is a sufficient stock of spirit in the reservoir, and that the automatic action is perfect.

Soft paraffin wax has also recently been submitted for trial as to its suitability for lighthouse purposes. It is now being used in what are known as the Cera lamps on board ships, and, to a limited extent, for domestic purposes. It has many advantages. When carefully freed from oil it requires less air for its combustion than other oils, and is therefore less liable to smoke under unfavorable conditions of burning. It gives more light than colza and other oils, is absolutely safe at a flashing point of 340° F. But it requires special arrangements to keep it fluid, and trouble in melting it in the first instance. For lighthouse purposes it is not obvious that it can compete with the mineral oils, as now used, especially as regards price and facility of employing it; but the lighthouse authorities will no doubt await further developments of the application of this material with interest.

From time to time oils of various character have been submitted for trial, with a view to their being used for lighthouse purposes; but the paraffin and high test petroleum have not been excelled, as regards efficiency and suitability, while, in respect of economy, they cannot be beaten. It will, doubtless, be observed that the Russian oils do not appear to have been brought seriously into competition with the paraffin and high test American petroleum. Possibly it has not been considered worth while to cut out of the burning oils produced the comparatively small quantity of special oil adapted for lighthouse and lightship requirements; but there can be no doubt that the Trinity House Corporation, and other lighthouse authorities, will gladly welcome any further competitor to supply their requirements; and I trust that the explanation of such requirements which I have offered to you this evening may be of service in making more widely known the special needs of the service, and in possibly stimulating the production of still more efficient and economical illuminating agents.

The supply of crude petroleum all over the world is very large, and, as the demand increases, the supply appears to be maintained; but should there come a time when the liquid petroleum resources show signs of exhaustion, the manufacture of paraffin can be continued, so as to supply the wants of the world for practically an unlimited period, seeing that bituminous shales exist in all parts of the globe in great abundance. It is much to be hoped that legislation will not do anything to cripple these important trades, but will allow full and free facilities for the transport and storage of all mineral oils which are admittedly safe for general use, and will, at the same time, in the interests of the general public, put such restrictions on the traffic in, and the use of, oils which give off dangerous vapors at temperatures below 100° F. (Abel test) as will prevent such oils being distributed all over the country for general use. In the Inflammable Liquids Bill of last session, the distinction drawn between dangerous and safe oils did not appear to be so clear as it might be, and that the safe lighthouse oils as now used would have been subjected to the restrictions applying to really dangerous oils. It might perhaps be desirable to enact that every retailer of mineral oil should inform the buyer of the flashing point of the oil, for that is, without question, the one simple and intelligible test of its safety or otherwise. At the present time no one really knows what is sold over the counter as mineral oil.

It may be of interest to state that the samples of all oils submitted to the lighthouse authorities with tenders are subjected to severe tests to insure only the very best quality of oil being supplied. The burning test lasts 16 hours without break, and no trimming of the wicks is allowed during that period. While the burning test is going on, photometrical observations are made after 4, 8, 12, and 16 hours, the mean of all being taken to indicate the real value of the illuminating power of the oil as burned in the test lamps. Of mineral oils the specific gravity and flashing point are carefully ascertained, and each oil is subjected to fractional distillation to show the range of temperature at which the whole is distilled over, and the proportions distilling in uniform fractions between those limits. For paraffin the specified range is between 302° and 572° F.; for the heavy mineral oil a much narrower range is specified, viz., between 530° and 660° F. Further tests are made as to the oil remaining liquid at a low temperature; as to the effect of the 16 hours' burning on the wicks; as to the relative consumption, and a comparison with the sample of the oil accepted in the preceding year. When a contract is made for the oil supply every delivery under such contract is carefully tested to determine that oil supplied is in all respects equal to the sample upon which the contract was taken, and no oil is accepted which does not in all respects come up to the contract sample. When very high-priced mineral or vegetable oils were the illuminating agents for lighthouses, it was necessary to keep a strict watch on the expenditure. On the one hand it was requisite to insure that a proper quantity of oil was used each night to maintain an efficient light; and on the other it was necessary to prevent waste, or possibly fraudulent dealing with so costly a commodity. Therefore a very elaborate system of accounting for every gill sent to the lighthouse was introduced and is kept up to this day, although the value involved is very small now as compared with former days. The maintenance of a never-failing supply of oil at each station is one of the most important obligations of the officers of the Lighthouse Boards, and to the credit of the service it may be stated that there is no instance on record of a lighthouse or a lightship having been unable to show lights at night through want of oil.

