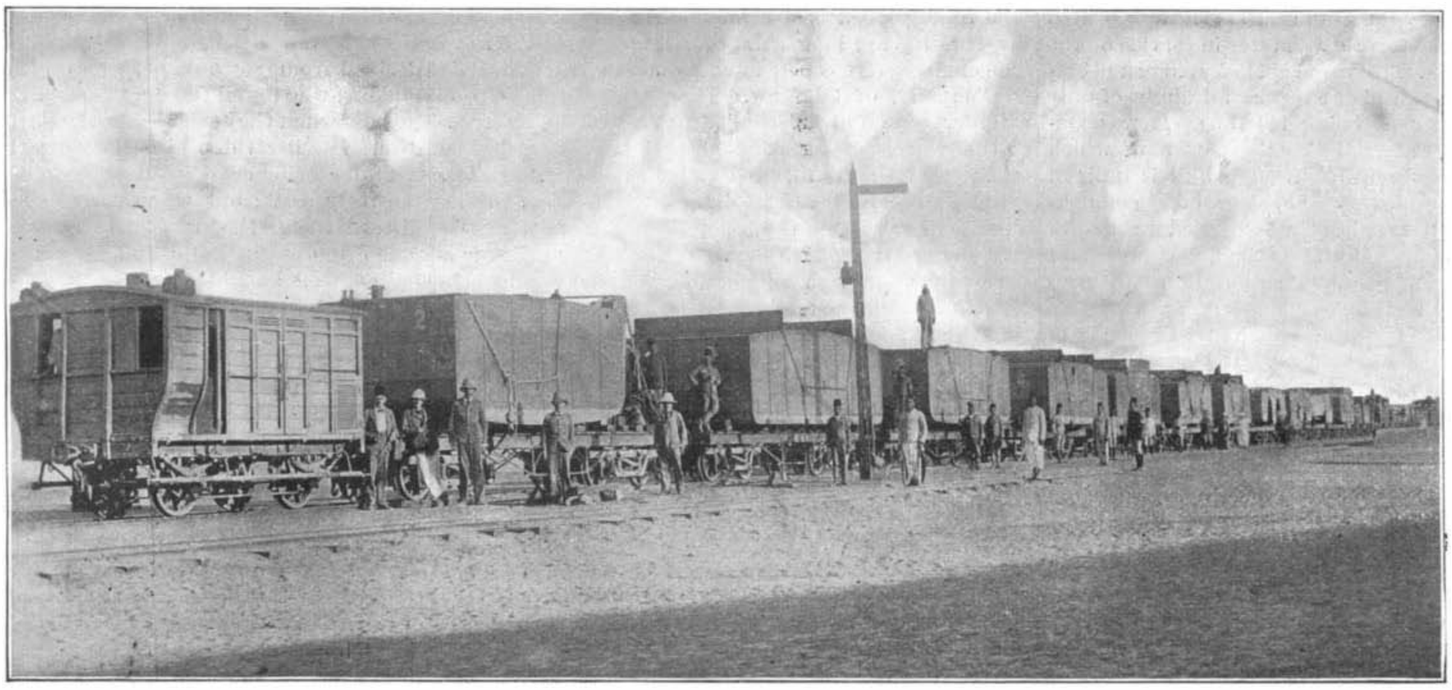
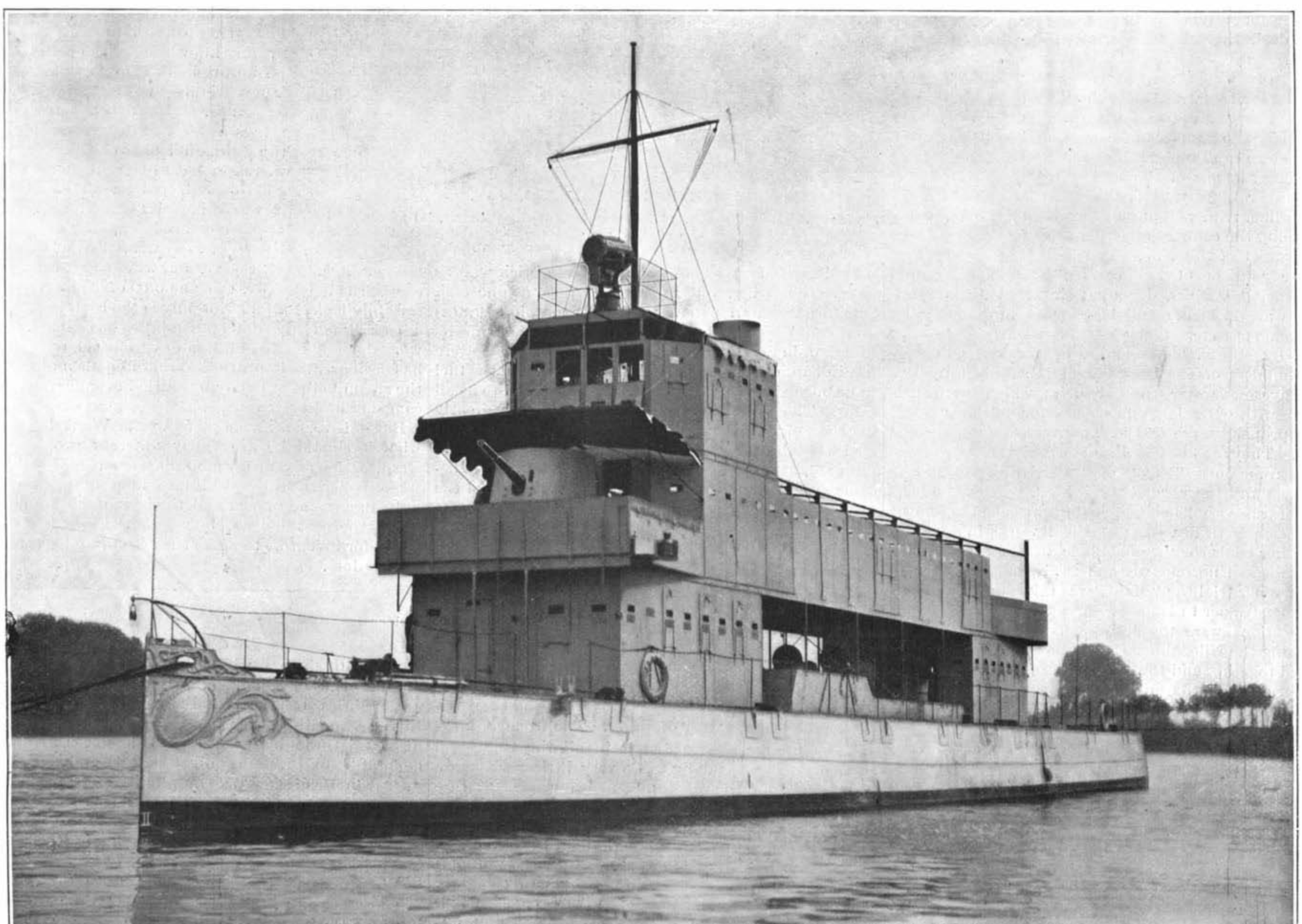
are employed a large force of inventors and mechanical experts under the direction of Messrs. Marvin and Casler, and constant efforts are being made to develop new and improved forms of moving picture apparatus and to discover new methods of taking and exhibiting moving picture views. All the intricate and special machinery involved in the process of reproducing these views with marvelous exactness is designed and built at this laboratory, and this work requires great mechanical skill and the most perfect tools and appliances known to the mechanical art. The accuracy of this class of apparatus will be better appreciated when one considers the enormous magnification at which these views are projected upon the screen and the rapidity with which successive views must follow each other in perfect registration. Imagine a sequence of two thousand pictures, each two inches by two and a half inches in size, following each other in turn through the projecting lantern of the biograph every minute, each picture being magnified on the screen to a size of twenty by twenty-five feet, and think how perfect must be the registration of each succeeding picture, in order that the result of the image upon the screen may not appear to dance about and vibrate, but may appear as one continuous set picture! Not only is precision in projecting required, but also in the printing of the positives from the original negative. The negative prints taken by the original camera do not always follow each other at equal distances upon the strip of film; consequently, in printing the positives the printing machine must be able to correct this imperfect spacing and produce a band of positive prints printed perfectly equidistant. The printing machine must also be able to properly register and print bromide pictures from the same negatives, but these pictures on a band of bromide for the Mutoscope have to be spaced much wider than when printed on celluloid strips for the Biograph. The printing machines are arranged to run entirely automatically, and so perfect is their design that if for any reason a print does not register perfectly, the operation of the machine stops and a bell is rung, warning the attendant that his attention is needed. The apparatus constructed at the laboratory is sent out to the various Mutoscope companies in England, Germany, France, and Holland, and any ideas in moving pictures developed by any of these companies are at once forwarded to the American laboratory for perfection and trial, and in this respect the position of the laboratory is somewhat peculiar, since it is the workshop for busy brains throughout England and the Continent.



