

February 27, 1855.

JAMES SIMPSON, President,
in the Chair.

No. 921.—“On the Comparative Cost of Transit by Steam and Sailing Colliers, and on the Different Modes of Ballasting.”¹
By EDWARD ELLIS ALLEN, Assoc. Inst. C.E.²

THE object of the present Paper, is to bring before the Institution some account of screw colliers,—their economy, in comparison with the cost of sailing colliers,—the different modes of ballasting, as forming an important item in the working expenses,—proposals for their more extended use,—and some notes on the coal trade, especially that of London.

With respect to the construction of screw colliers, although much might be said, and much remains to be done, before strictly economical working can be attained, yet it has not been thought desirable to embrace that inquiry in the present Paper, except so far as it depends upon the various methods of ballasting.

There does not appear to be any difference of opinion, as to the desirableness of having screw colliers fully rigged, and with steam power sufficient, of itself, to propel them at the rate of 7 knots an hour: many of those at present working, attain, however, an average speed of between 8 and 10 knots per hour, and for particular stations, especially where the state of the tide has to be considered, there are many reasons for preferring a comparatively high speed.

COST OF TRANSIT.

In 1840, the average cargoes of sailing colliers were 220 tons, and about 700 ships were engaged in the London trade; ten years later, the average was raised to about 280 tons, and about 1,200 ships were constantly employed. The screw colliers hitherto employed in the London trade, generally carry from 400 to 650 tons, and the total quantity of coal, imported by them into London during 1853, was 70,403 tons, which, divided by the 123 voyages made by the 13 screw colliers working during that time, gives an average of 572 tons. This will be found to be about double the average brought by sailing vessels during the same period; the total quantity of 3,302,853 tons, divided by 11,988 voyages, giving an average of 275 tons.

¹ The discussion upon this Paper extended over portions of three evenings, but an abstract of the whole is given consecutively.

² The Author was elected an Associate Inst. C.E., May 1, 1855.

In 1854, a total quantity of 202,607 tons were brought to London by screw vessels, which, divided by 348 voyages made by the 36 vessels, gives an average cargo of 582 tons. Thus the quantity brought in 1854, was nearly three times that brought in 1853, and the average cargoes were increased 10 tons.

The next important point to that of the quantity carried, is the time occupied in each voyage, or in other words, the number of voyages made in the course of twelve months, both by screw colliers and sailing vessels.

It appears, from careful inquiry, that sailing colliers make, on the average, 10 voyages per annum between Newcastle and London; some of them performing no more than 8, but those of recent build and where dispatch is used, as many as 14. Experience has not yet determined the average number of voyages, which can be made by screw colliers; at least, it cannot be stated with so much certainty, as in the case of sailing vessels. A statement, drawn up and supplied by Mr. Scott, the Registrar of the Coal Exchange, of the whole number of voyages made by screw colliers, between Newcastle, Sunderland and London, during the year 1853, shows that the greatest number made by one vessel, was 20, and in another case, 21; but these two vessels cannot be said to have been in actual work, for more than eight months during the year. The first vessel made 15 voyages from January to June inclusive, and the second, 14, from July to December inclusive. These are the best results of 1853; all the other vessels having made much fewer voyages: some of them, however, were not confined to the London trade.

In 1854, the greatest number of voyages performed by any one vessel, was 33, the next, 31, and the third, 29; and these were the only vessels which appear to have been kept at work during the entire year. The quantities of coal brought by the three vessels, were 20,033 tons, 17,461 tons, and 18,407 tons, respectively. The additional vessels set to work during 1854, seem to have been of greater capacity and speed, than those working in 1853, as the average shortest voyage for all the vessels in 1854, was only 7 days; the average voyages made in the summer months, being $9\frac{1}{2}$ days, and in the winter months, 11 days: whereas in 1853, the average shortest voyage was 8 days, average summer voyages, 10 days, and winter voyages, 13 days.

These particulars justify the conclusion, that 30 voyages per annum may be calculated upon, by an ordinary screw collier, working between Newcastle and London; but although this number has been assumed as a fair average, from what has been hitherto done, there can be little doubt, that an average of 36 voyages may be attained, after more experience has been gained in working the vessels, and proper arrangements made for rapidly

discharging the cargoes, and speedily repairing any damage to machinery, &c., from collision, or otherwise.

The two important data for comparing the expenses of screw and sailing colliers, being thus obtained; and assuming an average cargo of 600 tons for screw vessels, and 300 tons for sailing vessels, with an average number of voyages per annum, of 30 and 10 respectively: it results, first, that screw vessels carry double the cargoes of sailing vessels; and secondly, that screw vessels can make three voyages to one, as compared with sailing vessels. One screw collier will thus do the work of six sailing vessels, and such may be fairly considered as the comparative capabilities of the two classes of vessels, at present employed in the trade.

Each steam collier, when completely fitted, and capable of carrying an average cargo of 600 tons, may be assumed to have cost about £10,000, although just at the present time, £12,000 would be the cost of such vessels. That of sailing colliers is much more difficult to fix, inasmuch as the greater number, are old vessels. There is one at present working, built in 1752, or 102 years old; another in 1772, or 82 years old, and many others of nearly equal antiquity; the average age being from 20 to 30 years. As there are always vessels in the market, quite good enough for colliers, that is, vessels of about 200 tons register, about 15 years old, either not classed, or having the black diphthong, which may be bought for £1,200, and even oak-built vessels, which can be obtained for about £1,800; the first cost of six sailing colliers, carrying 300 tons each, may be taken as about equal to one screw collier, carrying 600 tons. It is quite clear, that as good average vessels are always to be had, it would be unfair to compare a screw collier, with new sailing vessels, costing perhaps from £3,000 to £4,000 each. So that as regards first cost, little or no difference can be said to exist.

It is now necessary to consider the working cost, which, in sailing vessels, consists of several items, all of which taken together, except insurance, are reckoned by collier-owners to amount to about 75 per cent. of the average freight, or amount received for the cargo carried, which is from 8 to 9 shillings per ton.

Taking the gross average freights, for one year, as about equal to the first cost of the vessel; it will make no difference, if each of the elements of the working cost, is reckoned as a certain percentage of the freight; although wear and tear, depreciation, and insurance, are usually taken with reference to first cost. Insurance is, however, reckoned on a sum exceeding the first cost by from 15 to 20 per cent. Considering the working cost under the seven heads into which it is usually divided, the following percentages may be apportioned to each :—

Wages	32½ per cent.	} 75 per cent.
Stores	10 "	
Port charges, &c.	17½ "	
Ballasting	5 "	
Wear and tear	5 "	
Depreciation	5 "	} 25 per cent.
Insurance	12 "	
Profit	13 "	

It is stated by collier-owners, that the profit usually ranges from 10 to 13 per cent. : it, of course, diminishes when the freights fall much below the average, or the price of provisions, cordage, &c., rises. The rise or fall of wages, will also somewhat affect the profits, but not to so great an extent as might be supposed, inasmuch as they generally bear a certain proportion to the freights. The Sunderland collier-owners lately settled upon the following scale of wages :—

The freight being 6s., the wages to be £3 15s. per voyage.

" 8s.	" £4 15s.
" 10s.	" £5 15s.
" 12s.	" £6 15s.
" 14s.	" £7 15s.

being a rise of 5s. per voyage, for each 6d. of the freight.

The proportion that the working cost bears to the average freightage, being thus stated, there remains to be determined, what is the actual amount, for vessels carrying an average cargo of 300 tons. At the present high rates, this will be found to be about £1,070 per annum, thus divided :—

	£.
Wages	390
Stores and provisions	120
Port charges and discharging	210
Ballasting	60
Wear and tear (5 per cent. on £1,200)	60
Depreciation	60
Insurance (12 per cent on £1,400), say	170
	<hr/>
	£1,070

For six vessels, this will give £6,420, when making 10 voyages each per annum.

It should be stated, that it is not usual to insure a number of vessels, when belonging to the same owner ; it is not, however, considered safe to go uninsured, except a person possesses at least eight vessels. When vessels are insured in clubs, the insurance

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usually amounts to from 7 to 9 per cent., including all risks: against total loss only, 5 per cent. may be considered a fair allowance. Lloyd's Committee only allow 20 years as the probable life of an ordinary collier, and charge 12 per cent. for insurance, which includes the running-down clause.

The working cost of screw colliers, may be divided into the following heads, and the amounts set against them, apply simply to vessels carrying an average cargo of 600 tons, and working between Newcastle and London, or any similar station. They are the results of two years' trial only, and will, no doubt, be considerably reduced, when the trade by screw colliers, becomes more completely developed. They may be taken at the present cost, and show a fair average.

	£.
Wages (15 hands)	1,250
Stores and provisions	340
Port charges and discharging	720
Ballasting (wear and tear of bags)	90
Coals, 1,500 tons, at 6s.	450
Wear and tear, machinery, and vessel, 7 per cent.	700
Depreciation 5 per cent.	500
Insurance 10 per cent.	1,000
	<hr/>
	£5,050

With respect to these amounts, it will be seen, that the ballasting has been separately considered, as in the case of sailing vessels; the ballast, that is, the water, costing nothing, but the ballast arrangements being considered equivalent in cost to the sum stated. Wear and tear, and depreciation have been taken at 12 per cent. on the cost; this per centage is, however, considered by some authorities as too high, and it is stated, that these items on some colliers now building, will not be more than 6 per cent., the present cost being about £12,000. In the above account, the cost for ballasting cannot be considered as at all diminished, by the adoption of either a water-ballast hold, or water-ballast tanks, as allowance must be made for extra wear and tear, and depreciation.

