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Gustav Schwanda & T. J. Haddy R.N.

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THE HYDRAULIC GUN MOUNTINGS OF FRENCH SHIPS.

By GUSTAV SCHWANDA, *Royal Marine Artillery Engineer.*

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By T. J. HADDY, *Staff Engineer, R.N.*

HYDRAULIC gun mountings present so many extraordinarily interesting details of construction that a description of them attracts and rewards us even now, although there is a constant retrograde movement taking place in such fittings towards the employment of hand power or electricity. In the fittings to be described principles are involved and arrangements made fundamentally different from those in general use.

First of these may be mentioned the numerous safety arrangements in the hydraulic fittings. In the French Navy there appears to be very little of that reliance on the intelligence, firmness, and coolness of the gun's crew, which is a fighting factor claimed by most constructors of other Powers, all the hydraulic gun mountings presenting safety arrangements which rigidly prescribe the routine for working the gun, and in most cases render any departure from this routine either impossible or very difficult, so that any mistake on the part of the gun's crew is at once made evident. Another leading principle in the construction is the ammunition hoist through the central pivot tube, and the vertical and oblique sliding guides for the carriage, so that it is brought fair with, and close to, the breech of the gun. The loading can be carried out independently of the training, as the carriage revolves with the gun platform in the central pivot tube. The delay and inconvenience of training the gun after every shot is obviated, the elevation only requiring adjustment. In conjunction with this arrangement hand power only is used for placing and loading the gun (see the installation of the 27-centimetre gun, "Achéron" type), as the fitting of an hydraulic rammer would necessitate two additional pipes at least through the central pivot. This, however, has already been done in later installations. The training arrangement must also be mentioned, as this is always worked from outside by means of a central drum around which two chains are wound, set in movement by two hydraulic presses; this affords a considerable saving of weight in construction, as the arrangement of the chain presses is a very convenient one, and the leading of the necessary chains presents no difficulties. Another advantage of this construction is the security of this important mechanism against gun fire, as it is generally placed under the gun platform, often under the protective deck, and nearly always under the water line, and consequently is not nearly so much exposed to the enemy's fire as is the

case with the English and German systems. Very large calibres also require hydraulic arrangements for opening and closing the breech, and this is generally effected by one or two small cylinders, which work as single or double acting machines for this purpose. The utmost possible employment of the power at hand is here, however, most prominently shown, and it would be in no way impossible to employ hand-power for this purpose, as has been proved in the case of slightly smaller, and also with guns of similar calibres.

Two conditions must be mentioned as specially characteristic of the French installations, namely, the employment of accumulators (*Kraft-sammler und Vervielfältiger*) for the hydraulic pumps, and the use of counterbalance weights for the hand levers in order to ensure their automatic and correct return on one side, and to counteract the weight of the numerous connecting rods, etc., on the other. These fittings will be mentioned in their proper places. The hydraulic installations for ships built up to 1885 are supplied by the Farcot Works, whilst the later installations on the Canet system are, for the most part, from the works of the Forges et Chantiers de la Méditerranée. On many ships separate parts have been supplied by various establishments who have contracted to supply of their best. In the following examples a Farcot installation of the "Caïman" or "Indomptable" type, to which also the "Terrible" and "Requin" belong, will be treated of, and a Canet installation as fitted on the "Marceau," with which that fitted on the well-known Spanish battle-ship "Pelayo" is identical. The hydraulic machinery of the 42-centimetre, 22-calibre long (16·6-inch, 76·8-ton) guns of the "Requin," "Indomptable," "Caïman," and "Terrible" will be described in the following order:—1. Training apparatus. 2. Loading apparatus. 3. Breech mechanism. 4. Running-in-and-out mechanism. 5. Elevating and lowering mechanism. 6. Safety firing arrangements.

1. *Training Apparatus* (see Fig. 1).—The training wheel *A* on the shaft *a' a''* works the toothed wheel *B* by means of the pinion *P*; the arms *TT'* on *B* work the slide valve *V* by means of the chains connecting the arms *TT'* to the valve spindle and balance weight, and in this way the hydraulic presses *P₁ P₂* are either filled or emptied, according to the position of the slide. The toothed wheel or collar *B* is carefully fitted with horizontal and vertical friction rollers *g* and *g'*, and works loosely on its axis. The arms *TT'* are fixed at opposite points, *T* being connected to the slide, while the other, *T'*, carries a counter-balance weight of 182 kilogrammes; the slide valve is fitted with a recoil valve, and its construction possesses nothing worthy of mention. The training is effected by two ordinary hydraulic presses carrying chain pulleys at the ram heads, the action being that of an inverted single purchase, the power being applied where the weight would be in the ordinary chain purchase, a common and well-known application of hydraulic power. On the slide valve spindle *V* is a bell crank *C₁ C₂*, whose vertical arm *C₁* is connected to the direction chain *T*, whilst the horizontal arm *C₂* carries a chain and balance weight so as to keep the direction chain continually in tension. On the arm *C₂* there is

also a guide bar D , on which a tripper f , worked by the press P_1 , slides, so that when this tripper comes into contact with one of the stop pieces d on the guide bar D , it is either raised or lowered, and the slide valve V is brought to the middle position, this forming the automatic stopping gear of the training apparatus.

The gun is supported on the movable platform E , which revolves on the axis H and the rollers G . The two training chains $R_1 R_2$ are secured to the drum S at the points $M_1 M_2$, and the action is as follows:—By means of the hand-wheel A and its connections the toothed ring B is revolved and the slide valve opened to the supply for one of the training cylinders, and, at the same time, to the exhaust for the other; the pistons begin their movement and revolve the platform in the contrary direction to that of the toothed wheel B , which stands fast during this movement of the platform and causes the hand-wheel A to revolve, the movement of which is followed up by the operator, and any tendency to stop at once checked by slight pressure on the wheel. In order to stop the training of the gun platform it is only necessary to hold fast the hand-wheel, when, by the continuation of the movement of the platform the ring B is moved and the slide valve brought to its middle position.