In the majority of cases the mineral oil is kept at the stations in tin-lined iron cisterns, but Sir James Douglass has in some recent instances recommended underground tanks built with rubble and cement, and lined with sheet lead. Such tanks are designed to contain at least twelve months' oil, and where they are constructed have given much satisfaction.

The annual deliveries of oil to the stations on the English coast are made by the attendant steamers. One in particular is detailed for the mineral oil business. Consignments of varying quantities are made to be taken on board this vessel at different ports, and the small steamer takes to each lighthouse its annual supply. The work of delivering the oil is often delayed or made hazardous by the weather, and at

the best of times is attended with much labor and difficulty.

In concluding my paper, I beg to say that the advantageous position now occupied by the authorities in respect to lighthouse oils is due mainly to the development of the mineral oil industry, through the enterprise of Mr. James Young, and those who encouraged and helped him in his early efforts; to the subsequent endeavors of those concerned in the mineral oil trade to meet the requirements for lighthouses, etc.; and to the desire of the lighthouse authorities, with their officers, to avail themselves at all times of new methods and improvements for the benefit of the important service over which they have control.

RUBBER GATHERING IN THE AMAZON VALLEY.

By JOSEPH O. KERBEY, Late United States Consul at Para.

To get a correct idea of the *modus operandi* of gathering and preparing the rubber, it is necessary to have some notion of the circumstances and surroundings, which also include the business customs and ways of the city and forest people. The traders (negociantes) in the rubber country are generally rough-and-ready Portuguese or Brazilians, the larger part of them with little or no capital of their own when accounts are all balanced.

Very many of the rubber swamp claims "belong" off and on, to business houses in Para and Manaos. These they are ready to sell or rent. They, as a rule, prefer the former, as they often get the swamp claim back again, through the failure or death of the purchaser, in a few years, and for, perhaps, a fifth part of the price they sold it to him for. The unfortunate widow and orphans, when there are any, are shoved out into the forest penniless. It is said that on the upper river, the widow, if young and attractive, is often bargained off to another trader, and the choice given her to become his mistress or die in the forest, or worse.

The margins of the larger navigable rivers have been generally "prospected," and the most valuable rubber forests are now "owned" by some one, although there are immense tracts of unexplored territory on innumerable small tributaries, to be reached by canoes or small steam launches. The first title of a rubber swamp is generally determined by discovery and first possession. Frequently this remains the only title for years, and on the upper tributaries especially this is the case, the legal survey and purchase of the land from the government being effected only when the land passes into the hands of the capitalists who receive it in payment of debt.

Meanwhile, the owner who pre-empted it must prove his right to it by constant rifle vigilance. No one leaves his hut without his sixteen-charge repeating rifle. There exists a class of desperadoes or "border ruffians," called in the frontier language "capangas." Many of the traders, both owners and renters of rubber swamps, have their gangs of "capangas" who are hired expressly for the purpose of maintaining the forest claim in question. Feuds often arise which at last end in a massacre and burn-out. Mention is made of a case in which such a massacre was surprised by a steamer suddenly rounding a bend on the river Jurua. Fortunately one woman had been tied to a tree to be kept until after the trading station was fired. She was rescued, and her testimony resulted in the arrest of thirty criminals implicated in the massacre. But generally the attack is not so daring; the night is chosen for the slaughter, and the criminals are undetected, though not usually unknown. It is a common saying that "he who has rubber will not go to jail."

Sometimes there is more formality even in the attack, and something like the rules of civilized warfare are observed. Capt. Guilherme G. Hoepfner, of the steamer Eufrosina, a few years ago, witnessed a formal battle between two gangs of capangas, headed by their employers, who were disputing the right to build a shanty for trading supplies at the confluence of two little rivers. The captain spent nearly the whole night before trying to persuade the stronger party to leave the other in the rightful possession of the point of land he had proper possession of, but to no avail. In the morning more than 2,000 shots were exchanged across the little river from the repeating rifles, all of which resulted in one bullet hole through the shirt of the leader of the attacking party. He immediately stuck up a piece of white cloth on a stick from behind his stump, and the firing ceased. A few minutes later he was in his canoe with his capangas and paddling unmolested down the stream in retreat.

Such was the state of things formerly on the Lower Amazon, but law has gradually taken the place of brute force as far as land titles are concerned.

