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Evening Meeting.

Monday, 7th February, 1870.

H. F. DOWNES, Esq., in the Chair.

NAME OF MEMBER who joined the Institution between the 31st January and the 7th February, 1870.

ANNUAL.

Hobson, Frederick T., Capt. 3rd Regt.

STEENSTRÜP'S CONICAL SCREW AND BREECH-LOADING CANNON.

By PETER JENSEN, Engineer and Patent Agent.

THE principal aims sought to be attained in modern ordnance are, "strength of construction" and "facility for quick shooting." The first is obtained by composing or building-up the ordnance; the second by breech-loading mechanism. Built-up cannon consist of an inner part or core of steel or iron, whereupon coils are shrunk.

It is of course of importance to form the greatest cohesion, as well between core and coils as between the coils themselves; but looking at the best modern examples of built-up guns, it will be observed that, were it not for the friction or cohesion between core and coils, there would be no cohesion at all, for the coils are not mutually joined, in fact, often have spaces of $\frac{1}{16}$ th of an inch between them after contraction and cooling; and the annular spaces thus formed round the core must always produce interruptions, which, however useful for the vibration, directly and seriously impair the strength. Such a construction is shown at *a*, in Fig. 1 (Plate xi). Could the coils be joined by screwing them together, by being formed as cylindrical screws, as shown at *b*, a greater cohesion, as in the direction of the axis of the cannon, would be attained, and also a somewhat greater transverse strength; but as the coil *c* must be shrunk on in a hot state, and while the coil *d* is cold, the expanded screw-threads of the hot coil *c* would not fit the cold threads on coil *d*, and their junction would not be so sure and exact as is desirable, while the transverse strength would be increased but

50 per cent. The inventor bearing this in mind, has therefore contrived a stronger means of junction by a conical screw, which he, as will be shown, also applies to the closing of the breech. At present we will point out how the principle is applied to the junction of the coil *e* (Fig. 1) to the core *k*, the coil *f* to *e*, the coil *g* to the coil *f*, and the coil *h* to the coil *g*.

As the conical-screw by reason of its nature, even with many threads, takes into the threads of, and gets into perfect contact with, its nut, after only say one and a-half turns, it will be seen that the heating and consequent expansion of the nut does not impede the complete junction of the screw and nut.

The following points may here be observed:—

1st. That the junction at *i i i i* becomes as perfect as possible.

2nd. That nearly the full transverse strength of the coil over the core from *m* to *n*, is obtained in contradistinction to what takes place at *a*; and that the vibration in the core is transferred to a dense, strong, and compact mass.

3rd. That the coils during the cooling and consequent contraction, pull the core together exactly in the right direction, against the influence of the powder-gas, while the contraction of the loose or unscrewed coils may take place in the very opposite, and consequently in a wrong or deleterious, direction.

If a stop-ring now be applied at *s*, then it will be seen that a longitudinally very strong junction of the core is obtained, and a very strong gun produced.

The turning and cutting of the conical screw offers no practical difficulties whatever.

Though it is a very easy matter to calculate the strength of such a conical screw by taking the collective areas at the base of the thread, the inventor had a screw made, as shown in Fig. 2. With an area of $4\frac{1}{2}$ square inches, exposed to a shearing strain, it withstood a force of 113,000 lbs., or more than 50 tons, without impairing the threads; with this force the bolt was torn asunder at *t*, but the nut was unscrewed with ease by hand, and its position, as marked by notches, had not altered.

The resistance of the screw against blows was next tried. It was put in the nut loose (without being screwed home), the nut was laid on an iron ring, and several powerful blows with a 100-pound hammer were struck on the protruding end of the screw, which in consequence got flattened as shown; the upper thread was even compressed, while all the threads in the nut were unimpaired, and the nut could be unscrewed by hand.

By calculation it is found, that the sectional area exposed to shearing strain in a coil-screw becomes so large that it about coincides with the limit of elasticity of the coil itself, and that consequently a corresponding amount of strength is gained in the longitudinal axis of the cannon.

The inventor considered these experiments as practical demonstrations of the strength and cohesion of the cone-screw; he then constructed a cannon in which the breech was closed by a conical-screw.

The drawings (Figs. 3, 4, and 5), show a 10½-inch breech-loading cannon of his construction, in half natural size. The model shows a 6½-inch cannon in one-fourth natural size; *a a* is the steel core of the cannon, *b b* the coils direct on the same, and joined by conical screws, and *c* is the conical screw closing the breech. This closing-piece rests with its neck or hind part, *e*, in the boss of a lever, *f*, movable round a fulcrum. The neck and boss fit each other, and form screw and nut of a pitch corresponding to the cone-screw, so that on turning the closing-piece one way or the other in the boss, the cone-screw may move concentrically and exactly in its nut, formed by the end or breech of the cannon.