2. *Loading*.—All movements of the loading apparatus are effected by hydraulic power; the fittings for this purpose forming the most elaborate and complicated parts of the construction, it will, therefore, be necessary to describe them separately in the following order:— a the ammunition carriage, b the rammer, c the locking bolt, and d the breech apparatus. The carriage M (Figs. a and c , Table I.) consists of three tubes, the upper one taking the projectile and each of the two lower a half-cartridge, all three holders being lined with wood, the upper one having in addition a copper seating on which the projectile rests. A buffer is fitted at the after end of each holder, that for the projectile of indiarubber and those for the cartridge of wood. At the foot of the carriage is the crosshead K , to the ends of which are attached the chains from the hoisting ram Pm , and at the upper part of the carriage is a wooden structure dm designed for opening the cover of the ammunition tube, and also the small iron arm $l'm$ for shutting this cover as the carriage is lowered. The carriage is guided in its movements by the two guide bars bm and the guides am ; at the upper end of these guides there are three steps, e_1, e_2, e_3 , giving the three positions for "projectile" and first and second halves of the cartridge; a fourth step, e_4 , limits the hoist of the carriage. The distribution slide Tm of the lifting rams Pm is worked by the hand lever lm ; gm is the water-pressure supply opening, and which also serves for the exhaust if the other cylinder of the press is in action. The pistons are guided by the guide bars nn ; a counter-balance weight of 12 kilogrammes is attached to the valve rod to balance the connecting rods and gear. In the combined supply and return tube tm there is an automatic disconnecting apparatus for cutting off the pressure supply when the carriage has reached its bottom position. At each side of the carriage there is a bolt O fitted to the casing of the tube, the ends of the bolt gearing into toothed racks or quadrants io . The axis of both the

quadrants is connected with the lever $I_1 I_2$ (bolt levers); the travel of the bolt longitudinally is limited; on one side projects the arm Ko , which carries a weight of 90 kilogrammes suspended by a chain, the chain being connected to the safety arm S by the arm Sa . As these bolts are fitted in guides and have a travel of 30 millimetres in a vertical direction, the blow of the carriage will lift them by this amount and also the chain and weight, and the arm Sa will be lifted, causing the safety arm S to be revolved. The rod $I_1 I_2$ has a small projection Ie which works the small arm of the lever H , the object of which will be explained in describing the rammer. The safety lever S has three arms— Sa fixed to the bolt chain; Sb enables the slide Tm to be fixed when it lies on the slide rod t_1 ; Sc fixes the slide Tr of the rammer when its end lies on r_1 of this slide rod.

The rammer (Table I., Fig. *a*) consists of seven wooden rollers R , connected together by curved bars, so that the whole can travel in a circular or curved path; it is actuated by an hydraulic press Pr , of similar construction to other presses of its kind. The upward movement is partly controlled by the resistance on loading, and partly by the lever H . When the telescopic tubes are out at their full extent the projection d has also arrived at its extreme position, that is, at the inner rim of the packing gland of the outside cylinder and the end of the inside cylinder p' , at the head er of the rod fr . In this installation the chief point requiring attention is the packing of the glands, which must be only packed sufficiently tightly to prevent the rammer from descending too quickly, the return movement being effected by its weight alone. The water pressure is led to the press through the pipe tr , which also leads to the valve Tr . The before-mentioned stopping lever H has its projecting end nh between the connecting links of the rollers, and the outer arm Sh in a fork of the hand lever rod. The weight of the crank lever is balanced by the counter-weight ph . The slide valve rod carries three (so-called) safety arms: r_1 serves for opening the valve if the loading carriage is in either of its three loading positions; r_2 carries a counter-balance weight of 90 kilogrammes for the rods; r_3 is divided into two smaller arms, one of which carries a balance weight, whilst the other gears in the eye of a press Z , called the "safety press of the loading gear." This is fitted in the lead of pressure pipes from the valve to the rammer press Pr , and serves to regulate the pressure in accordance with the work required, and to cut it off after the three loading operations have been performed. The safety press is a small cylinder, whose piston is loaded by a volute spring to 30 kilogrammes, so that the pressure in the supply pipe can rise to 50 atmospheres.

The "stop bolt" (Fig. *a*, Table I., and Fig. 2) holds the platform in

Fig. 2.

the loading position, and consists of a fixed piston Pv fitting in the cylindrical end of the stop bolt V ; the water pressure passes through the supply opening gv , which also serves for the exhaust passage. At iv is a safety rod I_6 , the other end of which works on the finger I_3 of the carriage lever lm , so that if the platform is not fixed by the stop bolt in the loading position, the lever lm cannot be worked. The distribution valve Tv of the bolt is underneath, by the valve for the carriage, and is worked by the hand lever lv from the platform deck by a chain connection. A counter-balance of 25 kilogrammes equals the weight of the rods and chain. On the movable platform is a counter-bolt formed of three parts, and when the stop bolt is forward or in gear it compresses the counter-bolt against the volute spring W , and also causes it to enter a hole in the elevating position rod Gv , in order to secure the elevating position whilst loading, as well as the training. The counter-bolt has two arms, one of which carries a counterpoise, and the other is in connection with the breech-opening apparatus. In addition to this, the counter-bolt is geared to a crank arm uou' with a rod leading to the running-in-and-out apparatus, and which holds the gun firmly in the loading position (Table I., Figs. a and b). The breech-closing apparatus consists of two simple-acting presses, $P_1 P_2$, fixed parallel to and supporting each other. The water pressure is supplied to them by the pipes ty_1 and ty_2 . Each piston rod is fitted with a crosshead, and the two are connected by a pitch chain passing over the sprocket wheel Ay . On one of the piston rods is an arm Ky , to which the above-mentioned chain Cy from the counter-bolt of the platform is secured. The distribution slide Ty of both presses is above, on the platform, and is worked by the hand lever ly , and on the valve rod gy a safety crank by is fitted, the two arms of which can rest against projections on the counter-bolt. The loading is effected as follows:—If the gun is in the loading position, the lever lm of the ammunition hoist is pushed forward, the crank arms $I_1 I_2$ move the slide Tm , and the lever I_3 , connected at S' , releases the catch y , which drops by its own weight, allowing the catch te to gear in the toothed segment of the arm Ke , and the carriage begins its upward movement.

