THE GUAYULE RUBBER INDUSTRY.

BY J. E. KIRKWOOD.

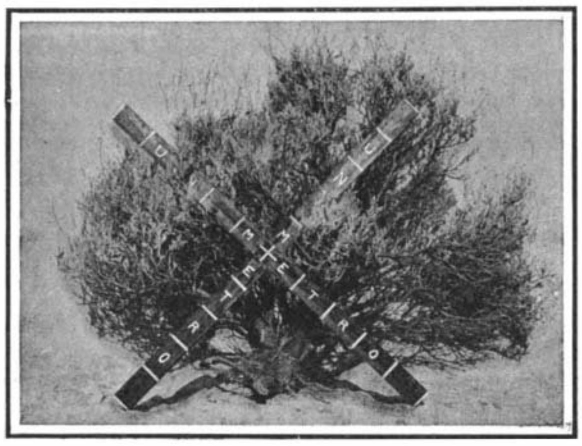
The increasing demand for rubber in the various manufactures of the present time makes the business of its production one of the most important of modern enterprises. Not only is the natural source of the supply eagerly sought and carefully guarded, but efforts for the cultivation of rubber-bearing plants are receiving attention in many parts of the world.

The rubber of commerce is derived from a number of different plants; in fact, there are many plants of more or less importance from the standpoint of the quantity and quality of the rubber they produce. Among those less generally known is a Mexican plant, called *guayule* (pronounced *wyúlie*), which is identified botanically as *Parthenium argentatum*.

The guayule is a desert plant. It thrives in those regions of relatively little rain throughout the northern half of Mexico and the neighboring areas of Texas. It is a small shrub, tree-like, and rarely attains a height of four feet or a stem diameter of more than three inches. Its leaves are small and of a silvery gray color, whence its specific name *argentatum*. The plant produces small yellowish-green flower heads consisting of many minute florets, only five of which in each head are capable of producing seeds, and each of these only one.

Most of the rubber of commerce is produced by plants having a milky juice, or latex as it is called, in which the gum is found. The trees are tapped by cutting into or through the bark, and the latex is collected as it flows down. In the guayule plant no latex is produced, and it must be subjected to an entirely different process to extract the rubber. This article occurs in the form of minute microscopic granules deposited throughout the tissues of the stem, branches, and roots, but especially in the bark of these organs. If one will take a very thin section of the stem or branch and examine it under a lens, he may see much of the tissue densely crowded with small, dark-colored granules. In these granules, deposited within the living cell, is the source of the rubber, to separate which requires a special process.

Methods of extraction of guayule rubber differ. Some obtain the rubber by trituration of the plant and a subsequent more or less mechanical process; others by means of solvents separate the gum from tissues after grinding them. But the details of the process are kept secret, the public not being admitted to the factories, which are surrounded by high walls with armed guards at the gates. However, several processes are described by Dr. F. Altamirano* in the Boletin de la



Extra large guayule bush.

Secretaria de Fomento, of Mexico. One of the methods consists in first crushing the plants by grinding them in a machine, in which they are tumbled among hard stones until thoroughly pulverized, and the gummy substance collects in lumps with a certain amount of woody tissue. To isolate the gum, this material is then boiled over steam in an iron vessel with a double bottom, and the woody particles afterward strained out. After this operation the mass is thrown into a tank of cold water; again it is strained and boiled anew with caustic soda until the woody particles are fully separated, and the gum is precipitated by chloride of calcium.

The process of extraction of guayule rubber involves therefore the immediate destruction of the plant. The natives employed to collect the plants uproot them, and take no pains to spare any part. The bushes are then packed on the backs of burros, and carried to some place for baling and shipment. The cheapness of labor makes it feasible to transport the plants for considerable distance by pack train or wagon. Sometimes the load is carried for as much as forty miles from where the plant is gathered to the railway station; such distances usually by wagon. The cheapness of labor makes such operations profitable; the wages of a peon being about thirty-seven cents a day, Mexican currency.

The manufacture of rubber from guayule is an industry of only recent development. The production of gum from this plant has been known from the middle of the eighteenth century. The Indians were accustomed to make rubber balls by chewing out the gum from the bark. If one takes a mouthful of the bark and thoroughly masticates it, rejecting the fibrous particles, he may soon obtain a small mass of rubber the size of a pea. The rubber thus obtained is soft and sticky, adhering to the skin as it is manipulated between the thumb and finger.