NILE GUNBOAT "MELIK" BEING CONVEYED BY RAIL, IN SECTIONS, ACROSS THE DESERT.

GUNBOATS AND RAILWAYS IN THE SOUDAN CAMPAIGN.

It is a fact which is pretty well understood that the remarkable success of the recent campaign under General Kitchener in the Soudan was largely due to the excellent judgment and forethought shown in carrying out what might be called the engineering features of the expedition. The distinguished soldier who more than anyone else was responsible for the planning and execution of the campaign, combined the training and experience of the engineer and the soldier in one, having been, we believe, in the earlier stages of his military career in the Royal Engineers. As distinguished from the unsatisfactory and barren expedition under Lord Wolseley in the previous decade, the present expedition undoubtedly owes its success to the completeness with which the whole problem was thought out, and the deliberation and accuracy with which each step of the advance up the Nile was made and each important position occupied and strengthened as a base from which to execute the next forward movement. Undoubtedly the most vital elements to the success of the British advance were the military railroads which were constructed through the deserts and the fleet of specially designed gunboats which operated in the upper reaches of the River Nile. The railroads were built largely for the purpose of convey-



LIGHT-DRAUGHT THORNYCROFT GUNBOAT "MELIK" USED IN THE SOUDAN CAMPAIGN.

Length, 145 feet. **Beam,** 34½ feet. **Draught,** 2 feet. **Speed,** 12 knots. **Protection:** Chrome-steel plating. **Armament:** Two 3-inch 12-pounder rapid-fire guns; eight 0·45 Maxims; 110 loop-holes for rifle-fire.

ing the gunboats around the impassable rapids of the river to a point at which they might be floated and proceed under their own steam up to the objective points off Khartoum and Omdurman.

In the accompanying illustration we show one of these gunboats, the "Melik," in course of transportation over the military railroad, and also as it appeared after it had been put together and was in service on the Nile above Dongola. The vessel is 145 feet long and 34½ wide, with a depth of hull of 6 feet and draught of only 2 feet, the displacement being 140 tons. It was constructed in eleven watertight sections, each of which was capable of floating by itself. The hull is built of two materials—chrome steel and the ordinary commercial mild steel. The machinery is carried in two of these compartments, one forming the boiler room and the other the engine room. These sections are constructed of $\frac{3}{16}$ inch chrome steel, having a tensile strength of 95 tons to the square inch and extension of 5 per cent on a length of 2 inches. Thin as they are, these plates equal in protective quality ½ inch of ordinary mild steel and they will stop a bullet fired point blank at twenty paces. The use of this material, which of course secures its great hardness at the expense of the toughness and ductility which characterize ordinary steel, provides a remarkably light, bullet-proof construction, and Sir William White deserves every credit for the success of a suggestion which is original, we believe, with him.

