regret that I have not sufficient data to calculate the boiler efficiency, as it would have a very important bearing on the fact that the initial cost and upkeep of the Colonial boiler is much less than that of the ordinary marine boiler.

These examples are rough, it must be confessed, but I have always found them to work out in practice in such a way that they cover all sorts of working conditions and ensure good results. But coupled with these heating surface values, the question of design generally is another governing factor, as the design of Colonial boilers and how the different proportions should work out is seldom carefully gone into. Builders of boilers are apt to let the economy of plate influence their sizes, and so we get long barrel boilers filled with small tubes, all giving an enormous heating surface, and consequently a high calculated horse power, without taking into consideration the fact that with a smoky coal small tubes are quickly rendered ineffective, and the boiler would almost certainly have given a better result with less heating surface in the tubes, a 3½in. tube being a fair thing for ordinary work. Then again, as 6 feet bars are used for ordinary boilers, it follows that a 12 ft. x 5 ft. boiler would have, say, 30 ft. grate area, and a 10 ft. x 5 ft. would have the same, yet I doubt if the 12 ft. boiler would evaporate much more steam than the 10 ft., and personally I would favor the short tube boiler. I have compiled the following table from sizes collected from time to time, and a reference to that table will show that the average of all the boilers there shown is about 17 sq. ft. heating surfaces to 1 sq. ft. grate surface.

Length.	Diameter.	Tubes.	Heating Sur.	Grate Surf.	Ratio.
12′ 0″	5′ 0″	56—3″	621	30	1 : 20.7
12′ 0″	5′ 6″	48—4″	708	33	1 : 21,5
8′ 0″	3′ 6″	28—3″	221	21	1 : 10.5
12′ 0″	5′ 0″	42—4″	620	30	1 : 20.7
14′ 0″	5′ 6″	54—4″	911	33	1 : 27.5
8′ 0″	4′ 0″	36—3″	276	24	1 : 11.5
10′ 0″	4′ 6″	30—4″	384	27	1 : 14.2
10′ 0″	5′ 0″	42—4″	518	30	1 : 17.3
10′ 0″	4′ 6″	52—3″	477	27	1 : 17.6
10′ 0″	5′ 0″	50—3″	472	30	1 : 15.7
9′ 0″	4′ 0″	36—3″	310	24	1 : 12.9

As a basis for determining boiler values and comparing one against another, the efficiency is the standard method. This figure is not an easy one to determine, and to get the best result from any particular boiler a number of experiments require to be made, for the rate of evaporation at which the boiler is worked while being tested is the determining factor. The whole test is a carefully worked out set of figures, and is to a great extent out of reach of most engineers. Any new type of boiler is put through a test before it is placed in competition with those already on the world's market, but the ordinary every-day boiler is seldom made to show its points in this respect. Accordingly there are comparatively few tests of the Colonial type which can be taken as standard. Then again, most authorities on the subject never give any one type of boiler much preference over another. In referring to a list of over 300 tests he has made and collected, Donkin said "most types of boilers when cvarefully worked and evaporating about the same quantity of water per square foot heating surface per hour, will yield a high efficiency," and from these tests he deduces the fact that averaging up all classes of boiler, the efficiency falls as the evaporation increases, thus:—

Evaporation. lbs. per sq. ft.	Mean efficiency. per cent.
1.5	71%
3.0	66.5
5.0	65
7.0	64
9.0	63
.5	55

It will be seen that the figure of 5 lbs. is one I have put forward earlier in these notes, and it comes second on this list. One might well assume that this is the survival of the fittest, or, in other words, that this ratio of evaporation pays best. The size of boiler to do a given work at the rate of 1.5 would be very much in excess of the average boilermakers' sizes.

I would like here to put forward two tables from Bryan Donkin's book. They are practically the only tests I have come across of Colonial boilers, and tests comparing Colonial with other boilers. Members can study these for themselves and make their own deductions, but it will be seen that the Colonial boiler, under the guise of its American name, "Return smoke tube," is not very far down the list.

Tables 1 and 2

The question of boiler initial costs is one that sometimes governs our attitude in selecting any particular type, and for this purpose I take one or two actual examples, which will serve as a basis of argument.