The above statements give the working cost of both screw and sailing vessels, transporting the same quantity of coals, and supposed to be equal in their original cost; and the difference is probably less than is generally supposed. The above amounts differ by £1,370, which, divided by 18,000 tons, the total quantity of coals transported, gives as nearly as possible 1s. 6d. per ton, a saving of about 20 per cent. in favour of screw colliers.

The next important question to be examined is, whether the

cost of transit is ever much reduced below what has been stated, and what reduction may be reasonably considered possible, in a compendious general system of working.

The first consideration is, that of increasing the number of voyages per annum, which may be done without much augmenting the cost of working. This extension of the number of voyages has been already accomplished, in the case of a few sailing vessels, both from dispatch being used in the discharge of the cargoes, and also from having a better class of vessels. There is no great difficulty in accomplishing 12, or even 14 voyages per annum, with good sailing vessels, using due diligence, and provided with proper facilities; and there appears to be little doubt, that 34 or 38 voyages per annum, will be made by screw colliers, when more experience has been acquired. Probably about the same amount of care and dispatch would be required, to increase the number of voyages of sailing vessels, to 12 or 14 annually, as to augment the number by screw colliers, to 34 or 38 per annum; and on this account, the following Table gives the cost of transit per ton, both by sailing and by screw vessels, when making 10, 12, 14, and 30, 34, and 38 voyages per annum, respectively.

In the case of the six sailing vessels, the quantity of coals carried, would be increased from 18,000, to 21,600 and 25,200 tons per annum, and the working cost for each vessel, to about £65 per voyage; the cost of transit per ton, being reduced to 6*s.* 8*d.* and 6*s.* 4*d.*, respectively. In the case of screw colliers, the quantity of coals carried, would be increased to 20,400 and 22,800 tons, and the working cost, to about £53 per voyage; reducing the cost of transit to 5*s.* 2*d.* and 4*s.* 10*d.* per ton.

The effects of the above-mentioned different modes of estimating the cost of transit per ton, will be better understood by reference to the following Table, which gives,—first, the number of voyages per annum,—next, the tonnage carried in the year,—then, the gross working cost per annum, for the respective number of voyages,—and lastly, the rate per ton. The remarks show in what manner, and to what extent, the gross amounts of working cost are altered from the original statements, in consequence of the number of voyages being increased.

It must be understood, that the average number of voyages generally made, at the present time, is 10, for sailing, and 30, for screw vessels. Twelve voyages are made by few vessels, and 14, by only about 5 vessels out of 2,000 in the trade. The number of voyages exceeding 10, for sailing vessels, and 30, for screw vessels, show rather what may, and probably will be done, when competition shall become more severe.

Cost of Transit by Sailing Colliers, including all Expenses.

	Tons.	£.	s.	d.
Total expenses for 10 voyages, transporting 3,000 = 1,070 = 7 1 per ton. For details of expenses, see page 321.				
" " 12 " "	3,600	= 1,200	= 6	8 "
" " 14 " "	4,200	= 1,330	= 6	4 "

Add wages £78, port charges £40, ballasting £12 = £130.

Add same again.

Cost, exclusive of Wear and Tear, Depreciation, and Insurance.

	Tons.	£.	s.	d.	£.	s.	d.	£.	s.	d.
Total expenses for 10 voyages, transporting 3,000 = 780 = 5 2 per ton. Deduct 120 + 170 = 290 = 10 & 13 per ton, total 23.										
" " 12 " "	3,600	= 910	= 5	1 "	"	"	"	= 8	& 11	"
" " 14 " "	4,200	= 1,040	= 4	11 "	"	"	"	= 7	& 10	"

Cost of Transit by Screw Colliers, including all Expenses.

	Tons.	£.	s.	d.
Total expenses for 30 voyages, transporting 18,000 = 5,050 = 5 7 per ton. For details of expenses, see page 322.				
" " 34 " "	20,400	= 5,260	= 5	2 "
" " 38 " "	22,890	= 5,470	= 4	10 "

Add wages £40, stores £10, port charges £100, coals £60 = £210.

Add same again.

Cost, exclusive of Wear and Tear, Depreciation, and Insurance.

	Tons.	£.	s.	d.	£.	s.	d.	£.	s.	d.
Total expenses for 30 voyages, transporting 18,000 = 2,850 = 3 2 per ton. Deduct 1,200 + 1,000 = 2,200 = 16 & 13 per ton, total 29.										
" " 34 " "	20,400	= 3,060	= 3	0 "	"	"	"	= 14	& 12	"
" " 38 " "	22,800	= 3,270	= 2	10 "	"	"	"	= 13	& 11	"

Add wages £40, stores £10, port charges £100, coals £60 = £210.

Add same again.

Add same again.

In the preceding tabulated statement of the working cost of both sailing ships and screw vessels, it will be seen, that the vessels are supposed to be ballasted in the ordinary way; that is, sailing vessels, by sand-ballast; and screw vessels, by water-ballast. When, however, the system of water-ballasting is used in sailing vessels, a reduction is made in the cost of transit, equal on an average, to about 6 pence per ton, (being about 7 pence, 6 pence, and 5 pence per ton, according to the number of voyages, as will be afterwards shown); to this may be added an additional saving of 5 pence per ton, when the vessels are discharged by steam-cranes: (the usual cost being 4 pence per ton, whereas 9 pence has been allowed, as one of the port charges). The cost of transit by sailing vessels is thus reduced, under these circumstances, from the amounts given in the Table, to 6*s.* 1*d.*, 5*s.* 9*d.*, and 5*s.* 6*d.* respectively, all expenses included.

Against these additional savings in the case of sailing vessels, may be placed some of equal importance in screw vessels. In the first place, discharging by steam-cranes, or winches, which are now very generally used on board screw colliers, effects a saving of about 6 pence per ton. In the second place, 12 per cent. has been allowed in the Table, for the wear and tear, and depreciation on £10,000, and 10 per cent. on the same amount, for insurance. It has, however, been already stated, that for some vessels now building, the wear and tear, and depreciation will not exceed 6 per cent., the cost of the vessels being £12,000, and, in all probability, the insurance will be reduced to 8 per cent.; thus making a difference per annum, of £520, equal to 7 pence, 6 pence, and 5 pence per ton, according to the tonnage carried. These amounts, added respectively to the saving effected by the use of steam-cranes, will reduce the cost of transit as given in the Table, to 4*s.* 6*d.*, 4*s.* 1*d.*, and 3*s.* 11*d.* per ton, including all charges.

These figures do not, however, show the lowest amounts at which it is possible to transport coals, inasmuch as the insurance on sailing vessels has been reckoned at 12 per cent., whereas from 7 to 9 per cent. is found sufficient to cover losses, when the vessels are insured in clubs; a difference, on the average, of 4 per cent., equal to nearly 5 pence, 4 pence, and 3 pence per ton, according to the quantity carried, leaving, therefore, only 5*s.* 8*d.*, 5*s.* 5*d.*, and 5*s.* 3*d.* per ton, as the cost of transit. The insurance on screw vessels, in like manner, has been reckoned at 10 per cent. in the original estimate of working cost, whereas 7 per cent. is the ordinary charge for other sea-going steamers, and only 4 per cent. is allowed by the Peninsular and Oriental Steam Packet Company, as sufficient to cover sea risk. Again, the Royal Mail Steam Packet Company reserved only £25,000 in

1850, their capital expended being upwards of £692,000, equal only to about $3\frac{1}{2}$ per cent. It may be concluded, therefore, that any Steam Collier Company, reserving about one half of the amount of insurance above given, on the cost of their stock, would be able to make good all losses that might arise, and would thus reduce the cost of transit 7 pence, 6 pence, and 5 pence per ton, according to the number of voyages made, leaving the final amounts, 3s. 11d., 3s. 7d., and 3s. 6d. per ton.

It will be well now to compare the cost of transit per ton, both by sailing vessels and steamers, when worked under the various conditions above pointed out; but, for simplicity, this comparison will only be made, in the following Table, between sailing vessels, making 10, and screw vessels, 30 voyages per annum. The differences in cost of transit, arise from the various systems of insuring, ballasting, and discharging.

COST OF TRANSIT per TON, by SAILING VESSELS (10 Voyages).

Systems of Working.	1	2	3	4	5	6	7	8	Saving.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Insured at Lloyd's . . .	—	—	—	—	—	—	—	—	—
„ in Clubs . . .	..	..	..	..	—	—	—	—	0 5
Ballasted with Sand . . .	—	—	..	..	—	—	—	—	—
„ Water . . .	..	..	—	—	..	..	—	—	0 7
Discharged by Hand . . .	—	..	—	..	—	..	—	—	—
„ Steam . . .	..	—	..	—	..	—	..	—	0 5
Totals . . .	7 1	6 8	6 6	6 1	6 8	6 3	6 1	5 8	1 5

COST OF TRANSIT per TON, by SCREW STEAMERS (30 Voyages).

