each) is about £10,000 (\$48,665)—a smaller output per day in accordance with the weight of the briquette.

No special machinery is absolutely necessary for the manufacture of these tar briquettes. It has been found

in practice, however, that a more perfect briquette is formed with a heavier impression than can be obtained from a rotary press of the Belgian type or other existing machines. Doctor Shedlock now em-

ploys a rammer working on a die with a combination of hydraulic and mechanical power. He has patented, or is about to patent, this rammer. His interests in the patent have been sold.

HEAT-BALANCING IN LOCOMOTIVES.*

STUDIES IN COMBUSTION AND RADIATION.

BY LAW FORD H. FRY.

THREE losses with the heat usefully employed in the production of steam must account for all of the heat contained in the coal, and complete the heat balance.

(1) Loss of Heat in the Products of Combustion.—The products of combustion consist of certain dry gases, and in addition to these a considerable amount of water vapor from the water of combustion of hydrogen in the coal, and from the moisture in the coal and in the air. There is also a trace of sulphuric acid from the combustion of the sulphur. In the St. Louis tests the water of combustion with the sulphuric acid amounted to 0.40 pound per pound of coal burned. The moisture in the coal was always in the neighborhood of 1 per cent, and, therefore, the water vapor produced, per pound of coal burned, may be taken with sufficient accuracy as 0.41 pound, as fired. In addition to this vapor, the moisture in the air admitted for combustion must be taken into account. The percentage of moisture in the air can be determined from the wet and dry thermometer readings which were taken. The weight of the dry gaseous products of combustion per pound of coal burned is 0.54 pound more than the weight of air supplied per pound of coal. The amount of heat carried off by the products of combustion depends on the weights of dry gas and water vapor produced per pound of coal burned; on the temperature at which they escape to the smoke-box; and on their specific heat.

(2) Loss of Heat by External Radiation.—This loss was not measured in the St. Louis tests. It seems, however, permissible to assume that the loss by external radiation is 5 per cent of the heat utilized by the boiler in evaporation.

(3) Loss by Imperfect Combustion.—This falls under two heads:

(i) Loss by production of carbon monoxide.

(ii) Loss by escape of unburnt coal at chimney and ashpan.

(i) The first mentioned loss can be calculated from the analysis of the flue gases. There is a general tendency for the loss by CO to increase as the rate of combustion is increased, but except in Series 100 there is no very serious loss on this score. In Series 100 one individual test shows a loss of 16.33 per cent by CO. This is due to the rapidity with which the air supply falls off as the rate of combustion is increased. Evidently the difficulty of getting air to the fire limited the power of this boiler, and prevented the rate of combustion being pushed above 90 pounds of coal per square foot per hour.

(ii) The loss of heat by the escape of unburnt coal is the most important loss in the heat balance when the boiler is working at full power. The coal escapes unburnt in three ways:

As sparks; into the ashpan; as unconsumed gas in the products of combustion, entailing a secondary loss by the sensible heat of the unconsumed gas in the smoke-box.

As the necessary observations were not taken, it is not possible in the present tests to determine the separate value of each of the four items of the loss by unburnt coal, but the total amount of heat lost can be determined by a method which is illustrated by the following example:

In Test 8,006 there is known—

	Per cent.
Heat of evaporation.....	47.20
Heat lost by external radiation.....	2.36
Heat lost in the production of CO.....	0.70
	50.26
This leaves as the loss to be divided between the products of combustion and unburnt coal	49.74
	100.00

The heat lost in this test in the products of combustion was 19.3 per cent of the total heat of the coal actually burned. Now if, for example, 25 per cent of the coal were to escape unburnt, the loss

in the products of combustion would apply only on the remaining 75 per cent actually burned, and would be 0.75×19.3 , or 14.5 per cent of the heat of all coal fired. Consequently, if P is the percentage of heat lost by coal escaping unburnt, the loss in the products of combustion is $19.3 [(100 - P)/100]$ per cent of the total coal fired, or calling this P we have $P_1 = 19.3 [(100 - P)/100]$, and $P_1 + P = 49.74$, whence, by simple algebra, it is found that P , the loss by unburnt coal, is 37.7 per cent.

The general results of all tests is that the efficiency of the absorption of the heat is practically independent of the rates of combustion and evaporation, so that under all conditions of working the heating surface absorbs about 81 per cent of the heat produced by combustion. Approximately, the same figure is obtained for all four boilers, although they vary considerably as regards design and ratio of heating surface to grate area. The figures show that the efficiency of the boiler, as a whole, is mainly determined by the efficiency of the combustion, which falls rapidly as the rate of combustion is increased.

Although the smoke-box temperature at which the products of combustion escape increases as the rate of combustion increases, the percentage of the coal heat carried away by these gases is reduced. This is due to the reduction of the weight of gas produced per pound of coal burned. When the rate of firing was increased from 30 pounds to 130 pounds per square foot of grate, the weight of the products of combustion was reduced from about 18 pounds to about 8.5 pounds per pound of coal fired. For complete combustion about 11 pounds of air are required, so that when the boiler was forced it was not possible to get enough air through the fire to burn all of the coal fired. The figures obtained show that the locomotive of Series 100 is particularly choked for want of air. The author learned with much interest, after writing the foregoing, that since the tests the Pennsylvania Railroad has increased the area of the air inlets in the ashpan of this locomotive, with the result that it steams much more freely and efficiently.