A Cornish boiler 23 ft. long x 5 ft. 6 ins. diameter, 4 Galloway tubes, costs at present time in Sydney £412. The evaporation with wood fuel can be taken at 1320 lbs. per hour, and the boiler would weigh about 6 tons 5 cwt. A Colonial boiler 14 ft. x 5 ft. 6 ins. would cost £437, weigh about 8 tons, and evaporate with wood fuel 2880 lbs. water per hour. The same boiler to build into brickwork would cost £470, weigh 7 tons, and would evaporate 3000 lbs. water per hour with wood fuel. Adding costs of erection and setting, we can make up a table of comparative costs as follows:—

Type of Boiler.	Approx. Weight tns.	cwts.	qrs.	lbs.	Wood Fuel Evaporation Actual.	With Iron Chimney and brick setting Erected Cost
Cornish	6	5	0	0	1320	£570
Multitubular . .	7	0	0	0	3000	£565
Colonial	7	10	0	0	2880	£470

This makes a good showing for the Colonial type, and were cost the only consideration, it would carry the day

TABLE I.

11 EXPERIMENTS ON **RETURN SMOKE TUBE** TYPE OF BOILER WITH EXTERNAL FURNACE, HAND FIRING—BRICK SETTING.

BOILER EFFICIENCIES FROM 56½ to 81 PER CENT.

NO ECONOMISERS—CHIMNEY DRAUGHT.