Systems of Working.	1	2	3	4	5	6	7	8	Saving.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Insured at Lloyd's . . .	—	—	—	—	—	—	—	—	—
„ by Reserved Fund . . .	..	..	..	..	—	—	—	—	0 7
Ballasted with Water . . .	—	—	..	..	—	—	—	—	—
„ but of im- proved construction. . . }	..	..	—	—	..	..	—	—	0 7
Discharged by Hand . . .	—	..	—	..	—	..	—	—	—
„ Steam . . .	..	—	..	—	..	—	..	—	0 6
Totals . . .	5 7	5 1	5 0	4 6	5 0	4 6	4 5	3 11	1 8

The majority of sailing vessels are usually worked on System 5, being insured in clubs, ballasted with sand, and discharged by whippers, at a cost of 6s. 8d. per ton; while steamers are generally insured at Lloyd's, use bag-ballast, and discharge their cargoes by steam-cranes, as in System 2, at a cost of 5s. 1d. per ton: the difference being, in round numbers, 1s. 6d. per ton, as before stated.

By combining these Tables with those previously given, in which the cost of transit varies, according to the number of voyages made in the year, almost every possible system is shown, under which a vessel can work; and it is believed, that examples of each are to be found.

COST OF TRANSIT per TON, by SAILING VESSELS.

Class.	Systems of Working.	1	2	3	4	5	6	7	8
		<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>
1	10 voyages .	7 1	6 8	6 6	6 1	6 8	6 3	6 1	5 8
2	12 „	6 8	6 3	6 2	5 9	6 4	5 11	5 10	5 5
3	14 „	6 4	5 11	5 11	5 6	6 1	5 8	5 8	5 3

COST OF TRANSIT per TON, by SCREW VESSELS.

Class.	Systems of Working.	1	2	3	4	5	6	7	8
		<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>	<i>s.</i> <i>d.</i>
1	30 voyages .	5 7	5 1	5 0	4 6	5 0	4 6	4 5	3 11
2	44 „	5 2	4 8	4 8	4 2	4 8	4 2	4 2	3 8
3	38 „	4 10	4 4	4 5	3 11	4 5	3 11	4 0	3 6

By these Tables it will be seen, that when every means of economy is employed, as in System 8, the difference in cost of transit amounts to 1*s.* 9*d.* per ton, though perhaps 1*s.* 6*d.* would represent, more correctly, the practical difference in favour of screw vessels, as compared with the majority of colliers now working.

There would be required for the London market alone, about 180 screw colliers in addition to those now at work, in order to keep up the present supply of coal; but when it is considered, that the first screw collier entered the Thames in September 1852, (little more than two years ago,) and that, notwithstanding all errors in construction, want of systematic working, and other drawbacks incidental to new undertakings, such an economy in the cost of transport has been already realized, the progress hitherto made, is most satisfactory, and it may be anticipated, that the trade by screw vessels will rapidly advance.

Notwithstanding the advantages thus possessed, by screw colliers over sailing vessels, there are, doubtless, many persons who, if desirous of investing a capital of, say £12,000, in either one kind of property or the other, would prefer doing so in the latter, for the following reasons:—First, eight vessels of average quality could be bought for the above sum, and the possession of eight vessels

would preclude the necessity of insuring either at Lloyd's, or even in a club, it being considered safe in such a case, merely to put aside a fund as a reserve; whereas with a single screw collier, an owner must insure at Lloyd's, and pay perhaps 10 per cent. on the first cost. Secondly, it would, doubtless, be less difficult to turn the sailing vessels to some other account, should freights considerably decline for the conveyance of coals, than it would be to find employment for a large steamer, except it could be chartered. Thirdly, unless the ship-owner were also a coal-merchant, there might be much difficulty in getting a speedy discharge of the cargo, which is an essential condition to the efficient working of screw colliers, and limits, to some extent, their employment; and even in the case of a ship-owner entering into a contract for a given quantity of coals, it would probably be necessary to deliver them gradually, say, a cargo, on the average, every four or five days, or as nearly as could be done; whereas it might be most inconvenient, or impossible, to receive and store 600 tons, in twenty-four hours. Fourthly, in the case of accident disabling one, or even two sailing vessels, it would only interrupt the delivery of the coals, whereas the disablement of a screw collier, would cause it to cease altogether.

The latter, it is true, would have an advantage in never being wind-bound, but it may be a question, where one screw vessel only is employed, whether a more regular delivery could not be better maintained, by a number of sailing vessels.

BALLASTING.

The ballasting of both screw and sailing vessels, must be considered under the different methods now employed,—

1st, sand-ballast; 2ndly, bag-water-ballast; 3rdly, bottom-water-ballast, or water contained between the floors, or in a double bottom formed for the purpose; 4thly, hold-water-ballast; and 5thly, tank-water-ballast, which consists of water contained in iron tanks fixed on the floors or ceiling of the vessel.

1. SAND-BALLAST.—The cost of the ordinary method of sand-ballasting, is wholly for material and the labour of loading and discharging it. That of the other methods depends on the arrangements necessary to contain the water, the labour being but very little, and performed by the ship's crew; allowance must be made, however, for wear and tear, and depreciation.

In ballasting vessels, it is usual to take on board, about one-sixth of the weight of the average cargoes carried. In screw colliers having bag-ballast, provision is made for about one-sixth of the greatest cargo carried, although it is not always all used.

The cost of sand-ballasting is usually taken at 3 shillings per

ton; this includes the ballast, loading, and discharging, together about 2s. 6d. per ton, and a delay of forty days during the year, equal to about 6 pence per ton.

2. BAG-WATER-BALLAST.—The introduction of this method is due to Dr. D. B. White, of Newcastle. In this plan, the bags are formed of strong canvas, rendered completely waterproof by a preparation of gutta-percha, naphtha, and coal tar. They are arranged on the floor of the vessel, as shown in Plate 4, and when filled, are secured from shifting their position.

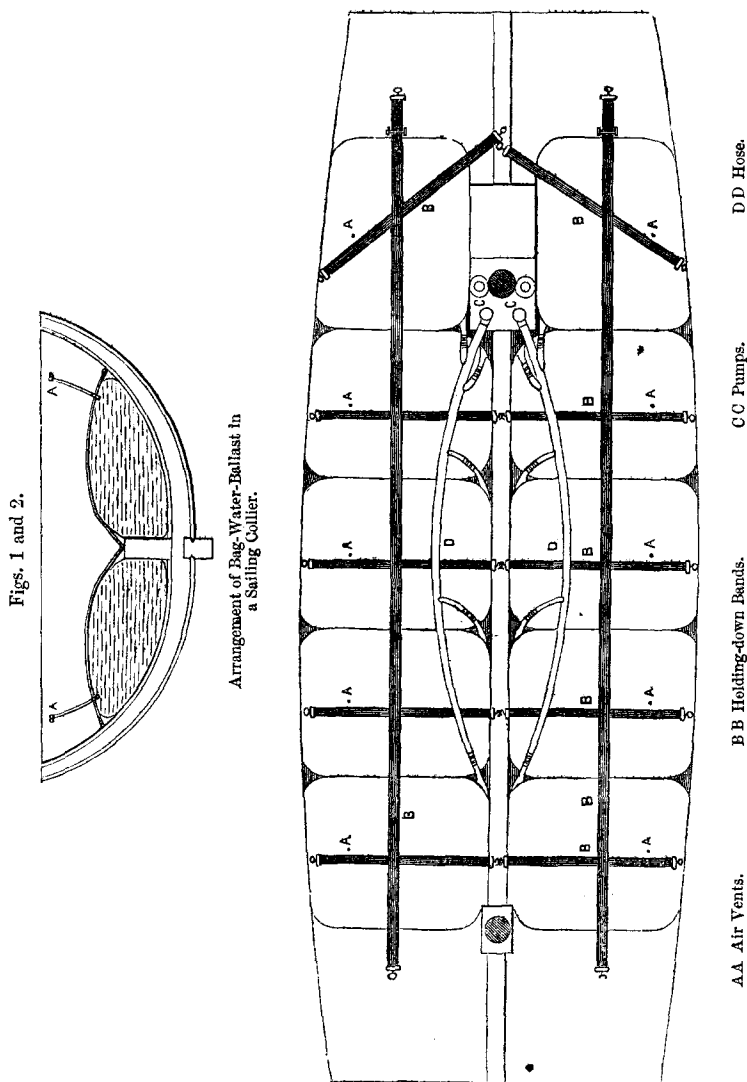
The bags were originally constructed of double canvas, but now, a single thickness is found to be sufficient. They are, however, enveloped in a canvas covering, to prevent injury to the bags themselves. The filling is accomplished by means of canvas hose pipes, from 3 to 5 inches diameter, connected with the bags by gutta-percha couplings: when not in use, the bags and hose lie flat, and are stowed one over the other. They are made to contain from 5 to 10 tons of water each, according to circumstances, and their weight is about 1 per cent. of the ballast they contain.¹

The only expenses of ballasting by this plan, are the first cost, and the wear and tear. The first cost is given by Dr. White, at from £2 to £3 per ton; but for the vessels here considered, requiring about 50 tons each, the first cost would be about £125, or 50 shillings per ton. Supposing the bags to last six years, the annual cost, including repairs, would be about £30. It must be recollected, however, that the economy of time would equal at least one voyage per year, or about forty days. By saving £30 per annum in ballasting, which, in the details of working cost, is put down at £60, and increasing the profits by an extra voyage, equal to £57, it may be considered, that £90 per annum is gained by the use of bag-water-ballast, or about 6 pence per ton. The first cost is thus saved in about a year and a half's working. The time the bags will last, varies, of course, with the care taken of them, but for sailing-vessels, six years would appear a fair allowance. For steamers, perhaps three years should be calculated upon; as although used three times, for once in sailing vessels, they are not subject to injury from lying long empty. The favour with which this plan has been viewed, may be judged of from the fact, of nearly 50 sailing and screw vessels having been fitted with bag-ballast, since the time of its introduction in 1851. The cost, where 100 tons are required, is now 45 shillings per ton.