When the closing-piece is turned one and a-half turns back, the cone-screw threads are out of contact with each other, and the lever *f*, along with the breech-screw, can be swung to one side, leaving the cannon open for loading. The projectile, which in the meantime has been placed in a cradle, on a lever, *g*, attached by a fulcrum-pin to the opposite side of the rear end of the cannon, can now with ease be inserted into the cannon by swinging the lever and cradle round, and after that, the powder-charge is inserted in a similar way; the cradle, with projectile or charge being just opposite the breech end, when its arm is swung home and stops against the breech. The breech screw is then swung in, and is then likewise in its proper position, without the cone-screw or nut being in contact before being screwed in.

The rear end, *k*, of the cartridge has a brass disc, with a collar and tightening disc of cardboard material, in the usual way, so that no powder-gas can escape into the threads of the breech-screw.

It must be particularly noticed that the construction or form of the screw threads, viz., with perpendicular sides where exposed to pressure, prevents any wedging or jamming against the threads in the breech; if the threads were the shape of an equilateral triangle, the case would of course be entirely different, and a very strong jamming action might be produced; as the now usual and approved method of preventing escape of powder-gas, as above described, will prevent any accumulation of dirt in the screw-threads, the breech-screw may in consequence be screwed home quite tightly, the same as is now done in the French breech-loading cannon; and it may at all times be screwed in or out with ease. The cradle on the lever, *g*, has got rifle grooves, corresponding with those in the cannon, if rifled, and the projectile and the cartridge will consequently always come in their right position in the cannon by the assistance of a short gauge rod.

The touch-hole, *v*, which is situated in the breech-screw, terminates at the centre of the cannon, so that central firing may be used, the brass plate on the cartridge having a central hole for the purpose. When the breech-screw is quite unscrewed, the touch-hole points downwards, and to prevent the insertion of the percussion-tube before the screw is quite home, a small, self-acting catch *p* (Fig. 6) is attached to the cannon, and has a hole through which the percussion-tube can only be inserted when the breech-screw is in that position.

The fulcrum pin, *t*, which carries the lever for the breech-screw has a small set or regulating screw for setting it up as it wears, thus always keeping the breech-screw central with the cannon.

The form of the breech closing-piece may be, as shown on the drawing, approaching the shape of the French system by Treuille de Beaulieu, or as shown on the model. The elevation mechanism may be of various constructions, for instance by rack and pinion. The closing-piece may be screwed into the breech by means of a double-handed lever, as shown by Figs. 3 and 4, or by a hand-spike or tommy, as on the model; and from experiments made with weights, as large as the closing-piece, it was found that one man was sufficient for executing the whole loading process and for firing a 10½-inch cannon when the projectile was put in its cradle.

To make sure that the closing-screw should not unscrew during the discharge (which the form of thread, it is thought, will prevent) a stop *h* (Figs. 7 and 8) may be added; but experiments made, seem fully to show the uselessness of such an arrangement. It will be clearly observed that the threads of the breech-screw fit into the core of the breech-piece and the outer coil, whereby a closer junction of the component parts of the cannon is established, and if the breech-piece be made the same as at Woolwich Arsenal, the strength will be increased. Against the possibility of dirt getting into the screw-threads, thereby causing a greater friction, there is provided a hole in the rear of the cannon, for admitting a tommy or rod; by inserting this and moving it a little, the screw is loosened immediately, as will be observed in the model.

On comparing the sections of the thread exposed to shearing strain in this conical breech-screw, with those in Sir William Armstrong's breech-loading gun, and with those in the French system (Treuille de Beaulieu's), where half the thread is cut away, it will be found that this cone-screw is quite as strong as the one of Sir William Armstrong's, and double that of the French breech-loading cannon. Looking at the few parts this breech-loading mechanism consists of, the ease with which it can be worked, and the quickness with which the loading and firing is done, it is clear that at least double the number of discharges can be obtained in comparison with a muzzle-loader. The other advantages appertaining to breech-loaders in general, compared with muzzle-loaders, are too well known to need any enumeration here. It may be added that in the author's opinion no system offers such great advantages for breech-loading, if a thorough efficient one could be found, as that of Captain Moncrieff.

