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ANCHORS: OLD FORMS AND RECENT DEVELOPMENTS.

*By Captain ANTHONY S. THOMSON, C.B.,
Elder Brother of Trinity House, Commander R.N.R.*

Wednesday, 11th June, 1902.

Admiral Sir N. BOWDEN-SMITH, K.C.B., in the Chair.

THERE is little reliable information about the anchors used in ancient days. As much mystery and confusion seem to exist in regard to the anchors of old time as attach to the arrangements by which vessels were in former days propelled by oars, in tiers one above the other. The reason in either case is perhaps that the historians were but slightly acquainted with the technical details, and unable therefore to transmit clear and intelligible accounts. It may be also that vessels, in the very early days of navigation, were less dependent on anchors than was the case in later times, the general practice which then obtained being to beach their vessels when unable to moor to the shore. It is certain however that the anchors used by the Phœnicians were made of wood, weighted with stones and later on with lead. There is no record that the Egyptians used any form of hooked anchor. The invention of the anchor proper is ascribed by Pliny to the Tuscans, but still without a stock and having only one arm. The anchors used by the Normans even do not appear to have been furnished with stocks. Time need not be taken up in attempting to trace the evolution of the anchor from ancient days; it will suffice at the outset to indicate certain stages in development which appear likely to assist us when considering the functions of the different parts, and the value of recent modifications.

In the first place, then, it is interesting to note that the earliest iron anchors were without a stock and that they had only one arm or fluke.

They were in fact mooring anchors as we have them to-day, and for such purposes quite efficient. Anchors of this kind, however, must have been chiefly useful for mooring vessels to the shore or to banks which occasionally uncovered. To make such anchors automatic, so to speak, it was necessary to provide three or more arms; hence the grapnel, a very old form of anchor.

Grapnel.—Grapnels are ill-adapted for penetration into the ground, and are prone to roll over on hard bottoms, their holding power being always slight in comparison to weight.

Mushroom.—From the grapnel to the mushroom is only a step in development, though the latter type is of comparatively recent origin. The bad points of the grapnel are accentuated in the mushroom, yet to the credit of the mushroom must be placed two very good qualities. Owing to its large surface and concavity the mushroom head is able to arrest moving particles at the sea bottom, and so produce an accumulation of sand or gravel under which it lies deeply buried. This property, technically called "sanding up," is a valuable one, but it is not available in cases of temporary anchorage. Mushrooms are not trustworthy anchors on hard bottoms, nor indeed are they to be recommended anywhere unless there is a reasonable certainty of their being sanded up. Another good point for the mushroom consists in its immunity from fouling by the cable. For this reason it was formerly always used for lightship moorings, and it is still the best anchor for telegraph buoys in deep water. It may be of interest to state here that whenever overhand or figure-of-eight knots have been found in the cables of lightships, this curious state of things has always occurred when a mushroom has been in use, and it may be accounted for by the bight of the chain working its way under the rounded mushroom head.

Ordinary Stocked Anchor.—The ordinary two-fluked stocked anchor seems to have been gradually evolved under the stimulus of necessity, and was probably first brought into general use by the Dutch. The stock, or wooden portion, as the name implies, may have been at first a mere stick passed through a hole in the end of the shank, as is sometimes the case with small boat anchors at the present day. The stock was originally provided simply to cant the anchor and to compel the arms to take up a vertical position so that the lower one of the two would bite into the ground. Even in later days, when fitted to the largest anchors, stocks were always constructed and arranged with a view to lightness rather than for strength, and intended to cant and keep the arms up to their work rather than to increase the holding power.

The Anchor up to beginning of last century.—Ships' anchors in general use up to the commencement of the last century consisted of a long round

iron shank, having two comparatively short and nearly straight arms or flukes inclined to the shank at an angle of about 50° and meeting it in a somewhat sharp point at the crown. The stock was generally a little longer than the shank and in the large anchors consisted of two beams of oak placed side by side, the shank end passing between them. A space of from one to two inches was left between the beams to admit of tightening them on the shank by hoops of iron. The surface of stock next the ring was generally straight, but always tapered away on the other side, towards the ends. This tapering of the stock on the inner side must, I think, have been intended to lessen the risk of the hempen cable catching under one arm of the stock and causing the anchor to come up foul, although I have nowhere seen it so stated. In the earlier anchors, indeed, the arms of the stock were bent backwards so as to make obtuse angles with the shank. In addition to their proper function for canting the anchor, the bulky wooden stocks of former days also served to ensure the anchor sinking crown first. When let go with way on the vessel, the great resistance offered by the stock must have been conducive to the anchor taking up a proper position for biting even before it reached the bottom.

It is quite otherwise with iron stocks, which offer comparatively slight resistance in the water when sinking to the bottom. Indeed it often happens that the iron stock sinks end on and sticks upright in a stiff bottom while the arms lie prone and useless. In such cases the vessel rides to the stock alone, and if the pull on the cable be sufficient to bend or break the stock, serious risks result. This may be the reason for the practice which I am told obtains in Chinese junks, of lashing beams of wood along the iron stocks of their anchors. It may be of interest to note here that in some early wooden anchors the stock is depicted as being secured to the shank only a very short distance from the crown, and this is essentially the principle of the modern anchor, where the cross-head takes the place of the stock.

About the year 1800 the shanks of large anchors were of composite manufacture. Four square iron bars of large cross section were placed together for the centre, and then surrounded faggotwise with smaller rods, some 70 or 80 pieces in all. This bundle of iron was then hammered at welding heat into a more or less homogeneous state by a mass of iron weighing about 5 cwt., which was dropped on the weld from a height of nearly 10 feet. This form of hammer was called a Hercules. Anchors were expensive items in those days, a 90-cwt. anchor costing about £415. The dimensions of an 80-cwt. anchor about the year 1800 were roughly as follows:—Shank $19\frac{1}{2}$ feet, stock 21 feet, and 12 feet across from pea to pea. Such an anchor would have large broad palms occupying nearly half the length of the arm.

