getting. Though usually more costly, it is often more practicable than an excavated dock, for though when docks are cut out of the solid rock like those here, their construction is comparatively plain sailing, when one has to be built or dug in the treacherous alluvium or silt on which many of the world's large seaports are established, the resources of the engineer and the capitalist are heavily drawn on. The collapse of the great Alexandra Dock at Belfast over two years ago shows the risk run of building on such sites at the "slob-lands" of Belfast Lough—but the damage has been repaired and the dock lately re-opened. Iron or steel pontoons, capable of lifting ocean-going steamers, have been installed at something like fifty seaports, including Rotterdam, which has seven; Venice, Port Said, and Callao; but Newcastle, N.S.W., still languishes without one.

The buoys and floating moorings for marking channels and dangers, and accommodating the large steamers of today, provide much work for the engineer; those laid down at Liverpool for the new Cunarders being as great things amongst buoys as the steamers are amongst ships. Fairly large work of this sort has been done locally, the mooring buoys for steamers lying off the harbourless shores of Ocean Island, whence there is now a great trade to our ports in phosphates, being the product of local workshops.

The increase in maritime commerce also brings an increase in the provisions of lights and beacons on the world's coasts, and the improvement of those already established. The French Service de Phares has done much to improve sea-lights. It led with the introduction of the electric arc for this purpose, and then with that of incandescent burners, using petroleum vapour, which supply an even better light than electricity in the opinion of nautical men: and the French lighthouses are often fine specimens of engineering architecture. Perhaps the finest light-tower in the Southern

Hemisphere is that of our French neighbours in New Caledonia, a graceful cast-iron tower, 160 feet high, on Amedee Island, the outer light of the harbour of Noumea, erected in 1865. The provision of less monumental structures, however, for harbour lights and beacons is a great function of the lighthouse engineer; gas buoys and acetylene beacons are getting familiar to us; our Harbour Trust has been successful in lighting its beacons with electricity conveyed in submarine conductors, an expedient that has not always turned out well elsewhere. There is much to be done yet in the provision of audible signals during fog or dirty weather. The under-water bells of the Submarine Signal Company of Boston promise well, and the somewhat conservative Elder Brethren of the English Trinity House are at length adopting them to Channel lightships.

But the engineering equipment of the individual steamship is enough to expatiate on. When I first went to sea, we had only one donkey pump in the engine room, besides the main engine, with its two cylinders and steam-starting gear. There was some deck machinery—three or four steam winches, steam steering gear, and steam windlass; and we had four engineers to look after this, the fourth being usually a boiler-maker, though it was being found that the heavier and better built boilers used with high pressure, viz., 60 lbs. steam, seldom needed his special services compared with the weaker structures of jet-condensing days; he kept watch in the engine room, however, and in due course qualified for a sea-going engineer's certificate.

To-day an up-to-date steamship contains a whole arsenal of machinery; the main engines have three or four cylinders, and are often duplicated. Independent circulating and feed pumps are the rule, and feed heaters and filters are almost necessities, as are evaporators or distillers for securing fresh supplementary feed. The provision of electric lighting, re-

frigeration, water ballast, and other conveniences unknown 30 years ago, needs many more engines, and the exhaust steam of these engines is led into an auxiliary condenser with its pumps. The ramification of steam, exhaust, and water pipes is almost bewildering, and the stop and change valves and cocks needed for these and their cross-connections run into hundreds.

I have here (Plate III.), by courteous permission of the A.U.S.N. Company, a rough diagram of the engine rooms of two of our interstate steamships, the "Kanowna" and the "Kyarra," which, though not the very latest, having been built in 1903, occupy the leading place amongst Australian steamers. There are fifty steam cylinders in the machinery of each boat, and this does not include steam winches, for these are replaced by hydraulic cranes. There are twin screws, and engines each with four cylinders and cranks, being triple expansion, with two equal low-pressure cylinders. Besides the hydraulic pump engines, triple expansion with a steam loaded accumulator, there are independent compound engines driving centrifugal circulating pumps, two dynamoes, with compound engines; a cold air refrigerating machine, and a numerous array of donkey pumps for all purposes, not only for boiler feeding and bilge pumping, but for producing the torrent that rushes the ash and the clinker up from the stokehold and overboard, steam ash hoists being also provided, and a pump for draining the cattle stalls. The forced draft fans, with their engines, casings, air-heating tubes and distributing valves, are a great installation by themselves; and although they increase the rate of combustion over that attained with natural draft, they materially reduce the labour of the firemen in the trying circumstance of running before a fair wind, when the deficiency of natural draft in the stokehold often makes their work of trying to maintain the steam pressure really arduous. The exhaust from all these

auxiliaries may be discharged into either the main condenser, the auxiliary, or the atmosphere; and this means a complicated array of pipes and change valves by itself. The steam steering gear, mounted on the rudded head itself, with the elaborate swivelling pipe connections thus needed, its "telemotor" or hydraulic connection with the steering wheel, the steam windlass, the hydraulic deck machinery, all provide work, while the main engine lubrication is largely done by a pump forcing lubricant to the bearings, which lessens the greasers' work, but increases the engineers'.