When the projection e_1 of the guide am of the carriage reaches the bolt O , this is lifted the small distance allowed in the guide go and the carriage is brought to rest; in this position the projectile is in line with the bore of the gun. When the bolt Ko is pressed upwards it also lifts the point of attachment of the safety lever Sa of the rammer and revolves the safety rod S a very small amount, but just sufficient to press the safety arm Sb against the valve rod of the carriage, and so fix it, and, at the same time, lifts the safety arm Sc from the bell crank r_4 , and sets the valve rod of the rammer free. By this means it is now impossible to move the carriage, but the rammer can be worked as required. If the lever lr for the rammer is now pulled back and the valve Tr opened, the lever rg , which is fitted with a small counter-balance weight, is also moved, and frees the slot of the safety press Z . The upward movement of the rammer now begins, and ceases only on completing the loading of the projectile. The forked lever be of the catch arrangement E (shown

plainer in Fig. 3) carries at its other end, secured at g_2 , a balance weight of 140 kilogrammes, which causes it to follow the movement of the rammer and reach its highest position, when the catch te falls into the first tooth of the sector E . If the projectile is now home and the rammer

come to rest, the pressure in the little safety press Z rises from 25 kilogrammes to 50 kilogrammes, the piston of the press compresses the volute spring and brings the slot of the piston rod in front of the lever rg , which drops in gear and allows the slide to be opened for the return; when this is done, the rammer sinks by its own weight, the projection ar strikes against the arms be of the catch apparatus and causes the catch holder z' to revolve on its axis; the catch te follows this movement and presses back the toothed sector by the arm Ke and moves the rods $I_1 I_2$ downwards.

By this movement the projection te strikes against the arm Sh of the crank-arm H on the bearing Oh , and pressing it down causes the other arm nh of this lever to project to about the centre of the rammer channel. By the downward movement of the rods $I_1 I_2$ the bolt Ko is drawn back somewhat through the small-toothed segment io , and falls away under the action of the balance-weight from the first step e_1 , of the

ammunition carriage, by which means the safety arm returns to its original position, freeing the slide valve of the hoist and fixing that of the rammer. If the lever lm is now again placed in the working position, the carriage will rise till the second step e_2 strikes against the bolt Ko , the safety arm S is again revolved, the valve of the rammer is freed, and that of the carriage fixed; this is the loading position for the first half-cartridge. The rammer is now worked, when the projection ar strikes against the projecting arm nh of the crank arm H , and carries it up against the buffer B , bringing the rammer to a standstill. In this position the half-cartridge is pushed out of the carriage, not into the full loaded position, but only in position for loading the second half, and the above movements of the ingeniously-designed mechanism are repeated for the latter, when the two halves are rammed home. After loading, the hoist lever is a fourth time put in action, the carriage rises the small amount necessary to bring the fourth step e_4 up to the limiting piece Cm , which causes the bolt again to take up its lower position, revolves the safety arm, releases the slide valve of carriage, and fixes that of the rammer, so that the former valve may be placed in the return position, and the carriage lowered to the magazine. As soon as this is done the levers $l_1 l_2$ of this slide valve, taking the arm le fixed on S' also with it, lifts the catch te out of gear. The counterbalance weight of 166 kilogrammes lifts the rods $I_1 I_2$, and pushes the bolt O forward to its original position, so that all the movable parts are again restored to their original starting positions.

The Breech Mechanism (see Fig. 4 and Table II., Figs. *a* and *d*).—

After the introduction of the heavy 42-centimetre guns, worked entirely by hydraulic power, the same power was also employed for opening and closing the breech, although the construction of the French breech screw is not so well adapted for the application of this power as the wedge system adopted by Messrs. Krupp and others, there being three separate movements in different planes, necessitating the introduction of various mechanical details in the French plan, a short description of the working of which is here given. It consists of an interrupted screw V , the forward end of which carries an obturator plate, which bears on a copper ring recessed into the bore. The opening of the breech is effected by first revolving the screw, so as to free the segments of the interrupted thread; it is then withdrawn its whole length and rests on the bearer C , which, with the breech screw is swung on one side, leaving the bore free. These movements are effected by two press cylinders $P_1 P_2$ (Table I., Fig. b) fixed parallel to each other under the platform; one of these cylinders serving to open, the other to close the breech; the pitch chain secured to the outer ends of the pistons is geared around a vertical shaft fv fitted to the movable platform, and with a forked head at the upper end to receive the T head b of the shaft Av (Figs. 4, and a and d , Table II.), on the upper end of which the toothed wheel Rv is keyed, its teeth at first being in gear with the teeth on the right-hand top side of the projecting part of the breech block, and so causing it to revolve and free the thread; as soon as this occurs the motion is transformed from a revolving to a direct linear one, and the continued revolution of the toothed wheel Rv draws out the breech block on to the bearer.

Under the bearer C a vertical bolt I is fitted, constantly pressed upwards by a spring; and the stop-bridle iv , secured to the gun by four screws, bears in a recess of this bolt. On the top of the bolt there is a projection, somewhat out of the centre line, bevelled off at the after side at an angle of 45° , and behind it, in a horizontal position, is a retaining bolt I' with a projection at its forward end; this is also kept constantly pressed forward by means of a spring. The manner in which the mechanism above described acts is as follows:—When the breech is closed the nose of the bolt I is pressed against the breech V ; the projection of the keep-bolt I' is in a recess of the bolt I , and the end of the bolt in contact with the fixed stop-bridle. When the breech is withdrawn, the nose of the bolt I enters a recess lv of the breech, and by this upward movement of the bolt its hooked end is lifted out of the stop-bridle iv , and the bearer can now be revolved. As the breech block can have no further forward motion the continued movement of the cogwheel Av (Table I., Fig. b) swings back the carrier until its stop-piece takes against the end of the gun. When the carrier is lifted clear of the stop-bridle on the gun, the keep-bolt I' is pressed forward by its spring and secures the bolt I ; it also serves to connect the breech and breech carrier. In closing the breech the other press is brought into play, and the toothed wheel Av is turned in the opposite direction, the carrier with the breech block is swung back; as it nears the stop-bridle the keep-bolt I' is pushed back, the breech is pushed forward by the wheel Av , and at the same time the bolt I pressed gently

down until it again springs back into its original position. The pressure supply to the breech presses $P_1 P_2$ is led through the pipes $y_1 y_2$ from the slide valve Z (Table I., Fig. *b*).