Taking the calculation and experiments on the strength of the cone-screw as a base, we may safely say, that this breech-loading mechanism may be advantageously applied to every old cast-iron cannon, converted according to Major Palliser's system; and that cast-iron new guns, cast on Rodman's principle, with core right through, lined with Major Palliser's coil tube, and having this cone-screw as a closing for the breech as described, would be at the same time very cheap, strong, and give quick firing.

In conclusion, it is contended that the breech-loading mechanism, as just described, will find ample application, because of its strength, sim-

plicity, and ease of manipulation, and last, but not least, because the whole mechanism is entirely exposed to view each time of loading.

The CHAIRMAN: Is the base of the cartridge of metal or of pasteboard?

Mr. JENSEN: Of pasteboard. There is a brass plate as well. The cartridge is made on exactly the same principle as those in use at Woolwich.

Captain BURGESS: Is the brass-plate blown away with the cartridge?

Mr. JENSEN: It is blown away with the cartridge, I believe; but upon that point I must confess I am not quite at home; only I know this much, that Mr. Steenstrup recommends exactly the same cartridge, with a disc on it, as is now used at Woolwich.

The CHAIRMAN: Can the breech-screw be easily worked?

Mr. JENSEN: Very easily. Only knock out this pin (showing the process with the model) and it is done. I have already shown the utility of the breech-piece. It is one entire piece. It has a screw here, which corresponds with this nut, and the whole is moved by a lever. On pushing the breech-piece in, and giving it a turn and a half with the lever, the breech is entirely closed. If at any time the breech-piece should jam, there is a contrivance here which puts a powerful leverage on this part, which at once loosens the screw, so that you can unscrew it with the hand. But there is very little or no chance of jamming in consequence of the peculiar form of the thread of the screw. The threads are vertical at the back, instead of being oblique as in the ordinary screw. The consequence is, that the pressure from recoil is carried straight against the back of the thread, instead of being carried in an outward direction, as in the ordinary screw; and thus jamming is prevented. You perceive how easily the breech-piece works. I close the breech with the lever as hard as I can, and yet, by simply giving it a tap, it is so loose that I can unscrew it by hand. The objection to many breech-loading cannon is, that the most important part of the mechanism is never exposed to view, so that dirt may continually accumulate, until at last you come to a dead stop, and you have to apply a very heavy force to get the gun put to rights. But in this gun the whole of the mechanism is exposed to view each time of loading. If there is any dirt, you can wipe it out. For instance, compare it with the cannon that has lately been brought out by Captain Stuart on an extremely simple principle, yet the most vital part of the mechanism is always closed up, namely, the ball which is inside, and any dirt accumulating there would necessitate taking the whole thing to pieces, a process which takes time; whereas here the whole of the mechanism is each time exposed to view. I may add that the Norwegian Government has thought well to adopt this principle, and they are now building some guns on it. As soon as the thing has gone so far that I can lay experiments before you, I shall be most happy to do so.

The CHAIRMAN: Has a gun on this principle been tested by firing?

Mr. JENSEN: I understand Mr. Steenstrup has made a small cannon, and found it very efficient. But the main thing is to try it on a larger scale, which he is now about to do.

The CHAIRMAN: Perhaps Mr. Forbes will tell us what he knows about the gun.

Mr. FORBES: I did not expect to be called upon at all. There is very little I can say. I know Mr. Steenstrup personally, and that he is an able mathematician. But this is the first time I have seen the model of the gun itself. I should not, therefore, like to venture an opinion upon it.

Captain BURGESS: I should like to ask how the iron rod, with the conical-screw and nut on the end of it (Fig. 2), was tested. Was the weight of 50 tons dropped or lifted?

Mr. JENSEN: It was lifted by means of a ring resting on the nut. The 50 tons weight broke the rod, as you see. But when it was examined afterwards, it was found that the nut was quite loose, showing that there had been no compression, not sufficient compression on the screw thread to injure it. In fact, you can by induction see that it could not be injured, because if you take a common screw, such as is in use every day, and turn it down to the bottom of the thread, it has been found by experiment that if you have a nut of the same depth as the outside diameter of the thread across here (showing), then that thread

is just as strong as the bolt itself. If that bolt will break with 10 tons, or 50 tons, or whatever the weight may be, it will take as much to strip the screw threads, for they are just as strong. But if you make a cone-screw, you have the whole of these areas very considerably larger in proportion to this smallest area than in this case, so much so, that a cone-screw of the dimensions given there, the strength of these threads together is, I should say, upwards of 50 per cent. more than the strength of such a screw as that, the diameter of the unscrewed part being the same in both cases.

Captain BURGESS: Was the weight applied at once, as a mass of 50 tons, or was it put on gradually?

