# 1/72 WEAPON SYSTEM
# (PNUEMATIC OR MECHANICALLY OPERATED LAUNCHER)
**by David D Merriman III**

***WARNING: Do not attempt, for any reason, to charge a weapon off-launcher. The torpedo tube serves as a containment to protect personal and property from shrapnel should a weapon cook-off (explode) for whatever reason. Only charge the weapon while it is safely contained within its launcher.***

A torpedo is a self propelled underwater missile, be it guided or unguided. A missile requires a launcher to support and contain it on or within the launching platform. In this case, the launching platform is a model submarine. The launcher projects the weapon in the proper direction clear of the launching platform. The launcher is half of a weapons system. The torpedo, referred here as the weapon, is the other half of the weapon system.

However, before going any further, I must acknowledge the innovative and important work of Mike Dorey, Ron Perrott, and Gene Berger have done in this field.

These men stand out as the early pioneers of gas jet propelled model submarine weapons. Mr. Dorey identified a source of readily available air-brush propellant as the motive power for the weapons. Mr. Perrott came up with some very sound weapon-launcher interface ideas – enhancements Ron's concepts resulting today in a launcher that almost never suffers miss-fires (unintentional launch) and very few hang-fires (failure to launch) and, to date, not one single cook-off (catastrophic failure of the weapons structure due to pressurization with propellant) incident. And Mr. Berger must be credited with the development of the mass production techniques that have significantly reduced the cost of weapon manufacture.

So, for the record: what I've come up with here is a refinement of several good ideas. Ideas authored by others. My systems functionality and reliability represents my efforts and very much the efforts of the above Craftsmen and others unmentioned. What stature I've secured in the field is because I've been able to stand on the shoulders of other Craftsmen.

For over twenty years I've worked on the problem of designing and building a practical launcher-weapon system suitable for use aboard my model submarines. It was a long, difficult road: Launchers that failed to retain the weapon reliably; weapons that leaked their supply of liquified gas; over-weight launcher sub-systems that could not be compensated for when installed within the model submarine – just a few of the many problems that had to be identified and addressed before a successful system was realized. My work progressing in parallel with that of others. We shared what we learned and the Craft advanced.

Interestingly, the only design element of the system presented here that has not seen radical change is the form of weapon propulsion. From the start I settled on the rocket principle; the weapon thrust forward as a consequence of the reaction principle – an amount of commercially available liquefied gas is the propellant. The pressurized liquid expands into a gas at the moment of launch, the instant the nozzle is clear and the contents of the weapon experiences a drop in pressure. That gas exits the weapons nozzle at a relatively high velocity, producing the reactive 'kick' that thrusts the torpedo forward, out of the launcher and into the open water.

There are any number of propulsion options that can be employed to drive the model torpedo through the water: Electrical or elastic band cranked propeller(s); elastic bladder water-jet; solid propellant gas jet; kinetic (think: bullet); and the 'cold gas' jet. Complexity, weight, and cost had driven me to settle on the use of the later form of jet propulsion aboard my weapons.

Commercially available air-brush propellant is what I use. Propellant is typically a Methane-Butane mixture (there are other, non-hydrocarbon substitutes that work equally well) that is transferred between the storage can and weapon via charge fittings on the can and at the stern of the launcher.

# THE WEAPON SYSTEM

Congratulations on your purchase of this weapon system. Included in your package are three weapons, a loading ram, pneumatic shuttle, and launcher. Spare parts are provided, they include breech-block O-rings, flexible hose, stop-bolt ball, setscrew, hose retainer, stainless steel locking-ball, a length of .008-inch wire bore-cleaner, and washer.

**Weapon Sub-System Functional and Physical Description** The weapon is propelled by the discharge of propellant gas through a nozzle at the weapons stern. A small amount of propellant liquid is injected, under pressure, into the weapon during the charging operation. This is an operation that can only be done with the weapon secured within its launcher. As long as the propellant is pressurized within the weapon (that pressure proportional to the temperature of the system) it will remain in the liquid state. At the moment of launch, when the breech-block is pulled away from the weapons nozzle, the sudden drop in pressure within the weapon causes the liquid to boil off as a gas. That rapidly expanding gas ejected through the weapons nozzle, producing the thrust needed to propel the weapon out the tube and through the water.

Four stabilizing fins at the stern of the weapon are canted to induce a left-hand roll to the weapon as it travels through the water. This helps to maintain the weapon on a straight track during the majority of its run. At the end of the run the weapon will typically circle to the left in a tight pattern on the surface, making location and eventual recovery of the weapon an easy matter.

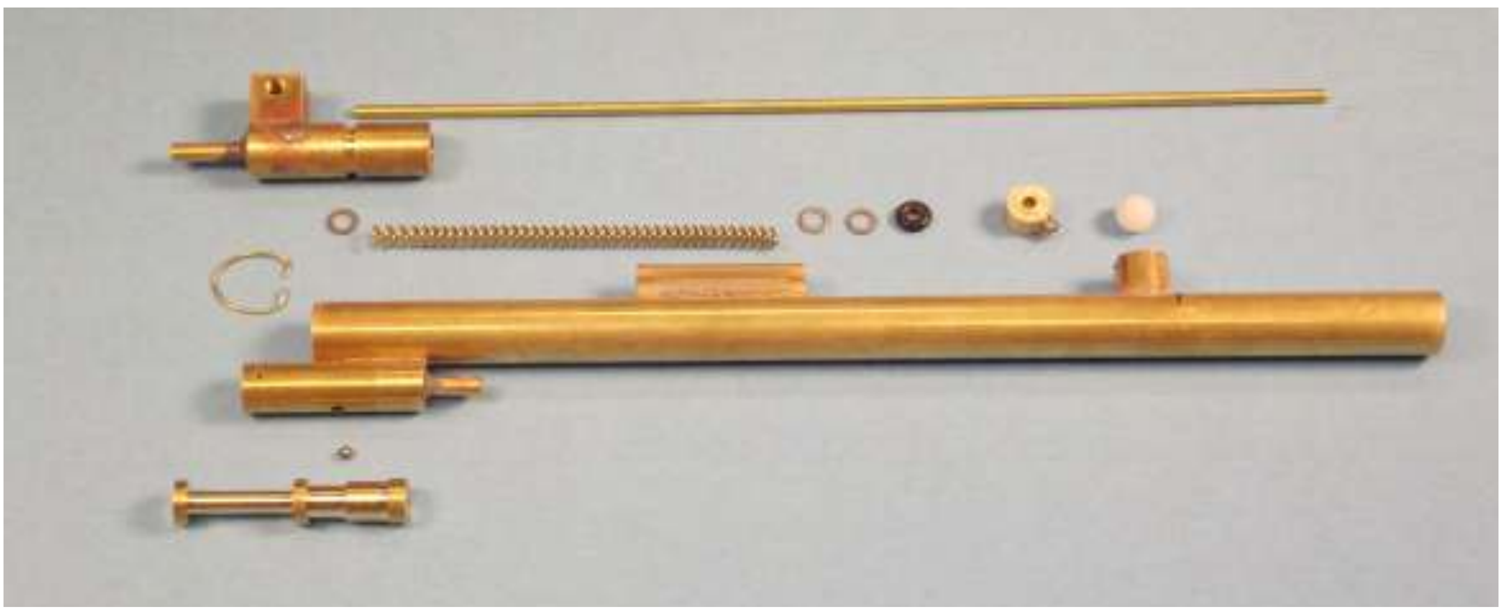
The weight of the weapon with its charge of propellant is very close to the weight of the water displaced by the submerged weapon – this accounts for the nearly negligible change in model submarine trim, with or without the charged weapon aboard. Run the submarine with or without the weapon(s) aboard and the boat will possess the same overall weight. Submerged model submarine trim will not be disturbed when weapons are loosed. No weapon compensation measures are required when using the Caswell-Merriman weapon system.

The weapon is fabricated from polyurethane resin. At the after end of the aluminum nozzle tube a .008-inch orifice forms the nozzle throat where the ejected gas begins its expansion through the divergent nozzle. The orifice is sized to produce just enough thrust to move the weapon along at a good pace without compromising range adversely. Typical range is between 10 and 20 feet with a single 'shot' of propellant. But, longer range is possible by chilling the weapon, an operation explained in detail later.

Now, as to any specific type of weapon you may wish to represent: the three weapons in your package arrive painted to represent a world war two era 'steam' powered torpedo. Old school. However, a fair representation of other type weapons can be achieved simply by painting the appropriate colors and applying specific markings that are unique to the type weapon you wish to represent. If you do elect to re-paint your weapons, insure that the paints, markings, and clear-coat chemistry are compatible to the hydrocarbon environment. You don’t' want any blow-back propellant stripping of your nice, new paint job!

As you can see below, the weapon is a hollow torpedo with a single aluminum nozzle tube within and projecting out its after end. The forward end of this tube forms a stand-pipe which only permits entrance of propellant gas, but no liquid. When charged with a shot of liquid propellant the weapon is nearly neutrally buoyant in the water. At the end of run, the propellant expended, the weapon is positively buoyant; it floats on the water, greatly aiding its recovery for re-use.

**Launcher Sub-System Physical and Functional Description** The launcher is a brass mechanism that houses, holds fast and provides for the charging of the weapon. The launcher releases the weapon on command, and as it does, it provides a shot of quickly expanding gas – contained within the flexible hose and breech-block – to the stern of the weapon, ejecting it at a considerable velocity.



The launcher is normally in one of two conditions: Ready to launch, referred to here as the BATTERY condition. Or, the launcher is in the LAUNCHED condition. The launcher can be in any of these two conditions with or without a weapon in the tube. With the launcher in the battery condition, with a weapon in the tube, the weapon cannot be removed. With the launcher in the battery condition, and empty, a weapon cannot be loaded until the launcher is cycled to the launched condition. A weapon in the launcher cannot be charged with propellant unless the launcher is in the battery condition.

It is the position of the breech-block and stop-bolt ball – the two working in unison through the interlink rod – that dictates which of the two conditions the launcher is in. The launcher is in battery when the breech-block is forward and the interlink rod pushes the stop-bolt ball down blocking forward motion of the weapon within the launcher. The launcher is in the launched condition when the breech-block is fully aft and the stop-bolt ball is free to rise up into its housing, freeing the weapon for forward travel.

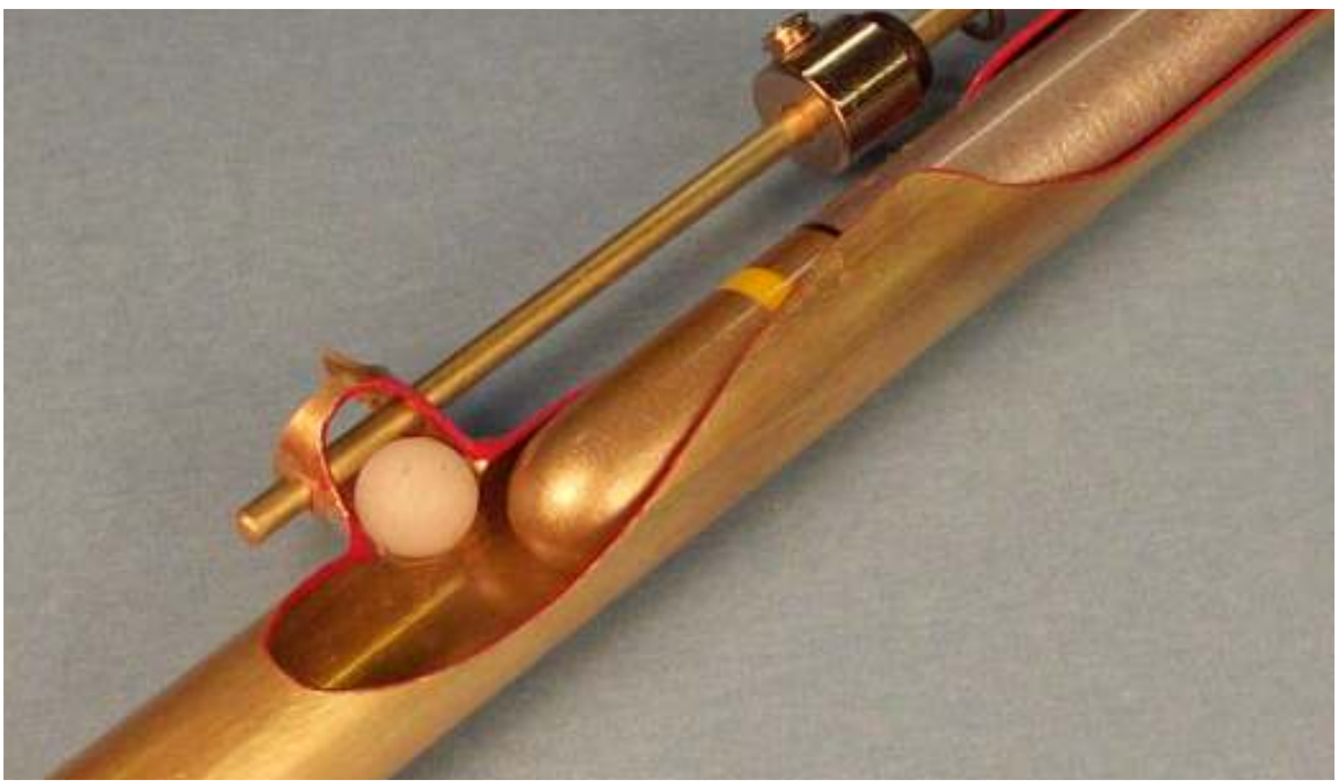
With the empty launcher in the launched condition, a weapon is introduced through the muzzle (forward) end of the launcher. The weapon is pressed home with the aid of the loading ram, the stabilizing fins of the weapon making contact with and kept from further rearward movement within the launcher by the weapon back-stop. As the weapon is held fast with the loading ram (very little force required here), the launchers breech-block is moved forward by applying thumb pressure, compressing the breech-block spring. When the breech-block is at the battery position, the shuttle button is pressed forward (pneumatic mode) or pulled back (mechanical mode) to lock the launcher in the battery condition. The weapon is ready for charging.

As the weapon was placed into the launcher and the breech-block moved forward, an O-ring within it girdled the weapons nozzle, forming a gas-tight seal between breech-block and weapon nozzle. That union established, it is then possible to make a transfer of propellant through the charge fitting (a modified tire-valve) at the after end of the launchers flexible hose.