The bags may be both filled and discharged while the vessel is

¹ Since the above was written, the former method of making the bags of double canvas cemented together has been re-adopted; the system of waterproofing being improved. The bags are now made without any canvas covering, and are thus capable, when not in use, of being rolled up, instead of being folded as formerly. The air vents and couplings are made of brass.

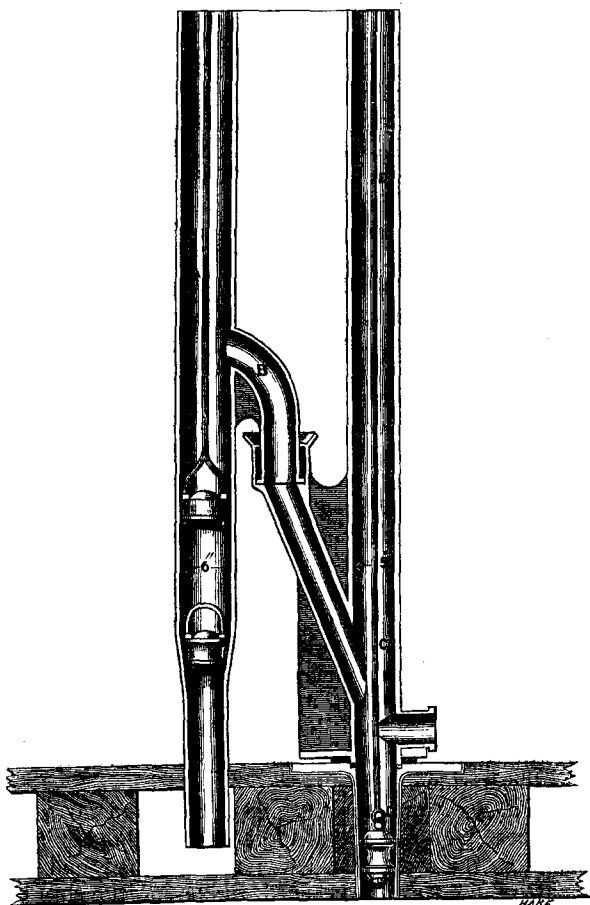
proceeding on her way, and so cause not an hour's delay. When they require to be emptied, the hose is unscrewed from the stop-cock attached to the ship's side, and the water is allowed to run into the bilge, or well, from which it is pumped by hand, or in the case of screw vessels, by the donkey-engine.



It is as well here to remark, that for facility of discharging

the water, the bags should always lie on an inclined floor, which, in sailing vessels, is usually, or always the case, but in steamers, where the floors are flat and the ceiling laid directly upon them, this has not been generally attended to; so that, unless the vessel is perfectly upright, the bags on one side do not empty themselves. This inconvenience may be overcome by having a second set of openings, on the side opposite to that to which the hoses are at-

Fig. 3.



Dr. White's Ballast-Pump.

tached, so that the water can be discharged on the lowest side of each set of bags. Should any case occur, in which, (with a vessel

quite light,) the level of the water outside the ship, should not be sufficiently high to fill the bags completely, the remaining quantity required must be pumped in.

A necessary precaution connected with the use of bag-ballast, is to secure them in their places, so as to prevent shifting, when the vessel rolls. This is done by bands fastened from side to side of the vessel, and when necessary, they are also secured by bands running fore and aft. Figs. 1 and 2 show the arrangement of bags and hoses, as also the bands for securing the bags, when fitted in a sailing collier.

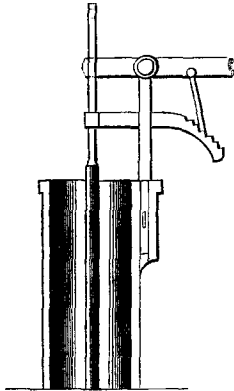
Another very important matter in the use of water-ballast, is the manner of discharging it from the bags. This subject has engaged Dr. White's attention, and the pump he has contrived, (Fig. 3,) perfectly answers the end in view, by discharging the ballast-water at the level of the water outside the vessel, and thus saving, on the average, about three-fifths of the labour. The pump **A**, which is of the ordinary kind, has an outlet **B** cast upon it near the lower end; this outlet communicates with a pipe **C**, which passes through the bottom of the vessel, and is carried up to the deck. A plug **D**, when raised by the rod **E**, opens the communication with the external water, and is worked from the deck: it is, when not in use, retained in its seat by the means shown in Fig. 4. When the plug is raised, the water in both the pump **A** and pipe **C**, is brought to the level of the water in which the vessel floats, and as soon as, by the action of the pump, the water is raised in the barrel **A**, it immediately runs away through the branch **B**, until the equilibrium is restored. The 50 tons required, on the average, for a vessel carrying 300 tons of coal, can be discharged in about one hour and a half, by means of two of Dr. White's pumps, 6 inches in diameter.

Figs. 5 and 6 show the most recent method of making the plug **D**, and the bucket of the pump. The washer, **C C** (Fig 5), and **A A** (Fig. 6), are made of vulcanized India-rubber, which has only been very recently introduced for this purpose: but from the experience already gained, it appears likely to wear well, and prevent the pump barrel from being destroyed by coal or grit in the bilge water. **B** is an iron nut, which, when screwed up, compresses the washers.

There are a great many advantages claimed in favour of bag-ballast and these pumps, such as the saving of labour by the use of the pumps, in the event of a leak; and if it is found desirable to throw part of the cargo overboard, lightening the ship immediately reduces the work on the pumps. Again, it appears by Dr. White's calculations on his own vessel, carrying only 13 keels, that the bag-ballast would prevent her sinking, as there is a buoyancy of 12 tons in favour of the vessel. With sand-

ballast, the specific gravity of which is from two and a half to three times that of water, the vessel could not float, if it became

Fig. 4.



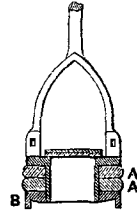
Arrangement for securing the Plug in place.

Fig. 5.

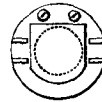


Sketch of Plug with India-rubber Washers at c c.

Fig. 6.



Improved Bucket with. Vulcanized India-rubber Packing AA, and Valve.* B nut screwed on.



* The India-rubber packing has only lately been used, but from the experience already gained it appears to answer much better than leather. The coal grit causes great wear in the pump-barrel when leather packing is used, and necessitates its being frequently rebored, which it is believed will be entirely remedied by the use of India-rubber.

water-logged. It is also stated, with considerable probability, that the bags, if filled with air, might float a vessel off a shore, or sustain her when foundering. The arrangements necessary for thus rendering them available in case of need, would neither be difficult nor expensive.

Before quitting this part of the subject, it will be well to direct attention to the plan of fitting wooden flaps, or shutters over the bags, so as to obviate the necessity of their removal. This plan, if properly carried out, would be a great improvement: it was roughly tried on board the 'Northumberland' screw collier, and would have answered, if the flaps had been well fitted. There would, doubtless, be much less wear and tear, and the space occupied would be inconsiderable, not more than 6 inches in depth.

3. BOTTOM-WATER-BALLAST.—This system, in which the water is contained in a double bottom of the vessel, formed for that purpose, possesses many advantages. The expenses are, first cost, wear and tear, and depreciation: the first cost, if the second bottom, or ceiling be formed of plate iron, say $\frac{1}{4}$ inch thick, is about £2 per ton, builders' measurement, which, for the vessels mentioned, would be on about 600 tons, and therefore amount

to £1,200; the wear and tear ought not much to exceed the 2 per cent. usually allowed on the hull, but it might be something more, as it becomes difficult to paint and clean the shell, or under side of the iron ceiling, which is covered with another of wood, well caulked. In screw steamers, therefore, something extra must be added to the fixed cost for ballasting, either for wear and tear, and renewal of bag-ballast, or for insurance, wear and tear, and depreciation of bottom-water-ballast. In some vessels which have been recently constructed, the mode adopted of building the double bottom complete in the first instance, and then raising the sides (Plate 4), seems to have reduced the cost, considerably below that above given, which refers to the cases where the second bottom was fixed, after the vessels were completed in the ordinary way, and which entailed considerable expense in rendering the second bottom water-tight.

These second bottoms or ceilings have been made entirely of wood, thus saving the whole cost of the iron; but owing to the difficulty of keeping the joints water-tight, this plan has been abandoned, and the vessels refitted with fore-and-aft tanks, as in the method of tank-ballasting.