With all these additions and complications, the improvement in construction and material of marine engines has been so great in the last thirty years that although the steam pressure has been trebled, the main engines give less trouble to keep in order than they did then. Improved piston rings and piston-rod packings, steel piston rods and shafting, well selected cast-iron for cylinder liners, piston valves, and improved lubrication, enable engines to be run half round the world without a stoppage, and be ready to complete the tour after a few hours adjustment. Thirty years ago, after a fortnight's run every thing wanted overhauling; and the nights spent, after 12 or 13 days' run from London, in the Suez Canal—there was no proceeding at night by electric light then—were nights of hard and hot work, to be ever remembered. Now, an engineer hardly ever touches a spanner, on the main engines, between London and Sydney. He usually finds plenty to do with so many auxiliaries; but if this is true, why is it that the auxiliaries are neglected in all the manning schemes that have been put forward in our Federal Draft Navigation Acts, and the main engine horsepower only, made the basis for determining the number of engineers in a steamship?

The progress of the electric motor will probably simplify the problem of the auxiliaries. The "Mauretania"

and "Lusitania" have each an electric installation of 1500 kilowatts, or 2000 horse-power, for lighting, and driving motors for various purposes; they are steam-turbine driven, in four sets of 375 kilowatts each. Over 6000 electric lamps are provided in each ship; and also electric lifts for passengers, stores, etc., between the various decks; the deck cranes, the cargo refrigerating machinery, the great installation of fans for forced draft and for ventilation and heating, the boat hoists, water-tight bulkhead doors, lifting gear in engine room, rotor turning gear, and even the steam whistle, are operated by electric motors. Electricity is also made useful in the galley, motor-driven machines for dough-mixing, meat roasting, plate and knife cleaning, ice-cream making, egg-whisking, potato-peeling, and sandwich cutting, being used; as are electric grids, grills, hot-plates, egg-boilers and milk and coffee heaters.

Notwithstanding all this use of motors, there is in each of those two ships, a very large installation of direct-driven steam auxiliaries, fully 100 separate steam cylinders in each, for circulating pumps, wet and dry air-pumps, feed pumps, sanitary pumps, and so on, which might have been driven by electric power more economically as regards steam consumption than by the simple engines that are used; but after all, the energy in the exhaust of these is not lost, the steam being used to heat the feed water, and the heat thus returned to the boilers. The exhaust steam of the turbo-generators is also thus used; large quantities of heating steam are needed owing to the low temperature at which the condensers are worked to obtain the high vacuum desired in the low-pressure turbines.

The most striking phenomenon in modern mechanical engineering is then the use of the electric dynamo and motor. We have gone far since Franklin's day, when the only

practical use he could make of electricity was to light a fire by an electric spark, and cook thereat a turkey killed by a shock from a Leyden jar. Electric lifts are superseding hydraulic ones, electric cranes and cable-ways are absolutely necessary in the construction of our great bridges and dams; and we get from the dynamo, light, heat, and power, in highly convenient forms. We have applied this long unknown force of Nature to the service of man, but the laws of Nature are as inexorable as ever, and we cannot take liberties with Statics and Dynamics. The year 1907 will be remembered as that of the success of the turbine Cunarders, but also as that of the failure of the great Quebec Bridge, and of the ruinous disaster at the launch of the s.s. "Principessa Jolanda," near Genoa. Therefore, be not high-minded, but fear.

Of the "personnel" of our great steamships, the engine-room staff forms a very inportant part. There are 33 engineer officers and 3 refrigerating engineers on the "Lusitania," so evidently the turbine is not going to cause the marine engineer's occupation to be gone, but provides new demands on his skill and attention.