The superstructure consists of two deck-houses built of chrome steel, ⅛ of an inch in thickness. They will resist bullets at a distance of twenty-two yards when striking at an angle of 60°. These two houses are loopholed for musketry fire and they are connected by a bridge deck with chrome steel bulwarks, above which are movable protective shields, loopholed for small-arm fire. The deck of this bridge is 13 feet wide by 79 feet long. Here the crew are berthed, underneath an awning, and it should be mentioned that the officers are quartered in the forward deck-house below and the engineers in the after deck-house. At each end of the bridge deck are two 3-inch 12-pounder rapid-firing guns, which are protected by shields and carried upon an extension of the bridge deck beyond the deck-houses. Upon this deck amidships there are also two 0·45 inch Maxim automatic guns on each broadside, or four in all. At the forward end of the superstructure deck there is another raised superstructure or flying battery, the sides of which are protected by chrome-steel plate. On each side of this battery are two ports through which Maxim guns can be fired, and the sides are also pierced for rifle fire. The great height of the firing line of the upper battery, 21 feet above the water line, renders it most effective in sweeping the country on either side of the banks of the Nile. The motive power consists of two pairs of vertical compound condensing engines, driving twin screws. The cylinders are 12 inches and 19½ inches in diameter by 11 inches stroke. They are of the standard type used by Messrs. Thornycroft, of London, who were the builders of the boat. Steel is supplied by two Thornycroft water tube boilers, which were provided with extra large fire-boxes for burning wood. The propellers are of the Thornycroft screw-turbine type. They are 3½ feet in diameter, and, as the vessel draws only 2 feet of water, they extend 18 inches above the normal water level, the bottom plating of the vessel being arched over above the screws, so that, practically, each of them works in a tunnel.

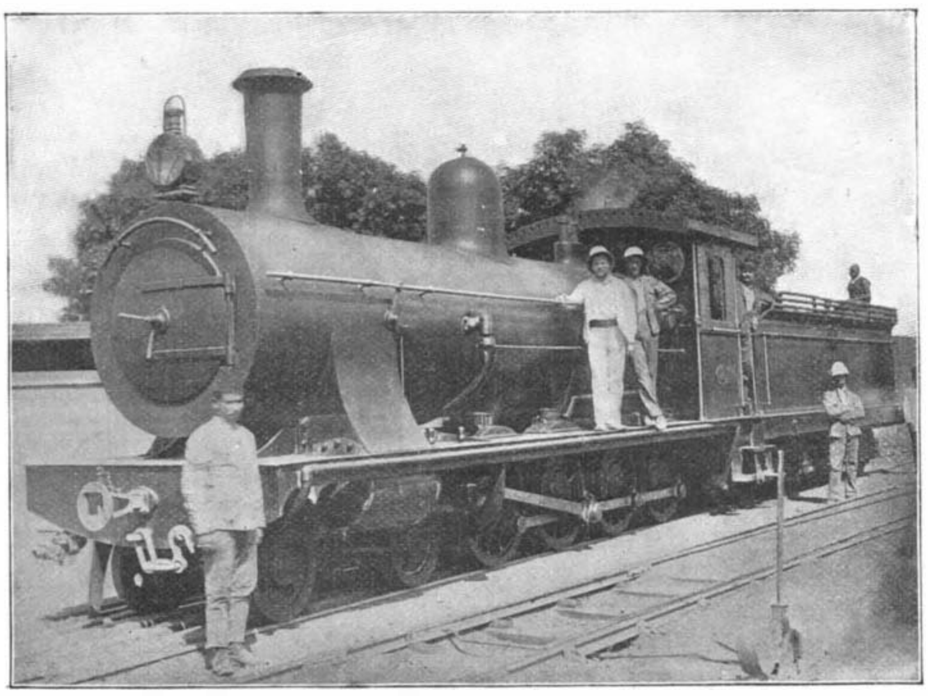
On her trials the "Melik" made about 12 knots, with 460 indicated horse power and 280 revolutions.

