and must be applicable only to some definite proportion of the width to the diameter of the fan. The example upon which the formula has been applied indicates that it is useful for fans having a width of about one-half the diameter; but increase or decrease the proportional width and the formula becomes inapplicable. He (the speaker) mentions this particularly because forced draught fans are usually somewhat differently proportioned to those for induced draught. For the former it is generally required to provide a fan of high peripheral speed and moderate capacity, while for induced draught a fan of probably lower peripheral speed but much larger capacity is generally called for. For these reasons one more often finds the single inlet forced draught fan of the more efficient proportion of width=¼ the diameter of impeller. and it is quite apparent that the capacity of such a fan is only somewhere in the region of one-half that of the fan in the example to which the formula is applied. With regard to the shape of the vane of a fan, the author refers to the experiments of Bryan Donkin, when eleven different designs of fans were tested, with the result that the fan with a few plane radial vanes was found to have the highest mechanical efficiency. These experiments were made in 1894, and are still very satisfactory reading for the engineer who wants a cheap, serviceable fan and one of an assuredly moderate overall efficiency. There seems little doubt, however, that, in one respect particularly, the plane radial vane does not meet the case, and that is in regard to the most efficient means of picking up the incoming air when its direction has to be changed from an axial to a radial one. It seems quite apparent that the shock and consequent loss of head occasioned at the inlet edges of radial vanes must seriously minimise their efficiency. There are so many types of curved vane fans that it is difficult to know which is the best shape. It appeared certain, though, that the nearer the inside edges of the vanes approach a tangent to a circle formed by their inside tips, the higher the manometric and volumetric efficiencies obtainable—and, in many cases, a higher mechanical efficiency also. Even in the tests referred to by the author one of the curved vane fans (in the best experiment on each) gave an overall efficiency of 68 per cent. as against 48 per cent. for the radial-vaned fan. The fan which appeals to him as being a very near approach to theoretical requirements is the "Pelzer" fan made on the Continent. It is a single inlet fan, and projecting into the inlet are about twelve curved vanes of "scoop" shape. Once the air has been fairly picked up by these curved vanes it is passed on to an equal number of radial vanes, which appeared to him a combination most likely to obtain very high efficiency. Of course, it must be remembered that it is not by any means a simple shape, and so, unless made in considerable numbers, must be expensive. Referring again to the tests of Bryan Donkin, one of the most striking features of the experiments was the apparent lack of knowledge a number of the makers had of their wares. In several cases the experimenter reversed the direction of the impellers of the fans, and in some cases found as much as 30 per cent. of greater capacity and correspondingly higher efficiency in regard to pressure, volume, and power required. Although the simple plane radial-vaned fan will prove a sound investment for many engineers, and especially for anyone requiring such for an induced draught installation, where large capacity, moderate pressure, and high temperatures have to be provided for, he thought that a closer enquiry into the question of the shape of vanes will especially repay the engineer who is looking for high mechanical efficiency.

He had read of a trial of a fan made purposely to ascertain the effect of fitting a properly shaped inlet funnel, and as he believed it is a small point that should be generally known but is not always sufficiently heeded, it will be interesting to quote what the difference was in favour of the fan with as against it without the funnel. No less than 33 per cent. more air was handled; the pressure efficiency was 31 per cent. higher, the volumetric efficiency 15 per cent., and the mechanical efficiency 9 per cent. greater. It strikes one pretty forcibly when one so often sees fans working with small, plain, thin-edged inlets. Of course, inlets of ample area in well-designed fans would not permit of such improvement; but it seems a point worthy of note.

Again, in regard to clean vanes, it is not, he thought, generally realised that a large difference in efficiency can be obtained by keeping the vanes of a fan cleaned. It is generally considered that the sanding action of the gases does all that is required; but very often a fan stands for a considerable time in the path of the gases while steam is being raised, and there is then a chance for soot to collect. Trials have proved that as much as 12 per cent. more air was obtained with clean as against dirty vanes.

Mr. J. Shirra (President) said that the author's notes were not intended to be historical, but he might have mentioned that the bellows is an ancient institution, and the bellows-maker's an artistic trade. A newspaper judiciously applied to the front of the sitting-room firegrate, so as to shut off the induced supply of air that enters the chimney above the fire and make all the draught go through the bars, is a dodge for reviving a dull fire every practical engineer has had occasion to try in the cold winter evenings; and from this to our forced draught fans and blowing engines is easy progress.

We use forced draught both as a bellows and poker: the poker removes the effete products of combustion that shield the fuel from the combining oxygen, and in the Belleville boiler compressed air jets are arranged specially to give this poker-like action; but he considered it better that the air should go in a uniform stream to the fire with just the velocity necessary to keep up the requisite supply

We should guard against the formation of eddies in the current by expansions or contractions of the channel, as these produce a great loss of energy in the current. In the designing of fans this is often forgotten, and hence we find that fans seem to work equally well with vanes curved forward, backward, or radial—one should rather say equally ill. When thin plates are used for vanes and the fan wheel has parallel sides—i.e., cylindrical—the channel for passage of air expands from the intake to the circumference; the air must receive its greatest impulse and velocity just as it enters the wheel, and if it continues to fill the passage in a uniform stream its velocity must fall considerably—but it does not, for the dead spaces of the passages are filled with re-curving eddies and backwashes of air. In some fans the sides of the wheel converge, so that the circumference is narrower than the intake, and this makes for efficiency by keeping the cross section fairly uniform. The Sirocco fan seems to owe its efficiency to its peculiarity of a short vane with a large diameter of intake. There is no great increase in the section of the air channel between the vanes, and the inside edge of the vane gets in its full work to give the initial velocity just the same as in a longer vane.