The Mercantile Marine has long been looked on as one of the best training grounds for practical engineers, and a first-class engineer's certificate of competency issued after examination by the Board of Trade or any of our colonial Marine Authorities, is deservedly looked on as a professional diploma, and is accepted as an undoubted credential of the holder's competency as engineer-in-charge of large power installations on land as well as on sea, as it shows that he must have had practical training and experience as well as correct technical knowledge. In steamers like the "Mauretania," the engineers will need all they have of both, and must be always getting more; but in the rank and file of

smaller boats, they may have little opportunity of getting experience with many modern developments. Still, as Mr. Macfarlane Gray, lately Chief Examiner to the Board of Trade, whose recent death, last January, is felt as a personal sorrow by many marine engineers, pointed out years ago: "There is no trade which possesses so rich a literature as Engineering, and there is none which is so well adapted for explanation by books. It is therefore desirable that sea-going engineers should be guided into preparing themselves to be able to read and understand all that is so well written for them in connection with the management and improvement of the Steam-engine." Most sea-going engineers avail themselves of some of this literature, but unfortunately there is a good deal of pseudo-science and superficial statement in some of the handbooks prepared for "coaching" engineers: and the practical man often finds the facts of experience do not agree with the airy statements of the books, and so regards the latter as only an aid to get a "ticket," and of little or no value in real life.

The education and training of Engineers have caused and still cause much discussion amongst us, but much of it is beating the air, because there is little common agreement as to what an Engineer is. One party proposes to train boys to be Works Managers and Chief Draftsmen, another proposes only to improve the ability and intelligence of fitters and machinists; both ideals are worthy, but the higher education can only be given to a select few who have displayed natural talents and inclination for it. Opportunity should be given to boys to demonstate this inclination, and a career should always be open to talents, so that the clever workman may become, as he often did before technical education was consciously thought of, the real head of the firm. The first necessity for a boy is a good elementary education, which will prepare him to be able to read and understand all that is so

well written for him, and will widen his outlook and lead him to take less petty and selfish views of life; and next is the provision of free and handy technical libraries which will give the ambitious workman the experience of the past, and the explanation of the practice he sees followed in the workshop.

The examinations for Marine Engineers' Certificates have done much to spread technical education amongst mechanics; these examinations are held by practical men who prescribe no particular course of study, recommend no text-book, publish no authoritative answers to the elementary questions set forth in the examination syllabus, but insist on practical acquaintance with engines and boilers afloat and ashore; on a creditable knowledge of the prominent facts relating to combustion, heat, and steam; and on ability to apply the elementary arithmetic learned by candidates when they were boys at school, to concrete problems of every-day occurence amongst engineers. They let the candidates pick up the technical knowledge as they best can, expecting that they will get it from, or at least corrected by, their superior officers who already hold certificates. This course is not without disadvantages, but is infinitely preferable to the usual style of examination, where a man is examined as to his study of a particular text-book, rather than as to his particular knowledge of some subject or thing.

As the work to be done by Marine Engineers developed, and their responsibilities increased with the care of electric machinery, refrigerators, oil-motors, and the hundred other appointments that may be found in a modern steamer, so the Board of Trade widened out its syllabus to include these, and the Colonial Marine Authorities followed in due course, since the understanding that their certificates will be accepted throughout the Empire as equivalent to the Board of Trade's,

depends on them being kept up to the standard of the United Kingdom.

I think these Engineer Certificates form a subject worthy of consideration by an Association like this, especially when the Commonwealth Legislature proposes to alter or add to the system that has been so successful throughout the British Empire hitherto. The proposed Navigation Bill affects all users of machinery, because, as I pointed out, a Marine Certificate is much valued for land service. Our legislators are as a rule deficient in knowledge of technical matters, and apt to be much influenced by interested cliques, who put the real reasons for legislation, the safety of passengers and crews and the encouragement of the shipping trade, in a secondary place. There is no question of class legislation involved; the present regulations for admission to the examination favour everybody, and allow men who are not skilled engine-fitters, not even trained mechanics at all, to go to sea in a subordinate capacity as junior engineers, if their intelligence and ability commend them to their employers; and after putting in four years extra watch-keeping, in lieu of an apprenticeship (or one extra year may be accepted if he is a skilled mechanic whose workshop experience has not been "fitting" or "erecting," but in other service that might be useful training for an engineer, such as boiler-making or brass-finishing) he is qualified to sit for a second, and eventually for a first-class certificate. No one understands what the Draft Act proposes to do re workshop service, whether it will bang the door to promotion altogether on such smart donkeymen or greasers as might eventually make good engineers-in-charge, or whether it will do away with the necessity of apprenticeship to a mechanical trade, or its equivalent, extra watch-keeping in a sea-going steamer. Much of the ambiguity in the Draft Act is due to the use of the expression "third-class engineer," which, in New Zealand, from whence some of the Act seems

borrowed, means something quite different from what it does in New South Wales. The regulations for the examination of engineers are no doubt capable of improvement, the rule for instance, that has been in force since 1901, that sea-service must be with engines of at least 66 nominal horse-power, to qualify for second-class, may bear hardly on those otherwise competent engineers who are getting their training in our smaller coasters; but the rule always was that the service must be such as gives the experience to make a man thoroughly competent as a sea-going engineer, and even for a second-class he must be qualified by experience and knowledge to act as chief engineer in an under-powered steamer of 99 nominal horse-power on a voyage, say, from England to Egypt, taking full responsibility for engines and boilers.

