisis in rubber when we stop to consider that rubber originated right next door to us in South America where native or wild rubber trees are situated. The seeds from which the extensive Eastern plantations have sprung were collected in South America in 1876. But by 1900, no more than 10,000 acres have been planted in the East.

The rubber plantations of the world now covering a planted area of approximately 9,000,000 acres have had in 1941 a productive capacity of 1,600,000 tons a year. The world's consumption in 1939 through 1941—a record three-year period—was at the rate of about 1,100,000 tons a year, which left a potential surplus of 50 per cent.

It has been my privilege to have visited the Eastern plantations and to have witnessed rubber manufacturing in most parts of the world, including Germany and Japan. In the course of many visits to Germany during the 1930's, I observed at close range the development of an imposing synthetic rubber industry as the Nazis prepared for war that is now resulting in the greatest death and destruction known to mankind.

During the war of 1914–1918, Germany had an inferior synthetic rubber. Research and development work—started at that time—has been diligently continued and intensified ever since. To-day Germany is probably living at least 75 per cent. on synthetic rubber.

Based on what I learned in Germany and Japan

[1] Read before the Academy of Political Science, New York, November 10, 1942.

and what I had become convinced were the aims and policies of the Nazis and the Japanese militarists, it has since 1937 been my belief that our country could not afford to be without a national insurance policy in terms of rubber. The only alternative was to have our entire national economy continually threatened by the possibility of disruption of the long rubber lifeline to the Far East.

In June, 1940, the stock of rubber in the United States totaled only 168,000 tons. The consumption for the year 1940 was 648,000 tons. The position of about three and a half months' stock was anything but a healthy one for our country and for its economy.

This precarious situation could be corrected only by a two-point program. To make certain that a continuing supply of rubber would be obtainable, new and dependable large-scale sources of rubber had to be created quickly here at home. And meantime, the accumulation of reserve stocks would provide a temporary bank on which to draw until American-made rubber could meet the nation's requirements.

In early June, 1940, knowing that rubber was too vital a material to be left to chance, the B. F. Goodrich Company decided to take action. At a reception in New York nearly two and one-half years ago we introduced for sale to car owners a tire in which American general purpose synthetic rubber replaced natural rubber by more than 50 per cent. This American man-made material was developed by our organization after a research program which was started in 1926, and was even then in 1940 being commercially manufactured in our own plants.

Although we felt and so stated at that time to the Senate Military Affairs Committee that synthetic rubber could be produced on a large scale at a cost of approximately 25 cents a pound, yet we knew that large-scale production of synthetic rubber could not be justified on an economic basis by industry.

Industry had to take a long-range view, remembering that as recently as 1933 crude rubber sold in New York at less than three cents a pound. The 1940 current market price of 20 to 22 cents a pound was artificial, having been brought about by restriction of production of plantation rubber and by war uncertainties. We knew that a cent a pound variation in the price of rubber amounted to approximately $14,000,000 a year based on a consumption of 600,000 tons a year.

Without artificial production restrictions, natural rubber in normal times might have a price advantage of 10 to 15 cents a pound, based on known processes of manufacturing synthetic rubber. This might mean a difference of from $135,000,000 to $200,000,000 a year, or certain disaster to private capital invested in general purpose synthetic rubber plants.

But our company pressed on and sold quite a few of those synthetic rubber tires—in 1940—several thousand of them—to cooperative firms and individuals who were willing to pay a higher-than-market price to help us get an American general purpose synthetic rubber program started. And we did accomplish the two main objectives that we had in view at that time. Our announcement focused the attention of the nation on our critical rubber supply situation, and we believe that we challenged the scientists throughout the country to increased efforts in the whole synthetic rubber field.

Shortly after this step by our company in June, 1940, our government took constructive action. Plans were put into effect for purchasing large reserve stocks of rubber. Under this arrangement the British and Dutch plantations removed the restriction of output bans and produced at capacity.

We had recommended the construction of two or more government financed large-scale synthetic rubber plants by competitive industrial organizations.

But synthetic rubber seemed at the time too revolutionary a step for prompt action on such a scale. A great potential capacity on the other side of the world for growing natural rubber was available, and the cost of creating synthetic rubber plants was admittedly high when figured in dollars.

Two and a half years ago before advocating American standby synthetic rubber plants as the only practical solution, we had given full consideration to other sources of rubber supply.