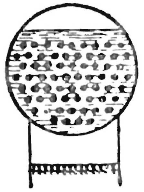
PARTICULARS OF BOILER TESTED.						**Efficiencies** or per cent. of Heat Value in Fuel utilised			Steam Pressure by Gauge and Steam Temperature F.	GASES.					WATER EVAPORATED			FUEL.				AIR.	Year of Test.	 RETURN LARGE SMOKE TUBES. CYLINDRICAL AMERICAN TYPE, STATIONARY BOILER. All Expts. on this page made in United States	Reference No. of Experiment.
Heating Surface Total.		General Dimensions.		Vacuum or Draught in Chimney in inches of Water	Area of Grate.					Temperature of Furnace Gases.		Analysis of Furnace Gases (at end of Boiler when not otherwise stated). Percentage by Volume.			Lbs. of Water Evaporated per Hour per Boiler from 212°.	Lbs. of Water per lb. of Fuel from and at 212° F.	Lbs. of Water Evaporated per sq. ft. Heating Surface per hour, Boiler only from 212°.	Name of Coal or Fuel. Coal when not noted.	Heating Value of Dry Coal or Fuel in T.U. per lb.	Ashes and Clinkers in Fuel, per cent. of Total Coal burnt.	Lbs. Fuel burnt per sq. ft. Grate per Hour	Excess of Air at End of Boiler in per cent. over that required for Combustion of Coal			
One Boiler only.	Economiser only.	Length.	Diameter.			**Boiler only.**	Economiser only.	**Total.**		At end of Boiler and difference above Steam Temp.	At end of Economiser	CO₂.	O.	CO.											
Sq. ft.	Sq. ft.	Ft.	Ft.	Ins.	Sq ft.	%	%	%	Lbs sq in.	F.°	F.°	%	%	%	Lbs.	Lbs.	Lbs.		T.U.	%	Lbs.	%		Authority, Reference, Experimenter, Locality, Remarks, &c	
939	0	24	5	0·6	58	**56·6**	0	56·6	98 336°	542° 336 206	0	5·4	9·8	0·43	6840	5·7	7·3	**Gillespie Small.**	9722	13·3	41⅓	250	1893	Bryan—St Louis—Dry steam. Much smoke—18—6″ smoke tubes. Ordinary grate, 6″ fires.	1
Do.	0	Do.	Do	0·8	53	**68·5**	0	68·5	99 337°	540° 337 203	0	7·6	9·5	0·14	7610	7·1	8·1	**Do.**	9976	14·3	41	155	Do.	Bryan—Efficiency higher, 56 to 68% 9″ fires—practically no smoke. Hawley down draught—2 grates—one above other.	2
329	0	20	3·8	0·4	38·6	**57·5**	0	57·5	74 319°	619° 319 300	0	Not taken.			2929	6·57	8·86	**Mount Olive.**	11,100	13	23	...	1895	Bryan—St Louis. Thomas smokeless furnace—8″ fires. Dry steam. 4—10″ smoke tubes.	3
728	0	18	4·5	0·4	25	**58·5**	0	58·5	73 318°	645° 318 327	0		Do.		4412	8·92	6·1	**Atlantic Main.**	14,700	7·5	20	...	1896	Whitham—Philadelphia—Quaker City. Ordinary grate—26—4½″ smoke tubes. 132 hours' test in both trials.	4
Do.	0	Do.	Do.	0·4	4·4 Two.	**70·0**	0	70·0	71 317°	524° 317 207	0		Do.		5420	10·97	7·5	**Do.**	15,125	5·7	11¼	...	Do.	Hawley down draught—2 grates—one above other. Efficiency improved from 58½ to 70.	5
1755	0	Not	given	0·25	36	**68·3**	0	68·3	148 365°	372° 365 7	0		Do.		3769	10·08	2·1	**George's Creek.**	14,240	8⅓	10	...	1894	Dean & Main—Boston. Lowell Water Wks.—Steam dry.	6
1112	0	...	...	Do.	21½	**72·0**	0	72·0	85 328°	389° 328 61	0		Do.		4994	10·71	4·5	**Cumberland Lump Coal.**	14,360	7·4	21·7	...	Do.	Do. do.	7
1692	0	20	6	1·0	64¼	**68·8**	0	68·8	95·5 335°	565° 335 230	0		Do.		10,697	7·8	6·2	**Mount Olive Lump.**	10,980	10·8	43·7	...	1895	Bryan—St Louis. 10″ fires—68—4″ smoke tubes.	8
Do.	0	Do.	Do.	1·1	Do	**76·4**	0	76·4	96 335°	439° 335 104	0		Do.		4876	8·6	2·9	**Do.**	10,965	6·5	18	...	Do.	Do. do. 2 Expts. on same boiler, difft. rates—both with Hawley down draught furnace. 7½″ fires—lower evap. of 3 lbs. giving higher efficiency.	9
877	0	16	6	0·14	36	**77·5**	0	77·5	69 335°	486° 335 151	0		Do.		1840	10·7	2·1	**New River and Cumberland.**	13,361	8	9·7	...	1892	Barrus—U. States—Lowell Pumps. Steam dry. 140—3″ smoke tube.	10
1260	0	16	5	0·4	20 22	**81·2**	0	81·2	108 343°	491° 343 148	0	10·6	10·0	0	4671	11·38	3·7	**Pocahontas Coal.**	13,553	6½	20 9	75	1897	Hale Report—Boston—Gases under boiler, through smoke tubes and over top—Hawley down draught—2 furnaces—upper grate water tubes—12″ fire upper grate, 9″ lower—dry steam. 91—3″ smoke tubes—Best efficiency this page.	11

TABLE II

SUMMARY OF 405 BOILER EFFICIENCIES FROM THE TABLES, ARRANGED IN ORDER OF MERIT FOR THE DIFFERENT TYPES OF STEAM BOILERS, AND AT VARIOUS RATES OF EVAPORATION PER SQ. FT. OF HEATING SURFACE PER HOUR.

With COLD Air Supply for Combustion, excluding Economisers.