For some time no effort was made to manufacture this rubber on a large scale. In 1890 a German chemist first attempted to extract it in commercial quantities, but a paying basis was not reached until some years later. In 1905, according to consular reports, the guayule rubber shipment from Durango amounted to $125,-478. From Torreon in 1906 rubber was shipped to the value of $917,571. During the year ending in June, 1908, there was shipped from the Durango consular district alone, guayule rubber to the value of two and a quarter millions. Since then the business has increased, and is one of Mexico's most important industries at the present time. Extensive tracts of land and millions of capital are involved in the enterprise. The Continental-Mexican Rubber Company of New York, in addition to their large factory at Torreon, acquired possession of the old Hacienda de Cedros in the northern part of the State of Zacatecas, consisting of 2,500,-000 acres, valued especially for the growth of guayule which it supports. The Madero brothers of Barras

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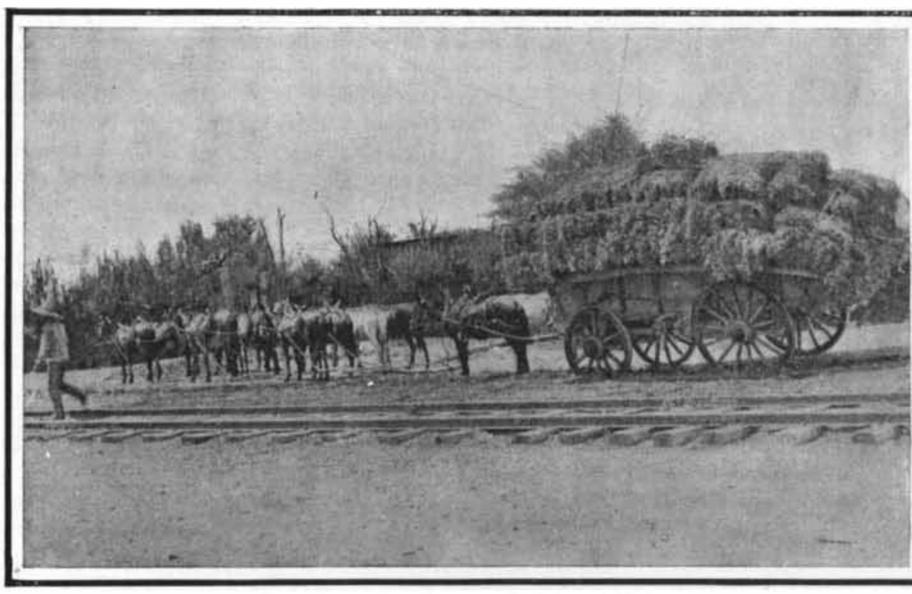
* Translation from the German of an article by Dr. Rudolf Endlich, published in Tropenpflanzer ix. 1905.



Fourteen-mule team with load of guayule.

The guayule bush in the desert.

Bales of guayule ready for shipment.

Packing guayule into bales.

erally reach a constant value within a few days, and their E. M. F. can be depended on within the above limits for at least a year.

The investigators at Washington have studied not only their own cells made in various ways, but also those of other investigators, particularly those of the Reichsanstalt, the National Physical Laboratory of Great Britain, and the Laboratoire Centrale d'Electricité, comparison with the cells of these institutions having been made both in Europe and in Washington. The conclusion was reached that standard cells could be set up by different investigators which will agree to within a few parts in 100,000, and that they can be constructed and carried considerable distances even on shipboard if ordinary precautions are observed.

In the present condition of the standard cell, the national laboratories can secure the desired accuracy and reproducibility, and this extending in turn to the secondary standards must have its effect on electrical measurements. If it is not feasible for the national laboratories and bureaus to construct these standard cells for ordinary testing or manufacturing laboratories, it has been suggested that they might supply the materials of the requisite purity, and thus obtain substantial harmony, as the mere following of the specifications is not difficult, while testing and certification by the Bureau would be a sufficient guarantee of accuracy. The Weston cell, which undoubtedly will be selected as an international standard of E. M. F. at the coming congress, though possibly without a legal numerical definition of its voltage to supplant the Clark cell of the present definition, has now been demonstrated as a convenient standard and one easily reproducible with exactness. It is for these reasons that many physicists, especially those in America, wish that the volt as defined by the standard cell should form with the ohm the two fundamental electrical units.

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are said to own or control 3,000,000 acres of guayule lands, and there are other large interests besides these.

The rate of consumption of guayule is a subject of interest and importance. With several well-equipped factories in active operation working, at least a part of the time, both night and day, the inroad upon the supply is a matter demanding consideration. Although the acreage above cited seems large, the fact is that only parts, favored situations, of these large holdings actually produce the plant—the foothills especially, of limestone formation. A single factory may consume 30,000 tons of guayule shrub in a year, or approximately 100 tons a day. This may represent the growth on anywhere from 25 to 100 acres of land. The number of plants on an acre, and the weight of the individual plant, vary so much that no constant figures can be given. One may find on guayule lands a stand of from 1,000 to 2,000 plants to the acre, and the plants weigh anywhere up to 15 pounds (very large); probably the majority of the plants taken weigh dry from 1 to 4 pounds. Thus on an acre we should find from 1,000 to 8,000 pounds of the shrub. If we call the average yield two tons per acre, we may estimate the area harvested at fifty acres for one day's consumption at a large factory.