Now, when a man decides to go into business as a trader, having but little capital, as is the case most frequently, he goes to some one of the native business houses which deal directly with the traders and are called "casas aviadoras," or "furnishing houses." With the firm he makes a bargain to take one of their rubber swamp claims and work it for one or more seasons for a stipulated compensation. He gathers up a number of persons—Indians, negroes, half-breeds, white men—any sort of fellows that he can induce to go with him for the season. He obtains on credit from the firm supplies for his company and goes to the swamp. He probably finds the principal shanty (baracao) still standing from the previous year; but the thatch roof will need some mending or renewing, as also the wattle and daub sides. This will be the trader's headquarters for provisioning his rubber gatherers. The men will build their huts for their own shelter. These are near the river brink, usually. Poles are driven into the mud and on these a floor of small palm trunks is laid. Taller poles support a palm thatch roof, and the hut is considered finished. If any of them have brought a woman along, they may make a room for her convenience by partitioning off part of the floor with palm leaves. In two or three days their homes are finished and they turn their attention to the forest paths, which they must clear out and open to reach the rubber trees; for since the previous season they have been overgrown by the luxurious tropical vegetation.

It is the closing of the rainy season, May or June, on

the Lower Amazon, when the milk of the rubber tree begins to be fit for gathering.

Each laborer rents from the trader a certain number of paths (estradas), so that he will have one hundred to one hundred and fifty trees to work. The rent he is to pay to the trader is 20 per cent. of the rubber yielded by the paths he takes. It is, further, "swamp law" that the gatherer is to obtain all his supplies from his trader and turn in to him all his rubber. Each gatherer has his own private mark, which he puts on his rubber, and it is shipped to Para to the furnishing house, where it is weighed, and each gatherer is credited with the market value of the rubber on the date of arrival. The trader is obliged by the "custom made" swamp law to turn in to his furnishing house all the rubber which the gatherer has in like manner been obliged to turn in to him. Peddlers in canoes visit the rubber gatherers, and by an easy game of hide and seek smuggle in provisions to the gatherers, and smuggle away rubber, just as steamer captains carry cash to purchase and smuggle away rubber from the traders, thus relieving the terrible monopoly which this credit system has thus rendered lawful. But the relief is small, as the canoe peddlers do not peddle just for the pleasure of peddling.

The provisions which the rubber gatherer receives consist mostly of salt fish, jerked beef, salt, sugar, coffee, mandioca meal and rum. The rum should have been placed first in the list and repeated with each item, for the average rubber gatherer never orders salt fish without rum, nor jerked beef, nor salt, nor sugar, nor anything else without heading the list with rum (cachaca). These provisions have paid a profit of from 25 to 50 per cent. or more to the furnishing house. The trader also puts an equal profit for himself on the price for the provisions. The freight is also no light matter; so that the rubber gatherer has to pay two, three, or four times the Para price for the plainest necessities of animal life. What the miserably fed swamp laborer pays for his mandioca meal, salt fish, and rum would give him excellent boarding house fare in almost any city in the United States.

In addition to what has been said already concerning the exorbitance, justified in part by the great risks, but none the less oppressive upon the poor laborers, the following translation from an article published by the Conselheiro Paes de Andrade in the paper *A Republica*, of Para, will help one to understand the desperate fight which the poor rubber gatherer has to make for his existence. The writer is also the author of a valuable series of articles on land property titles in Para. He says:

"The rubber gatherer obtains fabulous profits during four months of the year, that is, while he works; but he spends lavishly, without remembering the coming winter.

"From his first year onward the laborer loses his independence and mortgages his future.

"Debt confronts him from the very start, which, instead of being paid off, grows upon him until the laborer is reduced to the necessity of a life of disguised slavery.

"If he dislikes his employer because he maltreats him, he is sold to another employer for one, two, or three contos of reis (\$500 to \$1,500).

"These sales are made without cash payments, but the poor laborer is obliged to pay the debt with his labor, and he remains perpetually enslaved, because he continues to follow the same kind of a life without paying up anything.

"The business is bad for all concerned.

"The capitalist, the furnishing merchant, trusts his capital to the venturesome employer of labor, the country trader located in the rubber swamp, of which he is the owner or renter, and he bears the expenditures of the rubber gatherer, for whom he has paid an enormous debt to his former employer.