After her trial the "Melik" was taken apart and carried by steamer to Ismailia, Egypt. From that point the sections were towed by canal to the Nile. On reaching the Nile, above Cairo, the vessel was roughly bolted together and towed to Wady Halfa, the northern terminus of the military railroad. Here the sections were unbolted and transferred to flat cars, and the whole train, carrying the hull with its machinery, armament, and fittings, was drawn to a point on the Upper Nile above the cataracts, where the vessel was finally riveted together and proceeded under her own steam to Khartoum.

In company with the other gunboats which took part in the battle of Omdurman, this unique vessel did excellent service by directing a heavy fire upon the Dervishes who had passed between MacDonald's division and the river and were endeavoring to surround it. The diversion they created was of great service at that critical moment and greatly assisted in determining the fortunes of the day.

The Soudan military railway, extending from Wady Halfa to Dongola, a distance of about 200 miles, and from Wady Halfa to Khartoum, a distance of about 600 miles, is of 3 feet 6 inches gage. It was constructed with great rapidity; in some stretches of the road as much as 2 miles of track per day being laid down. The rails weighed 50 pounds to the yard. They are of the American T-pattern, bolted directly to the ties. The rolling stock is of a modified American type, the flat cars having long trussed bodies and end trucks. The engines were constructed by Messrs. Neilson, Reid & Company, of Glasgow. They are of the outside cylinder type and are carried on twelve wheels, eight of the wheels being coupled and the four-wheeled truck carrying the forward end of the engine. The cylinders are 17 inches in diameter by 23-inch stroke. The heating surface is 1,095½ square feet, the grate area being 17½ square feet. The working pressure is 160 pounds per square inch. The engine weighs 104,384 pounds and the tender 75,936 pounds.

Particular interest attaches to this railroad from the fact that it will probably form a portion of the great all-rail route from Cairo to Cape Town, which is destined to be constructed before the twentieth century is many years old.



LOCOMOTIVE FOR THE SOUDAN RAILWAY.

Cylinders, 17 by 23 inches. Heating surface, 1,095½ square feet. Working pressure, 160 pounds. Weight, 104,384 pounds.

Evaporation of Modern Steam Boilers.

BY EGBERT P. WATSON.

It has been remarked that, while the steam engine has been greatly improved in the past fifty years, the boiler has remained nearly stationary, and that the evaporation has not materially improved. This is erroneous; there has been a great change for the better.

Fifty years ago the boiler in general use was the cylinder boiler, which, as its name implies, was a mere tube of varying lengths, seldom less than 20 feet, and sometimes 40 feet. This was set over a brick wall as long as the boiler, and having a furnace at one end. The furnace was a mere fireplace; for that, in fact, was all it could be called. It was much too small for its function, in a majority of cases, and the grates were put in haphazard. So long as they would hold the fuel to be burned upon them, they were considered to be all right. The amount of air they admitted was greatly in excess of that required for proper combustion, and feed water heaters were unknown. Bridge walls were not used, as a rule, but, when coal was burned, it became necessary to have some obstacle at the end of the furnace to prevent it from being thrown over the grate into the space beyond it. The writer distinctly remembers opening the furnace doors of old time cylinder boilers and seeing nothing at the end of the furnace but a vast cavern which yawned the whole length of the boiler proper. In a few words, the old cylinder boiler was a mere tubular pot beneath which a fire was kindled. Where wood was plentiful and coal was dear, the former was used in four-foot lengths; and, from the fact that it made a great blaze, and looked as though it made a hot fire, it was supposed to be causing the evaporation of a great deal of water. The firemen, however, had to keep throwing it in all the time, and burned many cords daily to do very little work, as we now understand the subject.