An improved and more economical plan consists in placing the water-ballast between the floors, which, for that purpose, must have an intermediate depth of from $2\frac{1}{2}$ to 3 feet. A tank is formed under the forecastle, as also at the stern, as far forward as the end of the shaft tube (Plate 4), and these tanks, being in communication with the spaces between the floor, serve to keep them constantly full. The quantity of ballast is 160 tons, and the cost is stated to be about £2 per ton of ballast. When sufficient room can be thus obtained, the ballast does not encroach on the space for cargo.

4. HOLD-WATER-BALLAST. In this system, the water is contained in a separate hold, placed nearly in the centre of the vessel. This method was introduced by Mr. Scott Russell in the 'Pioneer' and 'Imperial,' and being considered satisfactory, has been adopted in two screw colliers now in course of construction. A plan of the arrangements is given in Plate 4. The hold, made to contain from 200 to 250 tons of water, is rendered nearly or quite water-tight, the bulkheads being strong and well secured to the ship's side by brackets. An iron deck is secured to the deck-beams, and the wooden deck carried over it. A comparatively small hatchway, $5\frac{1}{2}$ feet by 4 feet, is formed of iron, and has an iron cover fastened down by screw bolts, the joint being made good by a strip of vulcanized India-rubber. This water-hold, as it is usually termed, is used for cargo, when the vessel is laden. The water is run into it as high as possible, and the remainder pumped in, until it is quite full. Another

tank, formed under the forecastle, and containing about 35 tons, is sometimes used; the forecastle floor being of 3-inch plank well caulked, and fitted with an iron man-hole.

The manner in which the hold is fitted, and the iron deck above, add considerably to the strength of the vessel. The centre of gravity of the ballast, being much higher than in the double-bottom system, is said to render the vessels better sea-boats: this method also admits of carrying a greater quantity of ballast. The extra cost on a vessel fitted with a water-hold, is stated to be only from £300 to £400, say at most, £2 per ton of ballast.

Upon the whole, this method would appear to be the best, as also the cheapest, the interest on the extra first cost, with the wear and tear, and depreciation, probably not amounting to more than from £50 to £60 per annum, equal to about 4 shillings per ton on the whole quantity.

5. TANK-WATER-BALLAST.—The water, in this method of ballasting, is placed, by means of separate iron tanks, on the ceiling or floors of the vessel. They are arranged on each side, and across the fore end of the hold (Plate 4), and are usually made of plate-iron about $\frac{5}{16}$ th inch thick, and well stayed. The tops of those lately made, are inclined, so as to save the trouble of trimming the coals from off them, and a passage, 8 feet wide, is left between the two sets of tanks. They are constructed to correspond with the shape of the vessel, and contain about 60 tons of water, being kept full from a tank under the forecastle, which is made to hold about 45 tons. The fore-tank is shown, in this case, with an iron ceiling.

The cost of tank-ballast is stated to be about £4 per ton of ballast. These tanks are said not to occupy any of the cargo space, because there is usually room to spare in the hold, when the vessel is fully laden; but it is very evident, that space must be really lost by this arrangement.

In deciding between the relative advantages of the several ballasting plans just described, two of them may be at once set aside, as unquestionably inferior, viz., sand and tank-ballasting; the former being expensive and causing much loss of time; the latter being not only expensive, but causing loss of cargo space, if a great quantity is required. The choice thus lies between bag-ballast, bottom-ballast, and hold-water-ballast: the bag-ballast alone being suitable for wooden vessels, and also applicable to steamers whether of iron or wood; and the bottom-ballast and hold-ballast being suited only to iron vessels, whether sailing or steaming.

The first cost of these three methods of ballasting are so nearly equal, that a preference for either system must rest on their respective durability, or other qualities.

The bag-ballast can be speedily removed when required, is easily renewed, and when the bags are loose, does not affect the cargo room to any extent worth naming, as they are stowed away in a small compass. The bottom-water-ballast requires the floor to be from $2\frac{1}{2}$ to 3 feet deep, which, though not necessary so far as the strength of the vessel is concerned, is yet advantageous in adding to it. If the vessel so fitted, should afterwards be required to carry light cargo, the great depth of floor would lessen the cargo space; but this is not an objection with a cargo of coals. The hold-water-ballast certainly adds to the strength of the vessel, but divides the hold into many parts, and inconvenience is experienced in discharging through so small a hatchway. The wear and tear, and renewal of the bags, may be fairly put against the repairs to the double bottom. The water-hold is, of course, easily painted and kept in order.

For vessels already constructed, and requiring ballast, the bag-ballast is the most readily applied, and, as before stated, is the only system applicable to wooden vessels. In the case of steamers of iron or iron sailing vessels, the double bottom has many advantages; at the same time, if sufficient ballast cannot be contained in the depth of the floors, it might be desirable to partly employ bag-ballast; and this joint system, which increases the strength, without lessening the cargo space, has been adopted in one of the 'Union' Steam Collier Company's vessels.

EMPLOYMENT OF SCREW COLLIERIES FOR DISTANT COALING STATIONS.

The foregoing considerations, of the economy of screw colliers as compared with sailing vessels, and of the considerable saving of both time and expense, by the methods of ballasting recommended, induce the belief, that a more extended use of steam vessels as colliers, for long voyages, would be attended with the same beneficial results, which have followed their use, in the trade between Newcastle and London. For long sea voyages, there may, however, still exist some doubts as to their profitable employment. Without attempting to go so fully into the comparative working expenses of screw colliers and sailing vessels, when employed in transporting coals to such distant places as the Cape of Good Hope, or the Cape de Verde Islands, as of those employed in the coal trade at home, an endeavour will be made to show the price, at which coals could be delivered by screw vessels, regularly working between Wales and St. Vincent, one of the Cape de Verde's. The reason for selecting this station is, first, that many

vessels are now in the habit of coaling there, under most unfavourable circumstances ; and secondly, because the island of St. Vincent, from its position on the route to Australia and India, will, probably, at some time, become a very important coaling station, if arrangements are carried out, not only to facilitate the loading of vessels with coal, but also to keep a regular, constant, and reliable supply, for the use of steamers.

In considering these questions, it will be necessary to advert to a great commercial experiment, now about to be tried, by making a voyage between England and China and returning, without coaling. Assuming that a rate of 15 knots per hour is to be maintained, and that 10,000 or 12,000 tons of coals are to be shipped before starting, it is a most interesting and important matter to determine, whether coals, under all the circumstances, can be advantageously carried at 15 knots per hour ; and whether the capital, expended in the construction of that portion of the vessel, specially intended for the coals, could not be more economically laid out in the construction of several smaller vessels, in which coal and stores might be conveyed to convenient stations, where cranes, &c., could be erected to facilitate loading and discharging. The enterprising spirit, which has induced a Company to order the construction of a vessel of such unprecedented dimensions, can scarcely be sufficiently admired, nor can the result of the skill and ability, which have been brought to bear upon its construction, be doubted ; the only point to be considered is, whether the advantages of carrying so large a quantity of fuel, at the speed of 15 knots per hour, can be such as to justify the outlay and working cost.

At the present time, vessels carrying about 1,000 tons of coal as cargo, would be, perhaps, the largest that could be conveniently worked, out of either Newcastle, or the ports of South Wales ; and it will be, therefore, to vessels of this size, that the remarks must apply. The distance from Wales to St. Vincent (Cape de Verde), is about 2,400 miles, and the time such a vessel would take to perform the passage, may be put down at fourteen days each way ; say then, one month out and home, as the time actually under weigh. Six voyages per annum might be made, and the quantity of coal delivered, would, consequently, be 6,000 tons. If anthracite coal were used for the vessel's own use, 300 tons would take her out and home, being 1,800 tons per annum, even if she steamed throughout the voyage.

The cost of constructing such a vessel, with from 100 to 120 H. P., would be under £20,000, including a water-ballast chamber. The working cost, distributed among the following items, may be put down at £5,600 per annum, reckoning insurance at 7 per cent., and wear and tear, and depreciation at 6 per cent.

[1854-55. n.s.]

Z

	£.
Wages, including provisions	1,600
Stores	100
Port charges	300
Import duty, &c.	100
Coals, 1,800 tons, at 10s.	900
Wear and tear and depreciation, 6 per cent.	1,200
Insurance, 7 per cent.	1,400
	<hr/>
	£5,600

This amount, divided by the 6,000 tons, will give about 17s. 6*d.* per ton as the cost of freightage, if the vessel returns in ballast. There is, however, no difficulty in obtaining freight from St. Vincent, as various articles are exported in considerable quantities, say, however, one-third of a cargo at 15 shillings per ton, which will reduce the expense to about 12 shillings per ton. If this is added to the cost of coals at Newport, or Cardiff, say 8 shillings per ton, it gives about £1 as the cost price of coals at St. Vincent.

It would, however, be of little use establishing a line of screw colliers to St. Vincent, unless arrangements were made for quickly discharging and especially for loading them, which could only well be done, by erecting a proper storehouse, a landing-stage or jetty, and hydraulic cranes. These may be put down at about £7,000, for the quantity of coals already brought per annum to the island, for the use of steamers, which was, during the last year, about 8,000 tons, and in the same proportion, for the last nine months. The above sum would include the cost of store for 2,000 tons, a landing-stage, three hydraulic cranes complete, and trucks. Including wear and tear, depreciation, &c., this would give about 30 shillings per ton as the cost of coals delivered at St. Vincent, on board a steamer requiring them.