THE PHENOMENON OF TRIBO-LUMINESCENCE.

By the PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

In a paper presented to the Académie des Sciences, M. Adrien Karl brings out some points regarding the phenomenon which some bodies possess of showing light when they are broken or rubbed, this effect being known as tribo-luminescence.

This phenomenon appears to be a rather general property of solids. Many of the mineral substances which do not seem to possess this property would be seen to have it, provided the eye were kept beforehand in the dark so as to become more sensitive to such effects. In this way the author was able to observe the tribo-luminescence of oxide of thorium, titanite and tungstic acids, zirconia, cadmium sulphide, etc. Another cause of non-observation is the resistance to crushing. This is the case with natural silica, which becomes very tribo-luminescent when it is scratched by means of an emery wheel. Another cause is the great fragility of the bodies. This may be overcome by plunging the body in question in liquid air, when it is hardened and the phenomenon can be observed. But there are bodies which do not show this phenomenon, no matter in what condition they may be placed. The author recognizes, in the same way as for the cases elucidated by M. Urbain for phosphorescence, that in order to produce these effects we must have the co-existence of a diluting body and a phosphorescent body or phosphorogen. In phosphorescent bodies, in fact, M. Urbain shows that in general these consist of a very small amount of the phosphorogen, diluted in a large quantity of another body. In like manner, in order to produce tribo-luminescence we must have a large proportion of a diluting body and small quantities of an appropriate exciting substance (tribo-luminogen). It is observed that pure substances are not tribo-luminescent. A system which shows such property almost always keeps it when it is engaged under different chemical

forms. Thus manganiferous oxide of zinc which is tribo-luminescent will give products which are able to produce this effect when it is transformed into nitrate or sulphate. However, the fluoride product does not produce it. A systematic study of certain series of mixtures shows that there is a maximum of brightness and this corresponds to a certain quantity of the constituents. This quantity differs greatly for different bodies, as follows: TuO_3ZnS , maximum with 1/1,000 part of tungsten; $MnZnS$, 1/800 of manganese; $PbZnS$, 1/500 of lead; $UZnS$, 1/200 of uranium. Comparing this with the values which are found in the case of phosphorescence in the same bodies, we find that the proportions for the maxima are quite different. This point is of interest as we see that there is no doubt a distinct action of the exciting body for each of these cases. The sensitiveness of the tribo-luminescent phenomenon is very high for certain diluting bodies. A fractionation of six months upon ten fractions of nitrate of zinc was found to weaken considerably the tribo-luminescent properties of the sulphide which it contained, but it did not cause these to disappear entirely. The oxide prepared with the same fraction no longer showed the phenomenon. In general, a purification which is carried far enough enables us to see a total extinction. The author observed this fact especially in the case of an acetate of uranium which showed a distinct effect at first. Referring to the above figures for the maximum effect, it is found that such a maximum must not be exceeded, and that increasing quantities of the exciting substance will on the contrary cut down the luminous effect. In such case we must add more of the diluting substance so as to produce the highest effect. The author specially observed mixtures in which the diluting substance was sulphide or oxide of zinc, and where the exciting body was varied. To give the intimate mixture of these parts any of the usual means can be used, such as the simultaneous precipitation where this is possible. He then raised the zinc sulphide to a high heat in a Mermet furnace in a current of hydrogen sulphide. As to the oxides, they are heated to a less degree in a Leclerc furnace, or else in a muffle furnace. The different exciting bodies were silver, lead, tungsten, copper, uranium, iron, etc. It is found that the color of the light varies with the exciting body. For instance, it is blue with lead and orange with manganese. The diluting body also affects the color. Thus in the system (TiO_2 , ZnO), the light is a pale violet; with (TiO_2 , ZnS) it is a deep green. Another point is that the color of the light is not necessarily the same as for the phosphorescence of the same mixtures.

Metatolyl hydrazide acid carbonate, $CH_3 \cdot C_6H_4 \cdot NH \cdot CONH_2$, which has been in use for some years as an antipyretic, is confirmed as possessing valuable properties. It is very stable, being undecomposed in the system, so that its effects are lasting and do not give rise to cyanosis and collapse. It has a marked diaphoretic action. In fevers, doses of 3 to 4 grains reduce the temperature in thirty minutes, the minimum being attained in three hours. Afterward the rise in temperature is slowly resumed. In the case of very high temperatures, such as occur in enteric fever and pneumonia, a single dose rarely reduces the temperature; in these cases small doses of 2 to 3 grains should be given every two hours, but not exceeding 9 to 12 grains in twenty-four hours. Marettine is chiefly eliminated unaltered in the urine, and perspiration; it imparts a greenish-yellow tint to the former, which then reduces Fehling's solution. It does not depress the heart; on the contrary it has a marked tonic action on the cardiac system, which renders it of special value in many febrile cases. The lowering of the temperature by small doses is not abrupt, but slow and gradual, and is prolonged for three to six hours. It is specially valuable in enteric fever. In addition to this it has given good results in the treatment of acute and chronic affections of the respiratory system, diminishing the number of inspirations and increasing their depth, but it is inefficacious in dyspnoea due to cardiac trouble.—G. Florio and G. Zambelli (Il Morgagni, Nouveaux Remèdes, 1907, 22; 463).

* From a paper read before the Institution of Mechanical Engineers, dealing with experiments made on the locomotive testing plant of the Pennsylvania Railroad at the St. Louis Exhibition, and later at the Altoona (Pa.) shops.