While the fact is patent that the supply of guayule is decreasing and must ultimately be exhausted, the opinions of experts place the date, some at ten, some at twenty years hence. Large factories running steadily at Parras, Torreon, Saltillo, and elsewhere, using the product of no less than 100 acres every day; the activities of the camps which the traveler may see in a dozen places in a day's journey; the bales of the shrub piled high by the siding awaiting shipment, all point to the speedily approaching day when the factories must shut down for want of material.

This menace to the business interests involved has not been overlooked or ignored. To provide a continuous crop upon which the business could depend is an idea that has appealed, not only to the members of interested corporations, but also to private landholders, who appreciated the income prospective from such an enterprise. Experiments here and there have been tried, and various opinions have taken form as to the prospect. The most notable of these experiments was that conducted at the instance of the Continental-Mexican Rubber Company, who recently established an elaborate department of investigation at Cedros, Mexico, and spent much money in forwarding the work. Although less than a year was allowed for this large task, the time sufficed to show some insuperable obstacles to the cultivation of the plant on anything like an economic scale.

In the first place, the slow production of seeds, and the care required in their planting, and the rearing of young plants, make the procedure unprofitable from an economic standpoint. With a possible germination rate of 10 per cent of the seed sown, the failure through one cause or another of the young seedlings to pass the initial stages of development, the ranks of the young plants again depleted by pest or parasite, the loss by accidents or in the process of transplanting, and a few subsequent vicissitudes both possible and probable, make it doubtful whether one can count on as much as 1 per cent of the seed sown to mature plants, even under the most favorable conditions. Cuttings mostly fail to grow except from portions of the roots, or stems having part of the root system in connection with them, and only under certain conditions of irrigation; even then, as in the case of seedlings, the cost of the operation exceeds its value. Irrigation is quite essential to the starting either of seeds or cuttings, and in the subsequent growth the rapidity of development depends upon the quantity of water supplied.

But the rapidity of development is in inverse ratio to the formation of rubber in the tissues. Plants grown under irrigation grow rapidly, and attain in four years a weight of six pounds or more, but the rubber content in such plants is practically *nil*, while in native desert-grown plants it is about 10 per cent of the dry weight. If, however, water is withheld, as under desert conditions, the plants grow very slowly, and it is doubtful whether a crop could be matured much under twenty years. Of course, rubber is present in desert-grown plants at an age much less than this, but it is a question at what age plants may be most profitably taken, though certainly not in less than ten years.

Reforestation by natural processes must be very slow, and as in the case of the lumber forests of the North, the second growth is never equal to the first. A guayule seed in the desert has about one chance in ten thousand of coming up, and thereafter danger from drought, disease, and accident make its hold upon life exceedingly uncertain. The only hope of prolonging the business seems to be in so harvesting the plants that the roots are left in the ground; from these new shoots will arise, and in a few years possibly yield another crop worth the taking. How long this process can be kept up profitably is at present unknown. However, the guayule rubber industry seems destined to have its day and pass out.

The above statements are issued only after much observation and experiment, the details of which are soon to be published in a book under the joint authorship of the investigators.

A 5,000-TON TESTING MACHINE.

After the Quebec Bridge fell into the river, it was found that the special member which gave way had failed under a load far below that which theoretically it should have carried. The steel of which the bridge was built was of excellent quality, and in the compression member which doubled up under its load there was sufficient steel for the purpose, if it had only been assembled and braced together in the proper manner to develop its full strength. The engineers who built the bridge believed that the box-like form in which the plates of the bottom chord had been assembled and latticed together represented the strongest form of construction. They believed that the latticing was quite sufficient to hold the deep webs or plates of the chord in true line and prevent just that very buckling which brought about the fall of the bridge.

If we take a one inch cube of steel, of the same quality, say, as that in the Quebec Bridge, and subject it to compression in a testing machine, it will begin to give way at a certain maximum load, which represents the ultimate compressive strength of the material. If we take another piece of the same steel, one inch square and six inches long, and subject it to compression in the direction of its longer axis, failure will take place under a load less than that which was necessary to destroy the one inch cube. Similarly, if we take another specimen, one inch square but twelve inches long, there will be a still further decrease in the comparative compressive strength of the specimen. As the length of the successive bars tested increases, there will be a rapid decrease in their resistance, failure taking place, not as in the case of the cube by the actual crushing of the material, but by the bending or bowing of the specimen away from its longitudinal axis. If, however, as the length of the specimens is increased, sufficient bracing be applied to prevent their bending from the straight line, they will carry the same maximum load, or nearly so, as the first specimen measuring one inch on every side.