Mr. JENSEN: It was put on gradually; but, as remarked in the paper, the cone-screw was also tried with blows. Heavy blows with a 100lb. hammer were applied to the top of the screw, tending to force the screw through the nut and injure the threads. Instead of doing that, it did not injure them at all. It flattened the upper thread, as you see. You see that it has been handled very roughly, but the threads in the nut were not in the least injured, so much so, that the nut could be unscrewed by hand afterwards. So this cone screw is just as much stronger than the ordinary screw, as the area of all these threads is larger than the areas of the thread in an ordinary screw. Because if we compare two screws, one with the ordinary thread, the other with the cone thread, the plain or unscrewed part of which is equal to diameter at bottom of the thread at the small end of cone, you can see that the width of thread at its base times the total length or circumference of the same, which constitute the whole of the area exposed to the shearing strain, is very much larger in the cone-screw than it is in the parallel screw. You have the same number of threads here that you have there; but here you have a diameter very much bigger at its largest end than there; consequently, the total thread circumference, and hence the total area exposed to the strain, is so much larger here than it is there. If 50 tons will break that bolt, 50 tons will also break this bolt. But if this nut, for instance, is a little less than the diameter, 50 tons will pull the screw through the nut with the parallel thread; but 50 tons there will not do the conical thread the least harm, because the whole area of these threads is so very much larger than the whole area of all the threads in the parallel screw.

Captain BURGESS: Could you tell us whether Mr. Steenstrup ever tried letting a weight fall along the bar upon the cone-screw—the weight falling through a certain space. I believe that is how Major Palliser tried his plus-screw. A gradual drawing strain is different from a violent blow.

Mr. JENSEN: Just so; but Mr. Steenstrup put it to a more severe test than that, because he had a man hammering away at it with a 100 lb. hammer.

Captain BURGESS: I do not mean testing the screw with a hammer, but with a weight of 50 tons falling through space.

Mr. JENSEN: I believe not. But it stands to reason that this screw must be stronger than the ordinary screw, and still stronger than the closing screw in the French gun, in which, you are aware, half the area of the threads is cut away, and therefore you lose half the strength, and you must make up for that by making the screw so much longer, whereas here you can do with a very short screw, because it is so immensely strong.

Captain BURGESS: May I ask what is the difference in length of the threads in the cone-screw and those of an ordinary longitudinal screw?

Mr. JENSEN: I do not know exactly; but I should say nearly double the area and double the strength. The easiest way to get it is to take the mean of the diameter in the middle of the length of the screw, here and there. I should judge this diameter is very nearly double that diameter, but really I think that the cone-screw is shown longer on the drawings than there is any occasion for, because the strength of it is so much greater than the strength of the straight screw.

Captain BURGESS: The plan of grooving the cradle for carrying the shot appears to me exceedingly ingenious, because the shot finds its groove in the gun at once.

Mr. STEPHEN: Will you kindly show the revolution of the lever in closing the screw. You have shown it once, but I do not think it is quite understood. Your hand appeared to take more than one turn.

MR. JENSEN: No. You see this handle now stands horizontally. That is one turn, and that is half a turn (showing). In closing the gun, one turn and a half is required. Of course, the form may be varied. The cone of the screw may not be at all times exactly like that. It may be varied according to circumstances. In a very large cannon, I should think it would be advisable to have it somewhat more conical, so as to make it work more easily; whereas, in a small cannon, the screw might be very much more straight, and still work so easily that one can have perfect control over it.

THE CHAIRMAN: Can the pin that attaches the breech-piece to the cannon be taken out by hand?

MR. JENSEN: No; I do not think it ought to be so easily taken out as that, because it would be liable to fall out.

THE CHAIRMAN: But supposing, in case of a retreat, you have to leave a gun, by taking that breech-piece away, you would disable it.

MR. JENSEN: Certainly. That, no doubt, may be made so as to unscrew in a moment. That is a point which, of course, can be carried out in many different ways.

THE CHAIRMAN: I have seen a similar arrangement in another gun. The men take the breech-piece with them, and the tube is of no use to the enemy.

MR. STEPHEN: I think there can be no doubt with regard to the strength of the sectional area of the threads. That is an established fact by Whitworth; that is the rude principle upon which he established his measurements. But those are with the double-bevelled screw, while these have one flat side. Do you consider that gives additional strength, or does it only prevent the tightening by the concussion? Has it an advantage beyond that? I quite see that it does away with tightening by concussion; but has it any farther advantage than that? Do you think it adds at all to the strength of the screw?