Apparatus for running in and out, Recoil Brake (Table II., Figs. *a, b, c, d*).—The trunnions of the 42-centimetre gun rest in light slides working on horizontal planes, the recoil being controlled by two hydraulic recoil presses, the piston rods of which are attached to the trunnion slides; the presses are fixed to an extension of the planes on which the slides work, which permits of a symmetrical arrangement of the weights, but entails, however, an unequal effect on the recoil presses, as it varies with every change in the elevation of the gun at discharge. The recoil cylinders also serve to run the gun in and out, the arrangements and mechanism for this purpose being as follows:—The recoil cylinders EE' (Table II., Figs. *a* to *d*) have at their after ends valve casings containing five valves loaded with Belleville springs, and under each cylinder is a small reservoir, into which the water flows on recoil; the forward cylinder supply openings are in be and $f'e$, the after ones in ce , $c'e$. Each piston has a pass valve loaded with a spring, which allows the water to pass from one cylinder space to the other, and prevents the formation of a vacuum. These valve-springs are very weak, and of brass, so that on the gun trials of the "Indomptable" they lost their elasticity after fifteen rounds, and the valves being off their seats, the gun was run out with difficulty. The method of securing the piston rods is peculiar, as they run through the whole length of the slides, and are secured by nuts. When the gun is in the loading position, the piston rods are run out their whole length, and, in order to protect them from injury, a semi-circular shield plate is fitted, 90 millimetres thick at the after end of the slide $he h'e$ (Fig. *b*). At the forward end of the slide two buffers je and $f'e$ are fitted, formed of wood and indiarubber. The distribution slide Z , together with the slide valve of the elevating gear, forms a double valve, the details of which are shown in Fig. 7. The pressure is supplied through $t_1 t_2$ in the valve casing, and is led from these to the recoil cylinders by the pipes te and $t'e$; it can be seen by the lead of the pipes that in every case the pressure enters the forward cylinder spaces, and therefore in running out and in, the difference of pressure due to the difference of the areas of the two sides of the piston only, comes into action. The operation is effected by two levers, one of which is worked direct, and the other by a hand-wheel; the result is the same in each case, as both are fitted to a common shaft. If the hand-wheel is worked the lever slides in a recess of the platform, and shows the position of the slide by means of a graduated index and pointer; at its upper end this lever carries a projection ie (Fig. *b*), which serves for working or securing the platform bolt. In addition to this there is also a safety chain r_1 secured to it, and kept constantly extended by the weight K_2 , the other end of the chain is secured to the revolving arm $o_1 o_2$ fitted to the sides of the gun support; the forked end i of this arm embraces a bolt o_3 of the protecting plate, so that the lever is depressed by this bolt before the slide has reached the buffers when running out. By this automatic

Fig. 6.

Fig. 5.

Fig. 7.

checking arrangement the running-out slide valve is also shut off at the right time, and the gun is brought up gently against the buffers. In connection with this check arrangement is the carefully-constructed hand-wheel shown in Fig. 5.

The spindle Ax , on which the hand-wheel le is keyed, has at its lower end a square thread screw carrying the nut Cx which works in straight guides formed in the bronze bracket mn . On this nut the bridle Bx is secured by the trunnions $b_1 b_2$; the lower end of the bridle carries the guide block Dx , by means of which the slide valve rod is indirectly connected to the hand-wheel. The block Dx is not fixed to the bridle, but held simply by the friction set up by six pairs of Belleville springs, so that when the water supply is automatically cut off by the above-mentioned apparatus when running out, the valve shaft ae is also depressed, causing a lengthening of the rod which is limited by the stop bolts d_3, d_4 . The return or exhaust of the double valve is led through $F F'$, Fig. 6, and through the central pivot.

A very important addition to the above apparatus for the recoil is the snifting valve Z (Reniffard), the construction of which is shown in Fig. 6; it is in connection with the pressure supply and return, and with the elevating cylinder; the water coming direct from the central pivot enters at z_1 , the return from the slide valve at F' , and led further by F'' ; the water pressure of the elevating mechanism enters at lh , and escapes again by $l'h$ and lh , of which $l'h$ leads to the elevating cylinder and lh back to the compound valve. The snifting valve casing was introduced subsequently to the preliminary gun trials, as it was found that, although the 42-centimetre gun was perfectly balanced on its trunnions, at the moment of discharge a considerable downward kick was perceptible, which set up a dangerous vibration of the whole system. In order to remedy this defect the valve casing is divided into two parts by a horizontal partition, and the upper part further divided into three parts—1, 2, 3, Fig. 6. In each of these spaces is fitted a clack valve of thin copper; the valve 1 is kept to its seating by the pressure supply entering through z_1 . The valve in the space 2 is kept to its seating by the water pressure led through the snifting valve to the upper part of the elevation cylinder, from the slide valve of the elevating arrangement through the pipe lh opening into this space. Finally, the water pressure pipe for the lower part of the "elevation" cylinder opens into the space 3 and presses valve 3 on to its seat. When the projectile leaves the mouth of the gun and the downward blow at the breech end is produced, a considerable increase of pressure is caused in the pipe lh leading to the upper space of elevation cylinder, and also in space 2 of the snifting valve; at the same time a vacuum is produced under the piston of the elevation cylinder, which is also transmitted to space 3 and lifts the valve in this space so that the return water through $F F'$ can now pass through space 3 under the piston of the elevation cylinder, destroying the vacuum found there by filling the space with water, and so rendering any further vibration of the system impossible. The excess pressure in the upper cylinder space can open the valve 1 and allow a portion of the water

to escape into the main supply pipe, so that there is no danger that the slide valve may be forced off its seating by the excess pressure. This valve arrangement also serves to fix the gun during the discharge and to protect the distribution slide against an excess of pressure.

The Elevating Arrangements (Table II., Figs. *a*, *b*, *c*, and *d*).—This arrangement is good in construction, in so far that only the gun itself has to be lifted, resulting in a considerable saving in weight as compared with that in which the slide and mounting has to be lifted as well. The gun rests with its trunnions in the slide, and is connected by the band *z* to a beam *Lh*, working on the pivot bolt or hinge *h*₁. In the central plane of the gun a small sliding block *S* is fitted on the beam *Lh* connected to the band *z*, so that it may adjust itself on the beam to suit the movements of the gun in running in and out and during recoil. It follows also that during these movements the elevation of the gun does not remain constant, but varies according to the position of the beam *Lh* at the time. The horizontal position of the beam is fixed by the bearer *h*₂ secured to the platform, and in this position also the beam lies on the bar *Ga* (Table I., Fig. *a*), allowing the platform bolt to enter a recess in the rod, and so making any further movement of the elevating arrangement impossible. The movements of the elevating beam are effected by the elevation cylinder *H*, the supply pipes *ih*, *i'h* of which have been partly described, and, as indicated, the slide valve forms with that for the running-in-and-out arrangements a double valve (Fig. 7), and is worked by the hand lever *ih* (Table II., Fig. *c*) on the left of the gun. In this case also there is an index and pointer graduated between the extreme positions. The lever is so fitted to the platform that when in the extreme position for "elevate" the projection *ih* comes against the bolt *J*. A safety valve for the discharge, *K* (Fig. *c*, Table II., and Fig. 8), must be introduced into the elevating mechanism for the