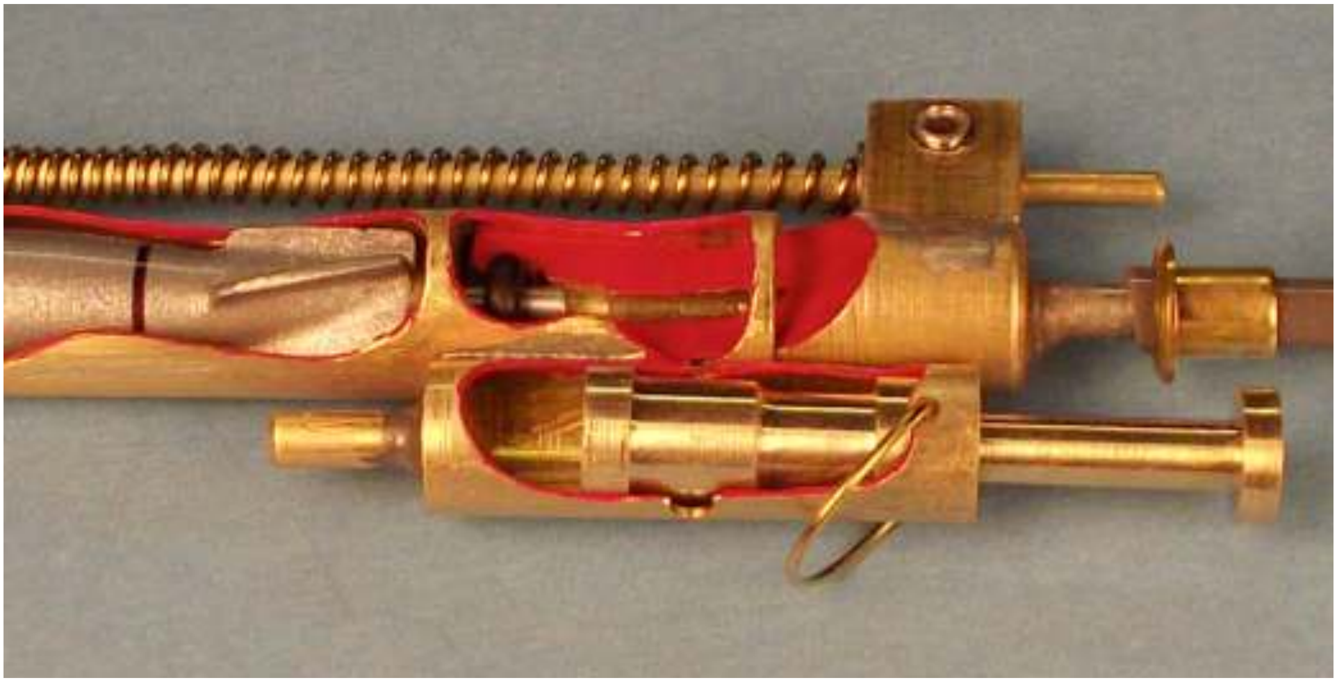
A standard Caswell propellant charging adapter, made up to a can of airbrush propellant, is required to make propellant transfer through the launcher charge fitting.

With the launcher at battery, there is no way for the weapon to leave the tube because of the stop-bolt ball preventing forward movement of the weapon. The weapon back-stop (soldered within the tube, just forward of the breech-blocks front end) prevents rearward motion of the weapon.

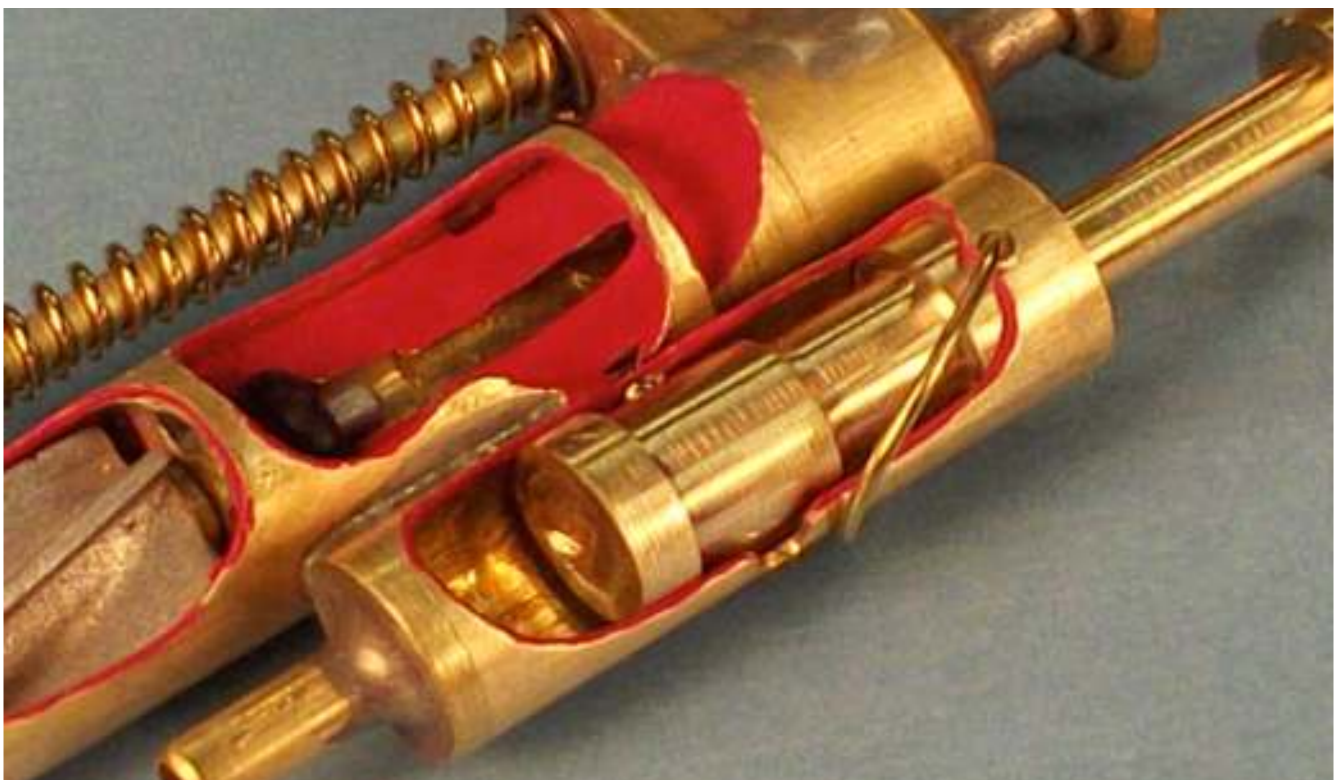
Below is a cut-away launcher in the battery condition, showing the weapon retained against forward motion by the stop-bolt ball. Note how the interlink rod pushes the stop-bolt ball down into the bore of the torpedo tube, blocking the weapon from forward travel. This feature prevents miss-firing of the weapon.



Note that the weapons nozzle makes a gas-tight union to the bore of the breech-block by the breech-block O-ring. The weapon can now be charged with a shot of propellant.



The photo below is a better look at the stainless steel locking-ball that holds the breech-block and stop-bolt ball elements to the battery condition. In turn, the locking ball is controlled by the shuttle beneath. When the shuttle moves in the desired direction it drops the locking-ball clear of the breech-block, permitting spring pressure to transition the launcher from battery to launch condition.



**Launcher Mode Selection** The launcher can be configured by the user to operate in one of two modes through the installation of a shuttle within the actuator housing. The mechanical mode of operation requires the physical movement (typically through a linkage connected to a dedicated servo) of the shuttle to cycle the launcher to the launched condition. The pneumatic mode of operation requires the application of actuator gas to the nipple at the forward end of the actuator housing, that gas acts on the piston side of the pneumatic shuttle to transition the launcher to the launched condition.

Removal of the actuator housing spring-clip, swap out of the shuttle, and re-installation of the spring-clip are the only tasks needed to change the operating mode of the launcher.

The launcher arrives to you with the mechanical mode shuttle installed. If you wish to convert over to pneumatic mode, simply swap out the mechanical for the pneumatic shuttle, and you're in business. Before installing the pneumatic shuttle, first slather its forward end with plenty of silicon based grease.

Also, whenever filed-stripping the launcher or changing out a shuttle, insure to identify, remove, and put in a safe place the tiny stainless steel locking-ball – it's very easy to loose!

Only at the moment of launching, when the shuttle is moved (permitting the breech-block spring to shove the breech-block aft, and through the interlink rod, releasing the stop-bolt ball) is the weapon free to leave the tube.

The below photo shows a cut-away launcher in the launched condition: the breech-block has been shoved back by the breech-block spring. That action, through the interlink rod, freeing the stop-bolt ball to move up into its housing, out of the way of the weapon. The instant the weapons nozzle clears the breech-block O-ring, residual propellant within the flexible hose and breech-block bore flashes to gas, ejecting the weapon from the launcher.

The launcher is designed for easy, basic dis-assembly (field-stripping) should the need arise for adjustment or repair.

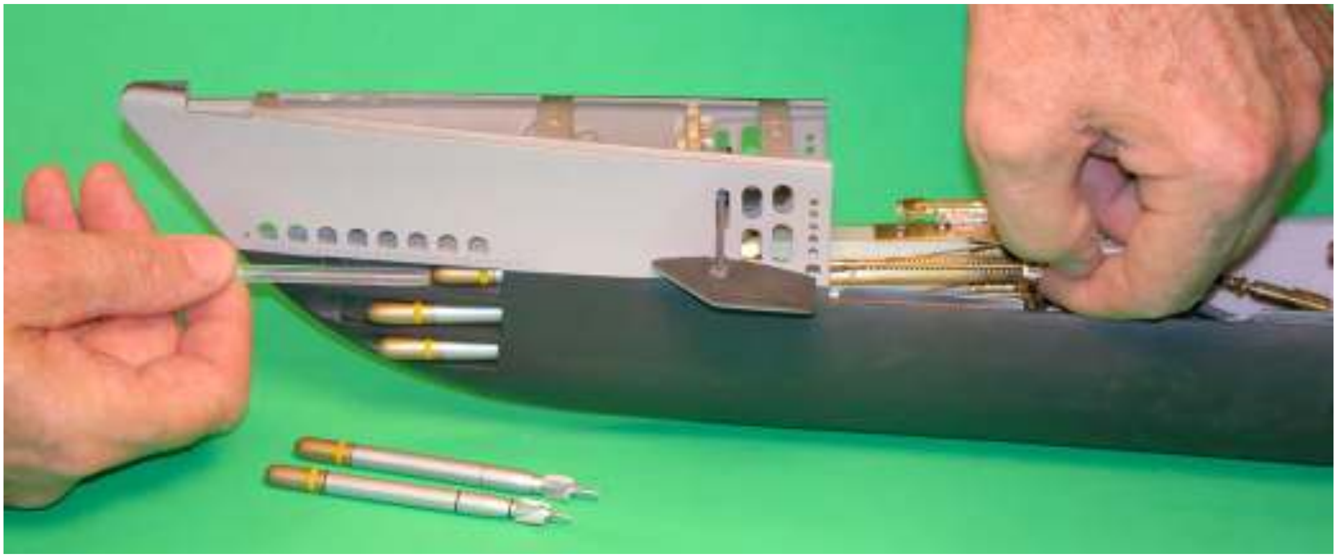
# WEAPON LOADING INTO THE LAUNCHER AND CHARGING

The cycle of operation of the weapons system goes like this: load the weapon into the launcher; set the launcher to the battery condition; charge the weapon with propellant; get the model out into the water, submerged and on the hunt for targets; and at a depth of three hull diameters or more launch a weapon; recover the weapons and the model submarine; and repeat the cycle.

I find it best to make the entire launcher nest one big, removable assembly – this permits you to do all the maintenance and loading chores without having to work your fat fingers within the tight confines of the models hull. Later I'll show you how I did that for the bow nest that fits within my 1/72 Revell GATO model submarine. This is the preferred method for model submarines depicting hulls of narrow beam. You'll find that the modern hull designs of today, with hulls wide enough to permit all operations on the launcher to be performed with the launchers fixed in place. I'll carry on this discussion assuming that you will be working the launchers as they sit in the hull.

**Loading the Weapon** Apply a small amount of silicon grease to the outside of the weapons nozzle tube, take care not to get any grease into the nozzle itself or there is the likelihood of the grease being driven into the .008-inch throat of the nozzle during the propellant charging operation, fouling the throat.

With the launcher in the launch condition – breech-block fully aft and the stop-bolt ball clear of the tube bore – place a torpedo into the muzzle of the launcher, rear end first. Finish pushing the weapon into the tube with the supplied clear plastic rod loading ram until the backside of the weapon makes contact with the weapon back-stop. From within the model submarine (the upper hull removed to afford access), with a finger or thumb, push the launchers breech-block forward and position the shuttle to lock the launcher in the battery condition (shuttle forward in the pneumatic mode, shuttle aft in the mechanical mode). Remove the loading ram.



**Charging the Weapon** The system is so designed that you cannot charge the weapon off-launcher. If the launcher is wet from recent immersion, insure that you blow out the little bit of water trapped within the face of the launcher charge fitting – failure to do so will result in water being driven into the system plumbing during the charging operation, where the water may flash to ice crystals as the propellant undergoes its state change at time of launch. Such ice may find its way into the nozzle tube, plugging the throat of the nozzle during the run, severely reducing the weapons range.

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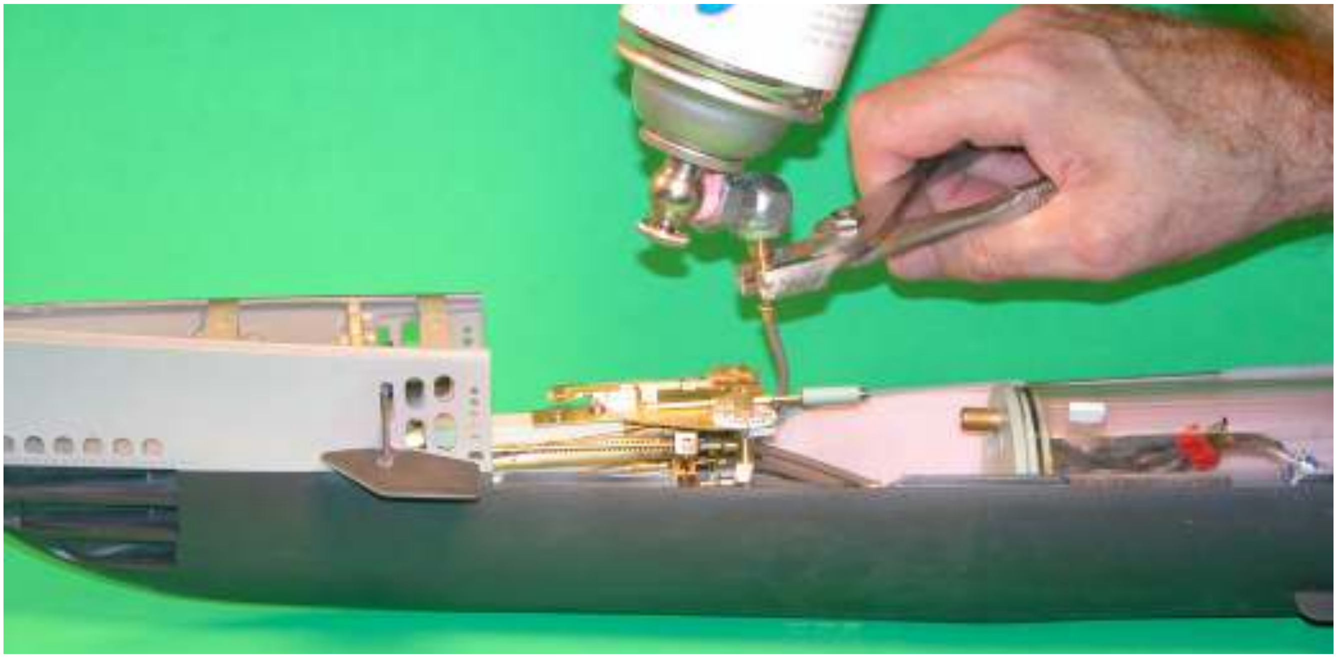
With a weapon secured in its launcher you then introduce a charge of propellant into the weapon and launcher through the charge fitting located at the after end of the launchers flexible hose.