Our good neighbors, the South American countries, could then provide little more than 5 per cent. of our peacetime requirements for rubber. Six or seven years are required to grow a rubber tree ready for tapping. It was estimated that it would take ten or more years for South America to supply substantially more rubber through increased planting.

Africa was then supplying less than 1 per cent. of the world's rubber, and even if that continent produced sufficient quantities, we would again be depending on another hemisphere.

Guayule, a shrub grown in Mexico and southwestern United States, and supplying less than 1 per cent. of America's consumption, was investigated. Our company has used guayule for more than 30 years and has been the largest consumer in the world of this type of natural rubber. Guayule is a serviceable rubber, but with the seeds then available, the time of growing would be too long for increased planting to meet the emergency that faced us. 75,000 acres of guayule are being planted by the United States government, but in all probability these will not be harvested until 1945, when 50,000 or more tons should be obtained.

But none of these sources of rubber was in 1940 or in 1942 prepared to supply our emergency demands. Synthetic rubber, a product of American science, was then and is to-day our hope.

It was not until the bombs fell on Pearl Harbor that a large-scale synthetic rubber program was announced by our government—400,000 tons a year—authorized in January, 1942. Unfortunately at that time no over-all planning of structural materials, equipment and raw materials had been carried out.

Hindsight is always easy, and it is readily understandable why the vast majority of people, even some of whom had spent a lifetime in rubber, did not foresee during 1940 and 1941 the possibility of the rapid-chain of events which have since deprived us of 90 per cent. of our rubber supply.

But that is water over the dam. It is not the past but the future which will determine our fate.

The January, 1942, authorization of a total capacity of 400,000 tons a year of butadiene synthetic rubber just mentioned, estimated to cost $400,000,000, has since been increased and the present program is made up of plants designed to produce 705,000 tons of synthetic rubber of the butadiene-styrene type, 132,000 tons of butyl rubber and 40,000 tons of neoprene, or a total of approximately 900,000 tons a year, with an estimated plant cost of $700,000,000. In addition, Canada is carrying out a program for creating a capacity of 40,000 tons a year of the butadiene type synthetic, and I believe that Russia has been producing as much as 50,000 tons a year.

Our company has recommended that we refer to the butadiene type rubber as AA (Pronounced—Double A), an abbreviation for All-American. We object strenuously to calling this new rubber by the German name Buna. The AA rubber, as we term it, will be produced in plants designed, constructed and operated by American engineers and will be made by a process incorporating the best features of the All-American research and development of the companies participating in the program.

Undoubtedly you would like to know something of how AA rubber is produced. The basic raw materials are three parts of butadiene and one part of styrene. Butadiene is a gas which can be made either by cracking petroleum, or by removing hydrogen from butylene, a by-product in the manufacture of high octane gasoline, or by catalytic conversion from alcohol. No matter from what basic raw material it is prepared, the resulting butadiene when properly purified is the same. The other raw material styrene can be most conveniently manufactured from the aromatic hydrocarbon benzene obtained from coal tar and ethylene, a gas which occurs as a by-product in most petroleum refineries.

The responsibility for the construction and operation of the plants to produce the butadiene and styrene to be used in the manufacture of All-American synthetic rubber has been delegated to the petroleum and chemical industries.

To the rubber companies has been given the task of building the polymerization or synthetic rubber plants and of producing AA rubber from raw materials supplied to them mainly by the chemical and petroleum industries.

In the polymerization process, butadiene which has been liquefied by compression and cooling is mixed with styrene, soapy water and several minor "salt and pepper" ingredients. This mixture is then heated and stirred under pressure, whereupon the molecules of butadiene and styrene polymerize or join together to form an emulsion of synthetic rubber which is quite similar in appearance to the latex obtained from rubber-producing trees. From here on the process of obtaining sheeted rubber is like that used for natural rubber.

Already much that is good and several things that are bad have been discovered about the usefulness of this new rubber. Test tires whose rubber content is 99.84 per cent. of this synthetic rubber are running on the highways in various parts of the country. Passenger car tires and small-size truck tires give excellent service. However, when we come to the manufacture of large-size truck and bus tires urgently needed for military use, several difficult problems arise due to the fact that synthetic rubber tires in service generate more heat than natural rubber tires, thus causing an earlier failure. We are now hard at work on this problem and we are confident that it can and will be solved as we gain more experience in the field.