About the commencement of last century, a clerk in Plymouth naval yard, Pering by name, suggested and carried out certain improvements, the most important of which was making the arms curved instead of straight. At first sight this simple change may seem of little value; but consideration will show that this is not the case. The holding power of an anchor depends on two principal conditions, namely, the extent of useful holding surface, and the amount of vertical penetration. The latter quality is necessary on account of the nature of ordinary sea bottoms, the surface layers of which are generally less tenacious and resisting than is the ground a short distance below. Now the measure of penetration, and also, to a limited degree, that of useful holding surface, is the vertical distance from the lower portion of shank to the pea, or extreme end of the arm, when fully buried. This distance depends on the length and on the inclination of the arm to the shank. Some inclination the arm must have, in order to bring about penetration; yet the more at right angles to the shank, the greater the penetration. These two opposing conditions are reconciled by curving the arm to the arc of a circle having its centre in the shank. Two minor advantages also accrue. During the process of tripping or breaking out the anchor, the buried arm continues its curved path in the ground until the shank is nearly vertical, and the pea ready to emerge with the least possible resistance. The old-fashioned straight arm, on the other hand, continued to offer resistance in the ground until the leverage derived from the effective length of shank became very much reduced. Again, with straight arms there exists considerable resistance to penetration, because the entire anchor must move longitudinally before the arm can bury itself; but with curved arms, the weight alone of shank and upper arm suffices to bury the anchor, in soft bottoms, without longitudinal displacement. This last consideration, which has some bearing in the case of modern stockless anchors with two flat blades, will be again referred to when dealing with the Martin's type of anchor.

Subsequent Improvements.—In the year 1831, chain cables began to supersede the hempen ones, with the result that the long-shanked anchors hitherto in vogue were no longer necessary, and anchors with shorter shanks and with heavier and stronger crowns gradually came into use. In consequence of these changes, a Commission was appointed, in the year 1838, to enquire into the holding power of anchors, and a principal result of their labours was the adoption of the so-called Admiralty pattern anchor, which continued to be used in the Navy up to 1860. The invention of the steam hammer in 1842 made the forging of heavy masses of iron a comparatively easy and reliable process, so that from this time onwards the strength of anchors fully kept pace with that of the chain cables which had come into general use. A great number of

patents for anchors were taken out prior to the Great Exhibition of 1851, and public attention having been called to the models there shown, in the following year a committee was appointed by the Admiralty to report on the qualifications of anchors of the various kinds. Practical trials were then instituted, and as a result Trotman's anchor took the highest place out of eight competitors, Rodger's anchor being second on the list. Some of the tests to which the anchors were submitted were of doubtful value, such for instance, as "facility for sweeping." Nowadays, at all events for deep ships in shallow harbours, it is considered an advantage for an anchor to offer as little obstruction as possible above the ground. In this particular test, as also in some others of small importance, Trotman's anchor was handicapped as against those of ordinary form, yet it came out first, owing to its undoubted superiority in holding power.

We may now proceed to consider the structure and qualities of the two anchors last mentioned, which may be taken as types of the best stock dependent anchors. This phrase is used advisedly, so as to exclude for the present certain modern forms falling between the designations "stocked" and "stockless."

Rodger's Anchor.—Rodger's anchor, dating back to about 1830, is named after the designer, Captain Rodgers, R.N., who, for forty years or more, devoted much attention to the subject of anchors, taking out many patents. This anchor, which, in its present improved form, has been in use for many years, is generally acknowledged the best of ordinary shaped anchors. It is made of iron of square section, possessing great strength in shank and crown. The palms were at first made comparatively small to ensure good penetration, but nowadays they are made somewhat larger. Mr. Richard Green, of Blackwall fame, in giving evidence before a Select Committee in 1860, said, "he preferred Rodger's original anchor on the whole, because it had very small palms, the crown going right into the ground. They did not make such a large hole and disturb the ground so much as broad-palmed anchors." We see the importance which this gentleman attached to good penetration without undue disturbance of the ground.

Trotman's Anchor.—The anchor generally known as Trotman's is the first and best of the so-called "patent" anchors, *i.e.*, anchors which depart from the ordinary type. It is an improvement on the earlier Honiball, better known as Porter's. The original, under the designation of the "Tumbling Fluke Anchor," was the invention of Lieutenant Belcher, R.N., in 1818. The anchor is forged in two separate parts, the arms and the shank, and the two connected by means of a pin passing through a fork at the end of the shank into which the crown fits. The crown and arms pivot on this pin, so that, when the anchor bites, the

lower arm enters the ground, while the other arm bears against the upper side of the shank. In this way great penetration is obtained, with a corresponding increase of holding power. During the repeated trials to which this anchor was at first subjected, the only important defect noticed was failure at times to bite quickly; that is to say, when the lower arm became jammed between the ground and the shank, the anchor occasionally failed to open out and bite, or dragged some distance before doing so. This defect was subsequently remedied by John Trotman, Esq., who added supplementary canting palms, which caused the anchor to bite readily. These supplementary palms, however, are not unmixed blessings; they make fouling by the cable possible, while they tend to lessen penetration and to break up the ground; they also offer considerable resistance to quick tripping, as is shown by the results of the Admiralty trials in 1852, when for quick tripping a proportion of 7 was awarded to Porter's as against 3 to Trotman's, the average value for the eight competing anchors being about 6. The weak points of this otherwise excellent anchor are to be found, of course, in the pivot and forked shank, especially when used on hard or rocky bottoms; but I believe breakages due to failure of these portions have seldom occurred when the anchors have been properly looked after. Notwithstanding its good qualities, this type of anchor is becoming practically obsolete, owing principally to the altered conditions under which anchors have now to be used. With the advent of bluff-bowed, wall-sided vessels and straight stems, these anchors were found inconvenient to cat, the long open arm being likely to hook under or across the stem. They are also somewhat difficult to handle in case of coming up foul, owing to the tendency of the arms to cant over at awkward times, during the process of clearing the chain.