Now, in designing steel compression members, whether in the form of columns to support the walls of buildings, or of posts or chords for steel bridges, an effort is made to so tie together the angles, plates, etc., of which they are composed, that the steel will stand a compressive stress as near as possible to that which is necessary to crush a one-inch cube of the same steel. Formulæ have been drawn up, based upon tests to destruction of built-up members of comparatively small size, which are used in designing the big compression members that are too large to be placed in any existing testing machine. All of the large bridges which have been built in this country during the past few years, including the Quebec Bridge, have been designed by these formulæ which were formerly believed to give closely accurate results. Consequently, when the failure occurred at Quebec, it is not putting the case too strongly to say that it produced positive consternation among bridge builders, not only here but throughout the whole world. And although subsequent investigation of the bridge proved that it was overweight, and that the latticing which failed was lighter and more openly distributed than in the judgment of many eminent engineers would be considered safe practice, it is still a fact that if the commonly accepted theory of latticing was correct the bridge should not have gone down. Hence there has risen a demand among bridge engineers for the construction of a machine large enough to take the biggest compression members and test them to absolute destruction. It has come to be understood that only by this means will it be possible to draw up formulæ which will be absolutely reliable in the design of compression members of unusual size.

Largely as the result of the agitation of this subject the United States Geological Survey is having built a mammoth testing machine, which will have the large capacity of 5,000 tons. This powerful plant, which forms the subject of our front page engraving, is now under construction for the Structural Materials Testing Laboratories of the Geological Survey by Olsen & Company of Philadelphia. The main purpose for which the machine is being built is the testing of large blocks of stone used for building purposes by the United States government. It was also desired to obtain data regarding the strength of columns of brick, concrete and structural steel. Originally designed to take members 25 feet in length, the machine is now being built to accommodate specimens up to 65 feet in length. It will have a total weight of over 200 tons and its height above its foundation will be 80 feet. With a view to exhibiting its great proportions our artist has shown how the machine would appear if it were erected at the corner of Broadway and Vesey Street, adjoining the southeast corner of the old Astor House, which is shown in the illustration. Although the machine has a total compression capacity of 5,000 tons, it will not be capable of crushing to destruction a chord section of the Quebec Bridge, or of the recently opened Queensboro Bridge in this city. The drawings of these two sections have been introduced into the picture merely to show their huge proportions. The Quebec Bridge section is shown adjoining St. Paul's Churchyard, and the Queensboro Bridge section is shown within the testing machine whose length is sufficient to include it.

During the present Congress a bill was introduced but failed to pass, authorizing the construction of a testing machine by A. H. Emery, who built the celebrated 400-ton testing machine at Watertown Arsenal from which such great benefits have been derived. This huge machine, which will have a capacity in compression of 11,000 tons and in tension of 5,500 tons, will be able to handle specimens one hundred feet in length. Its total length will be 153 feet; it will be 25 feet in width; its weight will be about 3,500 tons, and its cost would be $1,750,000. Had such a machine been in existence during the design and construction of the Quebec Bridge, it is safe to say that the catastrophe would never have occurred.

Returning now to the 5,000-ton Olsen machine, as herewith illustrated; the base contains a hydraulic cylinder or ram of 2,000 square inches cross-sectional area, upon which is placed the lower platform. From the four corners of the base extend four huge vertical screws, each 13½ inches in diameter and 72 feet 2 inches in length. At their upper extremities they pass through a massive upper head and are provided with four nuts which are operated simultaneously by means of gearing. The maximum clearance between the upper and lower heads is 65 feet, and the heads are each six feet square. After the member to be tested has been placed on the lower head the upper head is brought down to a snug bearing on the top of the member, and the pressure is then applied by means of a triple plunger pump connected to the main hydraulic cylinder in the base of the machine below the lower head, which, to secure an even distribution of pressure, is provided with a ball-and-socket bearing. The determination of the pressure which is being applied to the member tested is arrived at by means of a set of standard levers upon which is weighed 1/80 of the total load on the main cylinder, the reduction being secured by means of a piston and diaphragm. The weighing beam is balanced by means of an automatically operated weight, and it is provided with a device by which counterweights of one million pounds each may be successively applied. The machine will stand upon a foundation of concrete eight feet below the floor line, and the top of the machine will be about seventy-two feet above the floor. The main hydraulic cylinder is fifty inches in diameter, and each of the 13½-inch main screws will weigh over twenty tons. The contract calls for an accuracy of at least one-third of one per cent for any load over fifty tons and up to the full capacity of 5,000 tons.