Even now, almost all essential rubber articles can be made from AA rubber including hundreds of important rubber products used by the armed forces of our nation.

When will the production of this man-made rubber fully meet our necessary requirements? Certainly not until 1944. Compared to our consumption of 765,000 tons of rubber last year, we shall produce about 32,000 tons of American-made rubber this year, practically all from privately financed plants.

In 1943 the government plants will come into big production and estimates for all types range from 300,000 to 500,000 tons, and in 1944, from 700,000 to 1,000,000 tons.

This tremendous program for man-made rubber in quantities sufficient to meet our vital requirements must be fulfilled or the nation will, in a matter of months, be confronted with a critical situation highly dangerous to our military forces and our whole civilian economy. We must have rubber to win this war.

Late 1943 will see our stocks of rubber, and those of our Allies, near exhaustion.

It is imperative that we have the utmost speed in building and equipping the giant plants and in the actual production and use of man-made rubber. Every day lost now means irreplaceable loss of rubber, for we are living on our fat. And our fat is rapidly disappearing.

The construction of the government synthetic rubber plants is one of the most highly technical and complicated engineering jobs of all time.

Several hundred thousand tons of critical materials will be used. These materials necessary for the construction of the plants and equipment must be made available promptly or there will be further serious delays in completion of the production facilities so urgently needed.

Thousands of skilled mechanics, pipe fitters, electricians and construction workers are required, and I feel that unusual measures will be necessary to make them available when needed.

We must have enough rubber in time and not too much too late.

Mr. Jeffers, our rubber administrator, and his organization are working day and night on every phase of the problem and particularly on structural materials and man-power.

I have said that the real crisis in rubber will come next year. How well we shall meet and pass the 1943 crisis will depend mainly upon our ability to conserve rubber and to produce synthetic rubber. This statement of fact is made clear in the constructive and timely Baruch committee report which I feel would provide extremely interesting reading to members of the Academy of Political Science.

The Baruch committee, while critical of the handling of the rubber problem, did report encouraging progress in synthetic rubber, as for example the following, which I quote:

> Our committee is convinced that the government's present program is technically sound. From this time on, the important thing is to get on with it without delay. . . .
>
> It is our firm conclusion that present processes for manufacturing synthetic rubber and raw materials required must not at this late date be changed unless new processes can be shown beyond peradventure to have such advantages over these now employed that more rubber would be obtained in the ensuing months than would otherwise be the case. We have found no such process in the course of our investigations.

I think it is important that we consider another statement made in the Baruch report. Again I quote:

> Probably the most interesting and satisfying part of our study is the confidence we have acquired in the men from the industry who have the plans in hand and who are satisfied they can lick the problem in the given time. Their competence and experience, their resourcefulness and ingenuity, are the best guarantees that we can do so.

The stark fact that lack of rubber could cost us this war is clearly stated and fully explained in this enlightening report which should be a constant reminder to us that we must never again become wholly dependent on distant sources of rubber supply.

Fortunately, thanks to the farsightedness of our government, we had, when the Eastern plantations were captured, approximately 600,000 tons of rubber, which is a normal year's supply for our country. I mentioned that in June of 1940 this total was only 168,000 tons. Our stocks of crude rubber and that contained in finished products, as well as our stocks of scrap rubber and reclaimed rubber, must bridge the gap until synthetic rubber becomes adequate for military and other essential needs.

Rubber in tires on cars now on the nation's highways actually constitutes the largest stockpile of rubber in this country—approximately 1,200,000 tons—or nearly double our total crude stocks at the beginning of this year.

The Baruch committee in recommending mileage rationing recognized the absolute necessity to our war effort of keeping all cars in operation for essential driving.

We in B. F. Goodrich feel now as we have for the last two years that all cars are essential cars, but that all driving is not essential driving. The government now has a program to convert that basic fact into a nation-wide conservation habit.

The purpose of the rationing program which is scheduled to begin nationally November 22 is to insure on a fair and just basis the operation of all passenger cars for essential driving with a minimum consumption of rubber, reclaimed rubber and rubber substitutes.

I am confident that we shall all respond with good spirit to the requirements of the mileage rationing program until synthetic rubber becomes available in quantity for civilian use.