***CAUTION: The propellant can is outfitted with a propellant charging adapter, that item terminating in a tire-valve air chuck. When the air chuck and launcher charge fitting are firmly pushed together the transfer of propellant occurs. You'll want to take care to perform this operation quickly or you'll waste propellant through the leaky union. Excessive leaking of the quick boiling propellant can give you a cold burn if too much propellant gets on your hand.***

As the internal tire-valve of the charge fitting unseats, so does the check-valve within the air chuck of the propellant can charging adapter. Unseating those two check-valves permits the free passage of pressurized propellant liquid (the propellant can is inverted during the charging operation) from the can to the weapons cavity and bore of the breech-block where the pressurized propellant remains in the liquid state until the moment of launch.

A single shot charge into a room temperature system introduces enough propellant to produce a 15-foot or so range after launching. Now, if you wish to increase the range to about 30-feet, you need to chill the weapon and propellant charging path, this in order to decrease their thermal energy. The higher the thermal energy disparity between the weapon system and propellant can, the greater the amount of liquid transfer achieved before the energy between the two equalizes, stopping the exchange of propellant. You do so by first charging the system, then quickly unseating the tire-valve of the charge fitting, dumping the small quantity of gas initially placed within the weapon system, and charge the system again. This time you more than double the amount of propellant injected into the weapon and launcher.



It's a good idea to hold the launcher charge fitting with the aid of pliers – this to prevent cold burns should too much liquid propellant spill by the charge fittings as liquid is transferred from can to weapon system.

## LAUNCHER INSTALLATION INTO A MODEL SUBMAIRNE HULL

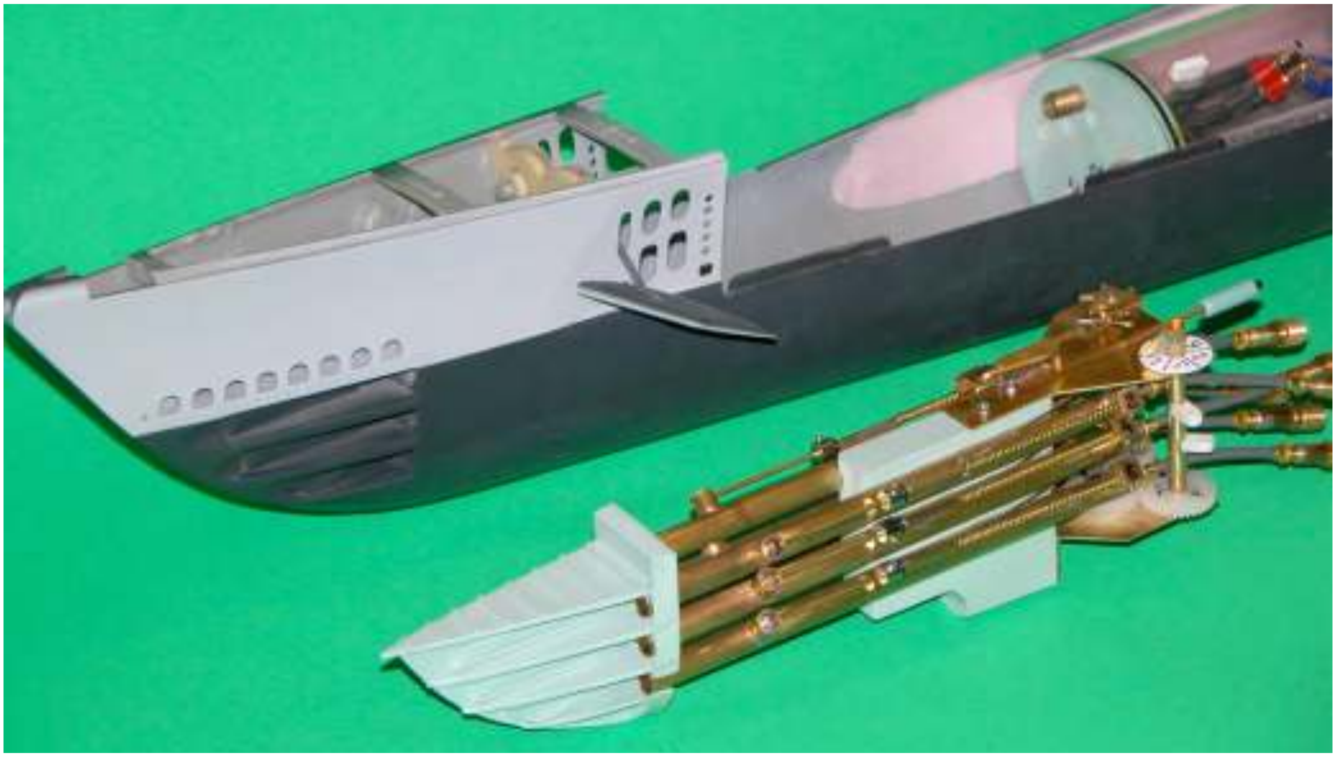
There is a reasonably large number of 1/72 model kits representing submarines that are suitable for conversion to r/c operation. These kits fabricated from either hand laid-up fiberglass (GRP) or the more traditional polystyrene injection formed plastic model kits.

The 1/72 submarine kits available to us today that can be outfitted with our weapon system include: ALFA, TYPHOON, ROMEO, KILO, FOXTROT, GATO, STURGEON, THRESHER/PERMIT, new SEAWOLF, SKIPJACK, COLLINS, I-53, old British K and M class, Type-23, Type-7, and Type-2. There may be other 1/72 scale model submarine kits I'm unaware of out there as well.

How the tube muzzle ends project into the water, and specifically how the bow (or stern, if we're talking the stern nest) of a specific class of submarine is configured is of vital concern to the careful kit-assembler and scratch-builder. The objective is to incorporate the same elements into your model display as are observed on the prototype. We're talking SCALE FIDELITY here, boys and girls! Your goal is to represent open torpedo tube muzzle and shutter doors that provide both the correct scale-look and will not interfere with the launching of a weapon.

More likely than not your model kit will not have the parts to represent the torpedo tube muzzle doors and associated shutter doors in the open position. It will fall on your shoulders to make your own scale looking doors and to integrate them into the models bow and/or stern. The below shot shows the work I went through to create a resin shutter and muzzle door assembly that represents all six of the Revell 1/72 GATO model kits bow muzzle and shutter doors in the open position. A painted unit has already been installed into the model. In foreground we see an unpainted GATO shutter door assembly fit to the muzzle end of the GATO bow launcher nest.

Incidentally, all these parts are now standard in our GATO fittings kit – a product offered to those wishing to convert the Revell GATO plastic model kit into a practical r/c vehicle. For all other projects, break out the research material and tools, you're in for a hell of a time working this sort of thing out for your specific model. Have fun!

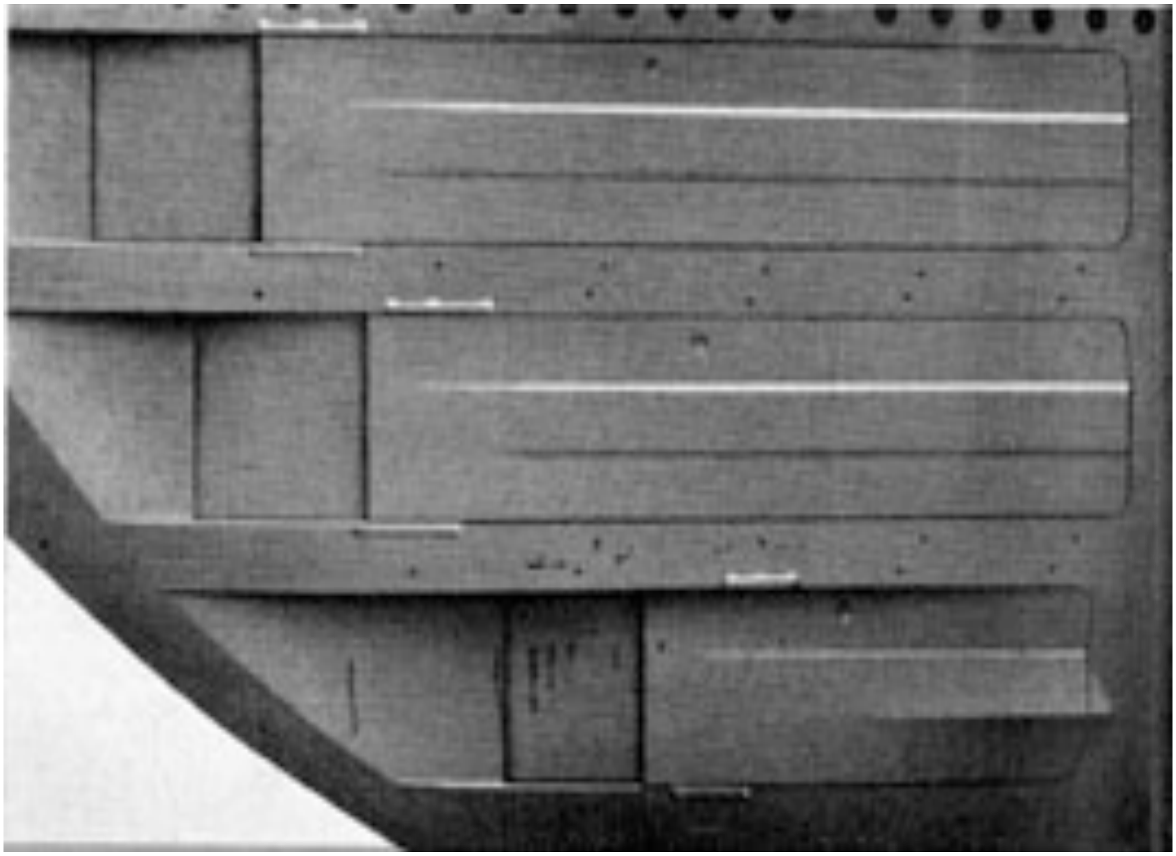


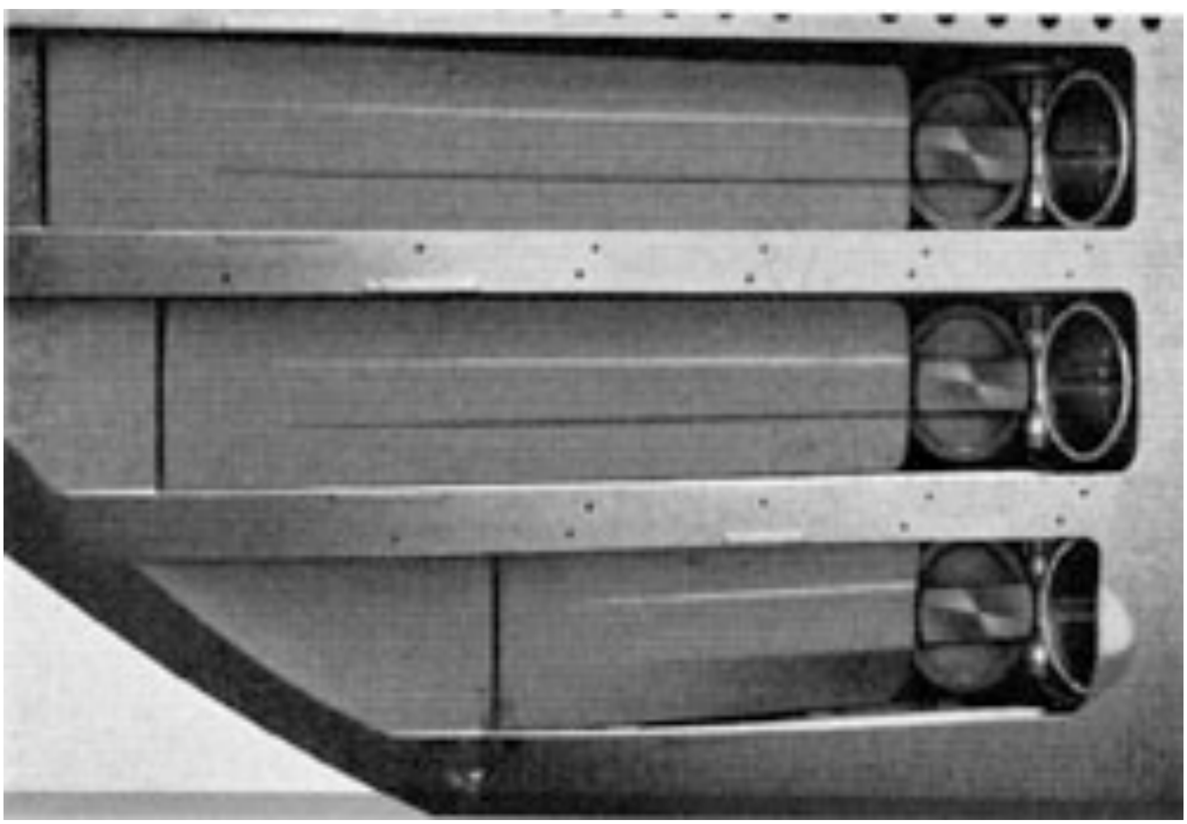
The following discussion deals with the conversion of the Revell 1/72 GATO bow for acceptance of the Caswell-Merriman weapon system. However, most elements of this discussion will find application on other conversions.

First thing is to cut and grind away the kits closed shutter door(s) at the positions you plan to install a launcher. Cutting GRP or styrene, the work will go pretty much the same. Just keep in mind that GRP is indeed glass and will dull your tools quickly – be prepared to go through several sets of rotary and hand tools as the work progresses. Punching out holes in styrene, by comparison,  is like sliding a hot knife through butter.

This photo of a boat in dry-dock clearly shows how the slide-and-tuck shutter door, carried by the open muzzle door, slide forward and tucked inboard, insuring clearance of the weapon as it was ejected out of its launcher. Note the 'rub land' on the inside face of the muzzle doors and built into the outboard faces of the shutter doors. The lands form a slide bearing that mitigated weapon damage should the torpedo come into contact with the boat as it sped out its tube. The reason for the rub lands is, in no small part, owed to the Bernoulli effect – the launched weapon, close to the side of the bow, sees the water on its bow side as a lower pressure fluid than the water on the outboard side of the weapon. This pressure differential producing a lateral force pushing the weapon into the bow of the submarine. A torpedo traveling through an open trough arrangement, like on our old diesel boats, is more susceptible to Bernoulli effects than weapons launched from boats featuring a bulbous bow or from the flank of a boat – both characteristics of today's submarine designs.


Below is an illustration of a GATO/BALAO/TENCH class American diesel-boats bow torpedo tube shutter door arrangement. How well I remember this – it was one of many illustrations in the operation pamphlet we Torpedoman studied as we learned the trade of operating and maintaining our torpedo tubes aboard the TRUTTA, a TENCH class boat.





