his untiring work, night and day, without remuneration, in mobilizing Canada's industries for the manufacture of shells. When further shell production became a financial rather than a manufacturing problem, the Imperial Munitions Board, composed mostly of financiers, succeeded the Canadian Shell Committee, but General Bertram's services were retained as vice-chairman of the new board. He was elected a member of the Canadian Society of Civil Engineers in 1911, and has taken considerable interest in the society's meetings. His name appears on the list of contributors of papers published in the transactions of that society.

PROGRESS IN ASPHALT REFINING; WITH NOTES ON MEXICAN ASPHALTIC CRUDES.*

By Leroy M. Law,
Chief Chemist, the United States Asphalt Refining Co.

THE merits of refined asphalt roads quite naturally resolve themselves into the merits of the asphalts used in their make-up, for, in the same type of construction, the mineral aggregates, their preparation, etc., will be practically the same for all asphalts. Let us consider, then, these changes which have been brought about in petroleum asphalts that enable one to discuss roads built from these materials, not as possibilities, but in the light of actual reality.

Petroleum doubtless entered the paving industry as a "flux," or softening agency, for the solid, native bitumens, which were too hard to be used for paving purposes in the condition in which they naturally occur. These fluxes were not straight mineral oils, but the residue of by-products of oil distillation, for in those days the major products of all refineries were the burning oils, and later on, gasolines and lubricants. The fluxes were, therefore, what remained in the still after these more valuable fractions had been taken out, and, under the name of "residuum," were generally considered as containing the lubricating oils, waxes and pitch base. That they were actually refuse products, with little or no care in regard to their quality, is shown by the fact that the oils were frequently subjected to so called "cracking" processes for an increase over the normal yield of burning oils, etc., this to the detriment and injury of the residuum.

There are about six more or less well-defined oil fields in this country, and in some of them the oils vary from well to well, yet all were distilled for practically the same major products. It was, therefore, not surprising that the resulting residues were variable in character, and doubtless many times unsuited even for the purpose of fluxing the hard asphalts. Under such circumstances, however, petroleum asphalts originated.

The increasing use of the more successful native bitumens early became the stimulus for the development of the residuals so that they might be placed in competition with the asphalts, to which they heretofore had served only as adjuncts, and, to do so, it was necessary that they be brought from their more or less fluid state to consistencies suitable for paving purposes.

It was early found that distillation of the paraffine and semi-asphaltic petroleum beyond the "residuum" stage, resulted in decomposition of the pitch or asphalt residues to such extent that their usefulness as paving materials could not receive serious consideration; so other means were sought to achieve the desired end. For example, it was found by Dubbs that the addition of sulphur to the residuum, maintained at elevated temperatures, resulted in a molecular condensation, with liberation of sulphuretted hydrogen gas. The resulting artificial asphalts received the name of "Pittsburgh Flux," and proved to be interesting products.

Byerly, working about the same time, found, too, that by blowing air through the heated residuum, the oxygen performed a similar function to the sulphur in the Pittsburgh flux, and in 1893 took out a patent covering the air-blowing process. This proved a most important step in the transition of petroleum asphalt, for air blowing was cheaper than sulphur, and by regulating the duration of the "blow," asphalts varying from soft to hard consistencies could be produced.

Another step in the evolution of asphalts from petroleum was accomplished by compounding with the distillation residues such quantities of hard bitumens, like gilsonite and grahamite, as to produce materials of paving consistencies. Many of these compounds contained as much oil as hard bitumen. On account of the large percentage of the oil residuum required the original element of uncertainty still prevails in regard to the finished product. This, together with the high price of gilsonite and grahamite, and other factors, has doubtless served to greatly restrict the use of such preparations to-day.

This brings us up to about the year 1900, previous to which the oil asphalts were truly artificial materials. They were prepared at best from oils of low asphaltic contents, and their solidity and consistency were proportional to the artificial means employed in their manufacture.

Asphalts from Texas and California petroleum next deserve our attention, and it is interesting to note that, while they differed widely in characteristics, both are still in use to-day, though doubtless in modified form. The original Texas asphalts were low in susceptibility to temperature changes, but low ductility retarded their adoption by many cities which were maintaining a minimum ductility requirement of 15 or 20 centimeters in their specifications.

On the contrary, the California materials possessed practically unlimited ductility. Their advent was the turning-point in the evolution of petroleum asphalts, inasmuch as their preparation could be accomplished by a simple refinement direct to the desired consistency without any air-blowing.

Mexican petroleum entered the field of raw materials five years ago. The asphalts produced therefrom met successfully recognized paving and road oil tests, and a plentiful and uniform supply of the raw material is assured. Mexican asphalts, it is true, had appeared in the paving industry years ago, but the early examples were but the more or less solidified effusions from the real supply, which lay thousands of feet below the surface.

In 1910, therefore, the opening of several large wells on the east coast of Mexico began a new epoch in the asphalt business. Two types of Mexican petroleum constitute, in general, the supply of crude material brought to this country: a heavy oil of 10° to 12° Beaume gravity, carrying about 70 per cent. of asphalt, and a lighter one of 18° to 21° gravity, with an asphalt content of 55 to 60 per cent. These issue from wells of 3,000 to 5,000 feet

*Abstract from paper read at Worcester Convention, December 16th, 1915, and entitled "Merits of Refined Asphalt Roads."