Martin's Anchor.—We now come to the type of anchor found more convenient for ordinary modern requirements, where the stock serves only as an auxiliary, or is altogether dispensed with. The first anchor of this kind, invented by a Frenchman named Martin, about the year 1865, was found to possess distinct and important advantages over most of its predecessors, and still retains a foremost position. It is interesting, however, to note, that from this time forward, owing to the rapid increase of steam propulsion, more and more importance was given to convenience of handling and stowage, qualities which are in evidence only when the anchor is idle, so to speak, rather than to good points afforded by the anchor when fulfilling its proper function of holding into the ground. Thus, the great feature of Martin's anchor is the small space it occupies when stowed; it is short, narrow, and lies flat. In common with Trotman's anchor, it is without a weld, being forged in two principal parts, but Martin's anchor has the greater strength in the crown. In

construction it is simplicity itself; a solid round bar having the palms already forged, and one arm bent to shape, is passed through a hole in the shank head, the straight arm being afterwards bent and forged to the required form. The short auxiliary stock is then fitted on the ring end of the square shank and keyed to its place. The stock, which is really unnecessary, this anchor being self-canting, is set on the shank edge up and bent away from the flukes on either side; it was probably intended as an addition to the useful holding surface, rather than as a stock proper, the function of which is to cant and keep the arms up to their work. The shape of the stock in Martin's anchor is similar to that of stocks in some of the oldest anchors, but the intention seems to have been to increase the leverage of the stock for keeping the shank down, and also to give better holding, rather than to facilitate the cable clearing itself, as we have suggested was the intention of the anchor-makers of old. As against great strength, close stowing and self-canting qualities, we must set a few faults, which, however, only in a very slight degree detracts from the great value of this well-known anchor. The most serious defects seem to be insufficient penetration, absence of vertical curvature in the arms, and a too general distribution of weight. The weight of an anchor should be concentrated as far as possible in the crown and arms, as provided for in Lloyd's Register's rules, which now require the heads of stockless anchors to be not less than three-fifths of the total weight. These anchors are also rather difficult to trip out of hard ground, owing to the long flat palms and small shank leverage. The form of stock too offers a certain resistance to biting, because, to obtain complete penetration, the anchor must move about half its own length, and this, the stock tends to prevent. On hard bottoms, therefore, there is a tendency to hold only by the tips of the palms and by the lower edge of the stock; and in soft bottoms, the anchor may break up the surface ground and drag, rather than penetrate to the harder layers below. Martin's anchors are generally used in the ships of the Royal Navy, where low flat stowage and economy of space are all-important; they are also very suitable for securing on inclined anchor beds, or for being stowed vertically against the ship's side as is now the ordinary practice in large war-vessels.

Since the above was written, I have received from Messrs. H. Charlton & Co., of Gateshead-on-Tyne, the following account of the Martin's anchors, which is so interesting and instructive that very little apology is needed for quoting it almost verbatim.

The first Martin's anchor was patented 6th May, 1864 (No. 1154), by Mr. François Martin, and it is of interest to note that it was provided with a centre trip, fixed securely to the arms, this would assist the palms in tripping promptly as well as holding more securely, a principle which

is now adopted in most patent anchors. There is no record of many of these anchors having been made, they would require rather more fitting up than was desirable, and possibly their cost was to some extent prohibitive; at any rate, we find that on the 21st October, 1864, Mr. F. Martin patented a second anchor (No. 2604), and in one opening paragraph of this patent specification Mr. Martin says: "Part of my present improvements are intended to simplify, and thus facilitate, the construction of such anchors, thereby reducing the cost of manufacture"; and from the tone of the following paragraphs we gather that his first designed anchor held so well that there had been difficulty in breaking it out of the ground, and that he now dispenses with the centre trip—which in later patents is again adopted—and substitutes the form of anchor shank so well known in Martin's patent self-canting anchors.

This anchor was adopted by the British Admiralty, and in 1865 H.M.S. "Vixen," "Viper," and "Favourite" were fitted with them, followed in later years by the "Industry," "Pallas," "Prince Albert," "Glatton," "Devastation," "Thunderer," "Hecate," "Gorgon," "Cyclops," "Hydra," "Rover," "Rupert," etc.

This patent was improved upon and a new patent secured for the same by Claud and Hyppolite Martin, dated 30th May, 1872 (No. 1632); this improvement being the adoption of a pin through the head of the shank, penetrating the arms, which had a corresponding slot of sufficient length to allow the arms to travel to their correct angle on either side of the shank. These anchors were fitted to H.M.S. "Colossus," "Edinburgh," etc., being extensively used in H.M. Navy as well as by most foreign Governments, shipowners, etc.

On 10th May, 1882, Mr. Claud Martin was granted another patent (No. 2197) on a further improvement in this anchor, when the centre trip was again resorted to as a means of assisting the palms in holding and biting quickly. This was accomplished in one design by fitting plates on either side of the head of the shank, blocks being fitted between them on either side. Mr. Martin died soon after, and this patent was improved upon and repatented by Mr. Barton—who had assisted Mr. Martin in his work—on the 7th December, 1883 (No. 5663), the shape of the side plates and blocks being improved, but the principle was the same as in Mr. Martin's last patent.

In 1885 a limited company was formed to work the Martin's patents, who adopted the style of the Improved Martin's Anchor Co., Ltd. Mr. Martin's older patents were known as Martin's Patent Self-canting Anchor, but the new form now introduced was called the Improved Martin's Patent Anchor, so as to distinguish it from the older patterns.