In view of the multiplicity of land-enginedrivers' certificates, issued under the Mines, Factory, and Inspection of Machinery Acts of the various Australian States, I am surprised that it has never been proposed to issue land-engineers' certificates on the same lines as marine ones. I do not say that this would be advisable, I see great difficulty in holding an efficient examination which would be a test of a candidate's ability in so diverse a field. Some guarantee that none but competent men are employed as engine-man is very necessary; but I recommend to you, as a subject for discussion, Is it desirable that the men in charge of land engines, boilers, and power machinery, should be drawn, exclusively, from the possessors of Government Engine-drivers' Certificates; and are the examinations now prescribed certain to select the best men for the work?

In New South Wales the engine-men looking after our factory, electric lighting, pumping, and other engines, need no certificates, unless in connection with mining or building enterprises. The Mines Act of 1901 enacted that engine-

drivers at mines should hold certificates, so four distinct grades are now issued; and the Government Architect, under the Scaffolding and Lifts Act, issues certificates to drivers of builders' steam-cranes. In Victoria, Queensland, and other States, however, no engineer can take charge of any factory or other engine unless he has an engine-driver's certificate issued after an examination by a Board. Agricultural engines are excepted, although the Board of Trade returns of boiler explosions in Britain show that these small farm boilers are most dangerous, being often neglected.

The engine-drivers' examinations are mostly written ones, we would be better able to judge of their value if the Boards were to publish average samples of the answers received. The practical service rendered before coming up for examination is usually that of assisting an engine-driver for a stated period, even a skilled mechanic must show such service. Everything should really depend on a candidate's experience and practical ability; and though a journeyman mechanic is not necessarily a competent engineer-in-charge, he ought to be able to be examined for a certificate without first acting as a fireman or cleaner. Care should be taken that the examination is a real one, and does not consist in writing out stereotyped text-book answers to a few stock questions; and that it is easily accessible to every one possessing adequate and well-defined qualifications. Surely, also, some distinction should be made between the certificate required for an engineman working under a permanent engineer-in-charge of the works, and that for one who may have sole charge of engines and boilers, and be the only technical advisor usually consulted by his employer. We want, too, a definition of what "in charge of" may mean, or we may see one day the certificated engine-driver ordering his employer and superintending engineer off the premises, at least this is a possible contingency. One State makes it a condition of granting a first-

class engine-driver's certificate, that the applicant produces testimonials signed by his employer or engineer, and by a first-class certificated engine-driver by whom he has been taught; this last seems superfluous and ambiguous.

The rise of electric and oil motors threaten us with several new brands of certificated engine-driver. One State which already issues such for motor-boats, requires the applicant to satisfy the examiner as to his knowledge of engines in vessels propelled by gas, oil-fluid, electricity, or any mechanical power other than steam—rather a comprehensive order—but probably the examination and certificate are restricted to oil-motors only.

Thus while in the higher branches of our profession an engineer is supposed to know something of everything, from a portable electric fan to a 70,000 horse-power set of steam turbines—in the lower branches some Australian legislatures forbid the man who made a machine to operate it—and a man who holds a certificate enabling him to take charge of any engine afloat, to look after a five horse-power one ashore; unless, possibly, he goes through some unnecessary but tedious formality and pays a fee to a Board; while there are throughout the Commonwealth about as many different classes of engine-drivers' certificates issued as there are castes amongst the Hindoos.

Are all these restrictions, classifications, and monopolies, really in the interest of the public welfare? That the effects of the Acts under which these regulations are made are beneficial, no one can doubt; the inspection of machinery, mining equipment, and so on, made under them, keeps the conscience of the management from going to sleep, or getting dulled by short-sighted commercial influences, as it often did in the old "laisser faire" days; but is not much of the un-

doubted improvement in safety and efficiency due to the spread of technical information brought about by Associations like our own, and by the diffusion of up-to-date technical literature, so that no one need be ignorant of what is being done elsewhere, and of the high standard of security that may be attained by intelligent and conscientious management in such countries as Great Britain, where these low grades of certificates, which divert attention from those really responsible for efficiency of equipment, are unknown?