Fig. 8.

following reasons. When the gun is laid horizontally, the elevating beam Lh makes an angle of 5° with the axis of the gun, so that the breech end is lifted a considerable amount during the recoil, and when fired with depression to such an extent that the chase comes into contact with the edge of the turn table, rendering firing at short ranges impossible. A branch pipe K_1 is fitted in the pressure pipe leading from the snifting valve (Reniffard) to the lower part of the elevation cylinder, which communicates with the lower end of the safety valve, and is connected with an air chamber X through the pipe K'_1 . The object of the latter is to take up the blow, and is in communication with the return water main by the pipe K (Fig. *c*). The valve K , loaded with Belleville springs, separates the two communication pipes K_1 and K'_1 . At the upper end of the valve spindle is an inclined plane, which is in contact with the gun slide, and the spindle can be lengthened or shortened as necessary. As soon as the recoil commences the valve is opened slightly and puts K_1 and K'_1 in communication with each other, and also with the lower end of the elevation cylinder, permitting a slight escape of water from this cylinder, which allows the gun to sink by its own weight, so that at the end of the recoil it has very nearly the same inclination as before discharge.

In carrying out some trials with the gun it was remarked that, in running in, there occurred a tolerably heavy blow just at the instant the gun was run in, and to avoid this the valve spindle was shortened so that the inclined end no longer remained in contact with the slide; this made the opening of the valve K impossible, and prevented the too sudden emptying of the elevation cylinder. Before the completion of the running-in movement, care must be taken that the gun is lowered so that the head b of the breech opening shaft Av (Fig. 4) is geared with the fork on the gun platform, so that there is no obstacle in the way of opening the breech. After this alteration, the "Reniffard" valve became superfluous, as there was now no necessity to hold the gun in a fixed position by the pressure supply; but rather to allow the breech of the gun to sink slowly by emptying the elevation cylinder through the safety valve; oscillations of pressure in the supply pipes being avoided by the air chamber.

The ships of the "Neptune" class, "Neptune," "Marceau," and "Magenta," are supplied with four 34-centimetre barbette guns, one of which, as bow chaser, is protected, the others unprotected, also with thirty-three quick-firers and eight mitrailleuses; they are armoured throughout at the water-line, the armour being brought lower down forward to strengthen the bow. The hydraulic fittings of these ships are the same as in the Spanish battle-ship "Pelayo," viz., a Canet installation, with some alterations by Lagane, directeur des Chantiers de la Seine. The platform is fixed to a strong central-pivot tube, which extends down to the magazine and serves for the ammunition hoist. For the service of the four barbettes three pumps are fitted, one for the forward, one for the after, and a more powerful one for the two central barbettes. The two former pumps supply at a steam-pressure of 4 atmospheres (60 lbs.), and 60 revolutions per minute, 300 litres (66 gallons) of water at 80 kilo-

grammes per centimetre² (1,130 lbs. per square inch), while under the same conditions the larger pump supplies double this amount (600 litres per minute).

Training Gear (Figs! 9 and 10).—In this case the training is not effected by two chains wound on a drum, but by a pitch chain, the two ends of which are secured to the two presses *A*, the chain itself passing over the toothed wheels of the pistons *E*, and around the toothed collar secured to the central-pivot tube *P*; the presses are sufficiently powerful to train the forward and after barbettes, through 127° on either broadside in 56 seconds, and the two central barbettes 90° in 40 seconds. The details of the training arrangement are the following:—The distributing valve *Th* (Fig. 10) is situated under the directing positions, and is worked by the hand-wheel *v*₁ on the upper end of the training spindle *V*, which is supported in bearings at *A* and *B*, and is fitted with another auxiliary hand training wheel *v*'₁ at the lower end, the shaft of which has a bearing at *E* and rests in the socket *D*. The spindle is screwed at two parts of its length, the upper part, with a screw of 20-millimetre pitch, having at each end of it, at the limits *b*' and *b*'₁, stop nuts to prevent the spindle revolving any further, and the lower part with a screw *V*' of 55-millimetre pitch for the reception of the toothed wheel *V*'₁. The latter wheel gears into the cog-wheel *R*, and performs the function of a lever for working the slide, by means of a collar which is in connection with the valve rod. The centring wheel *R* gears also into the small wheel *R*' and so revolves the pinion *G*₁ which gears into the collar *H* fixed to the ship's plating *Q*. The mode of action is as follows:—When the gun is in the position of rest the nut *b* is equidistant from *b*' and *b*'₁, and the slide valve is in its central position. When the hand training wheel *v*₁ is worked in the direction required for training, the cog-wheel *R* and *V*'₁ is raised or lowered, its teeth, however, being sufficiently broad to remain in gear with *R*, and by its movement works the slide valve, putting one cylinder in communication with the pressure supply, the other with the exhaust. The movable platform now commences to revolve, when the pinion *G* is worked by the toothed collar *H*, so causing the wheels *R* and *V*'₁ to revolve, and bringing the latter, and consequently the slide valve, back again to the central position; these movements will continue so long as the hand training wheel is worked, and should the stop nut *b* reach either of the limits *b*' or *b*'₁ in continuing the training, the spindle *V* is stopped and the slide valve automatically shut off.

Loading Arrangements.—As already mentioned, the central pivot tube is sufficiently large to serve for the passage of the ammunition up to the rear of the gun, and, from a tactical point of view, this arrangement is considered to be a necessary one. All hydraulic mountings of modern ships are on this system, which permits of the gun being loaded in any position of the platform, and considerably increases the rapidity of fire. In order to still further increase this rapidity of fire the ammunition carriage has been modified, so that instead of having to use the hydraulic lifting presses for three or four positions of the carriage, one fixed position

Fig. 10.

only is used, and a revolving carriage employed for the projectile and two half-cartridges. By this arrangement also the space in the central tube is used to the best advantage (see Figs. 1, 2, 3, 4, and 7, Table III.).