In 1885 also, the Admiralty carried out an exhaustive series of trials with anchors, and on this occasion the Improved Martin's Patent Anchor

gave excellent results, and was adopted by the Admiralty for their ships, many of the older Martin's self-canting anchors being converted into the newer form. These anchors were fitted to a great many of H.M. ships, amongst which, were H.M.S. "Royal Sovereign," "Hood," "Repulse," "Ramillies," "Resolution," "Revenge," "Blake," "Blenheim," "Pique," "Terpsichore," "Thetis," "Howe," "Collingwood," "St. George," etc., etc. They were also extensively used in many foreign Navies.

In 1893 the introduction of cast steel into the manufacture of anchors made it possible for the Martin's anchor to be still further improved and a patent (No. 5606) was granted to Mr. Henry Charlton for a new form of anchor head made of cast steel; the main features of the older patent were retained, but the manufacture was simplified so that an equally effective anchor was secured at a much cheaper rate. This anchor has also been fitted to a large number of H.M. ships including the new battle-ships "Duncan," "Cornwallis," "Exmouth," "Russell," "Leviathan," "Good Hope," "King Alfred," "Bedford," etc., etc. It is also extensively used in foreign Navies.

This anchor is known as the Improved Martin's Patent Anchor *Adelphi Pattern*, the words *Adelphi Pattern* being added to distinguish it from the former pattern.

Stockless Anchors.—Stockless anchors of modern type were first introduced about the year 1893, when cast steel began to be available for their manufacture. They are all modifications, more or less, of Martin's self-canting principle, though differing considerably in construction and detail. The shank, which is generally made light and taper, serves merely as a lever for tripping and for housing the anchor. The cross-head carrying the arms and canting pieces is a solid casting, so that these anchors consist practically of two principal parts. The shank is secured to the head in different ways according to the particular make of the anchor. Sometimes, as in the case of Byers' anchor, a long pin or bolt is employed going right through the head and riveted outside at the two ends. In other patents short pivot lugs are cast on the crown end of the shank, which is then entered through the crown from the back and the pivots secured in their place by keep bolts through the head. This is the method adopted in Hall's anchors. In the "Britannia" anchor the crown end of the shank is fastened to a ball which works in a ball socket in the head, the shank being entered from the back and kept in place by plate and cotter. In all cases the play or canting angle of shank is limited to about 90°, giving the blades an opening of 45° either way. The blades, which are necessarily straight in the vertical plane, generally project at right angles from the cross-head or parallel to the shank, but in some patterns they form a continuous curve in the plane of the cross-

head. Perhaps the most important differences in the various anchors are to be found in the means employed to ensure the arms canting downwards in order to bite when a pull is brought on the anchor. In some patterns the head almost approaches the mushroom form and so makes the addition of tripping pieces of minor importance; but in other cross-heads, designed to offer as little resistance as possible to penetration, large canting pieces or trips are provided. These are placed by some makers in the centre of the crown and by others at the outer ends of the cross head at the back of the arms. The latter principle seems the better of two, for when a central trip is employed there is a tendency for the anchor head to balance on it and roll, especially on hard ground. It is a pity that tripping pieces are necessary at all, because they tend to lessen penetration and do not always behave exactly as they ought in other ways. One of the causes of failure of stockless anchors to hold in certain bottoms may be traced to the tripping pieces. The tendency for a stockless anchor is to fall on the bottom with blades up, and supposing the head to sink at first deeply into soft ground, the effect of the trips may sometimes be to retain the blades in this useless position. Such, I believe, is the opinion of Mr. Lennox, of the well-known firm of Messrs. Brown and Lennox.

There are to-day many patented stockless anchors in more or less general use, each of which is supposed to possess its own special merits. The only one of which I have had practical experience is the Wasteney-Smith, one of the earliest cast-steel anchors. When in command of telegraph cable-ships I had opportunities for thoroughly testing this anchor, during a series of voyages commencing in 1884, with very good results, its performance comparing favourably with that of a Rodger's anchor of about equal weight. The anchor is, in my opinion, well designed, the arms and cross-head offering little resistance to penetration, while the horns, which serve as trips or canting pieces, are wide apart, so as to effectively steady the anchor and prevent rolling. The shank is connected to the head by a short strong pin, easily accessible. I am informed by the makers that upwards of 4,000 of these anchors are now in use, some up to 7 tons weight now being made for the Cunard liners and for mooring purposes in the Mersey. I was interested to find this anchor gave an excellent account of itself during the trials carried out by the Admiralty at Spithead, in March, 1900, with the object of testing the holding power and efficiency of stockless anchors. In these trials stockless anchors by different makers were separately let go from H.M.S. "Hero" in eight fathoms, mud bottom. Sixty fathoms of chain cable were veered away in each case, the ship's engines being then worked astern and power gradually increased to endeavour to break out or drag the anchors. Under these circumstances, one or two of the anchors

refused to budge, even when the engines worked at 80 revolutions, developing upwards of 3,000-H.P., the utmost available. These trials, though of a very thorough and practical nature, can scarcely be taken as conclusive for comparisons of the different anchors, yet they serve to prove the value and reliability of stockless anchors of approved construction. As a result of these and further trials, the Admiralty have adopted hawse-stowing anchors for some of their largest ships.

Hawse-Stowing Anchors.—For a long time stockless anchors were generally distrusted by seamen, and to this day the question of their holding power forms an ever-present subject of controversy. The fact that they are now usually supplied to new vessels is due, in a measure, to their undoubted merit; but also, in a much greater degree, to the modern hawse-stowing arrangement which the abolition of the stock has made possible. Indeed the advantages of being able to heave the anchor right up into a specially contrived hawse pipe are so manifest, that the adoption of this system has practically settled a vexed question, and has brought stockless anchors into general use much more quickly than would otherwise have been the case.