	I.	II.	III.	IV.	V.	VI	VII	VIII	IX
TYPE OF BOILER.	Fires External or Internal.	Tubes.		Stoking.	Page in Tables.	No. of Experiments.	Mean Efficiency, two best Experiments on each Type.	Lowest Efficiency of each Type, one Experiment only.	**Mean Efficiency of all Experiments.**
		Water	Smoke.						
							%	%	%
Water tube,	Ext.	Small 1½″	None.	Hand.	107–111	6	84·1	66·6	**77·4**
Locomotive,	Int.	None.	Small.	Do.	75–83	37	83·3	53·7	**72·5**
Lancashire (2 flue),	Do.	Do.	Do	Do	59	10	74·4	65·6	**72·0**
Two storey,	Ext.	Do.	Do.	Do.	99	9	76·1	57·6	**70·3**
Two storey,	Int.	Do.	Do.	Hand and machine.	85–89	29	79·8	55·9	**69·2**
Dry back,	Do.	Do.	Do.	Hand.	65–71	24	75·7	64·7	**69·2**
Return smoke tube,	Ext.	Do.	Do.	Do.	91	11	81·2	56·6	**68·7**
Cornish.	Int.	Do.	None.	Do.	21–25	25	81·7	53·0	**68·0**
Cornish,	Do.	Do.	Small.	Do.	27	9	81·0	55·0	**67·7**
Wet back,	Do.	Do.	Do.	Do.	73	6	69·6	62·0	**66·0**
Elephant,	Ext.	Do.	Do.	Do.	97	7	70·8	58·9	**65·3**
Water tube,	Do.	Large 4″	None.	Do.	101–111	49	77·5	50·0	**64·9**
Lancashire (2 flue),	Int.	None.	Do.	Machine.	29–35	40	73·0	51·9	**64·2**
Cornish,	Ext.	Do.	Do.	Hand.	26	3	65·9	60·0	**62·7**
Lancashire (2 flue),	Int.	Do.	Do.	Do.	37–57	107	79·5	42·1	**62·4**
Dry back,	Do.	Do.	Small.	Do.	63	6	73·4	54·8	**61·0**
Lancashire (3 flue),	Do.	Do.	None.	Do.	61	6	66·7	52·0	**59·4**
Elephant,	Ext.	Do.	Do.	Hand and machine.	95	8	65·5	54·9	**58·5**
Lancashire (2 flue),	Do.	Do.	Do.	Hand.	93	8	74·3	45·9	**57·3**
Vertical,	Do.	With and	without.	Do.	113	5	76·5	44·2	**56 2**
						405			
With HOT Air Supply for Combustion.									
Dry back,	Int.	None.	Small.	Do.	71	3	77·2	75·6	**76·7**

every time, but the local conditions of running and the duty demanded qualify all this.

In considering these surrounding conditions, the first one to engage attention should be the water supply. So many country waters are so highly impregnated with mineral that we cannot afford to go on blindly and put in any boiler. It is well known that a Cornish boiler will work with worse water than a Colonial, but as Colonial boilers are worked everywhere, the matter of water must be got over somehow. Every engineer has his own ideas, all based on past experience, and the numerous expedients to neutralise bad feed might well be discussed here in a brief manner.

First, there is the simple method of setting the safety valve to 60 lbs. pressure, and using the blow down cock every day, the temperature of the water in the boiler being about 306° ensures a precipitation of the bulk of the mineral salts which are then blown in the form of sludge.

Second, the pre-heating of the water in, say, an open boiler, and the treatment of the feed with lime, or the fitting of a water softening plant.

Third, a method used largely in the country is to make an evaporative condenser with copper tubes, say, 2 ins. in diameter, and allow the water which is to be used as feed to run over these tubes. This has the effect of encrusting the tubes with the mineral salts; the water falling off being comparatively pure, is caught in a tank, and, together with the condensed water saved, used as feed. I have in mind one plant where the scale so deposited amounts to a couple of cwts. in a week's run. These condensers are never chipped; all that is needed is to shut off the water and allow the exhaust to heat up the tubes, then put on the excess of water, and the sudden contraction does the rest. It is necessary, of course, to construct the condenser to allow for this drastic treatment.

The use of zinc plates in Colonial boilers is a doubtful expedient in most instances. Unless corrosion is particularly in evidence, they should not be used. Several bad breakdowns have been traced to zincs secured to the stays, as the deposit of wasted zinc settles on the boiler bottom. They are, therefore, better left out if at all possible, or, if they must be used, then the zinc should be put in an iron box. This emphasises the fact that in an internal fire tube boiler, such as the Cornish or Lancashire boiler, the heating surface does not readily hold deposits, whereas in the Colonial boiler the concave surface is a ready means of collecting dirt and scale of all kinds, and in boilers using muddy water, great care has to be taken. I have been struck with the fact that boilers in the country are often run with feed water which no Sydney engineer would ever dream of using without a lot of filtration, and nothing seems to happen. I remember, however, once being inside a large Colonial type boiler which had a deposit of mud all over the bottom. If I remember aright, the mud was $\frac{1}{4}$ inch thick. I was interested enough to clean away all the landings internally, and found the plate nearly grooved through in several places. I am convinced this was due to mechanical action, the plates being overheated and rising and falling correspondingly with the working times of the boiler. I mention this, for very few boilers have such a good chance of even heating as the Colonial fire tube.