This carriage comprises the platform *D*, the trolley *d*, and the revolving ammunition holder *R*. The upper side of the platform is fitted with rails for the horizontal movements of the holder, and a solid crossbar *Z* is fitted underneath, its ends being secured to the ends of the pitch-chain from the lifting presses. The carriage travels on guides *y* on the inner plating of the central pivot tube *P*, which revolves with the gun-platform. In order to hold the carriage in its lowest position for the reception of the charge, a holding ring *s* and stopper is fitted below it. The trolley *d* rests on light rollers *e*, and embraces the ammunition holder *R* with the two bands *d' d'*. At the sides four guide-rollers are fitted, the larger ones *f* for lowering, and the smaller *g* for hoisting and guiding the holder at the latter part of its ascent, so that it avoids the breech and is brought to rest directly in rear and in line with it. The revolving holder has the three lined tubes, *r r' r''*, for the reception of the ammunition, and is placed in the required position by the help of a handle and the cog-wheels 1, 2, 3, 4, and 5, a simple catch arrangement sufficing to hold it in the three necessary positions. In the magazine, a circular railway *O* around the pivot tube serves for filling the holder in any position of the platform. The projectile is laid on the loading-table *T*, and held by a stopper apparatus preparatory to loading; originally it was held by an automatic catch worked by the carriage, as shown by the counter-balance 6" and the rods 6 and 6', but this was soon abandoned, and the arrangements 7 and 7' introduced, which is freed by the pawl 8. For hoisting the charge, the two presses *Pm*, secured inside the pivot tube, are employed; these also are inverted block purchases, so arranged that the pistons travel downwards for hoisting, this being the most favourable position for taking the strain. At the upper end of the piston rod the chain 10 is secured, and is led upwards over the roller 11, then downwards by *y* over the roller of the piston rod 10, and again up over the roller 12, and finally down to the ammunition carriage, where the other end is secured. The axis of the roller 12 is somewhat lengthened outwards, and serves for opening the ammunition tube, which is closed by a horizontal sliding door resting on rollers; the arrangements are so simple that no further explanation is necessary. This door is fitted with a projection, which takes in a recess in the shaft of the breech-working arrangement, and renders any movement of the breech impossible while the ammunition hoist is open; the shaft of the breech gear is only freed when the ammunition carriage, in descending, has completely closed the sliding door of the tube.

Two automatic brakes, or check valves (Fig. 7, Table III.), are fitted to the supply pipes of the ammunition presses, to prevent the too rapid travel of the carriage when nearing the ends of its travel. They consist of simple piston valves, the spindles of which project through stuffing boxes and carry rollers; two grooves are cut in the platform of the ammunition carriage in slanting directions, *u* for the hoisting and *u'* for the lowering

TABLE IV

directions, and by this simple arrangement the water supply is throttled without the necessity of working the slide valve lever. The upward movement of the carriage is limited by its contact with the screw v , which causes two stop bolts to gear in s' and fixes the position of the carriage; when the hand lever is placed in the return position these stoppers are placed out of gear. The hydraulic rammer (see Table IV.) is worthy of notice, inasmuch as it is arranged to swing around a central support, and is fitted with an automatic "cut off" arrangement for loading the cartridges. At the first view its construction appears very complicated, but for the work required of it this is not the case, as the following description will show:—

The outer shell of the rammer is formed of the bronze cylinder B , the after end of which is closed by the cover B' , and to this cover is connected the pipe c_2 , the supply and return pipe to the slide valve Tr ; the joint between cylinder and cover is made watertight by a copper ring, and inside the cylinder are the three pistons, p, p', p'' , forming the telescopic rammer. The inner (smaller) piston is formed of the phosphor bronze tube p , fitted at the lower end with a packing leather and at the upper end with the rammer head T , screwed on, and covered with wood on its outer surface. The next following (intermediate) piston p' is formed of two phosphor bronze cylinders m' and m'_1 , screwed one over the other, leaving a small space between them, for water circulation, in communication with the other spaces of the rammer by connecting channels at the ends. The third and largest piston p'' is similar in construction and is formed of the phosphor bronze cylinders m'' and m''_1 . The tube c_1 , from the slide Tr at the forward end, is a pressure supply pipe only, while c_2 serves both for supply and exhaust; the pressure is led to the valve casing by the pipe c , and to the return water tank by the pipe c_3 . The slide valve generally used is not employed here, the water distribution being effected by the two spring-loaded valves s and s' , the former for the pressure and the latter for the exhaust service; both are enclosed in one casing, which we shall call the "distribution valve" casing. The outer parts of these valves form hollow cylinders b, b' , for the reception of the springs by which the valves are kept constantly pressed against their respective seats; the body of each valve is pierced with a small hole in order to prevent abnormal pressure in the spaces b, b' . These valves are worked by means of the hand lever L , which is fitted on the square of the short axle l working in the bearing o . This axle carries at its outer end the plate d , on which are the two projecting pins d', d'' , which gear in the recesses of a distributing plate e , the two other sides of which form the small pistons f, f' bearing against the lower ends of the valve spindles. In an elongated eye of the hand lever is geared the pin o' of a sliding block K , the object of which will be explained further on. In the sketch the lever L is in its middle position, the pressure valve s closed and the exhaust valve s' open; and, consequently, the return water from the cylinder B passes through the valve casing on to the water tank. It will be observed that the pins d' and d'' always move the distributing plate e in the same direction, that is, from right to left, whether the lever be

placed at "projectile" or "cartridge," as the plate only has lugs on one side for the pins d' d'' to take against, consequently the pressure valve s is opened in both cases, and s' closed by its spring as soon as the small piston f is withdrawn. The water supply at constant pressure from the pressure pipe c_1 therefore flows through the pressure valve s into the pipe c_2 to the after end of the rammer and pushes it forward; the pressure at the after side or larger surface of the rammer being in excess of the constant pressure at the forward or smaller surface. If the lever is now placed in its middle position the pressure valve s is closed and exhaust valve s' opened, and the pressure at the forward side of the rammer comes into play and pushes out the three rammer pistons p p' p'' from the cylinder B . The rammer turns on a pivot at the middle of its length, and is moved to the required position by means of the handles O , which also serve for securing it.