Parsons' turbines have done much to direct attention to the proper design of vanes, and so have influenced wider fields than that filled by prime movers.

The remarkable increase in the rate of combustion, due to the blast of the exhaust in locomotives, and the almost automatic adjustment of it to the demand for steam, has been noticed; locomotive firing, we know, has been developed almost into a fine art, and the ordinary marine fireman has much to learn from locomotive work. Much valuable information for those who can think it out can be got from the papers read two months ago to the Institute of Mechanical Engineers on "Combustion Processes in Locomotive fireboxes." He had not had time to study these yet, but could see that in the discussion Mr. Druitt Halpin said blast was not a universal feature in locomotives, many engines having been built with a fan driven by a separate engine on the tender to produce the necessary draught.

It is about a quarter of a century ago since our grand old pioneer engineer, Mr. Norman Selfe, introduced fans to blow up the fires of the locomotive boilers of our N.S.W. torpedo boats, "Avernus" and "Acheron." These must have been about the earliest applications of fans in steamships—it was for long after that time fervently believed in the Navy that forced draught was the invention of the Evil One; but he hoped we might see Mr. Selfe yet hailed as something very opposite—as Pontifex Maximus, in fact, as our greatest bridge maker. He did not like to conclude without referring to his short paper read at our last meeting, where he demonstrated that there need be no fear of a Quebec disaster if his plans for the North Shore Bridge are adopted, but that the design combines the two pillars of all architecture—strength and beauty. It was gratifying, too, to find that the canny Scot does not spare his siller when he wants something first-class, and that in the Forth Bridge we have a structure that will link the kingdom of Fife to the adjacent realms of Scotland and England, presumably till the end of time. Mr. Selfe's remarks on the strength of these three great works—the one we are most interested in having, indeed, scarcely got beyond the stage of a thought, but being all ready to materialise at once—were very interesting, and we are much indebted to him for giving us them.

Mr. Hector Kidd, in reply, said that Mr. Sinclair, in his remarks, refers to the troubles frequently found with marine boilers that are fitted and worked with "Howden's" system of forced draught. Personally, he did not consider the system should be saddled with being the cause of the troubles referred to, as difficulties and troubles of that kind are mostly caused by improper working or forcing the fires beyond the rate at which the coal can be efficiently burned and properly controlled. The object in fitting any system of mechanical or accelerated draught to boilers should be to produce efficient combustion, and not to enable them to be driven at a rate of evaporation that will cause troubles of the kind mentioned.

With reference to the styles of stoking when using natural or mechanical draught, with the former the most efficient results are obtained by keeping the fires as heavy as the draught will permit, keeping in view the rate of combustion necessary to supply a steady head of steam, and the interval between the times of stoking should be regulated with a view to keep a fairly uniform temperature in the furnace. With mechanical draught the fires can be worked heavier than with natural draught, and the rate of combustion can be regulated, as can also the distribution of air to produce the most efficient combustion. The interval between the times of stoking should not differ much from that for natural draught with equal rates of combustion.

Mr. Sinclair points out what has been in the past the cause of much trouble in the working of mecahnical draught, viz., cutting down the area of firegrate to the smallest possible limit. The area of firegrate should be such as will permit of the quantity of coal being burned with a water gauge pressure of $\frac{1}{2}$in. to $\frac{3}{4}$in. between the ashpit and the top of fire.

Mr. Stowe had indicated clearly the conditions that should be observed in the working of furnaces if good results are to be obtained, and these conditions can best be produced and maintained by means of some system of mechanical draught. The interesting point mentioned by Mr. Brain of the application of the "Temperley steam extracting tubes" touches the efficiency of the heating surface of the boiler rather than the efficiency of the furnace. However, any device, such as that mentioned, which has the effect of increasing the heat-absorbing capacity of the heating surface tends to raise the total efficiency of the boiler. He hoped that Mr. Brain will prepare a paper for the Association on the device, together with the results of any tests he has made.

The draught difficulties outlined in the remarks of Mr F. Mackay indicate clearly the advantage of mechanical draught when applied to a steam-generating plant to which additional boilers and flues are being connected up to an existing chimney. With mechanical draught of sufficient intensity the dampers of the different boilers in the installation can be so adjusted.

The formula referred to by Mr. Harricks is only applicable to fans of either the suction or blower type when working at moderate water gauge pressure—say, from two to three inches—and that covers the range of working in most mechanical draught installations. The ratio of diameter of a fan impeller to its width may be varied at the wish of the designer without impairing its efficiency. The two conditions usually laid down in a fan problem are discharge capacity and water gauge or vacuum. If the designer selects a fan to run at a moderate number of revolutions, it may require one of large diameter and narrow width to give the capacity, whereas if a higher number of revolutions could be used the same capacity could be obtained by a fan of smaller diameter and greater width.

The remarks of the President on the conditions which should be observed in applying forced draught to furnaces are very much to the point, as are also his remarks on the necessity of avoiding currents and eddies in the air passages entering and leaving the fan.