labour to collect this information. To all those who are engaged in water schemes perusal of the paper cannot fail to be of interest, but it will probably cause disappointment to find how little information as regards water is available in the United Kingdom in comparison with that available in some other countries.

The author concludes his paper by suggested lines of organisation in this country so as to have all matters relating to water administration under one central authority. It will probably take some time before such a complete organisation as is suggested can be attained, but there is no reason why some of the smaller suggestions should not be carried out at once. We feel sure that if the importance of the question were fully brought before the present President of the Local Government Board he would be able with very little expense and without a large supply of red tape to deal quickly with such suggestions as annual returns from all water-supply and sewage-disposal authorities, and the beginning of a hydrographic survey. If a start were once made and the importance of the matter realised, the larger details of organisation would gradually evolve themselves.

The author has added to his paper some tables dealing with the use of water in various countries, and there is also a useful bibliography. M. F.

THE COMPOSITION OF PINE WOOD.

A MONOGRAPH on the "Chemical Composition of Pine-wood," by Prof. Klason, of Stockholm, has been issued by Gebrüder Borntraeger, of Berlin, as the second of a series of "Schriften des Vereins der Zellstoff- und Papier-Chemiker." In addition to the importance of pine-wood as the chief raw material of the paper industry, this particular wood has acquired a special scientific interest from the important colour-reactions in which it has figured as a test material. Thus phloroglucinol imparts a red-violet colour to a pine splinter moistened with hydrochloric acid, aniline sulphate a yellow colour, pyrocatechol and resorcinol a red-violet, pyrogallol a grey-violet, pyrrol and indol a red, phenol a blue, α-naphthol with sulphuric acid a green, hæmatoxylin a violet, naphthylamine hydrochloride a yellow, aminoanthracene hydrochloride a red, phenylhydrazine hydrochloride a yellow, and so forth.

These reactions appear to be characteristic of a substance to which the name of "lignin" has been given; similar reactions are shown by the well-known flavouring substance "vanillin," but this is not present as such in appreciable quantities in pine-wood. Lignin is richer in carbon than cellulose, but contains the same proportion of hydrogen; it differs from cellulose in that it is not dissolved by ammoniacal copper oxide, and gives no blue coloration to zinc chloroiodide, but can be reconverted into cellulose by oxidation, and separated from it by dissolution in alkalis or by the action of sulphites, which appear to convert it into soluble sulphonates. The author has analysed the calcium sulphonate, and attributes to it the formula $C_{40}H_{44}O_{17}S_2Ca$; this corresponds with a composition $C_{40}H_{42}O_{11}$ for lignin itself, but molecular weight determinations give values above 4000. In addition to two molecules of sulphur dioxide, lignin combines with two atoms of iodine, and thus contains three double-bonds in the C_{40} complex; four methoxyl groups are present and one hydroxyl group. The substance is probably a condensation-product of coniferyl alcohol,

$$CH_3O.C_6H_3(OH).CH:CH.CH_2.OH,$$

(a substance which can be oxidised to vanillin), with an oxyconiferyl alcohol in which the substituents are grouped in the same way (1 : 3 : 4 : 5) as in gallic acid, thus

$$2C_{10}H_{12}O_3 + 2C_{10}H_{12}O_4 - 3H_2O = C_{40}H_{42}O_{11}.$$

Lignification appears to consist in embedding the pliable cellulose in a hard crust of lignin; by the action of a sulphite the lignin is dissolved out, and the clean cellulose which is left constitutes the paper pulp. The sulphite extracts, from which lignin can easily be recovered, might very possibly prove to be valuable raw material for the manufacture of artificial vanillin. T. M. L.

RECENT ADVANCES IN TURBINES.[1]

ON two previous occasions I have addressed this institution on the steam turbine. At the time of the first lecture, in 1900, the turbine may be described as having been in the "advanced experimental stage." Six years later it was meeting with "general acceptance" in certain fields. To-night I propose to review its progress from 1906 to the present time; but before doing so I shall, with the view of leading up to the subject, and at the risk of some repetition, briefly explain the chief features of interest, and recapitulate some of the earlier steps in its introduction.

The first turbine of which there is any record was made by Hero of Alexandria 2000 years ago, and it is probably obvious to most persons that some power can be obtained from a jet of steam either by the reaction of the jet itself, like a rocket, or by its impact on some kind of paddle-wheel. It is, however, not so obvious that an economical engine could be made on this principle. In the year 1888 Dr. de Laval, of Stockholm, undertook the problem with a considerable measure of success. He caused the steam to issue from a trumpet-shaped jet, so that the energy of expansion might be utilised in giving extra velocity to the steam. Recent experiments have shown that by such a device nearly the whole of the available potential energy in the steam is converted into kinetic energy of velocity in a straight line, the velocity attained into a vacuum being about 43,000 feet per second. Dr. de Laval caused the steam to impinge on a paddle-wheel made of the strongest steel, which was allowed to revolve at the highest speed consistent with safety, for the centrifugal forces are enormous. Unfortunately, materials are not strong enough for the purpose (in the large sizes the speed is nearly half that of a rifle bullet), and the permissible speed of the wheel can only reach to two-thirds of that necessary for good economy, as we shall presently explain.

Dr. de Laval also introduced spiral helical gearing for reducing the enormous speed of his wheel to the ordinary speeds of things to be driven, and we shall allude to this gear later as likely to play a very important part generally in future turbine developments.

In 1884, or four years previously, I dealt with the turbine problem in a different way. It seemed to me that moderate velocities were essential if the turbine motor was to receive general acceptance as a prime mover. I therefore decided to split up the fall in pressure of the steam into small fractional expansions over a large number of turbines in series so that the velocity of the steam nowhere should be great, and consequently, as we shall see later, a moderate speed of turbine suffices for the highest economy. This principle is now universally adopted in all except very small turbines, where economy is of secondary importance. This arrangement of compounding turbines also appeared to me to be surer to give a high efficiency, because the steam was caused to flow in a non-expansive manner through each individual turbine, and consequently in an analogous way to water in water turbines, where high efficiency at that date had been proved. I was also anxious to avoid the well-known cutting action of high-velocity steam on metal.

The close analogy between laws for the flow of steam and water under small differences of pressure have been confirmed by experiment, and the usual formula $= \sqrt{2gh}$, where h is the hydraulic head, gives the velocity of issue from a jet for steam with small heads and also for water, and we shall presently follow this part of the subject further in dealing with the design of turbines.

Having decided on the compound principle, it was necessary to commence with small units at first, and in spite of the compounding the speed of revolutions was still high.

Though, as we have said, the de Laval turbine appeared four years later, the de Laval cream separators were in use prior to 1884, and I had the advantage of seeing their beautiful means of balancing—the supporting of the bearings in elastic rubber sleeves, which at 6000 revolutions absorbed vibration and allowed the bowl containing the milk to rotate about its centre of gravity instead of its geometric centre. The first compound steam turbine

[1] Discourse delivered at the Royal Institution on Friday, March 10, by the Hon. C. A. Parsons, F.R.S.