Above the rammer cylinder is the automatic stopping arrangement S , the rods of which pass through the supports g , g' , and g'' ; g' is also the limiting block. The apparatus consists of the four steel parts h , K , Q , and I ; the cylinder h (in two parts) carries the pin i , which fits in the elongated eye of the hand lever; the cylinder itself is movable in the direction of its length through the bearing g'' , but is not free to revolve, and is fitted with four screws i , the inner ends of which enter grooves cut in the inner cylinder K ; this cylinder is free to revolve but cannot move in the direction of its length, as it is fixed against the bearing g' by the flanges n . The grooves in this inner cylinder run at first parallel to the axis, then for about a quarter of a turn in a spiral direction, and then again parallel to the axis; the revolution of the cylinder K causes the shell Q to revolve, and with it the square shaft I fitted through it, and which has at its forward end an elliptical head u , the smaller axis of which passes through an opening v' in the rammer head T , and when inside this opening v has sufficient room for its major axis in any direction. When these parts are in the position as shown in Fig. 1, the rammer can be pushed forward without taking the rod I with it, as the elliptical head u can pass freely through the opening v' ; but as soon as the rod I makes a quarter of a revolution the head u cannot pass, and the rammer head carries the rod I with it.

The action of the rammer is as follows:—When the hand lever is placed at the position marked "projectile," the pressure valve s is opened, the exhaust valve s' shut, and the rammer goes forward without taking the rod I with it, for during the movement of the hand lever the casing is moved along by means of the pin i , and the screws i slide in that part of the grooves which is parallel to the axis, so that the shaft I is not revolved and its head passes freely out of the rammer head T ; the rammer completes its full stroke and sets the projectile "home." If the lever L is now brought back to its middle position the rammer returns as the pressure valve s is shut and the exhaust s' opened. When the lever is placed at the position marked "cartridge" for loading the first half, the valve s is opened and s' shut, the cylinder h is moved along and in such a position that the screws i slide in the spiral part of the grooves and so

Fig. 1

Fig. 3.

cause the shaft t to revolve, coupling it to the rammer head T , which carries the shaft with it, and the head g''' at the after end approaches the cylinder h . As soon as the first half-cartridge has nearly reached the position required for the reception of the second half, the head g''' comes into contact with o_1'' of the cylinder h and carries this cylinder forward till its after end o_1'' arrives at o_1' . The distance $o_1'' o_1'$ equals $o' o''$, so that the lever L is brought back automatically to the return position, the return movement of the rammer follows, and at the same time the shaft t is revolved back to its original position, so that all the parts are again in position as at starting. The second half-cartridge is loaded in a similar manner, during which operation the first half is pushed forward to its proper position.

Breech-working Arrangement.—The breech of the 34-centimetre gun is the same as that already described for the 42-centimetre gun, but the opening and closing mechanism is different, being simpler and more effective; it is, therefore, shown on Table V., Figs. 1, 2, and 3, so that it may be described. The movement of the breech is effected by one hydraulic cylinder only, which, however, is double-acting, and consists of the horizontal cylinder Pc fitted at the rear of the gun. In the cylinder is a fixed piston, with a piston rod at each end of it, and the necessary pipes leading to the piston, which are so arranged that one pipe is under pressure while the other is open to exhaust. On the upper surface of the cylinder is the rack a_1 , which gears with the pinion e' (on the spindle f). This pinion gears with the following wheels in succession, $h' i' j' l' m' n' o'$, and the shafts $k' p'$, so that the movement of the cylinder Pc is transmitted to the tooth wheel q' , which opens and closes the breech in the manner already described in the 42-centimetre fittings.

The Running-in-and-out and Recoil Fittings (Figs. 1 and 2, Table V.).—The recoil presses Pr , placed at the sides underneath the gun, are employed for running in and out. The steel cylinders of the presses are secured to the gun slide by the bolts x , and are fitted with packing glands at both ends for the passage of the piston rods tr . The piston pr is solid with the rods, and fitted with double packing leathers, and the after ends of the rods are fixed to the carriage ar . For the forward ends of the cylinders are the supply pipes 9 and 9', and for the after ends 8 and 8', and both leads are connected by the branches 11 and 12, opening into the valve casing $S_1 S_2$. The pressure supply comes from the working slide, through the pipe 6 (Fig. 1), and from here through the pipe 7 into the connection 12 (after cylinder spaces) and through the other pipe 7' into the connection 11 (forward cylinder spaces).

On the outer side of the trunnions are the bends r'' by which the water pressure passes through the trunnions, and is led by the pipes 10 and 10' to the slide valve of the breech-working apparatus; the pipes 7 7', and 10 10' are so arranged that when 7 and 10 are pressure pipes 7' and 10' are exhaust, and *vice versa*. In the valve casing $S_1 S_2$ are the two valves $S_1 S_2$, one of which, S_2 , shuts off the communication between the pipes 11 and 12, and is kept on its seating by Belleville springs. The valve S_1 forms an integral part of the recoil brake, as it is so worked that

Fig. 12

Fig. 13

the pressure in the recoil-presses during recoil is kept constant, which would not otherwise be the case, as the cylinders are not grooved and the piston works in them water-tightly. For this purpose the outer end of this valve spindle is fitted with a roller which runs in a curved path, so formed that the area of the valve opening is adjusted in proportion to the velocity of recoil.

The action of these valves is as follows:—If the gun is run out the valve S_1 is wide open and S_2 shut off; to run in, the distribution slide is so placed that the pressure supply can pass through the pipe 7' into the branch 11, and from there through 9 and 9' to the forward cylinder spaces, and at the same time the after cylinder spaces are placed in communication with the exhaust through the branch 12 and pipe 7; to run out the operation is reversed. When the gun is in the firing position the valve S_2 is closed and S_1 open, and the return water is forced through the valve casing to the forward cylinder spaces; at the end of the recoil the pressure in the pipes is only normal (the area of the passage being regulated by the valve S_1 as already mentioned), and the gun is afterwards automatically run out so that re-loading can at once be proceeded with.