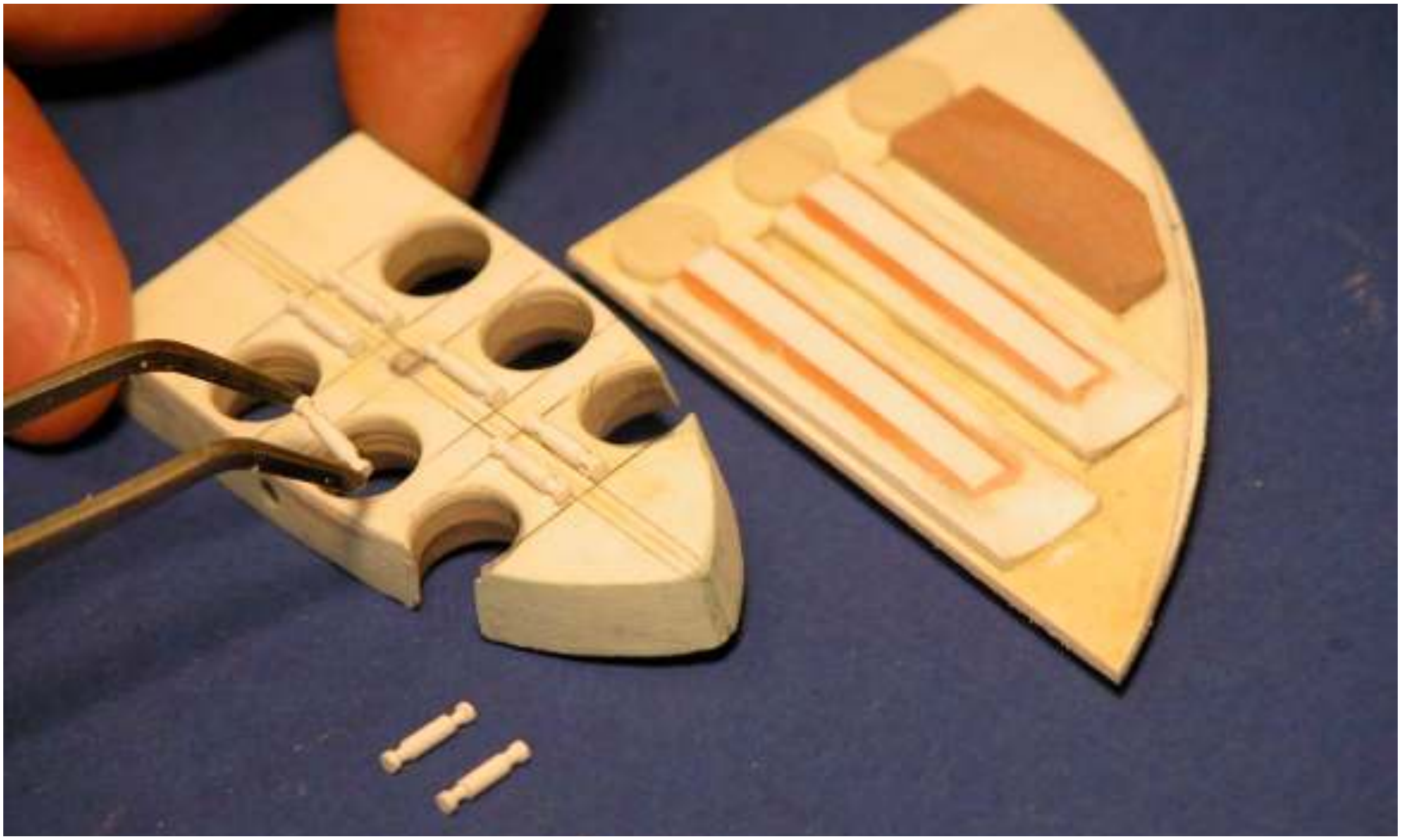
No, the shutter door geometry seen in the above illustration does not reflect that of the Revell GATO kit. Surprised? Don't be. Not all world war two era American diesel submarines of the same class were the same. So, if you are a stickler for detail, you may wish to make alterations to your Revell GATO kit to show the arrangement specific to the boat your are representing in model form.

Basically, boats within the GATO/BALAO, and TENCH classes differed from one another owing to the fact that a specific boat would have been built to the standard of one of two general designs. The boat was built to either the government/Portsmouth (a Naval Shipyard) or the Electric Boat (a private shipyard) design – both designs matching in overall hull, machinery, and compartments, but differed in many details, such as shutter doors. Adding to the confusion are the field changes, refit alterations, and evaluation equipments installed over the life of any particular boat. Further variances of detail from one boat to the next occurred because of different yard construction methods employed during the hectic war years.

(Yes, yes … I know this is all a bit too much rivet-counting nonsense for a weapon system manual. However, I include it here to illustrate just how stupid things can get when you go about the task of building a scale model component).

A Web search netted me these shots of the shutter doors of this rather poorly preserved GATO/BALAO museum boat. Important as this particular boat shares the same type shutter doors as those of the Revell 1/72 GATO model submarine kit.

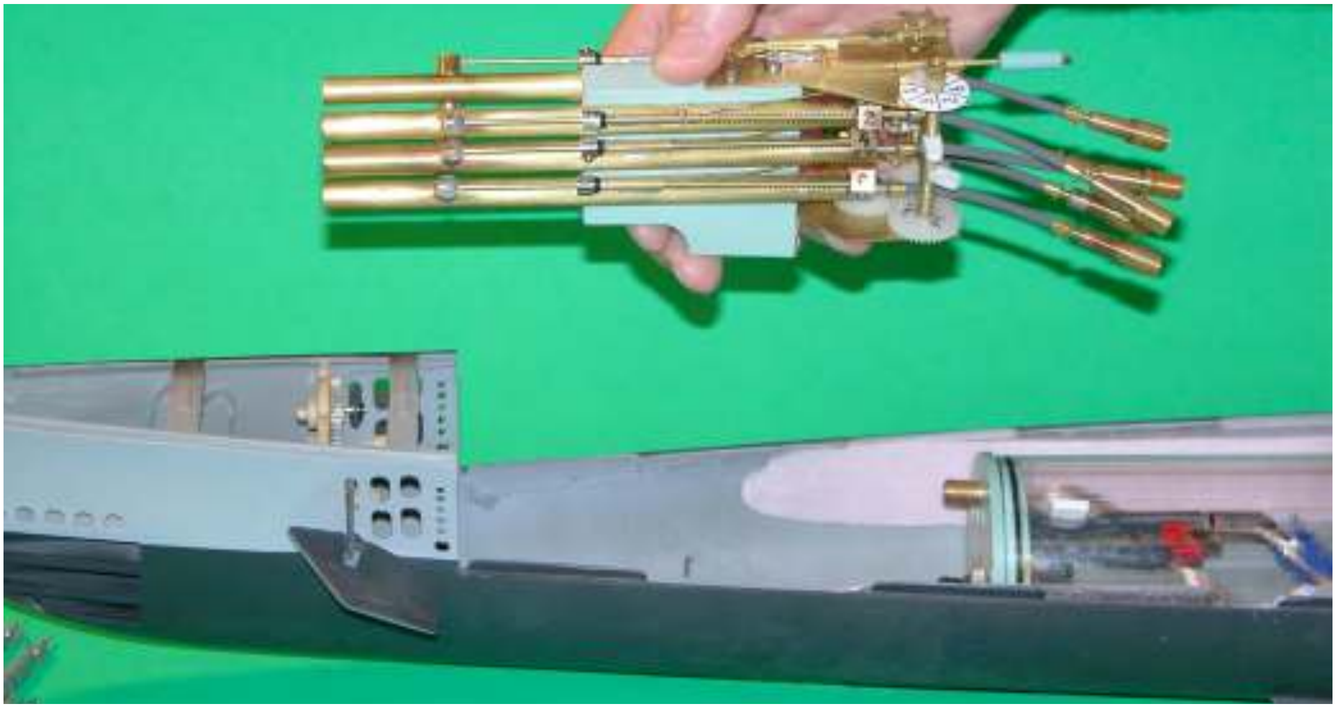

I used these shots almost exclusively as I built the masters from which I eventually produced model parts representing the GATO shutter doors in the open position. That work seen below.

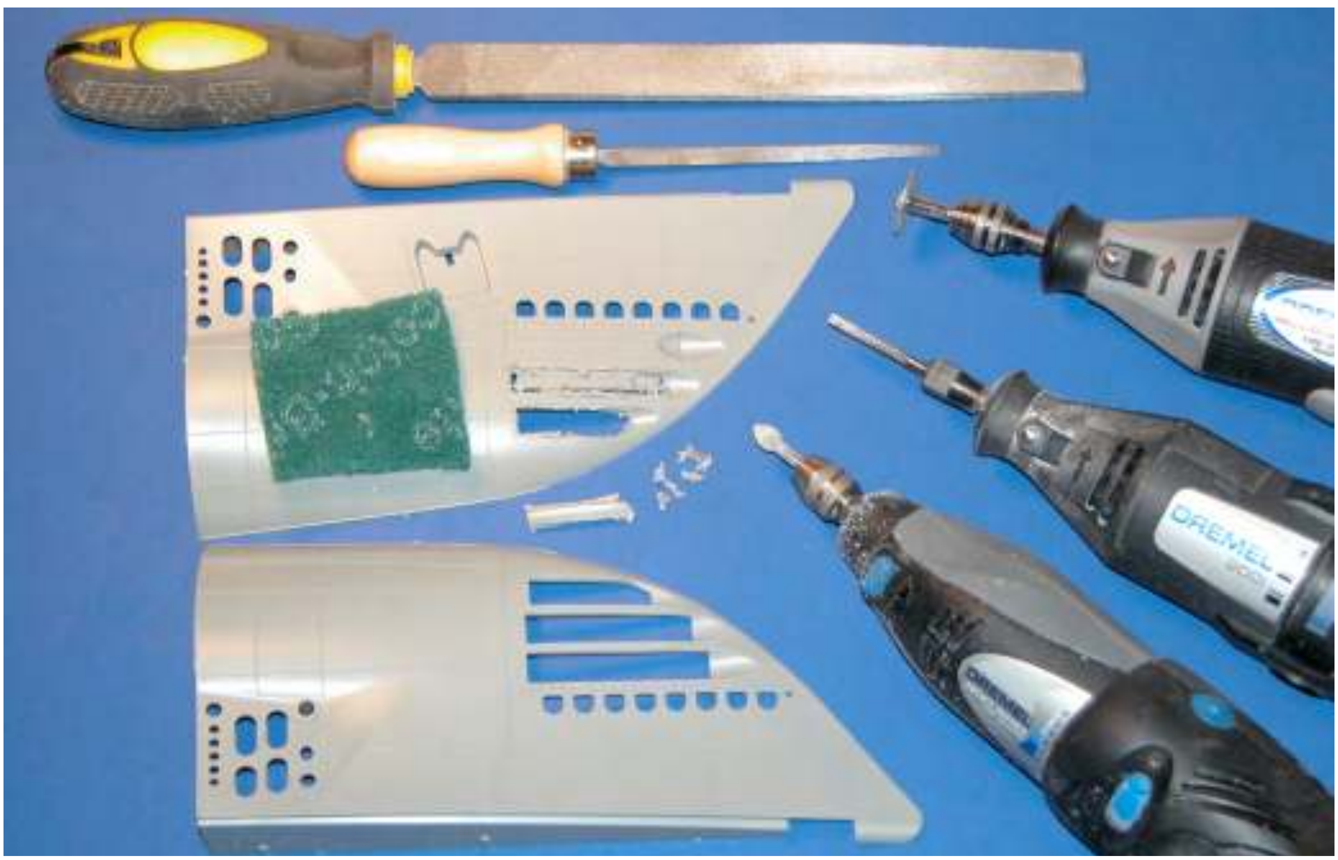


Let's say you are going to install all six launchers into the bow of the GATO kit. As the kit is engineered with the hull divided into three main sections (a left-right part comprising each section), you would be well served to fit the foundations for the launchers into the bow section before joining its two halves permanently. Remove the 'closed' shutter doors – represented on the model by engraved lines. Just follow the engraved outline of each shutter door and the work is done in no time. An easy process with drill, grinder bits, and small circular saw, all swung by the Dremel Moto-Tool. Finish off the rough edges around the shutter-door openings with files and sanding sticks.

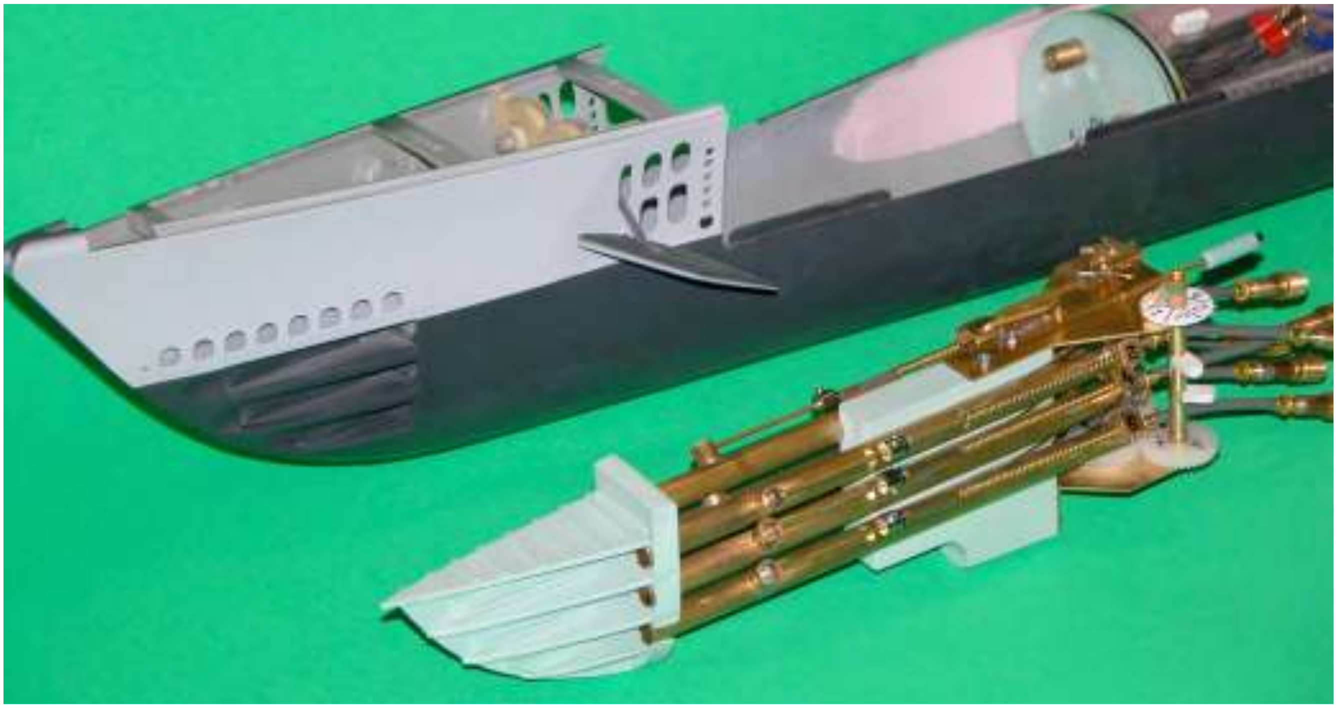
When installing two or more launchers you first establish the distance between the center-line of each tubes bore and the adjacent tube(s) in height and width. You form a block, that when positioned between the adjacent tubes, acts to hold the launchers to the correct distance apart in width and height. The block is indexed with shims or is machined with grooves to maintain the launchers in the correct nest pattern. I call it a launcher nest foundation.