To Messrs. G. Tyzack, of South Shields, belongs the credit of having originated the hawse-stowing system. In the year 1884 a new steamship, the "Albano" of 3,300 tons dead weight, was fitted with one of their single-fluked anchors heaving up into a specially shaped wrought-iron hawse pipe. This anchor was practically the same as the single-fluked stocked anchor brought out by Messrs. Tyzack in 1877, but to enable it to stow in the hawse the stock was now shifted from the ring end of the shaft to the crown, passing through the forked shank and forming the pivot on which the single arm worked. In principle this anchor, suggesting a cross-bow in appearance, was thoroughly good, but the width of forked shank was inconvenient, necessitating a funnel-shaped hawse pipe of unusually large diameter at the lower end, up which the sea could rush with great violence. This is perhaps the reason the self-housing system was not very generally appreciated until the introduction of cast-steel anchors with light shanks which could be hove up into hawse pipes of ordinary form and diameter. Messrs. Tyzack have been kind enough to inform me that the first experiment of heaving the "Albano's" anchor up into the hawse pipe was conducted in Mr. Laing's graving-dock at Deptford, Sunderland, in February, 1884, in the presence of a large number of ship-builders, ship-owners, marine superintendents, and other interested persons. They also sent a copy of a certificate signed by the master of the "Albano," at the expiration of a voyage to Calcutta and other ports, in which he expresses entire satisfaction with the holding power and general working qualities of the anchor. The hawse-stowing system is now rapidly becoming universal,

and has been adopted not only for the largest battle-ships, but also in small sailing coasting vessels.

There is some question as to the best angle for the hawse pipes, to which Messrs. Byers, the well-known makers of the "Reliance" anchor, have drawn my attention. They are of opinion that the angle should be a certain compromise between what is good for the chain and what is most convenient for working the anchor. On thinking the matter over, I have come to the conclusion that the anchor is the chief thing to be studied, and that the practice in the Navy of making the pipe fairly steep is right. Certainly it would seem that the angle with the vertical should be always considerably less than 40° . Under ordinary circumstances the chain will hang between the pipe and the water at a much steeper angle, and even when the cable tautens out, the nip against the upper lip of the pipe will never be so serious as is the side nip when the vessel has a sheer or when she is riding ahead of her anchor.

Before leaving the hawse-stowing system, I must mention a practical difficulty of some importance which experience at the Admiralty Court has shown to exist in modern tramp steamers with stockless anchors. As a general rule such vessels are not now fitted with cranes or with any appliances for getting out or lifting in anchors over the bows. The result is that in case of breakdown or other mishap necessitating their being taken in tow, they are unable to use the hawse pipe for towing purposes unless they abandon an anchor and sometimes also a length of chain cable. Where anchor cranes are not provided, this difficulty would be best met by providing a third hawse pipe specially for towing and mooring purposes. For some years Messrs Byers have provided their anchors with one or with three heavy links between the anchor shackle and the end or bending shackle. This arrangement seems a very good one. It causes the bending shackle to enter and leave the hawse pipe on the same cant as the anchor shackle, thus avoiding the risk of the latter straining or opening out, the additional links also bringing the end shackle above and clear of the pipe, so that, if necessary, the anchor when stowed can be slipped without sacrificing chain. These anchor links have now to be proved to the breaking strain of the cable for which they are intended. Owing, presumably, to the difficulty anticipated in dealing with heavy anchors over the bows, when specially adapted gear is no longer provided, and in order to have a third anchor ready at all times, H.M.S. "Albemarle," of 15,000 tons, and other war-vessels now building, have two hawse pipes on the starboard bow and one on the port bow, for stockless anchors. Were we not assured that the matter must have been carefully considered, and that there is a good reason for it, this lop-sided arrangement would seem somewhat open to criticism, because a spare hawse pipe is at times very convenient for mooring and towing

purposes and also when clearing hawse. Sometimes when unmooring ship, both anchors come up together in a terrible jumble, and at such times the absence of the ordinary anchor davit and gear may be severely felt. The "Albemarle's" stockless anchors are of 115 cwt. each.

After all, in regard to anchors of whatever form or type, by far the most important considerations are weight and strength. We propose to deal with the latter quality first, as being the most easily dismissed.

Strength of Anchors.—A rough rule is that the safe working load of an anchor should about equal the resistance of the ship at a speed through the water of 12 knots. In order that we may put this to a practical test, H.M.S. "Greyhound," of 1,157 tons displacement, required a pull of 9 tons to tow her at the speed mentioned. The testing or proof strain is generally taken at twice the working load, and the breaking strain at about six times. The anchor of such a vessel as the "Greyhound," therefore, should be proved to about 18 tons, and should presumably withstand a strain of nearly 54 tons. According to Lloyd's Register Rules, the proof strain for the anchor of a merchant steamship of similar tonnage should be 23 tons, and the breaking strain of her chain cables about 61 tons. Since the above was written, Mr. R. Denny, of the firm of Denny Brothers, Dumbarton, has most kindly furnished me with a schedule of some 30 vessels of various types, giving the weight of best bower anchor and safe working load by Lloyd's test, also the block co-efficients of the vessels at load draught, and their calculated resistance at 12 knots. From this table it appears that the rough rule referred to is approximately correct only in the case of full-built ships whose block co-efficients are between .75 and .80. In almost every case the proof strain is in excess of the resistance at 12 knots; indeed in the case of yachts and very fine vessels the resistance at 12 knots is only about half the strain to which the anchors are proved. Most stockless anchors have an advantage in strength over anchors of ordinary form, very rarely breaking under steady strain and fair conditions.