The Elevating Gear (Table III., Figs. 1, 5, and 6, and Table V., Fig. 2).—This consists of the elevating cylinder Ph , on which works the trunk piston ph , the rod of which is connected to the piston and gun-slide by universal joints. The press has two supply openings, the upper one communicating constantly with the pressure supply and the lower alternately with the pressure and exhaust. The method of packing the piston is shown in detail in Table III., Fig. 6. The working parts of the elevating arrangement are sketched out in Figs. 11, 12, and 13. The hand-wheel V , at the controlling position, is connected with the horizontal shaft a , which carries a sprocket-wheel with the pitch chain b . This upper shaft a is screwed at one part of its length, on which is fitted the nut a' working in guides and limited by the stops $c' c'$ if the gunner should not shut the hand-wheel v at the right time; this also serves as brake and disconnecting gear for the extreme elevation and depression. There is also the shaft d provided with a screw and the nut e , which is in connection with the valve rod of the elevating valve. At the right-hand end of the shaft d is the toothed wheel f , worked by the pitch chain i and the wheel g , the latter being actuated by the curved rack on the gun-slide.

The action of the elevating gear is as follows:—When all the parts are in the position of rest and the slide in its middle position, the nut a' is equidistant from $c' c'$. If the hand-wheel v is turned in the required direction for elevating, the nut e moves along the screw and opens the slide valve, allowing the water to escape from the lower part of the elevating cylinder Ph , and the after end of the gun drops. The curved rack n then causes the wheel m (and also by means of the pitch chain, the shaft d) to revolve, and the nut e can be brought back to its original position; that is, if the hand-wheel v is held fast, the screw of the shaft d comes into play, and brings back the nut to its original position, centres the slide valve, and the movement ceases.

Longitudinal section.
Fig. a.

Fig b.

*Plan of Platform
Breach Apparatus.*

Plan of underside of Platform.
Fig. c.

Safety Arrangements.—These form a highly-ingenious combination, and a very interesting speciality of these mountings, and are of such an instructive nature that we will describe them by the help of Fig. 14. The levers for the distribution slide valve are on the right of the gun, fitted on the movable platform in the following order:—

1. For running in and out.
2. For the elevating gear.
3. Breech-working gear.
4. Ammunition hoist.

The positions of the corresponding levers before and after loading can be seen by the figure:—

1. The lever *A* is placed at “*en batterie*”; the gun is therefore run out.

2. Lever *B* is at zero, 0, and the gun is horizontal.

3. Lever *C* of the breech is at “*ferme*,” and the breech is consequently closed.

4. Lever *D* is at “*descend*,” and fixes the lowest position of the ammunition hoist (in the magazine).

These levers are connected to each other by rods and catches, so that in working them a certain rotation must necessarily be observed; these catches are either single or double armed, working on a fixed pivot, and always determine the position of the neighbouring levers. It will be seen by the combination of these crank levers that the elevation, to a certain extent, dominates the others, as its lever *B* can be worked freely both for elevating and lowering, and determines unalterably the positions of the other levers. Further, it is to be observed that the lever *A* remains constantly at the “run out” (*en batterie*) position, which would give rise to difficulties in firing if it were not for automatic valves, fitted so as to allow the water locked up in the return pipes to overflow at the instant of firing. At the end of the recoil the “run-out” gear comes again automatically into action, and the gun is run out without any interference on the part of the gunner. In order to have a correct idea of the co-operation of these levers, all the operations which are necessary to bring the gun in all respects ready for firing are described in proper rotation:—

(a) Since the gun is run out, it must first be placed at extreme elevation, as it can only be loaded in this position. For this reason the lever *B* is placed at “positive,” and the rod *a* is drawn to the left, which places the crank arm *a a'* at such a position on its fixed pivot that its end *a'* takes on the bolt *b* of the lever *A*, and fixes its position; and so long as the gun is at extreme elevation it cannot be run in.

(b) The breech must then be opened by means of the Lever *C*. In placing the lever *B* the end *p'* of the crank arm *p p'* is put out of reach of the bolt *p''*, and it would be possible to work the lever *C* if it were not held by the bolt *V*. This bolt only releases the breech lever when the gun is quite lowered—that is, when the boss *n* on the slide pushes the lever *E* to the left, and by means of the rod *k* at its lower end, and the bell-crank lever *f f'* draws the bolt *V* out of gear, and frees the lever *C*. This lever can now be placed at “*ouvrir*,” admitting the pressure to the breech press. From this instant the elevating lever *B* cannot be moved, as the end *p'* of the breech lever *C* takes on the bolt *p''* of the

elevating lever, and fixes it in position ; a second safety arrangement is provided, as the cylinder of the breech apparatus has a projection *w*, which gears into a spiral groove of the shaft *u*, by its movement causing the latter to revolve, by which the bolt *S* is geared into a recess on the lever *B*, and holds it fast so long as the breech is open.

(c) The ammunition can now be hoisted, as, after the breech lever has been placed at "ouvre," the hooked-shaped crank arm *v* is thrown out of gear, and releases the bolt *r* of the carriage lever *D*, which can now be placed at "monte." This brings the lower surface *l'* of the crank-arm *v* over the before-mentioned bolt *r* of the lever *D*, and although allowing free movement of the latter (as the surface *l'* is formed to suit the path of the bolt *r*) it fixes the position of the breech lever *C* during the ascent of the ammunition carriage. In this way the whole of the levers are secured, and after loading, the carriage lever *D* is placed at "descend," which frees the breech lever *C*, and the breech could be closed before the carriage is clear of it. In order to prevent this, there is another bolt *T*, worked by the cover of the ammunition tube, and so fitted that it fixes the hand lever *C* of the breech as soon as this sliding cover is opened, so that the breech cannot be closed until the ammunition carriage has descended into the tube, and the door is closed.

(d) After the ammunition is placed the rammer is swung on its pivot into position, and held by a spring ; and in order to fix the ammunition carriage during the operation of loading, a chain *jj* is fitted to the rammer, led over rollers, and hooked to the lever *H*, and carrying a counterbalance weight to keep it in tension. Whilst the rammer is in the loading position the lever *H* is drawn to the left, and holds the lever *D* fast in the position "monte."

(e) After the operation of loading is completed, the rammer is swung back to its idle position, and lever *D* is freed.

(f) The lever *D* can now be placed at "descend," and the carriage lowered, and as soon as it is below the door of ammunition hoist, and this sliding door closed, the bolt *T* is withdrawn, and lever *C* freed.

(g) The breech lever can be placed at "ferme," and as the breech begins to close, the projection *w* turns the shaft *u* back again, and so frees the lever *B* of the elevating gear.

(h) Finally, the gun can be laid, and through the raising of the gun the stop bolt again takes in the recess of the breech lever *C*, and holds it fast, as well as the lever *D* of the ammunition carriage until the loading re-commences.