You then form a muzzle bulkhead piece. This conforms to the frame-station within the bow where the torpedo tubes end. Into this muzzle bulkhead are punched holes that will fit the muzzle ends of the launchers. The muzzle bulkhead and launcher nest foundation are the elements that secure the tubes and hold them in correct alignment within the bow of the model submarine. Additional parts, later added to the forward face of the muzzle bulkhead, include the bottom of the bow-buoyancy tank (which can be seen through the bow buoyancy tank limber holes), the central muzzle-door and shutter-door piece, and the six platform pieces that define the troughs that clear the bow structure from the weapons as they are launched.






The photos below clearly show the bow launcher nest foundation and muzzle bulkhead assembly. These position the six launchers within the bow of the GATO kit. RTV silicon adhesive is used to hold the brass tubes of the launchers to the cast resin foundation piece. The entire nest of six tubes is removable. Installing the nest is an easy matter: the nest is positioned into the bow, the forward edge of each launcher tube sets within a hole in the muzzle bulkhead, which is permanently mounted within the bow. The bottom of the nest foundation makes contact with the bottom of the hull. The nest foundation piece is shaped to give the correct angle of the launchers in relation to the hulls center line. The nest is secured within the bow of the model submarine with a single small machine screw that makes up to a bracket at the after bottom edge of the launcher nest foundation.

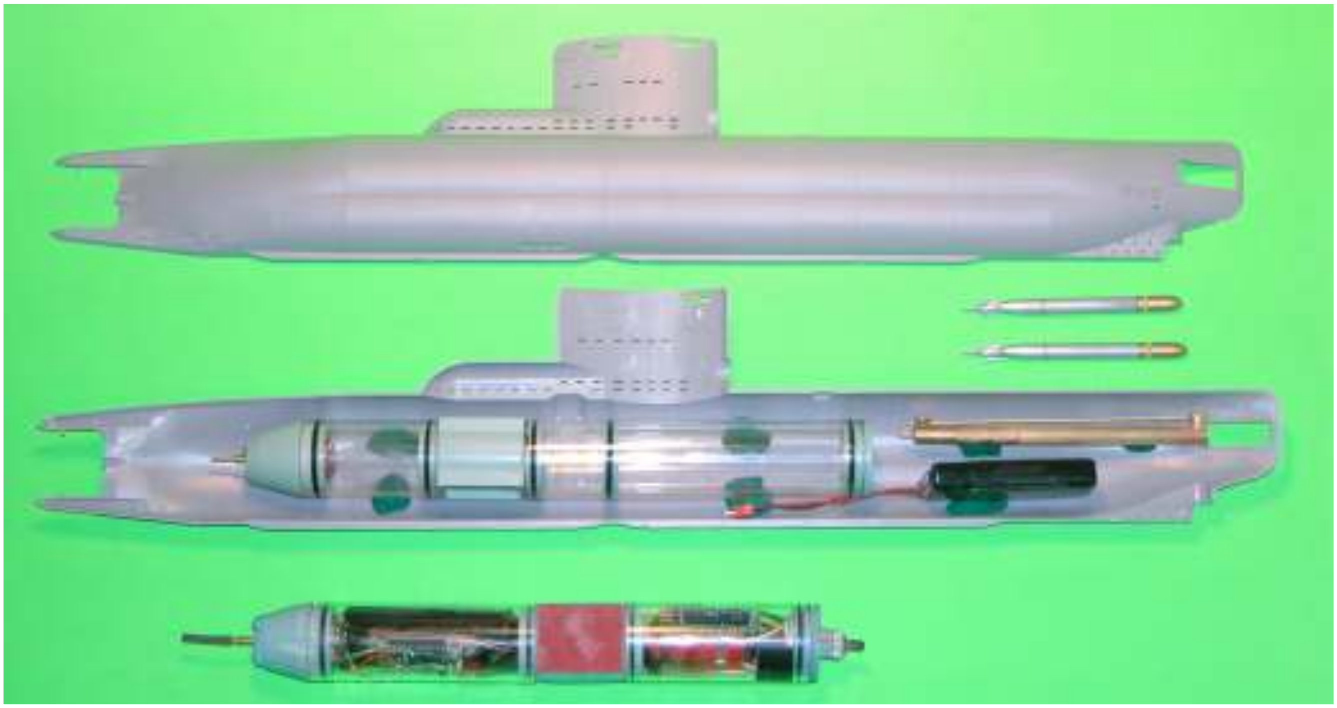


As you can see, things are a bit tight in the bow of the GATO with a complete set of launchers and the attached single-servo sequencing mechanism. Mounting of the four-tube nest at the stern of the GATO is done in a like manner.

Of course there are variations of installation, the form and utility of the tube/nest/installation you come up with is limited only by your imagination and craftsmanship.

I've made no attempt on this model to make the shutter doors operational. It was enough for me to install a set of false shutter doors represented in the 'open' position. However, depending on your wants and ability, there is nothing stopping you from making the shutter doors work – likely a staggering trip working off the same mechanism that engages the launcher shuttles, which would allow a spring-loaded shutter door to open an instant before the launcher transitions from battery to launch condition.


You must allow unobstructed after travel of the launcher flexible hose and attached charge fittings so that the launcher can transition from the battery to the launch condition. Any obstruction of that action could result in a jam, a miss-fire, when attempting to launch a weapon.



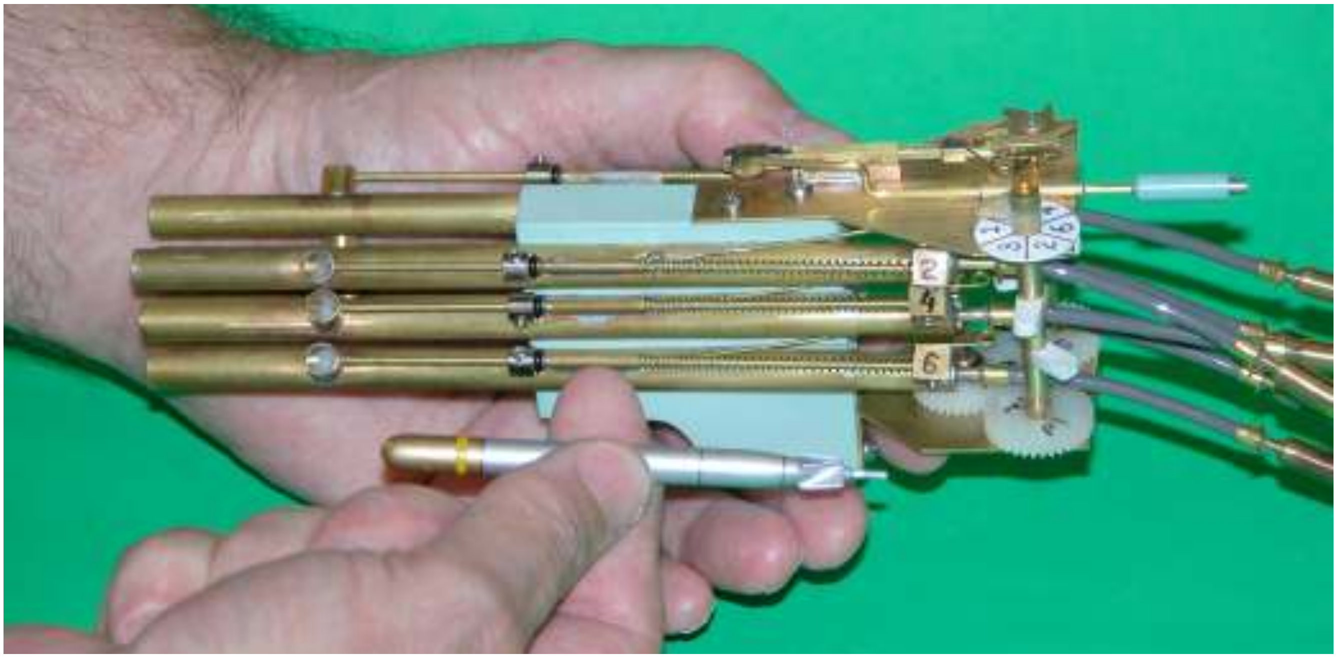
Smaller 1/72 model submarine kits can be converted into weapons platforms as well: This styrene plastic model kit of the above pictured Type-23 is one example. Note that through careful design of the 1.25-inch diameter SubDriver, room can be made for inclusion of the two launchers this type submarine featured. Preliminary study of where to locate things within the hull is being conducted in this photo: I'm finding where to place the SubDriver, battery, and launchers (only one fit here) by temporarily holding these items in place with clay. Later, once the internal layout of items has been finalized, foundations will be built into the hull to secure them in place; the two halves of the hull glued together; and the hull split into a more useful upper and lower half that better provides access to the mechanisms within.

## MECHANICAL LAUNCHER SINGLE-SERVO SEQUENCER MECHANISM

Scale model r/c submarines vary as to the number of launchers they employ. Some as many as ten launchers, some as few as one. Whatever mechanism you come up with to get your launcher from battery to the launched condition, the objective is the same: your sequencer mechanism must reliably depress a single launcher shuttle button each time the servo cycles, and perform this operation with as little mechanical resistance to the servo linkage as possible. Whatever the mechanism you come up with, it must not exceed a weight that can be compensated for with fixed buoyant foam. And the mechanism must fit the available space between launcher nest and other structures within the model submarine.

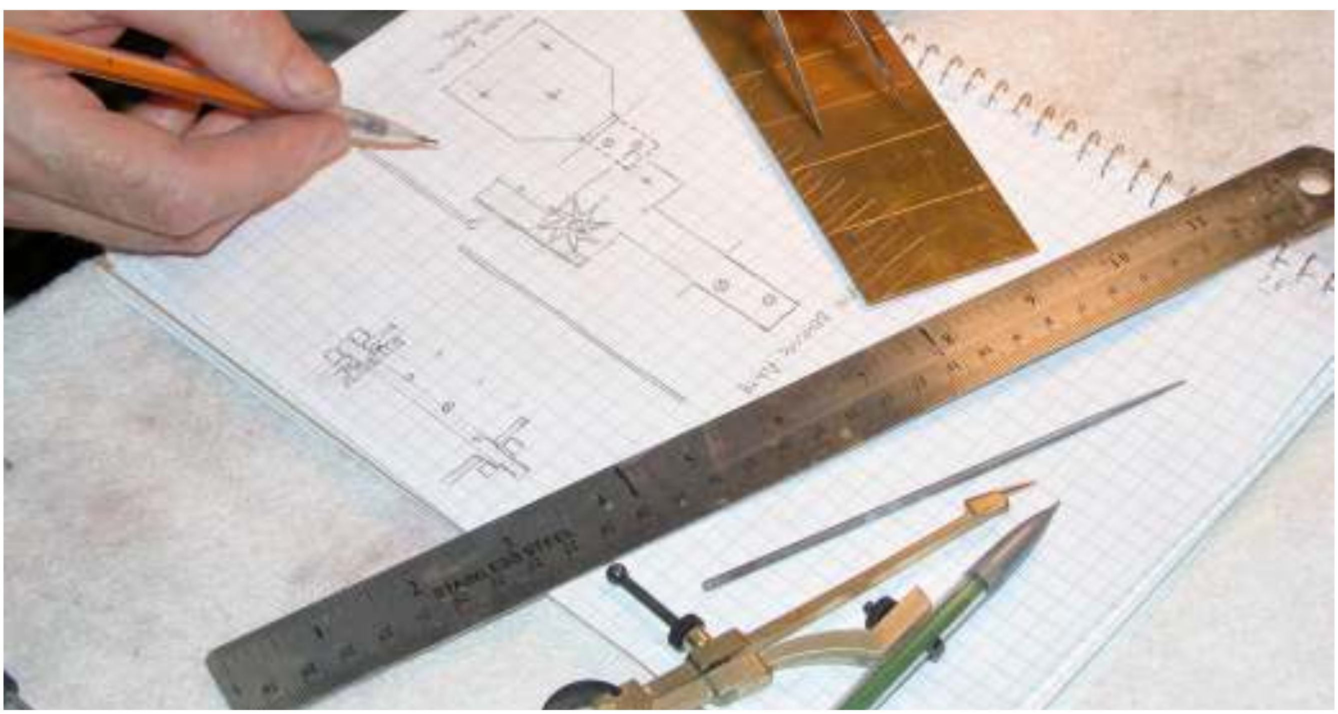
The simplest means of tripping the launcher shuttle button is to employ a servo to swing a bell-crank arm. Each end of the bell-crank so arranged to press a button at each extreme spring of the bell-crank. A single servo in this arrangement can be used to actuate two launchers, one-at-a-time, at your command, using a single r/c channel. The servo in neutral, no weapons are launched. Full throw in one direction of the servo pushes one end of the bell-crank into a launchers shuttle button, launching a weapon. Full throw of the servo in the other direction, and the other end of the bell-crank pushes the other launchers shuttle button, and that weapon is launched. Very simple. One servo for each pair of launchers. A bit cumbersome.

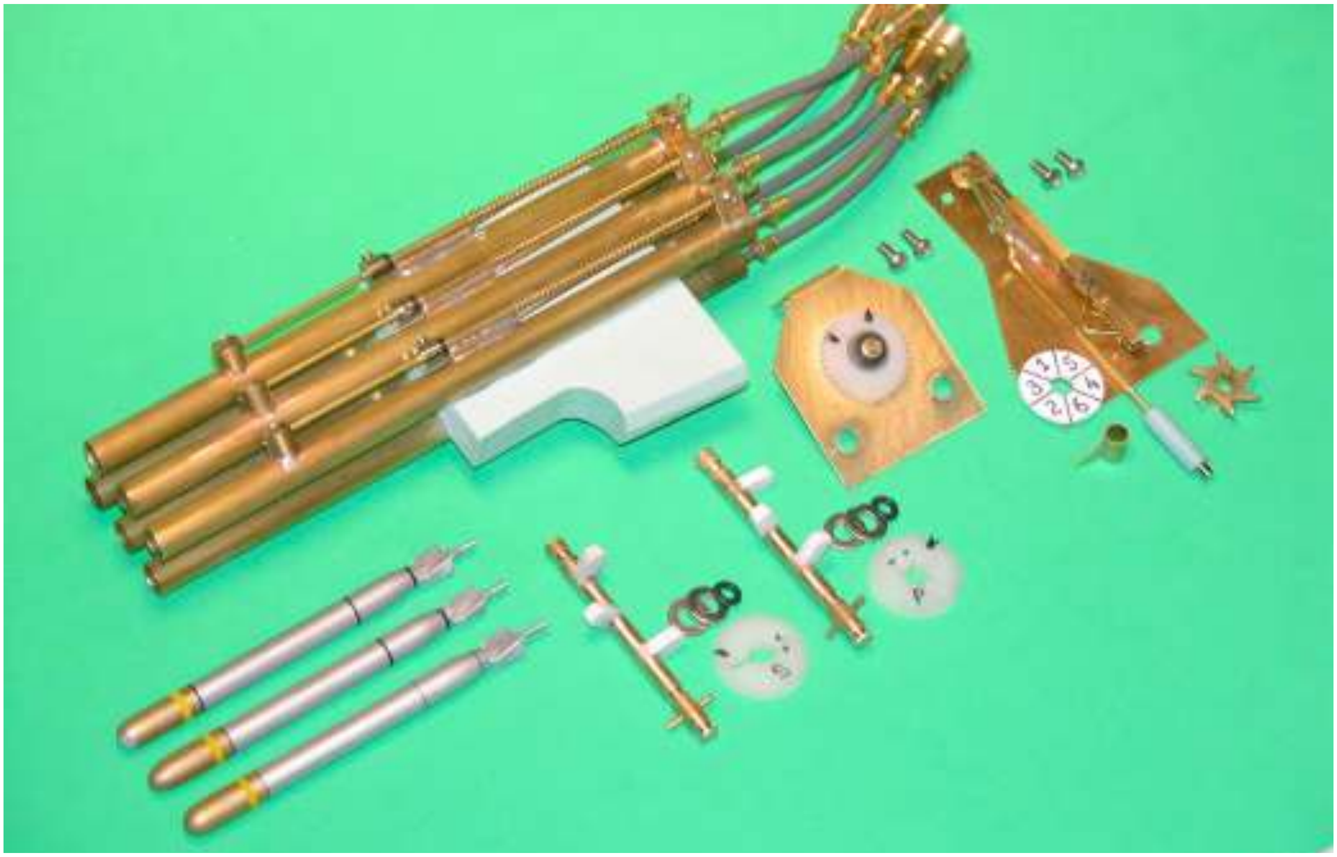
With a bit of thinking and shop skills a mechanism can be devised that employs one servo (and only one channel of your r/c system) to launch weapon with each cycle of the transmitter switch. Or, depending on how you 'program' the mechanism, it can ripple fire the entire or a portion of the nest with each throw of the switch. It's all mechanics, my friend. Look up, 'Rube Goldberg'!