Weight of Anchors.—In the days of wooden vessels the rough rule was 1 cwt. for every 20 tons of a merchant-ship's burthen, and in the Royal Navy 1 cwt. to every gun. Up to the beginning of the seventeenth century the largest anchors in use must have been very light, for we read in "Derrick's Memoirs of the Royal Navy" that the capstan for weighing anchors was first invented in 1610. In 1637, however, the "Sovereign of the Seas," a vessel of over 1,600 tons burthen, carried eleven anchors of about 2 tons each. From information kindly afforded by the builders, I am able to say that the "Celtic," the largest vessel now afloat, is supplied with three Hall's hawse-stowing bowers, each weighing $7\frac{3}{4}$ tons. It appears that in 1859 the "Great Eastern" was exclusively supplied with Trotman's anchors not much exceeding 5 tons in weight, exclusive of

stock. It was, of course, claimed for Trotman's anchors that a saving of weight might be effected without sacrifice of holding power; but this is scarcely consistent with modern views, weight and strength being practically synonymous. Before the advent of steam, the labour of raising and securing heavy anchors was great; lighter anchors, therefore, were used on ordinary occasions, the heavier anchors being reserved for use during bad weather and in exceptional circumstances. Anchors of varying weight and size were known as "bowers," "best bowers," and "sheet anchors"; although it seems that about the year 1800 "bower" and "sheet" anchor were interchangeable terms. Nowadays the working or bower anchors are generally the heaviest carried, yet there is reason to suppose they are in many instances too light to ensure safety at critical times. This is perhaps a natural outcome of steam propulsion, a steamship being much less dependent on her anchors for safety than a sailing vessel. For instance, in 1858 Lloyd's advised 54-cwt. anchors for 2,000-ton vessels, but in 1894 this weight sufficed for steamships of 6,000 tons under the Underwriters' Registry. In the Navy 5-ton bowers were supplied to all vessels over 3,500 tons displacement, yet to-day a merchant-vessel displacing 10,000 tons may have anchors of under 3 tons weight. It is true the largest men-of-war until quite recently carried nothing heavier than 5 tons; and the difference in the conditions affecting the two Services must be taken into consideration. While the tendency of modern practice is in the direction of lighter anchors of improved construction, with chain cables the tendency is rather the other way. Whether it be that experience has shown chain cables to be less trustworthy than they were formerly considered, or whether a heavier is required to supplement the lighter anchor, certainly the cables are heavier in proportion to size of vessel than they used to be. The "Great Eastern," for instance, with her 5-ton Trotman anchors, ex-stock, equivalent perhaps in holding power to 7-ton stockless of the present day, had only $2\frac{1}{2}$ chain; whilst under Lloyd's Register Rules the size of chain corresponding to 7-ton anchors is $3\frac{5}{8}$. The "Celtic" can certainly be no heavier on her anchors than was the "Great Eastern," yet the former vessel's cables are $3\frac{3}{8}$ inch. However desirable increase of weight may be for chain cables, it is, in the writer's opinion, still more important in the case of anchors. Under ordinary circumstances, it is true, a long length of heavy chain cable will almost hold the ship of itself, and in deep water the catenary of a heavy chain acts very beneficially in preventing jerking or irregular strains which might affect the hold of the anchor. It is, however, under extraordinary conditions that real danger of dragging the anchor arises; times during which vessels will tauten out their cables like bars, especially in shallow water. Then it is that all depends upon

the anchor; if it will not hold, of what avail the weight and strength of the cable?

Tramp Steamers in Ballast Dragging their Anchors.—I remember some few years ago, a large tramp steamer, flying light, coming into Portland, during a moderate gale from W.N.W. She let go two anchors, and paid out apparently plenty of cable, yet during the night she dragged and sheered all about the harbour, and in the morning collided with the vessel in which I was then serving. We were lying to a single anchor and 45 fathoms of cable quite comfortably. This tramp carried her hawse pipes close up to the level of the forecastle, and consequently showed a long length of taut cable above and out of the water. The impression this produced was an unfavourable one; yet it is difficult to see what bad results can be directly traceable to the hawse pipes being so far above the water—a moral, applicable to vessels in light trim, we may certainly deduce. It is, that in such cases, the old rule applicable in light weather, to pay out chain equal to at least three times the depth of water, requires modification. It should be three times the distance from hawse to bottom. Thus for a vessel, such as the one described, having her hawse 30 feet above the water, anchoring in 7 fathoms, the minimum scope of chain should be three times $7 + 5$, or 36 fathoms, rather than 21 fathoms. The ship I have referred to afterwards put into Plymouth, again taking charge of the harbour and doing further damage to other vessels. Similar instances must be familiar to many of those present, and they naturally raise a doubt whether the anchors carried by large tramp steamships are of sufficient weight to ensure safety under all the varying conditions of their employment. The weights given in Lloyd's Rules for vessels of varying size are well understood to be the minimum weights required; yet in practice, they represent the maximum it is in most cases thought necessary to provide. This is a disadvantage for which it is not easy to find a remedy; but it seems to me worthy of serious consideration by Lloyd's and kindred institutions, whether the rules governing the weights of anchors, now in force, are sufficient to meet the circumstances of modern navigation, and whether some revision should not be effected in the general interests of shipping. When the present minimum weights were decided on, it could scarcely have been anticipated that steamships would be sent on long voyages in exceedingly light trim, which has of late, become the rule rather than the exception. Another matter which seems difficult to justify from a strictly nautical point of view, is the reduction of weight permitted by the Rules in the case of spare anchors and second bowers. If the anchor, which is somewhat heavier than the required minimum, is lost or injured, it seems scarcely right to replace it with an anchor of less than the minimum weight. A vessel may, in fact, during a whole voyage have to

depend on anchors which are of less weight than the minimum applicable in her case. This arrangement is probably a relic of the practice prevailing, as already pointed out, before the days of steam windlasses. It would seem to accord better with modern ideas and seamanship, to carry bower anchors, all of the same weight and holding power.