Upon these data may be shown, by way of example, the saving which would result from the establishment of a coaling station at St. Vincent, and also at the Cape of Good Hope, working the large steamer alluded to. It is stated, that she will carry 12,000 tons of coal, which, it is presumed, will take her to Calcutta and back; this quantity, however, being only equal to steaming at full power, for about two-thirds of the passage out and home.

Supposing the price of coals to be so high at Calcutta, as to render it desirable to take a sufficient quantity to work the vessel from the Cape to Calcutta and back, say 6,000 tons, and that she started from England with that quantity, it would then be necessary to ship 1,500 tons at St. Vincent and also at the Cape, both on the outward and homeward voyage, to make up the 12,000 tons. This arrangement would give 6,000 tons of cargo space,

which, at 120 shillings, equals £36,000. The cost of 12,000 tons of coal in England, at 15 shillings, would be £9,000, and against this, is to be placed, on the other plan of coaling,—

	£.
6,000 tons shipped in England, at 15s. =	4,500
3,000 „ at St. Vincent, at say 30s. =	4,500
3,000 „ at the Cape, at say 50s. =	7,500
	<hr/>
	£16,500
	<hr/>

If this amount is taken from the additional freight of £36,000, there remains £19,500, which, added to the above £9,000, gives a total gain of £28,500, without reckoning any of the extra space of 3,000 tons, which could be occupied by freight, on the homeward voyage. This saving is for one voyage, and if any return cargo was obtained to fill the extra space of 3,000 tons, might amount to £40,000, or for two and a half voyages per annum, to the sum of £100,000.

The price of coals at the Cape is assumed at 50 shillings per ton; the cost of transport being about 20 shillings per ton more than to St. Vincent.

It may be urged, that the additional 6,000 tons of cargo space would not be required; but in reply, it may be asked, why a vessel of 6,000 tons less burthen, would not have answered all the purposes, for which the present vessel is designed. The question of coaling must be considered, on account of its being the first vessel, in which it has been proposed to take sufficient coal for the entire voyage out and home, and the quantity required being so great, as to render it a matter of the utmost importance, to determine the most economical method of coaling.

With a large Company, the outlay required in order to establish coaling stations and steam colliers at one, or more places on the route, would be no difficult matter; the cost of one vessel, and the establishment at St. Vincent, not exceeding £30,000.

The quantities of coal exported from the United Kingdom to the Cape of Good Hope and St. Vincent, in 1852 and 1853, and during the first nine months of the present year, were as under:—

	1852. Tons.	1853. Tons.	9 months of 1854. Tons.
Cape of Good Hope . . .	25,804	31,281	about 5,000
St. Vincent (Cape de Verde)	3,961	8,004	„ 6,000

showing a great decrease, from some cause, in the quantity exported to the Cape during the present year, but a considerable increase, as respects St. Vincent, both this year and in 1853, over 1852.

In order that these remarks may not be confined to any one vessel, the case of the 'Cræsus' may be noticed, which left in January last, with about 1,000 tons of coal for her use out, and 400 tons of patent fuel for her homeward voyage. At her departure, it was stated, that she would save by this arrangement between £6 and £7 per ton, on the quantity taken out for the homeward voyage. This is certainly wrong, as nothing is said about the loss of cargo, the freight at that time being £6 per ton. There was, therefore, no gain in this case, that is, if cargo could have been obtained.

For the sake of simplifying the matter, suppose the 'Cræsus' required 1,000 tons out and 1,000 tons home, and that 250 tons were required to St. Vincent, and 250 more to the Cape; then the advantage of regularly coaling on the passages out and home, will appear as follows:—

On the present plan, she leaves			£.
Southampton, with, say,	1,500 tons at 15s.	1,125	
Coals shipped at St. Vincent	250 „ at 30s.	375	
Coals shipped at the Cape	250 „ at 50s.	625	
			<hr/>
			£2,125

This is giving all the advantages of a coaling station at each of the above places; otherwise, the expense must be increased about £500, making the cost of coaling £2,625.

On the proposed plan, the cost would be as follows:—

	Tons.	£.
Coals shipped at Southampton	500 at 15s. =	375
„ St. Vincent	250 at 30s. =	375
„ the Cape	250 at 50s. =	625
„ Australia	500 at 120s. =	3,000
„ the Cape	250 at 50s. =	625
„ St. Vincent	250 at 30s. =	375
		<hr/>
		£5,375
		<hr/>
The space for cargo would be increased 1,000 tons, as only 500 tons coals are supposed to be shipped at starting, instead of 1,500 tons, and this, at £6 per ton, would be		6,000
From which is to be taken, the difference of the cost of coals, on the two plans of coaling, viz., (5,375 less 2,625)		2,750
		<hr/>
		£3,250

leaving a balance on the voyage in favour of the proposed plan, of upwards of £3,000.

The calculations of the cost of coaling on the proposed plan, are based on the supposition of the coaling stations being properly established, in which case, the delay would not be very considerable, not exceeding a few hours at each place,—the additional coaling being only on the outward voyage, viz., at St. Vincent and the Cape.

There may be considerable difference of opinion as to the cost, at which goods can be transported by the Eastern Steam Navigation Company's vessel. But the question of cost in proportion to speed, with the same vessel, and on the same voyage, is not difficult to arrive at, and by well considering the matter, it will be found, that for a vessel of 5,000 tons displacement, making a voyage of about 3,000 miles, the cost of transit per ton, per voyage, would be about twenty times as great, if taken at 16 miles per hour, than if taken at 8 miles.

It may be said, that the greatly-increased size of the vessel will render it possible to convey cargo at 15 knots, as cheaply, or cheaper than an ordinary vessel can do at 7 knots; and therefore that the cost of coals taken to Australia in the Company's large vessel, will not exceed, or perhaps be less than that at which they would obtain them, by having coaling stations at the places proposed.

This, however, if true, is not to the purpose, for it does not answer the objections made to carrying coals at 15 knots per hour. It could only hold good in a particular instance, when cargo could not be obtained; but as a regular plan of working, it is obvious, that no reduction of cost of transit, could render it desirable to carry coals, instead of cargo, unless the freight be reduced to an exceedingly low amount. Supposing it to be as low as 15 shillings, then no good could arise from making room for cargo, having to buy coals at St. Vincent, at 30 shillings, instead of paying 15 shillings for them in England.

The following Table is calculated, on the supposition of 2,000 tons being required for a passage out and home, and, for simplicity, it is supposed, that one-fourth of that quantity is consumed from England to St. Vincent, and back, and one-fourth from St. Vincent to the Cape, and back, the remaining half being required from the Cape to Australia, and back. The cost at the various places is assumed to be, in England, 15 shillings; St. Vincent, 30 shillings; Cape of Good Hope, 50 shillings; and Australia, 100 shillings per ton: then the freight being at any amount, from 15 shillings to £6, the amount of profit is shown on the different plans of coaling.

Any quantity of coals shipped elsewhere than in England, allows of a like quantity of cargo being carried from England.

Where the word 'nothing' occurs in the Table, it means, that there is no profit, but it must be understood that there is no loss. The amounts above the words 'nothing,' show the loss which would result from coaling anywhere but in England.

The Cost of Shipping, in England, 2,000 Tons of Coal, at 15s. per Ton, would be £1,500.

TABLE.

Quantity of Coals shipped in . . }	Tons.		Tons.		Tons.		Tons.	
	London	1,750	London	1,500	London	1,000	London	500
	St. Vincent	250	St. Vincent	250	St. Vincent	500	St. Vincent	500
	—	—	Cape . .	250	Cape . .	500	Cape . .	500
	—	—	—	—	—	—	Australia .	500
Additional cargo . }	250 tons.		500 tons.		1,000 tons.		1,500 tons.	
	Profit.		Profit.		Profit.		Profit.	
Freight at	Profit.		Profit.		Profit.		Profit.	
	£.	s.	£.	s.	£.	s.	£.	s.
15	Nothing.		— 250	Loss.	— 500	Loss.	— 2,250	
20	62	10	— 125	Loss.	— 250	Loss.	— 1,875	
25	125	0	Nothing.		Nothing.		— 1,500	
30	187	10	125		250		— 1,125	Loss.
35	250	0	250		500		— 750	
40	312	10	375		750		— 375	
45	375	0	500		1,000		Nothing.	
50	437	10	625		1,250		375	
55	500	0	750		1,500		750	
60	562	10	875		1,750		1,125	
65	625	0	1,000		2,000		1,500	
70	687	10	1,125		2,250		1,875	
75	750	0	1,250		2,500		2,250	
80	812	10	1,375		2,750		2,625	
85	875	0	1,500		3,000		3,000	
90	937	10	1,625		3,250		3,375	
95	1,000	0	1,750		3,500		3,750	
100	1,062	10	1,875		3,750		4,125	
105	1,125	0	2,000		4,000		4,500	
110	1,187	10	2,125		4,250		4,875	
115	1,250	0	2,250		4,500		5,250	
120	1,312	10	2,375		4,750		5,625	

From this Table, it will be understood how important a saving to any Company it would be, to establish coaling stations at the most suitable places on their respective routes; taking care, of course, that such stations be well stocked with coal, and regularly supplied by screw colliers.