But, what if you wish to employ the Caswell-Merriman launchers in the mechanical mode, launching only one weapon at a time with each throw of the transmitter 'fire' switch? Did you look up Rube Goldberg like I told you? No? OK then – if you won't listen to Rube, read how I do it. This is where we separate the men from the boys: How to take a single servo and get it to launch one weapon each time the servo is cycled from one end-point to the other end-point:

The objective is to translate the linear servo travel, via pushrod, to a sixty-degree rotation of two cam shafts – the sixty-degrees achieved through the use of a six-point ratchet wheel driven by a pushrod linked ratchet pawl. From a basic working drawing I laid out the form of the parts, (essentially two bearing plates and two cam shafts with associated gearing, ratchet mechanism, and mechanical fasteners) onto some brass sheet and rod and worked the metal with saws, milling machine, lathe, and hand-tools.





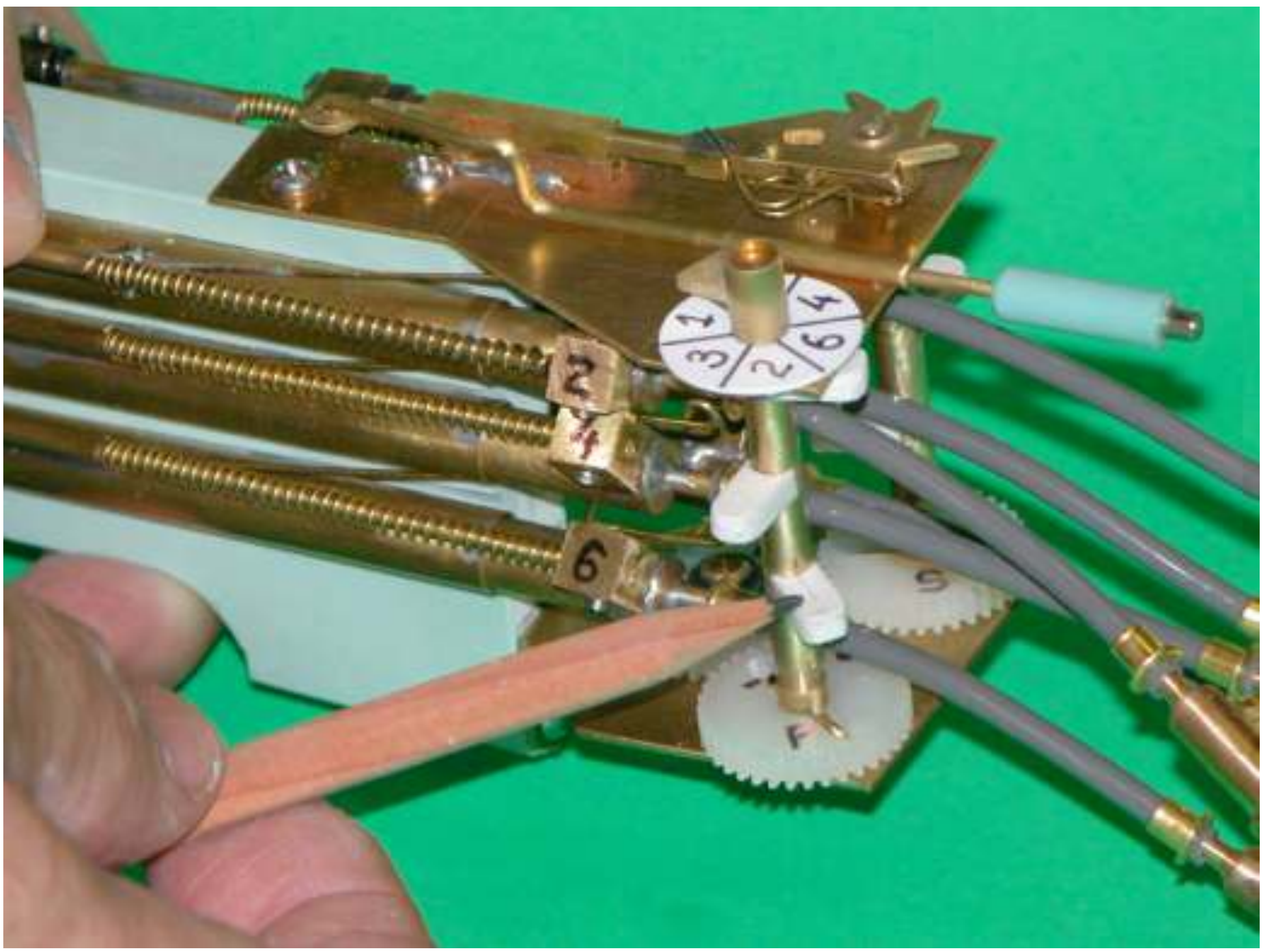

As you can see, if you are working on the GATO nest ( and using the nest foundation piece supplied with the Caswell-Merriman GATO fittings kit) the base of the launcher nest foundation is a perfect grab-point for the jaws of a small machine vice – the vice serving as a  holding fixture, supporting the work as you go about the task of installing a mechanical launcher sequencer. Here you can see that I've installed the two cam-shaft bearing plates to the nest foundation and am working on the ratchet portion of the gizmo.

(You'll notice that the six launchers here employ spring-triggers instead of the shuttle button to actuate the launcher. The launcher design has matured since these pictures were taken. Though the spring-trigger and shuttle type mechanical mode launchers differ in function and physical arrangement, the cam based sequencing mechanism described here works on both type launchers).

The heart of this single-servo sequencing mechanism are two cam shafts (one for the port tubes, one for the starboard tubes) who's lobes come into contact and unseat the individual launcher shuttles. There are three cam lobes on each cam shaft, these lobes positioned sixty-degrees from one another. As the servo cycles through, pulling a ratchet element through sixty-degrees, a single cam lobe rotates the same amount, unseating a single launcher shuttle, launching a weapon. After three-hundred-and-sixty degrees of rotation (six servo cycles) all launchers have been transitioned from battery to launch condition.

(You likely are still hung-up on why I used the term, 'program' above. Remember, I'm an old-school type of guy, and not all code is zero's and one's: in the good old days of  computers, electrical and mechanical analogs were employed as mathematical expressions that, when integrated together, expressed a precise, repeatable logic. And that's what this sequencing mechanism is, it's an analog computer. It's logic, or code, is embodied within the lobe spacing about the mechanisms cam shafts. A wind-up clock is an analog computer. Duh!).

By staggering the lobes about the radius of the cam-shaft (providing that the radial displacement between the lobes is 60-degrees, or multiples of 60-degrees), I can vary the tube order of fire by simply placing the lobs in different radial locations about the cam-shafts. I can 'program' the mechanism. Note the white circular dial with brass pointer affixed atop one of the two cam-shafts. It indicates launching order, and  which  launcher is next to be activated when the servo is cycled.

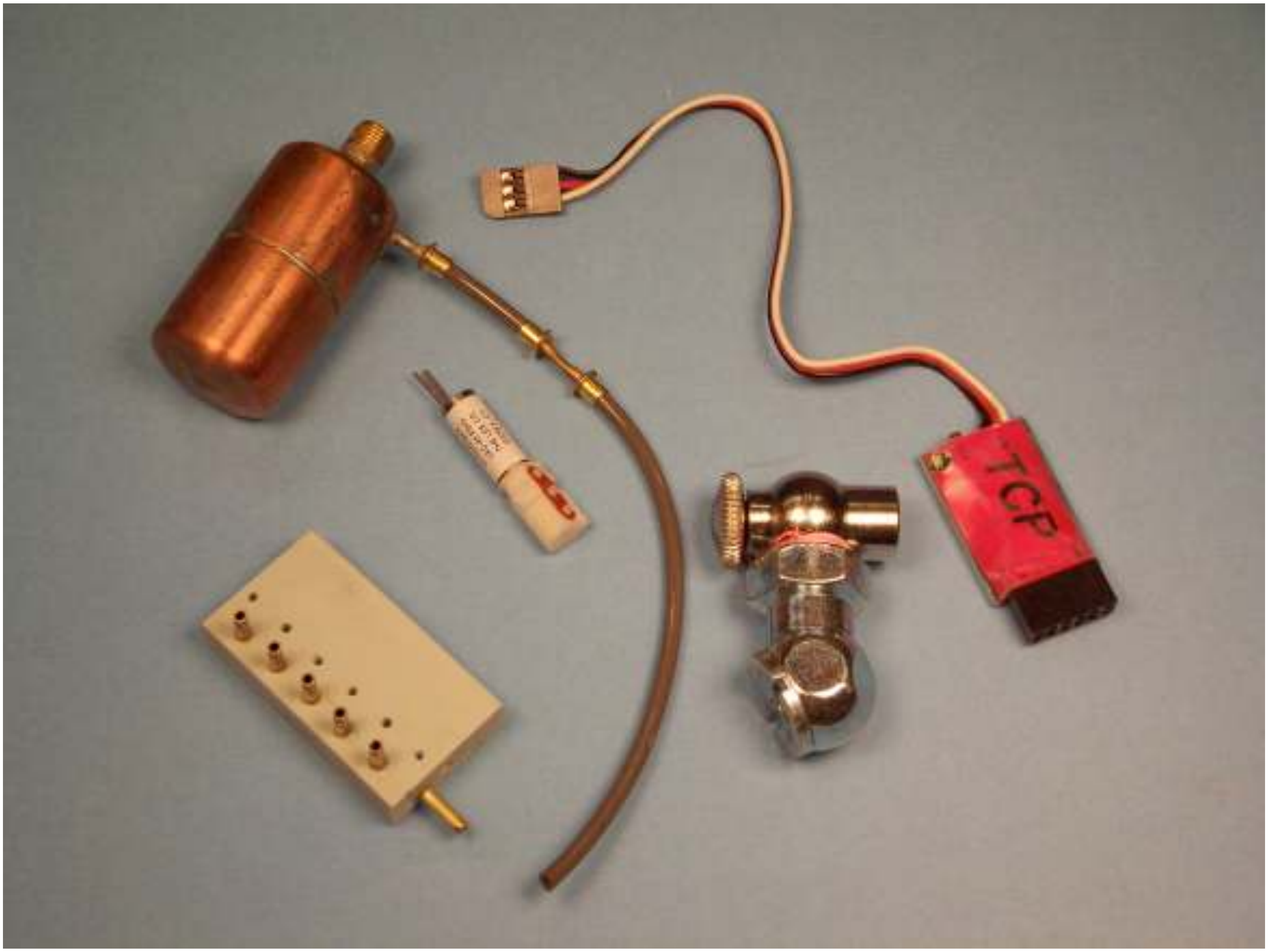


Anyway … that's how I came up with a single-servo sequencing mechanism. Hope it gave you some good ideas. Have a bottle of heavy-duty aspirin nearby when you start in on this gadget!

## PNEUMATIC LAUNCHER SINGLE-CHANNEL SEQUENCER DEVICE

# (TCP) AND PLUMBING

The major elements that define a pneumatically operated launcher: gas bottle with restrictor, solenoid-valve(s), solenoid-valve manifold, propellant can charging adapter, TCP.

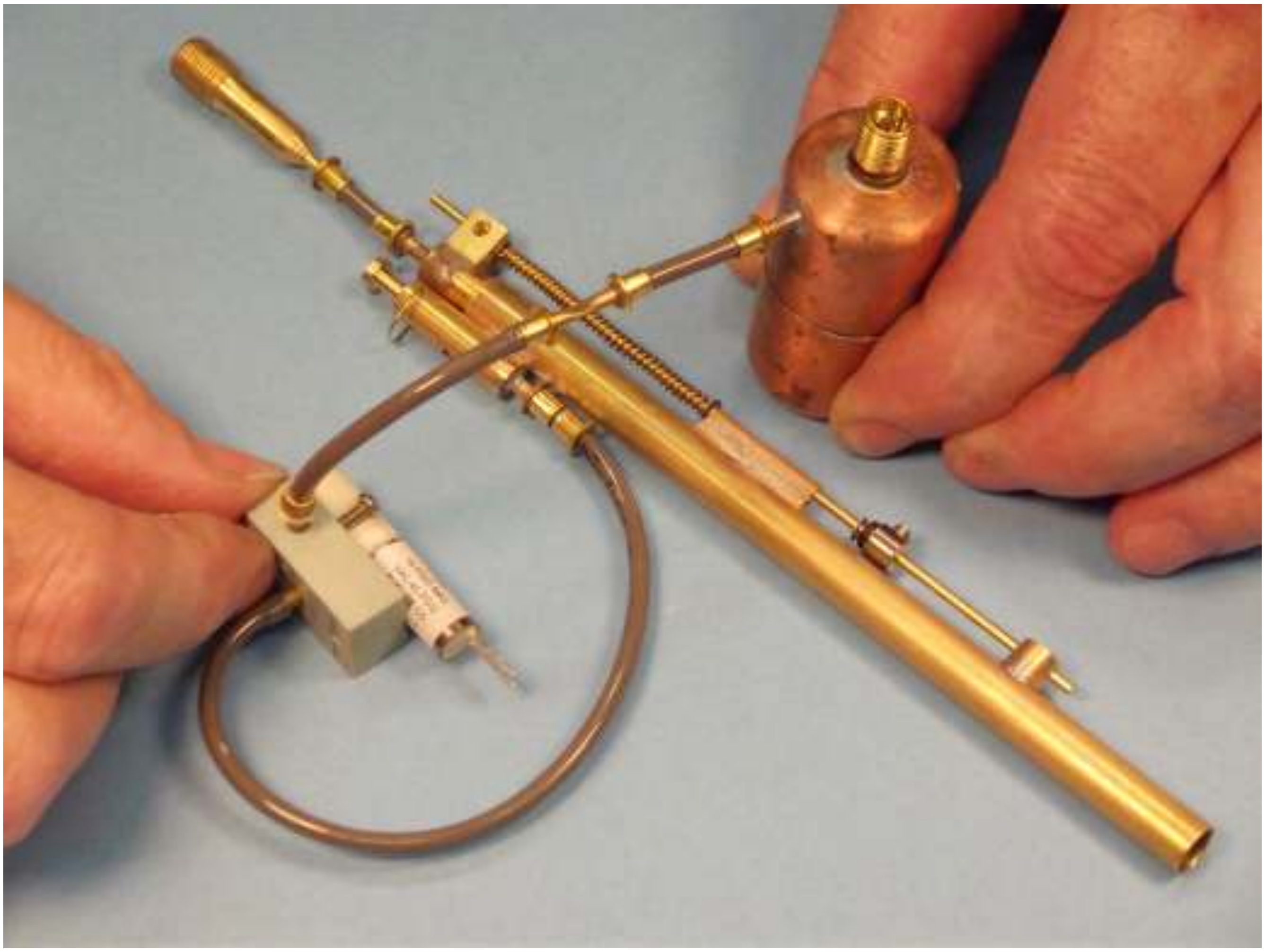



The major draw-back of the mechanical mode of launcher operation is the need to run rigid, hard to adjust, and space filling linkages between the weapon system servo(s) and breech-ends of the launchers – these problems compounded when you have two nests of tubes, each at an extreme end of a very crowded model submarine interior. The pneumatic mode launcher dispenses with most of these negative points by centralizing the agent of launcher operation – a gas (pneumatic) working source and distribution center – into a compact unit that can be mounted anywhere within the models interior, and routing a single flexible hose to each launcher. It's much easier to run those hoses than it is to run rigid, subject to fouling, mechanical pushrods and the like. This is what makes the pneumatic mode of launcher operation a more flexible, and easier to install and maintain arrangement than a system employing the mechanical mode when dealing with multiple launchers divided among two nests.