Recent Developments of Stockless Anchors.—Quite recently a number of anchors have been patented, presenting very unusual features both in design and in construction, models of which are amongst those on the table for inspection by any who may be interested in these latest developments. In one case, the shank is connected to the head by a ball and socket arrangement, whilst the stock also is loose and free to revolve on the shank. In another instance there is a sort of parallel motion, which, however desirable, necessitates a number of weak points at the pivots. Again, we have an anchor in which the shank takes the form of a frame enclosing the one arm, which is, so to speak, all blade or fluke. In forming an opinion on the merits of anchors in general, it may be useful to remember that a pickaxe holds better than a rake and is stronger. Rodgers' anchor exemplifies the pickaxe principle, and possibly some of the modern stockless anchors verge on the rake principle. Then again an anchor is better than a mushroom. In some stockless anchors the head appears to revert in some measure to the mushroom form, the arms being comparatively short and weak.

In a stockless anchor desirable qualities seem to be strength and accessibility of the connection of shank to head, side trips or horns instead of central trips, blades and form of head to give good penetration. Correspondingly bad points, in my opinion, are: inaccessibility or concealment of shank to head connection, wide flat head reverting to mushroom type, arms curved in the plain of cross-head, central trips or canting arms.

In conclusion, I wish to acknowledge the assistance I have received in the preparation of this paper from various firms of anchor-makers, including Messrs. Charlton, Byers, Tyzack, and Wasteney-Smith, all of whom have furnished me with valuable information as to their respective anchors. To Colonel Hozier, to Mr. R. Denny, and to Mr. Goodall, of the Trinity House, my thanks are also especially due.

During the reading of the lecture the Chair was vacated by Admiral Bowden-Smith and taken by Commander Caborne, C.B.

Admiral Sir E. OMMANNEY, K.C.B., LL.D., F.R.S.:—Are stockless anchors much in use now?

Captain A. THOMSON:—Yes; they are coming into use quite universally.

Mr. TYZACK:—The paper which has been read by Commander Thomson is so exhaustive, that it does not leave much further ground for comment. There are, however, one or two small matters which may bear a little explanation. For instance, the ball-joint anchor is alluded to as something new. That is not new. There was a ball-

joint anchor in existence a good many years ago—I should say 15 or 16 years ago. I am not prepared to show the anchor, but I have the drawings of it and so forth. That is only a mere matter of detail. I am not aware as to whom the present ball-joint anchor belongs. I am not making any invidious remarks about it; but that is the case. One matter, however, has not been touched upon, namely, stockless anchors in sailing ships. For some reason or other, Lloyd's will not permit the use of stockless anchors in sailing ships, for the alleged reason that their holding power is not equal to the ordinary stocked anchors. That is a matter which requires inquiry, because if the stockless anchors are used in the Government yards, there is no reason why they should not equally be used in sailing ships. It is a much greater advantage to have an anchor which can be stowed in the hawse pipe than to have a stocked anchor, which is very difficult to get on and off the forecastle. Besides, in getting a ship under way you often want to get your anchor in very quickly, and sometimes it is not possible to do so with the ordinary anchor, which requires perhaps a matter of ten or fifteen minutes to get it on to the forecastle, whereas you can heave a stockless anchor right up into the hawse pipe.

Captain MONRO REED, Secretary to the Shipmasters' Society :—I should like to say that in 1862 I had a Martin's stockless anchor on board a ship. It was very much the same anchor as is in vogue now. There was a flat stock about one foot on each side. We had very little experience with them. We took them on board in London and took them out to Shanghai, where I had them down for four days.

Captain BARRETT (late P. & O. Company) :—One point has not been alluded to by the author in this very interesting lecture. The question of the quality of the ground that these anchors hold in best has not been mentioned at all. For instance, in good heavy clay there is no doubt the Martin's anchors and the stockless anchors are good, but for other purposes—for all kinds of ground and under all circumstances—there is nothing to be compared to the old-fashioned Rodgers' anchor. Stockless anchors are very little used for large rivers, such as the Hooghley and Yangtse. I know these stockless anchors possess an enormous advantage in that they do away with the anchor gear, the davits, the cat-heads, and the cat-falls, but when you come to an anchor which will hold a ship in heavy weather, there is no anchor to be compared to the Rodgers'. I think anyone who has been at sea will corroborate what I say.

Mr. G. E. PUGH COOKE :—I had a Martin's in use many years ago, and once at Shanghai when letting go the same from a Hartfield's patent windlass, the chain snapped in the hawse pipe. As the anchor was buoyed, lighters and gear were sent to pick it up, the intention being to leave the lifting gear tight at low water, and allow the rising tide to break the anchor out of the ground. The holding power of the anchor, however, was so great that the lighters had to let go or sink.

Admiral Sir E. OMMANNEY, K.C.B., LL.D., F.R.S. :—This is the first time I have ever heard a connected history of anchors, and I believe it is the first occasion on which we have had the subject brought before this Institution. The lecturer has rendered a most valuable service to the maritime world in general, and I am sure the paper will be read with very great interest by all naval men. As the senior member of Council present, I beg to thank him for having brought the subject before us. I am quite sure it will add much to our knowledge of the subject in general.

Captain THOMSON, in reply, said :—I was very interested to learn from Mr. Tyzack that there is nothing new in the principle of ball and socket connection between head

and shank. I did not know that such an arrangement had been applied to anchors before. The anchor I showed you, which has a ball and socket arrangement, is certainly a new production as far as it goes. It is called the "Britannia" anchor. I do not now remember the name of the makers. It is a good deal advertised, but I do not think it has been much used as yet. I think you will agree that it has the advantage of giving a very strong connection. Mr. Tyzack referred to the question of stockless anchors for sailing ships. I was very much interested to hear what he said, because it has entirely escaped me that the Rules of Lloyd's Register do not sanction the use of stockless anchors for sailing vessels. As a matter of fact, however, stockless anchors are used a good deal by sailing ships at present. Only the other day, at sea, I passed a coasting vessel, quite a little schooner of the modern type, with stockless anchors carried in the hawse pipes. I only mention this to show that very small sailing ships use the stockless anchor. In Messrs. Byers' advertisement there is a picture of a very large sailing ship indeed—one of 2,630 tons—also carrying hawse-stowing stockless anchors. No doubt many more instances might be mentioned, but I think these are sufficient to show that sailing ships do use stockless anchors.

