ter. No doubt in many cases superheated steam is carried through considerable distances in badly clothed pipes, and the most that it can accomplish is effecting some reduction in the condensation which would otherwise go on in these pipes, the superheat never reaching the cylinder.

"We have failed to find any record of detailed experiments made with really large engines to settle numerically the effect on the consumption of fuel, save those conducted by Isherwood and recorded in 'Experimental Researches in Steam Engineering,' published as far back as 1865. They were made with paddle-wheel beam engines of great size; thus the SS. Adelaide had a single cylinder 50 in. diameter, and 12 ft. stroke, driving paddle wheels 31 ft. in diameter. Another ship, the Georgeanna, had a cylinder 44 in. diameter, 11 ft. stroke. The general result was a saving of over 20 per cent. secured by moderate superheating. This investigation was conducted with great care, and Isherwood's report is worth very careful perusal by engineers interested in superheating. We cannot better conclude this paper than by the following extracts from it: 'The very great increase of economic effect practically resulting from even such moderate degree of superheating as will just prevent condensation in the cylinder, can be easily understood when it is considered that—supposing the condensed steam to be precipitated on the metallic surfaces and not suspended like a mist or fog in the steam remaining in vaporous form—this condensation counts twice against the fuel; once in the reduction of the power, and again in the quantity of heat which has to be imparted to these surfaces by the boiler steam to re-evaporate the water of condensation from them. In other words, all the steam condensed in the cylinder has to be twice evaporated, while no useful effect whatever is obtained from it. Practically, however, it appears that the whole of the steam condensed in the cylinder, due either to the production of power or the expansion per se, is not precipitated upon the metallic surfaces. The condensation due to these causes takes place uniformly throughout the whole mass of steam in the cylinder, and the portion which remains in the vaporous form is able to hold a certain weight of it in suspension, while the remainder must fall upon the surfaces. All the condensation, however, due to external radiation, and to the coldness of the interior metallic surfaces, after their exposure to the condenser temperature and action, must be deposited on those surfaces and re-evaporated by the heat of the boiler steam entering for the next stroke of the piston; consequently all such condensation certainly counts twice against fuel, while the previously described condensation, due to the production of power and to the expansion of the steam per se, may count only once or they may count in any proportion between once and twice against the fuel.'

"We have referred above to the smallness of the effect of superheating on indicator diagrams. Referring to his experiments with the SS. Georgeanna, with various changes of superheating, Isherwood writes: 'It will be seen that the expansion curve formed by the steam pressure in the cylinder after the closing of the cut-off valve, was almost identical with what it should be according to the simple law of Mariotte; that is to say, the pressures were inversely as the volumes, without regard to the variation of temperature. The same coincidence will be found in steam engines in good condition, working without air leaks and with saturated steam; and it is interesting to note the agreement in cases of extreme diversity in the kind and pressure of steam used, size of cylinder and measure of expansion. It obtains whether the steam pressure be high or low, whether it be saturated, slightly superheated or greatly superheated, and whether the measure of expansion be great or small. Of course it is purely a coincidence, but being a constant one, it has its practical value for approximate results from boiler pressure when the indicator evidence is wanting.'"

Such, then, is, in brief outline, the history of the invention and early development of superheating, together with a review of some of the difficulties encountered in its application, and of general considerations bearing upon the theoretical or scientific aspect of the subject. At the present time superheated steam is in successful use in many stationary power plants, on steam locomotives and aboard ship. Aside from the question of economy, engineers realize from long experience that water carried with steam frequently does serious injury to engines, turbines and pipe lines. When superheated steam is used, water is almost certainly absent from the steam, and the latter is dry upon, and generally for some time after, reaching the engine. The development of satisfactory lubricants for superheated work has done much to bring superheated steam into general use.

The improvement in economy actually attained is well illustrated by comparative tests made by Prof. D. S. Jacobus on the machinery of the steam yacht, Idalia, with saturated and with superheated steam. Quoting from the report made by Professor Jacobus:

"The engines are of the four-cylinder triple expansion type, with cylinders 11½", 19", 22-11/16" and 22-11/16" diameter by 18" stroke, the steam being supplied by a Babcock and Wilcox marine boiler having 65 sq. ft. of grade surface, 2,500 sq. ft. of heating surface and a superheating surface of 340 sq. ft. * * * With 105 deg. F. superheat the saving in steam consumption was 15.3 per cent. and in heat consumption about 10 per cent."

The principal results are given in the following table:

Results of Idalia Tests.

Date, 1909.	Oct. 11	Oct. 14	Oct. 14	Oct. 12	Oct. 13
Degrees of Superheat, F..	0.	57.	88.	96.	105.
Steam pressure by gauge, pounds sq. in.	190.	196.	201.	198.	203.
Vacuum, inches mercury,.	25.5	25.9	25.9	25.4	25.2
Revolutions per minute ..	194.3	195.1	195.1	191.5	193.1
Total water per hour, lbs.	9397.	8430.	8234.	7702.	7790.
Water per I.H.P. hour, lbs.	18.3	17.0	15.8	15.8	15.5
B.T.U. per I.H.P. per min.	314.	300.	284.	286.	283.
Per cent. saving of steam.....		7.1	13.7	13.7	15.3
Per cent. saving of fuel, calculated		4.4	9.5	8.9	9.9

In conclusion it should be repeated that the saving in steam consumption is usually not a true indication of the actual fuel saving due to superheating, but at the same time it is generally recognized that superheating does result in an actual saving of fuel. This has not always been true in the past, and it has been a common experience that a saving equal to that due to superheating could have been, and later was, effected by other and more easily operated means than superheating. For example, in the early days of superheating, steam pressures were low,—25 to 50 lbs. per sq. in. by gauge. Superheating then showed in the neighborhood of 20 per cent. fuel saving. But it was soon found that increasing the steam pressure to 75 or 80 pounds gauge caused about as much increase in economy as had been caused by superheating, and also greatly increased the power that could be obtained from a given weight of machinery. Of course materials and designs had to be developed to meet the demands for increased strength as the pressures increased, but these