"If rubber brings a good price—that is, if the year is good—the employer of the laborers saves himself and the capitalist, but the laborer remains always enslaved; but if the year is financially bad, the capitalist breaks; the tricky trader changes his house, and gets his new furnisher to buy for a third of their value the paper of the unfortunate man who broke, and he goes to pay up all his debt to the liquidators of the broken house, thus profiting by the misfortune of the one who helped him on.

"Meanwhile no discount is made on the debts of the laborers, of whom he then becomes master and possessor, often exercising his lordship even over the poor man's family."

The above quotation reveals but a small part of the crookedness that is practiced in the rubber swamps. What the Conselheiro has stated is all "legitimate" business in rubber circles, and censured only by the sufferers and such high-minded men as he. The confessedly fraudulent methods of cheating and robbing, which the perpetrators prefer not to confess, are multitudinous.

The rubber gatherer rolls out of his hammock as soon as it is light in the morning, takes his gulp of rum and his calabash of coffee, starts out to visit his rubber trees. He wears a short pair of breeches, and sometimes a shirt. He goes barefoot, for he must wade through the swamp mud and ooze of the tide up to his knees, and often up to his waist in water. He takes a basket full of earthenware gill cups, a hunk of adhesive clay and a little narrow-bladed hatchet.

If he adopts the most approved method of tapping the trees, he reaches as high as he can with his hatchet, making an incision in the bark, but not reaching through to the wood. The milk immediately begins to issue in rapid drops or little streams. With a spat of the adhesive clay he immediately fastens one of his little gill clay cups just below the bleeding gash, and moulds the clay so as to make all the rubber milk flow into the cup. Three such gashes, at equal distances around the tree, and at an equal height, is the rule. The next day he will make three more gashes in the same way, just a little below these three, and so continue, until by the end of the season he will have reached the level of the ground. Each of his 100 or 150 trees is treated in the same way, and he returns home after having traveled from three to five miles, barefoot and almost naked, through thorny thickets and malaria steaming swamp.

When he reaches his hut again he takes another gulp from the demijohn, snatches a breakfast of salt fish and mandioca meal, which are often mouldy from the

reeking damp of the swamp, and then starts out again with his calabash buckets to gather the milk, which by this time has ceased to flow. His gill cups are full, or nearly so, and when he reaches home he has milk enough to make four kilos of rubber, on an average. The next task is the coagulation of this milk. For this purpose he has a jug-shaped furnace, made of earthenware, called a *boiao*, open at bottom and top, and with a small aperture at the side to admit the air for the combustion. In this piece of furniture he builds a fire, or rather a smudge, with the nuts of the inaja or urucury palm. The dense black smoke which rolls from the open top of the *boiao* is the reagent which coagulates the milk. For this purpose the rubber gatherer has a circular-bladed paddle, like the paddle of a canoe, which he smears over with clay, so that the rubber will not adhere to it. This is suspended by means of a cord from the limb of a tree just above the smudge. The milk is poured over the blade of the paddle, which is then turned over and round about in the smoke, and in a few moments the film of rubber is coagulated. The same process is repeated of wetting with milk and smoking the growing lump until it reaches the weight of from five to twenty-five kilos or more. Then it is slipped off from the paddle as a mitten is pulled off from one's hand. This ball is the crude rubber of commerce. If the coagulating has been carefully done it is "fine" rubber; if carelessly done, and the ball on being cut open at the exporting warehouse shows signs of poorly coagulated milk or slight mixtures of foreign substances, such as mandioca meal, it is classified as "middling fine" (*entrefina*). There is also a coarser grade still, called *sernamby*, the native Indian word for "shells." This grade is composed of the scraps and bits that have dried without coagulation proper, especially the linings that form in the little earthenware cups and in the calabashes and buckets used in handling the milk, as also the drippings that run down the trees from accidental wounds. These are all rolled up together in a mass and would bring as good a price as the middling fine, were it not for the leaves and other rubbish that manage "innocently" to stow themselves away in the lump.

The method of gathering and preparing the caoutchouc of Para is to fell the tree and cut it up into bits, limbs and all, and let the milk run out from the wood into hollows dug in the ground. It is then coagulated in these pools by mixing it with ordinary soap. It produces a most vile-smelling compound, which sells for about the same price as Para *sernamby*. Other methods of coagulation have been tried, but none have given such satisfactory results as the laborious method of fumigation. Alum stirred into the milk will coagulate it rapidly and with far less labor, but the rubber thus prepared is of poorer quality.