I am informed that the 35-mile speed law now a national regulation is being splendidly observed. Sales of gasoline in unrationed areas have already sharply decreased, reflecting a reduction in mileage that is startling only to those who underestimated American willingness to make personal sacrifices if they will help to win this war. That to me is most heartening. It proves that the American people will respond even to bad news if they know fully what is required of them.

This war, more than any other war in history, is a conflict of materials and resources, as well as a battle of men. Rubber is one of the strong and versatile threads that we must weave through the fabric of our industrial production and transportation systems to supply and maintain our modern armies and navies.

By contributing to the solution of America's rubber crisis, each one of us will do a wartime job of No. 1 importance. Any circumstance or any policy that prevents the effective functioning of our home-front industries and essential civilian transportation can be just as disastrous to our war effort as a defeat in battle.

Our gallant fighting men know that courage alone is a thin weapon against Axis planes and tanks. They look squarely to our country to deliver in time and where needed superior weapons and equipment—weapons and equipment which require thousands of tons of rubber.

The design, construction and capacity operation of our many giant synthetic rubber plants—in time—will be one of the greatest industrial achievements of all time. Conservation of rubber must bridge the gap until our rubber problem has been solved.

Industry is supremely conscious of its part in this grave responsibility, and the American people are now fully conscious of their own important role.

SCIENTIFIC EVENTS

RECENT DEATHS

DR. GARY N. CALKINS, emeritus professor of protozoology, of Columbia University, died on January 4, in his seventy-fourth year.

DR. DAVID M. LICHTY, who retired in 1932 from an associate professorship of chemistry at the University of Michigan, died on December 24, at the age of eighty years.

THE death is announced of Alfred Nelson Finn, for many years chief of the department of optical glass of the National Bureau of Standards, at the age of sixty years.

DR. JAMES EDMUND IVES, until his retirement in 1936 senior physicist of the U. S. Public Health Service, died on January 1, of injuries received when struck by a street car on New Year's Eve. He was seventy years old.

DR. ANDREW H. PALMER, who from 1914 to 1924 was a meteorologist of the U. S. Weather Bureau and was later superintendent of crops and weather insurance of the Aetna Affiliated Companies, San Francisco, died on December 26, at the age of fifty-six years.

DR. PURNENDU NATH CHAKRAVORTY, a native of India, research chemist with the Upjohn Company and formerly associated with the department of chemistry at Princeton University, was killed in a railroad crossing accident on December 23. He was thirty-seven years old.

HARVEY L. WESTOVER, senior agronomist in charge of forage crop investigations in the Bureau of Plant Industry of the U. S. Department of Agriculture, known for his work with alfalfa, died on January 2, at the age of sixty-three years.

FREDERICK DIXON CHESTER, chief chemist of the Mimex Company, Long Island City, died on January 1, at the age of eighty-one years.

DR. E. J. ALLEN, from 1895 to 1936 secretary of the Marine Biological Association of the United Kingdom and director of Plymouth Laboratory, died on December 7 at the age of seventy-six years. The Linnean Gold Medal was awarded to him in 1926; the Darwin Medal of the Royal Society in 1936, and the Agassiz Medal for Oceanography of the National Academy of Sciences in 1936.

AMERICAN LIBRARIES AND FOREIGN PERIODICALS

IT is reported by Harold Lancour, librarian of Cooper Union, chairman of the Engineering School Libraries Section of the Association of College and Reference Libraries, that American librarians are tracking down hundreds of publications which seep into this country from Axis-dominated areas and which contain valuable technical and scientific data eagerly sought by scientific workers.

Through an investigation in progress since last August, the section has already ascertained that more than 800 periodicals published in Germany and Japan as well as in countries occupied by the Axis are reaching the United States sporadically and by devious channels, despite mailing restrictions and accidents in transit.

Many foreign periodicals legally mailed go down with torpedoed ships or are held up to make room for more vital cargo. Others, not permitted to go outside the country which publishes them, are smuggled out by refugees; some pass the censor in limited numbers; still others reach Americans by mail from scientific men in conquered lands which do not permit bulk mailings but which allow individuals to send out one or two periodicals.

Spotty holdings of foreign periodicals by libraries throughout the country, with many issues and titles missing completely since 1939, has created a demand for a master file through which every library will be able to find quickly any issue of any foreign peri-