COAL TRADE.

It is necessary, in conclusion, to briefly consider the condition of the coal trade of Great Britain when compared with that of other countries; and more especially, the extent and surprising growth of that trade in London. This is done, not only to show the importance of the subjects considered, as tending to an

economical means of transport, but also to exhibit the field which lies open to manufacturers and others, engaged in the construction of screw colliers.

The following Tables give the area of the coal formation in the different countries of the world, as also the production in 1852.

TABLE OF AREA OF COAL FORMATION, IN SQUARE MILES.

United States	130,000
British North America	18,000
British Isles	12,000
Spain	4,000
France	2,000
Bohemia	1,000
Belgium	520

TABLE OF THE PRODUCTION IN 1852.

	Tons.
Great Britain	32,000,000
Belgium	5,500,000
France	4,150,000
United States	4,000,000
Prussia	3,500,000
Bohemia	700,000
Spain	500,000

The following Table is taken from a small work published in 1853, entitled, "Our Coal Fields and our Coal Pits."

TABLE of Comparative Production of Mineral Fuel.

Order in 1845.	Countries.	Square Miles of Coal Formation.	Tons of Fuel Raised in Year 1845.	Relative Parts of 1,000.
1	Great Britain	11,859	31,500,000	642
2	Belgium	518	4,960,077	101
3	United States	133,132	4,400,000	89
4	France	1,719	4,141,617	84
5	Russian States	Not defined.	3,500,000	70
6	Austrian States	Ditto.	659,340	14
	Totals . . . . .	..	49,161,034	1,000

The annual produce in Great Britain is now estimated at 35,000,000 tons,¹ and of this quantity, about 2,728,000 tons are exported; the remainder, 32,272,000 tons, being used for domestic and industrial purposes: the quantity exported is thus about 8 per cent. of the quantity raised.

¹ A recent Report, published since writing the above, gives the annual quantity of coal raised in England, at above 50 millions of tons.

The following Table gives the area of the Coal Fields of the United Kingdom, taken from the work above referred to.

ENGLAND AND WALES.

Districts.	Area in Square Miles.
1. Northumberland and Durham	840
2. Cumberland (West)	96
3. Yorkshire	964
4. Lancashire	308
5. Cheshire	90
6. North Wales	160
7. Shropshire	75
8. Staffordshire	302
9. Warwickshire	105
10. Forest of Dean	35
11. Gloucestershire and Somersetshire	48
12. Derbyshire (conjectured, 190,000 sq. acres ¹)	
13. South Wales	1,945
Total for England and Wales	4,968

SCOTLAND.

A great Coal field extends from Cupar and Dalkeith on the East, to Irvine and Ayr on the West coast, with interruptions	1,700
Total for Great Britain	6,668

IRELAND.

1. The Shannon coal field	1,408
2. Kilkenny (South)	126
3. Kilkenny (North)	205
4. Dundalk	49
5. Sligo	307
6. Dungannon	32
7. Ramoan	10
Total for Ireland	2,137
Grand Total for United Kingdom	8,805

The following statement gives the importations into the Port of London by sea, as also by railways and canals, during 1852, 1853, and 1854. These returns are published by Mr. J. R. Scott, of the Coal Exchange.

¹ As there is some doubt of Derbyshire, it is excluded from the total.

COALS IMPORTED INTO LONDON.

Years.	Coastwise.	Railway, Canal, and Road.	Totals.
1852	3,330,428	411,821	3,742,249
1853	3,373,256	653,729	4,026,985
Excess	42,828	241,908	284,736
Equal to	1.28%	58%	7.6%

Years.	Coastwise.	Railway, Canal, and Road.	Total.
1853 .	3,373,256	653,729	4,026,985
1854 .	3,399,561	979,170	4,378,731
Excess	26,305	325,441	351,746
Equal to	.78%	.50%	8.73%

The following Table gives the ports whence the coals were shipped, and the railways, by which they were brought into London in 1853, with the respective quantities.

COALS BROUGHT INTO LONDON, 1853.

Coastwise.

Ships.	Port.	Tons.
4,451	Newcastle . . .	1,411,207
2,016	Sunderland . . .	594,344
1,331	Seaham . . .	318,861
2,486	Hartlepool . . .	693,709
582	Stockton and Middlesboro'	133,271
325	Blyth . . .	65,737
78	Scotland . . .	13,611
335	Wales . . .	82,542
333	Yorkshire . . .	24,247
1	Liverpool . . .	130
124	Small coal . . .	31,778
<hr/>		<hr/>
12,062		3,369,437
2	Culm . . .	440
47	Cinders . . .	3,379
<hr/>		<hr/>
12,111		3,373,256

By Railway and Canal.

	Tons.	Tons.
Great Northern .	358,774	
North Western .	173,347	
Eastern Counties .	68,149	
Great Western .	16,590	
South Eastern .	12,852	
	<hr/>	629,712
Grand Junction Canal	21,602	
River Thames .	42	
	<hr/>	21,644
Total for 1853 .		<hr/> 4,024,612 <hr/>

The following Table gives the relative numbers of sailing and steam vessels, with the quantities of coal brought by each, in 1853.

		Tons.		Tons.
Sailing Ships	11,988	bring	3,302,853,	an average of 275
Screw Colliers	123	„	70,403	„ 572
Total .	<hr/> 12,111 <hr/>		<hr/> 3,373,256 <hr/>	<hr/> 278 <hr/>

The quantities by railway and canal, compared with that brought coastwise, in 1852 and 1853, give the following per-centages of the whole :—

	Coastwise.	Rail, Canal and Road.	Total.
1852	89 per cent.	11 per cent.	100
1853	84 „	16 „	100

which show the rapid advances made by railways, since the quantity brought coastwise in 1853, was only $1\frac{1}{4}$ per cent. over that brought in 1852, whereas the increase by railways amounted to 58 per cent. The increase of 1854 over 1853, was .78 per cent. coastwise, and 50 per cent. by railway.

The following are the charges now made on colliers, in the port of London :—

Light dues, on their registered tonnage,	
collected by Trinity House, which, on	
average-sized vessels, amount to .	1 <i>d.</i> per ton.
Tonnage Duty, collected by Custom House,	
(on all vessels above 40 tons register) .	$\frac{1}{2}$ <i>d.</i> „

Considering the registered tonnage equal to two-thirds of the tonnage carried, these charges amount together to about 1 penny per ton, on the cargo carried.

Those on the tonnage carried or metered, are,—

Whipping—(if employing the crew, or <i>bona fide</i> servants, exempt)	9 <i>d.</i> per ton.
Meterage—(optional)	2 <i>d.</i> „
Coal Duty—(within 20 miles)	1 <i>s.</i> 1 <i>d.</i> „
Lighterage below bridge	1 <i>s.</i> 0 <i>d.</i> „
„ above bridge	1 <i>s.</i> 6 <i>d.</i> to 1 <i>s.</i> 9 <i>d.</i> „

The light dues and tonnage duty, the whipping and half the meterage, fall on the shipowner, amounting in all to about 1 shilling per ton carried. The buyer pays half the meterage, and of course the lighterage. When a whole ship-load is sold, the buyer pays half the whipping in addition to the above, but, of course, buys the coals at a reduced rate. The coal duty of 1*s.* 1*d.* per ton, is paid by the seller of the coals.

Most of the important features of the coal trade of London have now been glanced at; and considering its vast extent, the importance of an economical means of transport cannot well be over-estimated. Regularity in the supply is also of considerable consequence, as it prevents those excessive rises in price, of which, last year, there was some experience, coals being sold retail at £3 3*s.* per ton. This was not owing to any deficiency in the quantity raised, but to the irregularity of supply.

The number of screw colliers at present working from different ports of England, may be taken at about 60, and considering the short time which has elapsed since their first introduction, the progress they have made, is very satisfactory.

There are also a considerable number building, both on the Thames and other places.

The one thing necessary, in order to render the working of screw colliers profitable, is that of giving them despatch. A cargo of 600 tons is frequently cleared in a single day, when the vessels are discharged by hydraulic wharf-cranes, or by steam-winchcs, fitted on board; the clearance is also very rapidly effected, when they discharge into railway trucks. Otherwise, the necessity of quick discharge, renders it imperative to have a large fleet of barges, or lighters ready to load, and thus, persons who have a good coal trade, are likely to profit most, in working screw colliers. It must be evident, that it would be suicidal to the system, for a screw collier to have to wait her turn, and so be delayed a week, or a month, as the case might be.

The foregoing considerations supply the following questions for discussion:—

- 1st. Whether the working cost of screw as compared with sailing colliers, really gives an advantage in favour of screw vessels, equal to that stated in the first section of the Paper?

2ndly. What is the best method of ballasting screw colliers, and whether the expenses of the different plans have been fairly estimated?