Below is pictured a simple single launcher, operating in the pneumatic mode. As gas pressure is used to move the shuttle from the battery to the launch position, there is considerable plumbing involved, but most of that is embodied by the solenoid-valve manifold block. The major components needed to operate the launchers in the pneumatic mode include: A copper bottle to hold a charge of liquified propellant gas (the same as used to charge the weapon), attached to this bottles flexible hose is a restrictor tube that limits gas flow to the system; a manifold block to distribute working gas and solenoid-valve discharge gas to a specific launcher; and the highly specialized low-voltage, medium pressure solenoid-valve; and (not pictured here) the

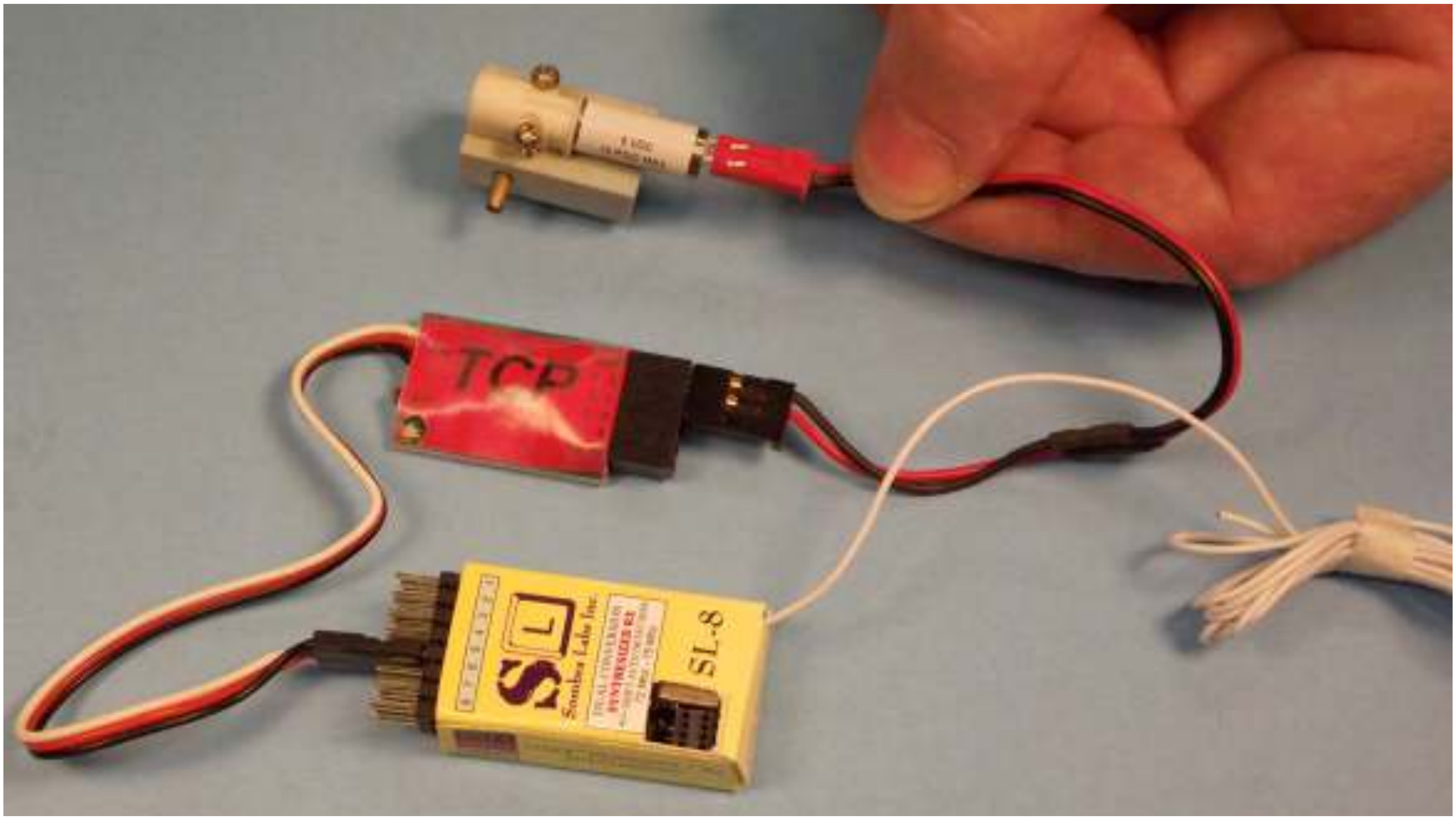
TCP, an electronic switch designed to work off of one r/c channel to energize a solenoid-valves with each pull of the transmitter switch.

For clarity I've omitted the TCP and receiver so you can get an undisturbed picture of the plumbing involved with a launcher configured to operate in the pneumatic mode.



The TCP can control as many as ten launchers from a single r/c channel, and do it in two modes: one will permit a straight sequencing of launch from 1-10; for each pull of the transmitter switch, a launcher will transition to the launch condition. Or, in mode-2, using a three-position transmitter switch, you can select which nest to launch from, and launch, in order, from the selected nest. A very versatile, and useful device.

And, as you can see, the connections between TCP and the manifold mounted solenoid-valves are through flexible, small-gauge, electrical wires – easy to run in and around the crowded interior of a model submarine.

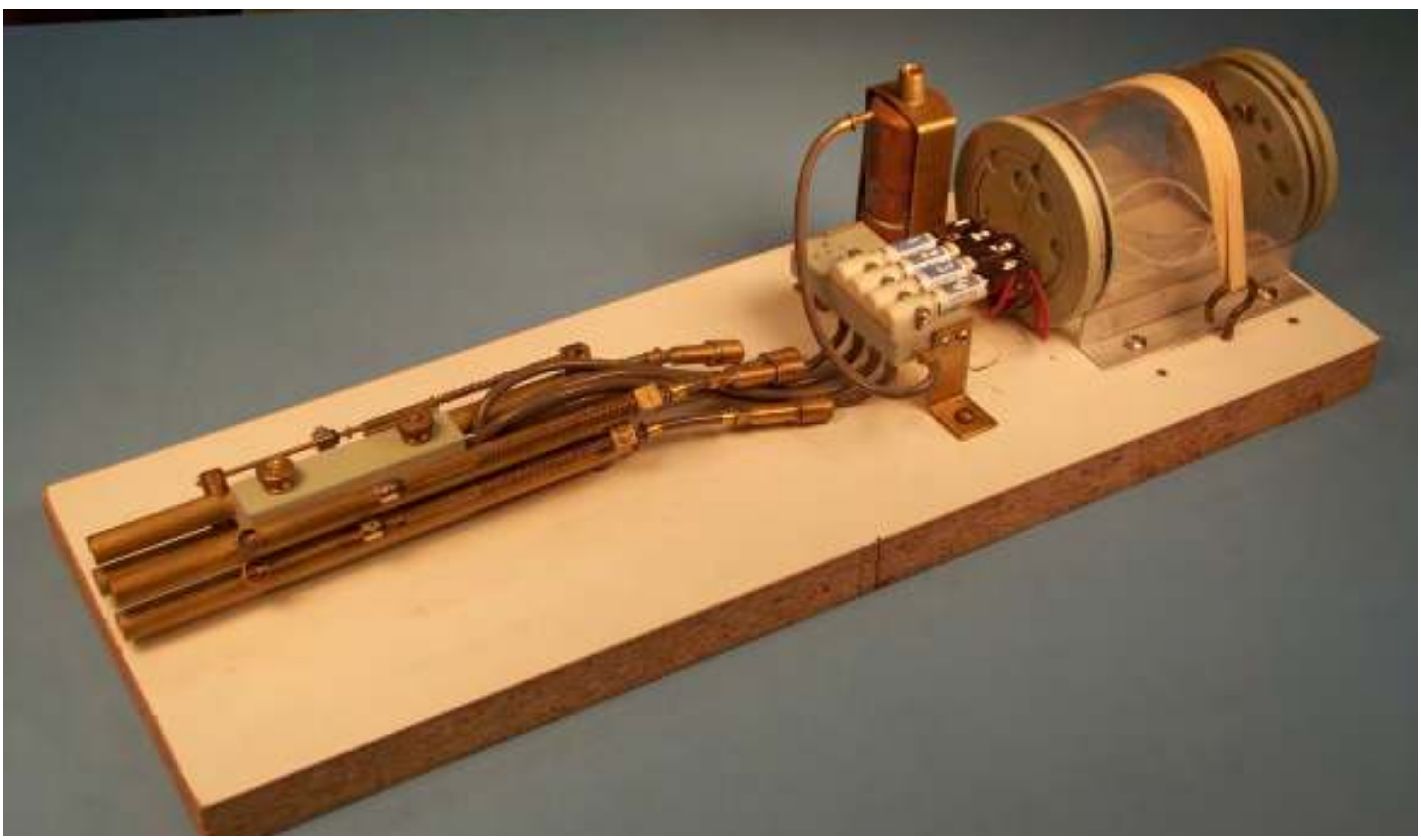



Here's a close look at a cut-away launcher, equipped with the pneumatic mode shuttle. Note how the locking-ball works to hold the breech-block in the launch condition when the pneumatic shuttle is forward. The mechanical mode shuttle does the same thing, but works in the opposite direction.

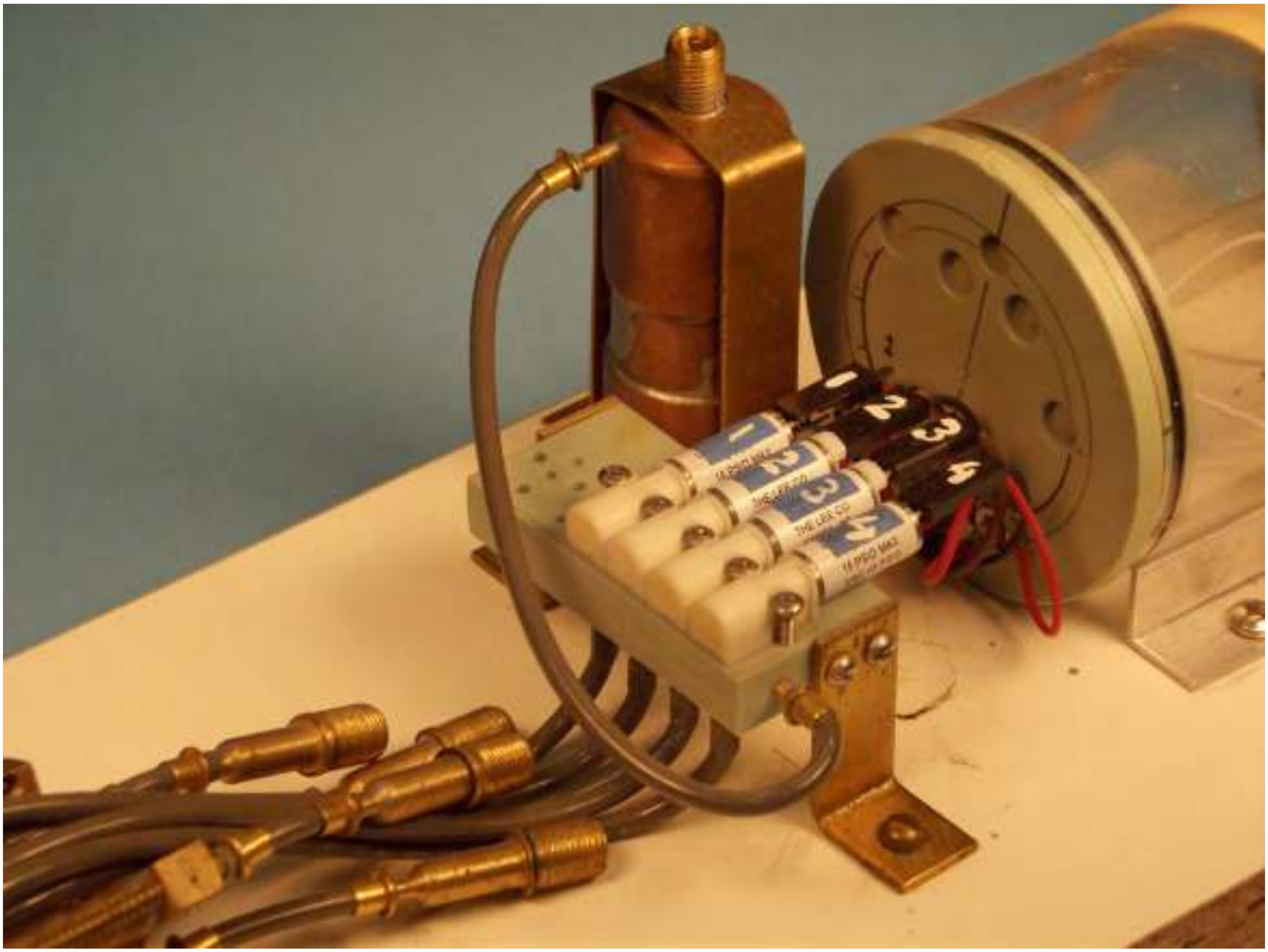
The upper shot shows the launcher at battery (the swapped out mechanical mode shuttle is below the launcher).

And here's the launcher at the launch condition.