MR. JENSEN: No; I do not think it adds at all to the strength; it makes no difference at all. As long as you have the same strength across from here to there (pointing to the base of the thread) as you have from here to there, it matters not at all whether you have both sides conical, or one side conical and the other straight, or have a square thread. It all depends upon the width of base. In some cases I think Mr. Steenstrup proposes to have square threads.

MR. STEPHEN: He could give them all the same depth at the back, and half in the front.

MR. JENSEN: Instead of making them go off to a sharp edge there, he might make them more like that (showing on the black board), with a flat or rounding at the apex.

THE CHAIRMAN: Then would he not lose a certain area?

MR. JENSEN: He would lose that area there; but I think he might take some of the point off, because it is not very advisable to have them come up to a sharp edge, because they might be damaged if anything knocked against them. I do not know that I have dwelt upon the point of the strength of the gun. If you compare that kind of jointing the coils, as shown at *a a*, Fig. 1, you see that there is really no junction at all, because each coil is independent of the other; there is no cohesion between them. If you compare that with this mode of joining, as shown at *g g g g*, Fig. 1, you will see that the whole of the gun is tied together so powerfully that it forms one mass, whereas in that, each piece is independent of the other.

CAPTAIN BURGESS: In the Woolwich guns I believe the coils are hooked over one another. They do not simply abut one against another.

MR. JENSEN: Yes, they are; but it does not give any better joint. They are hooked one over the other, in that way (showing); but I do not see how you can get a good joint unless you screw them together. The whole process is to heat one coil when you want to put it on, and just push it up against the adjoining coil: all the junction you get is just none at all, because if there is no screw to the joint, there is no joint at all, especially if the subsequent contraction on cooling draws them asunder. It gives a certain amount of weakness, which, as mentioned in the paper, may be well enough to some extent, to prevent vibration, but certainly at the expense of strength and cohesion. One would think that Mr. Steenstrup's mode of joining

would be very much stronger. With the conical screw, all you have to do is to turn it a turn, or a turn and a half, according to the cone you have, and that can be done so quickly that it can take place before the coils get at all cool. If you join them together with a straight screw, you would have to turn it half a dozen times before you could get it joined thoroughly, whereas here it is done in a moment. The coils are heated; they contract when cold, and fit the core tight. If you shrink one coil upon another, and you put it in the lathe and turn it, you cannot see the joint; it is so tight that you can only, by getting it up with a very fine surface, detect that it consists of two pieces. I mean, supposing that to be a section of one coil shrunk upon the other, if you were to turn that in the lathe, you cannot see that line at all; it shows like one mass; it is only by polishing it up that you can at all detect that there is a joint. So the system of shrinking it on makes it very tight, indeed it forms like one mass.

Captain BURGESS: I wish to mention that when Mr. Steenstrup, who is the Chief Engineer of the Royal Norwegian Navy, was over here, he showed me several letters from the manager and foremen in Sir William Armstrong's works at Elswick; they spoke in high terms of the cone-screw.

Mr. JENSEN: He showed me the same, and they certainly spoke of it in the highest terms. He had some from the manager, and some from the foremen, and they all said they had never seen anything like it. The simplicity of it, the strength of it, and the thorough workman-like and mechanical way in which the principle was carried out, was something they had never seen before; and they were Sir William Armstrong's people.

The CHAIRMAN: Is the shape of the thread of the screw novel?

Mr. JENSEN: This system of cone-screw is not new; it has been known for years. But the novelty in this case is its application in this particular way. It so happens that now-a-days very few things are entirely new. But it is new so far as to be a novel application, and a novel combination of mechanical parts, each of which may have been known before.

The CHAIRMAN: The guns with the cone-screw breech have not been tested on a large scale yet?

Mr. JENSEN: Not yet. The Norwegian Government are making several guns, and I hope to be able to give you the results of experiments in due time. But the matter moves very slowly. I understand from Mr. Steenstrup that it has to go through Committees; and money is not so plentiful there as it ought to be in such matters. Things are done economically and slowly; consequently he is not so well situated as he would be in this country.

The CHAIRMAN: We are very much obliged to you, Mr. Jensen, for the explanation you have given us of this invention, and I beg to convey to you the thanks of the Institution.

Mr. JENSEN: Allow me to thank you very sincerely for the very kind compliment you have paid me. You will be pleased to remember that my part is very small indeed. I have translated the paper, and tried to explain it in the best way I could. I shall have much pleasure in telling Mr. Steenstrup of the very courteous and polite way in which his paper has been listened to.

The CHAIRMAN: You will communicate to Mr. Steenstrup how much obliged we are to him for the paper you have read?

Mr. JENSEN: With pleasure.