With no circulation whatever, and the effective fire surface only a narrow zone, or comparatively small area of the actual surface exposed (half the circumferential length), it is not surprising that the cylinder boiler did very little work in proportion to its superficial area and its weight, in which latter must be included the weight of the setting, since the boiler is inoperative without it. In this type of boiler there was a vast difference between the temperatures of the front and back ends, particularly as the latter was occasionally stuck through the building for want of room inside. The average evaporation was not over four pounds of water per pound of fuel burned with natural draught, although it must be admitted that owing to the fact that fifty years ago no one paid much attention to this aspect of steam using, it is very difficult now to find authentic logs of actual performance. If there are any records, they have not been made public, to the writer's knowledge, and the statement made above is derived from some experiences of a firm of boiler makers, who found the cylinder boiler a formidable opponent when they undertook the introduction of their own. Having this object in view, they visited large manufacturing centers where cylinder boilers were extensively used; but when they asked steam users to discard them, the water tube men were considered much too enthusiastic. The idea of throwing out boilers that had been in use thirty years, and looked as though they would last thirty more, to install a "new-fangled" evaporator in their place, was not to be entertained for a moment, and some of these conservative men are still holding on to their old cylinder boilers.

Although modern boilers are a great advance upon the crude evaporator of fifty years ago, the changes made have been gradual. Engineers, seeing the sluggish action of the cylinder boiler, put in two flues running the entire length of it; and finding that no disasters occurred, as had been predicted by some timid souls, they went further and made the tubulous boiler, or return tube boiler, which is to-day in general use. It is a boiler which is easy to make and is cheap, for the reason that it is all machine work, but it requires a more or less cumbrous brick setting, so the ultimate cost is but a little less, if any, than other types. Return tubular boilers when properly set and carefully managed will show excellent evaporative efficiency; nine and ten pounds of water per pound of coal is not unusual, although this is higher than the average rate. Add to this that repairs are light if oil is kept out of the boiler and we have cogent reasons for its popularity.

In well-managed plants, where skilled engineers are employed, the average evaporation is more than double what it was fifty years ago; but in other places, where the boilers are foul with scale, where the air leaks badly through the brickwork, where the boilers are looked after only semi-occasionally by youths or laborers, the evaporation is very low. Such places, however, do not represent the engineering knowledge of the period.

Improved efficiency in steam boilers is not wholly due to improvements in boilers per se, but depends upon other things as well. Fifty years ago anything which looked black and hard was supposed to be coal, at all events good enough coal for a steam boiler; it was dumped upon the consumer pretty much as it was dug out of the bowels of the earth. Steam users will not accept such fuel to-day, and where large quantities are burned annually, the amount of combustible is carefully looked after. Not only is the coal cleaner, but a better knowledge of its possibilities has enhanced the work done by it. In addition to better fuel, the furnace has been greatly improved, so that in little and in gross the steam boiler of to-day has little in common with its congener of fifty years ago.

But it is very far from perfect yet. What it is and what it should be are vastly different propositions. Despite the advance which has been achieved, the steam boiler is still wasteful in many ways, the heat units in a pound of coal and the heat units accounted for by the best boilers show serious losses, and it remains for inventors to make the account balance closer than it does.

France and the Immigration of Foreigners.

In France, says Le Chasseur Français, there are 1,130,241 foreigners, while in foreign countries there are but 517,000 Frenchmen. The Europeans of various nationalities residing in France number 1,112,072; there are, on the other hand, but 217,000 Frenchmen dispersed through Europe. Of Belgians, 465,870 have emigrated to France; only 52,000 Frenchmen have settled in Belgium. The hospitality of France is accorded to 286,042 Italians, while in Italy there are only 11,000 Frenchmen. Of Germans there are in France 83,333; the number of Frenchmen living in Germany is 24,000. France has within its borders 14,337 Russians; but in Russia itself there are but 5,200 Frenchmen. The number of Austrians in France is 12,000; the number of Frenchmen in Austria, 3,000. For Spain and Switzerland the figures are more nearly equal. There are 77,000 Spaniards in France and 25,000 Frenchmen in Spain; 83,117 Swiss in France and 54,000 Frenchmen in Switzerland.