MR. TYZACK:—But not under Lloyd's regulations. I have had a lot of correspondence with them on the subject.

Captain THOMSON:—I am glad of that information, because I did not know it. Of course, the fault is not with the stockless anchors, but with Lloyd's, who, no doubt, will see the error of their ways in good time. Captain Monro Reed does not like stockless anchors. We all know that the older navigators did not like them, and they do not like them now, and they never will; but it is, I think, beyond question that stockless anchors have come to stay. It does not matter whether we like them or not, we have to use them and make the best of them, and, therefore, I thought it well in this paper to endeavour to show their good and bad points, so as to have something to base our judgment on. I have given a reason why stockless anchors do occasionally fail. There is no doubt they have failed sometimes very badly; and it may be because the anchor drags with the blades out of the ground, as may easily happen. With an accumulation of mud or of gravel in front of the trips there is always danger that the pressure against the upper trip may almost equal the resistance at the lower trip, and if that be the case the anchor will drag without biting. In stockless anchors good holding is a quality, less in evidence perhaps than convenience of stowage; but I have no doubt their holding qualities will be improved as time goes on. We may be sure that if anchor-makers find that a ship drags with a certain kind of anchor, they will improve it and make it so that the ship will not drag with it. There can be little doubt that the stockless is the form of anchor for use in future years. Captain Barrett spoke in favour of the 'Rodgers' anchor, the ordinary shaped anchor. I am sorry I have not a model of it here. That, as I said in the paper, is the very best anchor of ordinary form. I quite agree with him. Mr. Cooke mentioned a fact that is quite true—that stockless anchors cannot be swept. They cannot be recovered easily. At the same time, they are not likely to knock a hole in the bottom of your ship, as an ordinary anchor might. You must put the advantage against the disadvantage. I should like to tell you a little story in this connection. I can scarcely think you will believe it; but the facts are as I tell them to you. In the telegraph steamer "Silvertown" we anchored one day on the West Coast of Africa, in eight fathoms of water. This is the anchor we let go—a Wasteneys-Smith—and you see it has not much to catch hold of. It has nothing except a shank shackle. When we let go, the chain broke. As it

was my favourite anchor, I did not like to lose it; so we thought we would try and recover it. We knew it was no good sweeping for it. Luckily we had an anchor-buoy —always use anchor-buoys with stockless anchors when you can. We pulled up the anchor-buoy tight. The ship was then manoeuvred over the buoy, and the ordinary cable grapnel let go. The grapnel was not down more than two minutes when we began to heave it up with a big steam engine. To my surprise and delight, the moment the drum had made one revolution the dynamo-meter went up to three tons, and I knew that we had got our anchor. When it came above the surface the grapnel was found to have hooked in the shackle. That shows, at all events, that stockless anchors may sometimes be recovered. I wish to thank Admiral Sir Erasmus Ommanney, for his very kind remarks. I quite understand that people cannot be expected to take much interest in a paper like this on a very dry subject. At the same time, I think the present is an opportune moment to bring the subject forward, because we have come to a turning-point in the history of anchors. In the Navy stockless anchors are being adopted entirely. All the new battle-ships now being built are being fitted with stockless hawse-stowing anchors. Anchors will be hove right up into the hawse pipe, and there they are. It does not look nice, but it is useful. I feel certain that whenever our ships have to get under way in a hurry to chase the enemy they will find their stockless anchors very handy. I beg to thank you all for coming here this afternoon and for your kind attention to the paper.

The CHAIRMAN (Commander W. F. Caborne, C.B., R.N.R.):—The lecturer has remarked that the subject of anchors is a dry one; but I venture to think that he has put it before us in a very interesting guise this afternoon. I regret that personally I possess no more special knowledge of anchors and their development than falls to the lot of seamen generally; but as it is very certain that in the present day anchors are not of much use unless connected with efficient chain cables, I may, perhaps, be permitted to say a few words about the most recent development which has taken place in the construction of the latter. Hitherto, as we are all aware, the links have been welded, and strengthening studs have been inserted in them; but some clever men have devoted their energies to improving upon this plan, and ingenious machines have now been invented for stamping chains out of bars of iron or steel by means of an elaborate arrangement of dies. To put it tersely, a bar of iron or steel of the necessary size enters the machine from the furnace, through which it moves automatically and attains the requisite amount of heat, and leaves the former in the shape of a practically complete chain, without the employment of any welding process whatever. The enormous pressure used while transforming the bar into a chain causes considerable elongation of the metal, and the completed chain, accordingly, much exceeds in length the original bar. The ends of the links, where the principal wear usually takes place, are made of larger section, thus giving the chains a greatly prolonged existence. Up to the present time I understand that the maximum size of the chains made in this way has been 1 inch, but preparations are being carried into effect to manufacture much larger ones. There are, I believe, two firms in Great Britain engaged in introducing this new method of manufacture, and it is claimed that with mild steel chains from 50 to 100 per cent. of strength is gained over the ordinary welded iron ones. This being the case, it should be possible to use lighter cables, a matter of some importance from the point of view of the naval constructor, who is generally anxious to diminish the weights as far as possible. In conclusion, I will ask you to accord a hearty vote of thanks to Commander Thomson for his lecture, and for his able handling of an important, if at first sight unattractive, subject.