If but three gashes per year are made in the bark of the rubber tree, and the hatchet in the careless hands of the native does not penetrate or strike the wood, the tree does not appear to suffer from the treatment, except that the trunk grows thick and the scarred surface becomes irregular and bumpy. It will continue, however, in good health and yield milk in abundance for thirty or forty years. If the blow from the hatchet, however, wounds in the slightest degree the wood of the tree, it dies. Decay begins at this wound. As the wood is soft, a little weevil called in Brazil "*punilha*" enters the decayed spot, as a worm does the body, and hastens the destruction. The tree may drag out a miserable half dead existence, but, as they say in Portuguese, it is "*cancado*." It will be seen how very easily the destruction of even almost "inexhaustible" forests may be completed by a mere blow of a hatchet in the hands of a marauding native. Renters of swamps are naturally less careful of the trees than are the owners, who manage their property from a central rubber station.

A SHORT HISTORY OF BRIDGE BUILDING.*

By C. R. MANNERS.

WE now come to the third division, or arched bridges.

Arches may be of timber, stone, brick, cast or wrought iron, or steel, and in all cases the supporting material is compressed by the stress due to the load.

Before, however, proceeding with my remarks upon

FIG. 12.—ARCHED OPENING AT ARPINO.

this class of bridge, I think we may, in connection therewith, first glance at the early history of the arch itself, previous to its application to bridge building.

The actual origin of the arch seems to be involved in doubt and mystery. It is probable that, in the course of their building operations, some of the architects or builders among the ancient races noticed that when two long stones or lintels were laid from opposite walls, and leaned against each other at the top, they gave mutual support, and that a larger opening could thus be spanned; nor is it unlikely that this would lead to the introduction of a third stone, placed between and supported by the two others (as seen in sketch of Campbell's Tomb), and that so the arch was gradually developed by more and more stones being added. Be that as it may, we have in the third pyramid a chamber roofed over by what at first appears to be a pointed arch, but which in reality is not an arch. In this roof

long stones have been placed, supported at one end by the side walls and abutting against each other at the center, as shown in Fig. 13, and dressed off inside to give the appearance of a pointed arch. A somewhat similar arrangement is also found at the entrance to the great pyramid.

At Thebes, a city of ancient Greece, some arched chambers of crude brick have been found, supposed to date from about 1200 B. C.

Mr. Perring says he found at Thebes some well formed arches of 12 ft. to 14 ft. span, built in concen-

obtained their knowledge of the arch from the Ethiopians. Diodorus Siculus tells us the Egyptians learned from the Ethiopians to honor their kings as gods, to bury their dead with great pomp, and also received instructions in sculpture, etc. Mr. G. A. Hockins, in his travels into Ethiopia, describes one elliptical brick arch which he discovered in a tomb at Thebes. The span is about 8 ft. 6 in. and the rise 3 ft. 4 in.

Along the center was a line of hieroglyphics containing the name of Amunopole I., which would seem to

FIG. 13.—CHAMBER IN THIRD PYRAMID.

FIG. 14.—CAMPBELL'S TOMB.

FIG. 15.—GATEWAY IN CENTRAL AMERICA.

FIG. 16.—GATEWAY NEAR MOUNT CYNTHUS.

FIG. 17.—TREASURY OF ATREUS.

FIG. 18.—CHINESE BRIDGE.

FIG. 19.—SECTION OF THE CLOACA MAXIMA.

FIG. 20.—VIEW OF THE PORTA MAGGIORE, ROME.

FIG. 21.—ROMAN AQUEDUCT AT ANTIOCH.

A SHORT HISTORY OF BRIDGE BUILDING.

tric half brick rings, the bricks being marked with the name of Sesostri, one of the early Egyptian monarchs who conquered Asia and Ethiopia.

In the island of Meroe, in Ethiopia, long the seat of the kings of that empire, there are a great number of pyramids constructed of red sandstone. On the east side of each of these pyramids is a portico, one of which is regularly arched, and it has been thought to be the earliest arch known, and that the Egyptians

prove that the arch was known in that part of Egypt at least 15½ centuries B. C.

Again, in one of the tombs at Ghizeh, known as "Campbell's Tomb," and supposed to date about 660 B. C., there are indications of springing stones, from which it is thought it was covered by an arch, and if so it would be the oldest known stone arch of any considerable size; the ground space being 30 ft. 6 in. by 26 ft. 3 in. In the center of the excavation was actually

* Continued from SUPPLEMENT, No. 845, p. 13500.