The experiments were divided into three periods. From 1904 to 1907 the work was carried on at St. Louis, and the Johnson, American Compressed Fuel Company, and Renfrow machines were used. From 1907 to 1910 at Norfolk, the Johnson and Renfrow (improved) plants were employed, together with a German Schlickeysen peat-machine. And at Pittsburgh, from 1910 onwards, the experiments were confined to the German lignite plant and to the small hand-press, although the English machine has been placed on its foundation.

The physical tests to which the briquettes were subjected were called the "drop" and the "tumbler," the absorption, density, weathering and compression tests. In the first, the briquettes were dropped on the floor, and the pieces, which were held by a screen with 1-in. square holes, were dropped again. This procedure was repeated five times, and the weight of the pieces, which, after the fifth drop, would not pass through the screen, was determined. In the tumbler test a weighed quantity of the briquettes (about 50 lb.) was rotated for two minutes at 28 revolutions per minute in a sheet-steel cylinder. The parts which were held by a 1-in. screen and a 10-mesh sieve were then weighed. The absorptive qualities of the briquette were tested by weighing, and the rate of absorption each day, and the time required for the absorption to become complete, or for the briquette to disintegrate, were determined. The density was taken by means of a Nicholson hydrometer, and the weather-resisting qualities were assessed by observation extending sometimes for as long as 286 days. For measuring the crushing strength a 200,000-lb. Olsen testing-machine was employed, although it is stated that the amount of handling which the briquettes will stand is given more accurately by the tumbler and drop tests.

The chemical tests included analyses and moisture tests, and extraction tests, using carbon bisulphide as a reagent, were made to determine the percentage of bitumen in the raw and the briquetted fuel. To determine the evaporative and burning qualities, the briquettes were burned under a stationary boiler. Special tests were also made on locomotives and on a torpedo-boat, and in domestic furnaces and foundry cupolas. The locomotive tests show that the evaporative efficiency of briquetted as compared with raw fuel is greater; that firing is easier; and that both the clinker and smoke produced are less. On the torpedo-boat it was found that there was no gain in smoke production, or in efficiency, but that the work of the stokers was lightened, and the boiler capacity increased. The domestic furnace tests proved that, for the low temperatures common in house-heating boilers, pitch is an unsuitable binder, as it volatilized and escaped unburned, or became deposited as tar. It also gave rise to too much smoke.

In the experiments the question of what binder can be used has naturally been investigated in great detail. The coal-tar pitch binders at present employed give briquettes which are waterproof, do not crumble during transport, leave little ash, and can be manufactured at a reasonable cost. Other binders, notably cereals and "sulphite pitch" (selpech) have an advantage over pitch, inasmuch as they are smokeless in burning, but they are unfortunately not waterproof, so that the briquettes crumble after exposure to the weather. Such briquettes can easily be rendered waterproof, but the cost has hitherto been considered prohibitive. The American experimenters, however, state that their investigations on this head show that the discovery of a cheap waterproofing process is not an impossible achievement. And the patentee of Middleton's starch binder declares that he has already solved the problem, using 2 per cent. of cereal and ½ per cent. of tar, against, in the ordinary process, 8 per cent. of pitch. The cost of manufacture, he claims, is cheaper than in the pitch process so long as the price of pitch is above 42s. 6d. per ton. He states that the fuel, after exposure to the weather for several weeks, shows practically no deterioration.

In addition to detailed experiments with various kinds and percentages of pitch, the bulletin reports the testing of a large number of other binders. These include creosote, asphalt, petroleum (both of paraffin and asphalt bases), lime, clay, wax tailings, and sludge; various wood products, such as resin, tars, wood pulps, and sulphite liquor; various sugar-factory residues, such as beet pulp, lime cake, and the different molasses; starches, slaughter-house refuse, and petroleum products.

In the tests of pitches it was found that the pitch obtained from the distillation of petroleum gas-tar gave the best results, although other pitches distilled from by-product coke-oven tar, illuminating-gas tar, and producer-gas tar proved quite satisfactory. Water-gas pitch, another binder tested, has an advantage over ordinary coal-tar pitch in that the production of free carbon present is only 10 per cent., as against as much as 30 to 40 per cent. with the ordinary material. The free carbon is useless as a binder, and acts merely as a diluent of the bituminous matter. In all pitches it is important to select a material that is not too hard. The actual hardness required varies with the time of year and the climate; but, generally speaking, it was found that pitch which becomes brittle when dropped into water at 55 deg. Fahr. is of the correct texture. The harder pitches have been robbed of the creosote and lighter oils during distillation, so that pitches from which these oils have been distilled off should be avoided. It is also better for briquetting purposes that the pitch should be prepared in this way rather than by distilling all the oil, and then reducing the pitch with the naphthaline and creosote oils, as is sometimes done. As an example of the disadvantage of using the harder pitches, it may be said that in one experiment with a pitch of this kind, 13 to 18 per cent. was found necessary to make good briquettes, while, when a pitch with the proper amount of light oils was tried, 6 to 9 per cent. proved sufficient. Other experiments show that from 7½ to 14 per cent. of volatile oils is the correct proportion to give the proper binding qualities, and that from 6 to 9 per cent. of pitch of this kind will make good briquettes from most bituminous and anthracite coals. To mix with a non-coking coal 10 to 20 per cent. of a coking coal is better than increasing the percentage of pitch.

Of the other binders tried, it was found that clay, lime, cement, magnesium oxide, plaster-of-paris, acid sludge, sugar-factory residues, slaughter-house refuse, and wood products are all unsatisfactory, although some of the last-named give good results in combination with other binders, and seem for that reason to deserve further investigation. Wax-tailings give fair results, but are not considered altogether satisfactory, while crude petroleum, although answering well, is deemed unsuitable for working on a commercial scale. Resin, used in conjunction with pitch or petroleum, and a percentage of lime to prevent smoking, makes a good binder; but here, again, the cost makes commercial application impossible. Asphalts are also rather too expensive in most places, and give only fair briquettes, but asphaltic tar was found useful as a waterproofing material in briquettes made with starch.

In fact, the only really good binders besides pitch were found to be starch or flour, and sulphite pitch. None