The other question is the fuel easiest obtained, and here the Colonial boiler, with its large grate, is a great temptation to heavy firing, resulting in a reduction of the boiler efficiency, and engineers are often placed in a dilemma in this respect. The good name of the boiler they have installed is dependent in almost every case on the man who fires it. If he is a fireman of the ''light and often'' type, then there is a good name for the boiler designer, and the coal bill is a fair thing for a given amount of work; but given the same boiler and a fireman whose creed is a heavy fire and long spells, then the anticipated results are not there, consequently engineers, knowing this eventuality, often are forced to fit large boilers with big grate areas just to get over this difficulty and to ensure that there will be satisfaction. The only way to make sure of a minimum size boiler is to use some method of mechanical stoking, and there are several boilers of the return multitubular type in Sydney fitted thus which give great satisfaction, and I firmly believe that more could be likewise treated with great advantage. This opens up a big question, and one that could not be properly dealt with in this paper, more especially as the matter is one which must include accellerated draft, some stokers being combined with that method of air supply to the furnaces.

The firing of boilers with wood fuel to a great extent makes a Colonial type of boiler almost a necessity. To see a fireman putting huge billets into a furnace is often a revelation as to what a boiler will stand; the fire doors are wide open, and kept open for long spells while the logs are put in, and if a log won't go completely in, then the door is left open a bit. The amount of cold air taken in is considerable, but the tube ends are a long way in, and are therefore well protected against this usage.

The question of mountings in boilers, especially of the Colonial type, does not receive the attention that it should. I have often been struck with the well-built boiler and the cheap light mountings supplied with it, or, rather, attempted to be supplied, for in these days were are all on the lookout for something that will stand up to its work. The main stop valve should not be anything but an outside bridge valve, and so constructed that the valve can be held fast when full open. A rattling valve is a terror to all who have to depend on it. Deep stuffing boxes are required, and if some of the better class valves now on the market can be fitted, so much the better.

An auxiliary stop valve to connect to feed arrangement should be supplied.

A safety valve, strongly made, of the lever pattern, should be provided, and all these fitted preferably on steam dome.

The feed valves are a matter of much discussion, and just what is best to supply is hard to state definitely, but some method of overhauling the non-return valve is desirable. The internal pipe should not be perforated where the water is mineralised, and should have a fall so as to drain the pipe. Many instances are on record of these pipes becoming a solid mass, and the feed being stopped altogether through the gradual deposit of scale in the internal feed pipe. The blow-off cock is especially interesting, as it is seldom tight if fitted in the usual pattern. The best place for it is on the boiler front, outside of all heating influences. Pipes in the back end have a very short life, and pipes through the top of the shell do not quite empty the boiler.

Water gauge mountings, test cocks, and gauges, should be of the best type. Asbestos packed cocks are not common, but if they can be fitted there is more satisfaction when the boiler has run a few years.

In conclusion, I would say that it has not been an easy matter to adhere strictly to dealing with the Colonial type boiler; one has a feeling that it is like one engineer telling another all about stripping a set of brasses—that is, there seems to be nothing in it to talk about, and I have felt like that in jotting down these notes, but nevertheless it is one of these simple things on which men never agree. Given one set of conditions, one man will advocate a Lancashire boiler, another a Watertube, another a Colonial. They will all be right probably in so far that perhaps one boiler is as good as another, but results all seem to show that our old friend, the Colonial boiler, is by no means the back number that some people think, and I have often wondered why Australia and America are the largest users of this type, and Britain and the Continent of other types. Is it just custom, or are there any real solid reasons?