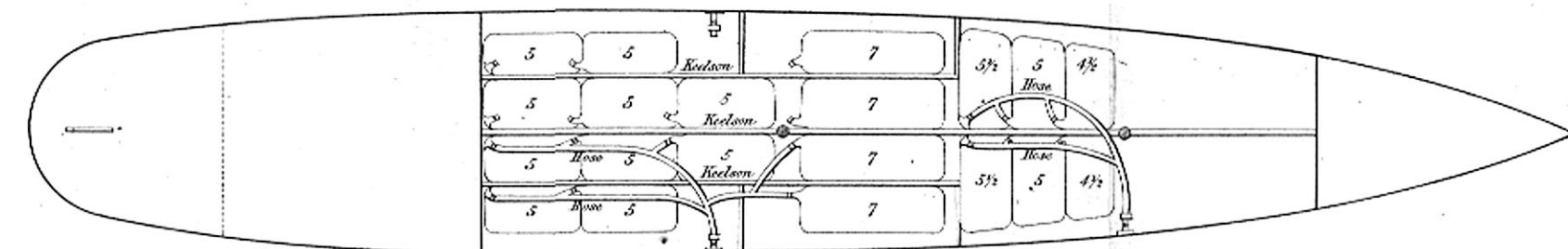
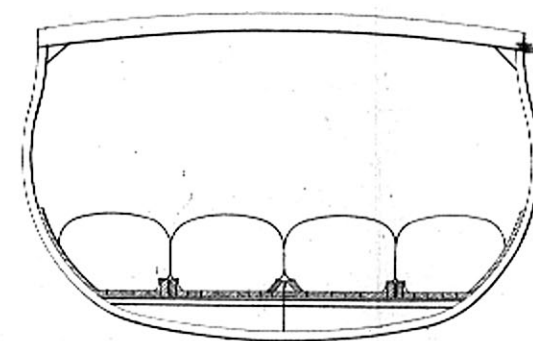
3rdly. Whether it is desirable to extend the use of screw colliers, in supplying distant coaling stations?

4thly. Whether proper coaling stations should be established for the coaling of steamers, in preference to constructing the vessels of sufficient size, to carry out the quantity required from England?

The Paper is illustrated by a series of models, maps, and drawings, showing the different methods of ballasting, from which Plate 4 and the woodcuts, Figs. 1 to 5, are compiled.

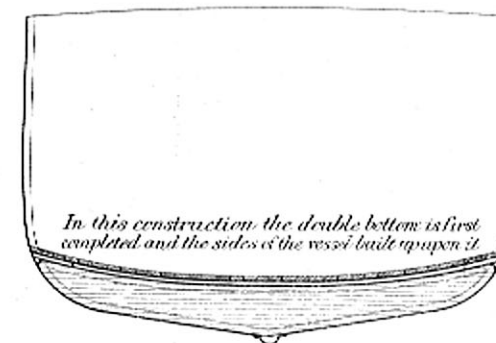
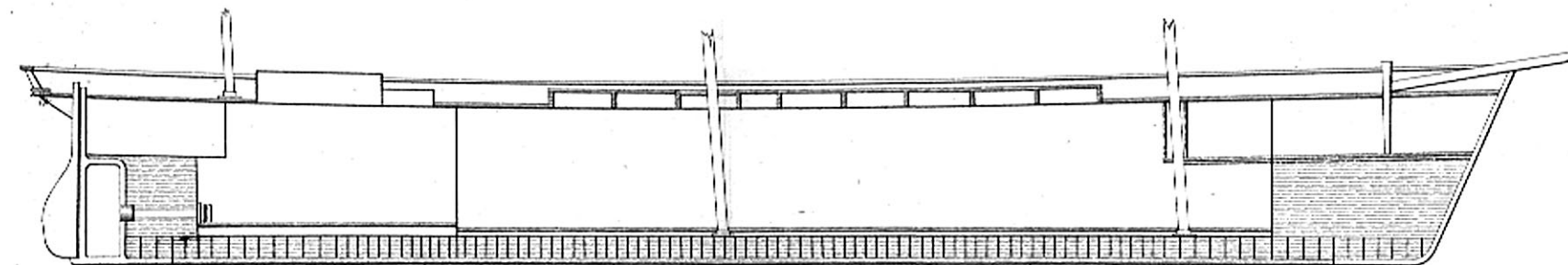
[Mr. FLETCHER

D^r D.B. WHITE'S
BAG WATER-BALLAST.
ARRANGEMENT OF BAGS IN "FALCON," "HAWK" & "EAGLE."
108 TONS.



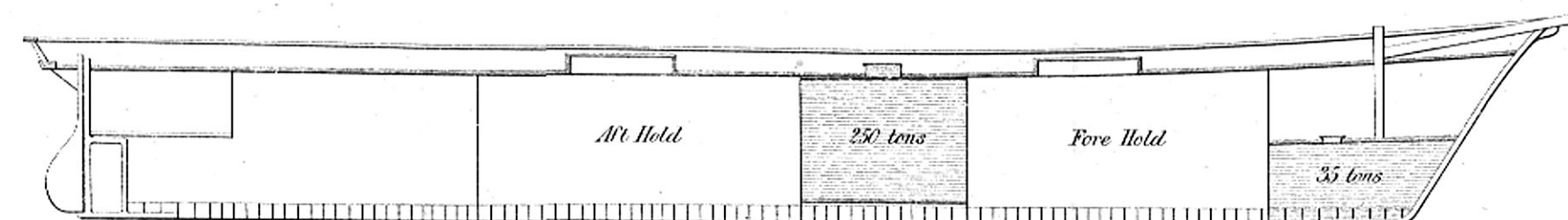
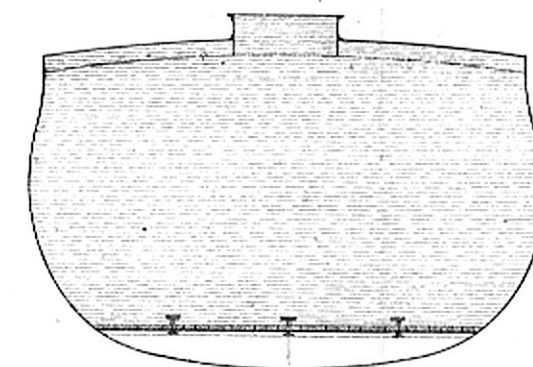
Note — The Numbers shew the tons of water in each bag

BOTTOM WATER-BALLAST.
ARRANGEMENT OF BALLAST IN "BLACK PRINCE," "FIRE FLY," "CHESTER" & "TYNE"
BY GRANTHAM & CROOME.
160 TONS.



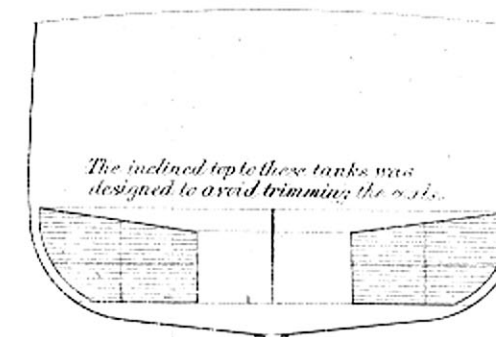
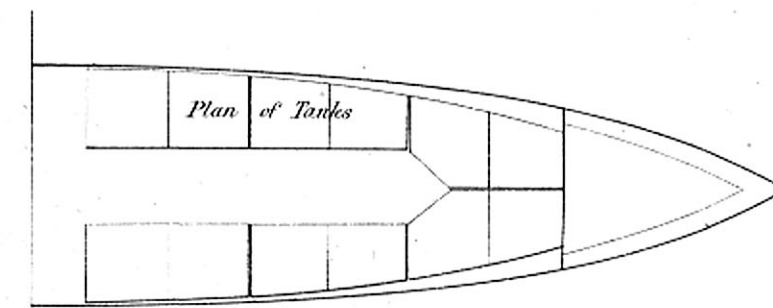
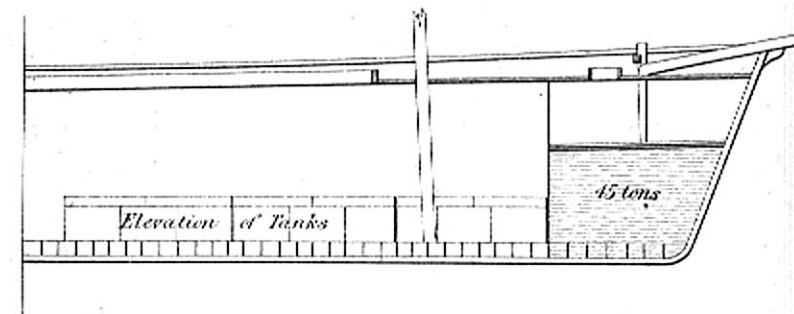
In this construction the double bottom is first completed and the sides of the vessel built upon it.

HOLD WATER-BALLAST.
ARRANGEMENT OF BALLAST BY J. SCOTT RUSSELL & CO
250 TONS.



Note — The Fore Tank is not used when the Hold Tank is filled

TANK WATER-BALLAST.
AMENDED ARRANGEMENT IN VESSELS OF GENL SCREW COLLIER CO
105 TONS.



The inclined top to these tanks was designed to avoid trimming the vessel.

SCALES
Longitudinal Sections & Plans — 20 feet — 1 inch
Cross Sections — 10 feet — 1 inch