OK, enough basic description. Lets look at a practical arrangement of the elements that comprise a working six-tube launcher nest operating in the pneumatic mode:



First thing that becomes obvious – and what constitutes the major virtue of the pneumatic mode of launcher operation – is that the interface between the SubDriver and weapon system is not a bunch of mechanical linkages (as is the case with the mechanical mode), but rather, flexible wires and hoses. From a single, common manifold are run flexible tubes between it and the individual launchers. The gas supply bottle and manifold block can be placed anywhere within the model. Making this a very adaptable element of the model submarine – you don't have to design around a bunch of rigid pushrods; rather, you run your wires and flexible hoses to suit the existing arrangement of model submarine sub-systems and structural elements. Flexibility of installation is the hall-mark of the pneumatic mode of the weapon system.



Threaded brass studs, that pass through the forward bulkhead of the SD, are the conductors between the wiring of the TCP (in the dry cylinder) and solenoids (in the wet portion of the hull).

## LAUNCHING AND RECOVERING THE WEAPON

**Launching the Weapon** Normally, you will launch a weapon as the model submarine is underway and submerged. The recommended launch depth is three hull diameters. That depth typically the maximum periscope depth of most submarine types. If you launch too shallow there is the possibility of the weapon broaching (breaking the surface) and flying through the air for some considerable distance, never to be seen again!

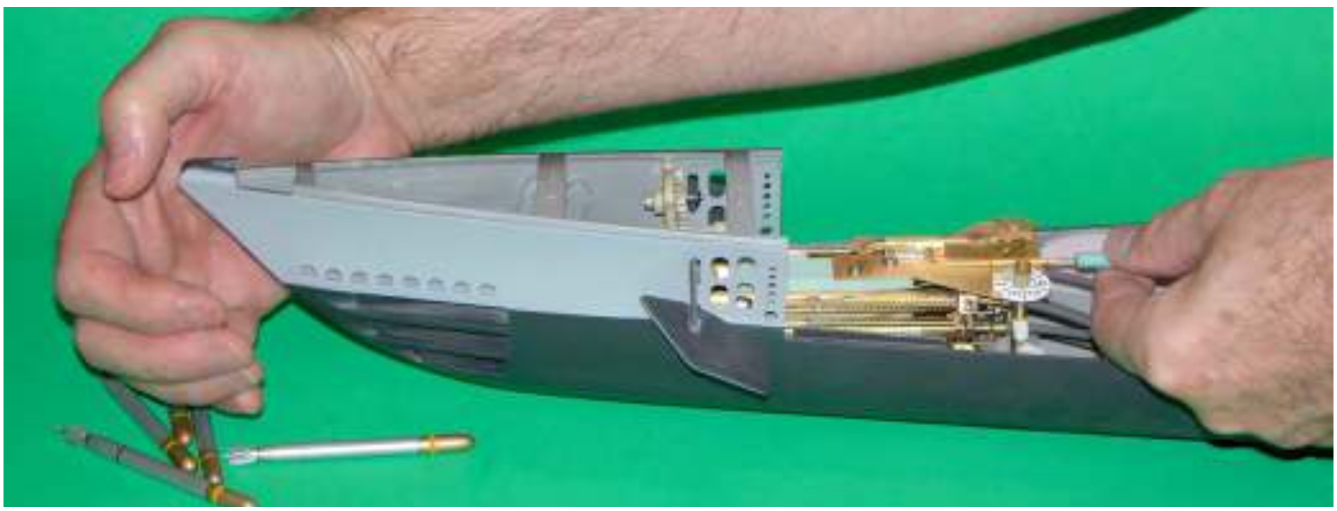
***CAUTION: Do not keep a charge of propellant on board the weapon any longer than six-hours. Also, do not permit the***

***charged weapon system to become heated above one-hundred-degrees, Fahrenheit. The nominal pressure within the system at seventy degrees Fahrenheit is about seventy PSIG – that pressure increases radically with temperature. A submarine sitting in the July sun with a charged weapon system will soon heat to the point where the four-hundred PSIG burst pressure of the flexible hose is exceeded, resulting in a catastrophic failure of the hose or cook-off (explosion) of the weapon itself. However, the launcher sub-system is designed to totally contain the debris resulting from a weapon cook-off. Never charge a weapon off-launcher.***

**Recovering the Weapon(s)** To aid you in the recovery of your weapons make it a practice to maneuver your r/c model submarine in such a way as to place the target between where you stand on the shore and your model submarine – the track of the weapon through the water will be towards shore, where you can pick it up at the end of its run. Another means of quick and easy weapon recovery is to outfit a small tug type model boat with a bow mounted net – you use the tug to scoop up your torpedoes that can't be reached from shore. Or, you can go swimming. Think before you shoot: "how will I get that expensive torpedo back?".

In the event you need to unload a weapon from its launcher, simply place your palm over the muzzle end of the launcher, transition the launcher to the launched condition, and catch the charged and thrusting weapon in your hand.

***WARNING: A charged weapon, set free in the air, for all practical purposes, is an unguided missile which will attain a significant velocity before the on-board gas is used up. A loosed weapon in the air is very much a 'missile hazard'. Do not launch weapons underway from a depth that is less than three hull diameters deep.***



# WEAPON AND LAUNCHER MAINTENANCE

Any mechanical system is subject to wear, damage, and the need for preservation and occasional adjustment. So is the case with the elements that comprise the Caswell-Merriman 1/72 weapon system. I've laid out specific checks and operations needed to be performed in order to maintain your system in good working order. The list is not exclusive. There might be other things you will need to do to get your system working and to keep it working reliably and add them to these lists. Then post a copy of the checks and operations over your shop work-bench and, FOLLOW THEM!!!!

Basic shop hand tools, silicon grease (automotive distributor grease), and silicon oil must be on hand when performing shop or field repairs/adjustments.

**Pre-Mission Checks and Operations** Before you begin a days use of the r/c model submarine, with the intent of firing torpedoes, you'll perform these checks and operations in the shop:

1. To the weapons, you'll use a piece of .008-inch wire and will run it up through the throats of each weapons nozzle. This to insure that the nozzle tube is clear of any potentially clogging matter.
2. Apply a very light coating of silicon grease to the outside of the nozzle – insure that no grease gets into the nozzle where it might be driven into the throat during the charging operation.

3. If so designed, remove the launcher nest(s) from the model submarine. Examine each launcher, looking for obvious damage and loose fittings. Examine the flexible hoses, looking for 'ballooning' or rupture. Check for free operation of the breech-block by cycling it between the battery and launch condition – observe that the breech-block, forced rearward by the breech-block spring, travels fully. If not, remove the breech-block and apply a coating of silicon grease, and pull on the breech-block spring to increase its tension a bit. Re-assemble the launcher and check for correct operation.
4. If employing the launchers in the pneumatic mode, charge the gas bottle.
5. Load all tubes, get them to battery, charge all weapons, and launch each weapon into the palm of your hand to check for proper function of the launchers and weapons. As each weapon is caught, put it's nozzle near your ear and listen for the sound of escaping gas. A single shot of propellant should be heard hissing out of the weapons nozzle for at least fifteen-seconds.
6. Load all tubes again, get them to battery, but do not charge. Re-install the nest(s) into the model submarine.

You have completed your weapon system pre-mission checks. Once the boat has been checked out, you're ready to load things into the car and go to the lake.

**Mission Checks and Operations** These are the checks and operations done at the operating site to get the weapon system ready for use and re-use.

1. Charge all weapons. Cover muzzle ends of launchers with a towel as you energize the r/c model submarine – a small chance exists of a 'transient' occurring during power-up that might cycle the launcher firing servo or TCP which may inadvertently launch one or more weapons.
2. Recover weapons, reload, blow down launcher charge fittings, and recharge weapons as required.

When you put things away and get ready for your trip back home, inventory your weapons – leave with the same number you arrived with – those things are expensive! And cycle the nest to insure that no charged weapons remain aboard. Gun Safety! It applies here too.

**Post-Mission Checks and Operations** These are mostly preservation operations, intended to minimize corrosion. Post-mission checks and operations are performed in the shop. Ideally, the launcher sub-system is designed so that the entire nest can be removed from the model submarine, making these chores simple ones.

1. Rinse all launchers and weapons in clean, fresh water to dislodge any sand or dirt that might have gotten in there at the lake. Blow dry the launchers and take care to remove any water trapped within the bore of the breech-block and charge fittings.
2. Load, charge, and launch a weapon from each launcher to insure correct operation.
3. If employing the launchers in the pneumatic mode, discharge the gas bottle and remove the pneumatic mode shuttle from the shuttle housing, wipe away old grease, slather on a fresh coat of silicon grease, and re-install
4. Check that all launcher breech-blocks and interlink rods move freely from the battery to the launch condition when the shuttle is moved to the launch position. Leave the launchers in the launched condition in order to preserve breech-block spring tension.
5. Apply silicon oil between breech-block and after end of tube, and onto the interlink rod guide-bearing.

After all weapon system post-mission checks and operations have been successfully complete are the model post-mission checks and operations performed, after which the model is either put on display or placed in safe storage.

# TROUBLE-SHOOTING THE WEAPON SYSTEM

This is not a perfect world and things do break and require adjustment. Basic shop hand tools, silicon grease and oil should be on hand when performing shop or field repairs/adjustments.

**WEAPON FAILS TO CHARGE** In the event you go through the weapon charging operation and the weapon either fails to accept or will not hold the charge of propellant:

1. The breech-block-to-nozzle O-ring unseated from its machined groove. Remove the breech-block from the launcher

by loosening the breech-block-to-interlink rod set-screw and slid the breech-block off the rod. The shuttle must be in the launched position to move the breech-block. Take care not to loose the small stainless steel locking-ball – in fact, it's a good idea to remove it from the breech end of the tube and put it in safe storage. If the O-ring is missing, you'll find it tucked up within the tube, against the after face of the weapon back-stop. Inspect the machined groove of the breech-block for foreign matter or deformation and correct if necessary. Re-install or replace the O-ring after applying a layer of silicon grease. Re-assemble the launcher and test ... don't forget the locking ball!

2. There is a rupture in the flexible hose. Replace the hose. Duh!
3. The charge fitting core-valve is loose. Re-tighten the core-valve
4. Propellant gas is leaking from the weapon. This rare situation can be identified by charging the system then dunking it into water. Leaking gas from the muzzle end of the tube or through the opening atop the stop-bolt ball housing indicates a crack or pin-hole somewhere on the weapons body. Replace the weapon.
5. Failure to press the propellant can charging adapter down upon the system charge fitting tight enough to effect a gas-tight fit between the two is a likely reason the weapon does not charge.

**UNABLE TO GET LAUNCHER FROM LAUNCHED TO BATTERY CONDTION** When the attempt is made to push the breech-block fully forward to latch it with the shuttle, the shuttle can not be moved completely to the battery position:

1. The weapon is not fully seated against the weapon back-stop so that the stop-bolt ball makes contact with the cylindrical portion of the weapon. The still elevated stop-bolt ball prevents the forward end of the interlink rod from traveling further forward – as a consequence the attached breech-block will not make its full travel forward. Use the provided weapon loading ram to seat the weapon against the weapon back-stop while, at the same time, you push the breech-block fully to the battery position.
2. The weapon is properly seated against the weapon stop disc, but the stop-bolt ball has not dropped in front of the weapon. This can occur if the system is inverted or if water in the stop-bolt ball housing exerts enough surface tension force to overcome gravities pull on the stop-bolt ball to drop it down past the point where the forward tip of the interlink rod can act to push the ball down. Tapping on the launcher as you push the breech-block to battery will unseat the sticking stop-bolt ball.
3. The last launch cycle unseated the breech-block O-ring and it is blocking full forward travel of the breech-block as you attempt to position it to the battery position. Remove the breech-block, re-install the O-ring, and re-install the breech-block to the launcher.

**WEAPON FAILS TO LEAVE LAUNCHER AT MOMENT OF LAUNCH** When an attempt is made to launch a weapon and the weapon fails to leave the tube.

1. Failure of your linkage to fully depress the shuttle button in the mechanical mode. Either increase the throw of the linkage or find what is blocking full throw of the linkage.
2. Failure of gas pressure to fully push the shuttle to the launch position in the pneumatic mode. The shuttle O-ring has not been greases and offers too much friction within the actuator housing, there is a restriction somewhere in the flexible hose between the manifold and launcher, or there is insufficient charge in the gas bottle.
3. Failure of the solenoid-valve to cycle when commanded to launch. TCP improperly set-up. Receiver bus voltage too low. Improper make up of ground and 'hot' wire between TCP and solenoid-valve. Improper transmitter switch assignment.
4. Excessive binding between breech-block and the bore it rides in. Or, excessive binding between the interlink rod and its bearing. Or, binding of the forward end of the interlink rod where it passes through the stop-bolt ball housing.
5. You either failed to charge the system or there is a leak somewhere in the system.

**WEAPON BROACHES (JUMPS OUT OF THE WATER) AT MOMENT OF LAUNCH** The velocity of the weapon at the moment of launch is high. This is a consequence of the combined thrust of the weapon and the impulse provided by the rapidly expanding gas within the breech-block cavity the moment water gets to it. It is during this critical moment of weapon travel, as it makes the sometimes disturbing transition from gas to liquid, where the weapon may go astray from its intended course. Launching at too shallow a depth is the main cause of weapon broaching.

You can mitigate weapon broaching by reducing the launch velocity of the weapon. Cut holes into the torpedo tube, just aft of the weapon back-stop. These 'throttling holes' dump a significant portion of the impulse gas (propellent within the flexible hose, charge fitting and breech-block bore that accumulated during charging), lowering the pressure pushing the weapon forward, reducing its ejection velocity.

Keep in mind that if you incorporate throttling holes in the launcher, a lot of gas bubbles will be set loose within the bow of your model submarine. Provision has to be made to vent these gas bubbles quickly out the top of the hull or the entire model will broach when you launch a weapon.

**WEAPON EVIDENCES VERY SHORT RANGE** Range of the properly running weapon is a function of how stable it ran, and the amount of propellant you got into the weapon during the charging operation.

1. Insure that the bore of the weapons nozzle throat is not blocked – your pre-mission work-up called for you to run a length of .008-inch wire through the bore of each weapons nozzle, insuring it clear of obstructions.
2. During the charging operation you may not be holding the propellant can charging adapter up tight enough against the launchers charge fitting to fully unseat the two check-valves – only enough liquid gets into the system to achieve a low velocity launch, but not enough propellant gets into the weapon to achieve a reasonably long run. When you press the two charge fittings together, do so quickly and with force.
3. You may not be holding the two charge fittings together long enough to transfer enough propellant. Five seconds is the minimum time to hold the fittings together, that's usually long enough for the propellant energy in the can to match that of the weapon system.
4. There may be a small leak somewhere in the system, venting off the charge of propellant. Identify the leak and correct it.
5. Water could have gotten into the weapons hollow interior. As a weapon is launched, that water will crystallize and some of it may enter the nozzle tube and find its way to the nozzle throat, partially or completely blocking the flow of gas. Insure that no water is introduced into the system during the charging operation – blow out any water that accumulates within the launcher charge fitting before introducing a charge of propellant.

That's it. Now you know all about the care and feeding of your 1/72 weapon system. Good luck, and …

...**GOOD HUNTING!**

David Douglass Merriman III