Zen and the Art of Gerard Barrel Maintenance

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1 GENERAL DESCRIPTION

What is now commonly known as a Gerard barrel was first developed by M. Ewing and R. Gerard (1956) to collect large volume water samples for radiocarbon analysis. After some significant modification, Gerard and Ewing (1961) described a 220 liter sampler constructed of galvanized steel with an epoxy resin liner and Melamine lid.

The Gerard barrels in use today are constructed totally of 316 stainless steel and have a capacity of ~270 liters. The total U.S. inventory consists of 13 barrels which were constructed in the early 1980's under a NSF grant to WHOI. In 1990 the bottoms were replaced under a NSF grant to SIO ODF. The total inventory is currently stored at and maintained by SIO ODF.

The barrels primarily consist of a cylinder with a longitudinal divider plate and a butterfly type spring actuated lid. During lowering, an inverted scoop forces water down one side of the interior and out the other around the divider plate. They are deployed on 1/2"-9/16" trawl wire and closed with a messenger.

In order to determine the trip depth and to assure that no significant water leakage has occurred, a Niskin bottle with reversing thermometers is attached to each barrel. If the salinity samples from the Niskin and Gerard agree and the thermometers give the expected pressure, then one can generally be assured of having captured a representative sample. Nitrate and phosphate samples taken from Gerard barrels have found to be systematically offset from those collected at the same depth using a Niskin bottle equipped Rosette sampler. Silicate samples from Gerard barrels can be quite reliable. While there are numerous theories, the reason for the nitrate and phosphate offset is unknown. While Gerard nutrients may be offset, they can be useful as confirmation data in regions having a low salinity gradient with depth. Silicate is especially useful in the deep Pacific.

During the major sampling programs of the 1980's, Gerards were used to collect samples for ^{14}C, ^{228}Ra, ^{226}Ra, ^{39}Ar, and ^{85}K. Several thousand samples were taken from 84.5°N to ~63°S in the Atlantic Ocean. Significant results have already come from these measurements and many more are expected as analyses and interpretation continue.

2 DEPLOYMENT AND RETRIEVAL

Gerard barrels are easiest to deploy over the side near midships using a large "A" frame. They can be deployed at the stern, however, pitching can be troublesome. Sea state and launch area can be compensated somewhat by trip-tension settings (see below). Increased sea state and/or stern deployment require higher trip tension to prevent pre-tripping. With side-near-midships launching, Gerard casts have been successfully taken in sustained 35kt winds from ships in the 230-300 ft range (Knorr, Melville, Meteor). Launching under these conditions should not be attempted without thoroughly experienced personnel at all key positions.

Under flat calm conditions a Gerard cast could be hung by 3 people including the winch and crane operators. The process is significantly safer and faster with 4 or preferably 5. During rough seas, extra hands are necessary to help transport the barrels from the A-frame area to the storage racks and to steady the barrels while they are being hung on the wire.

The following is a reasonably detailed description of deployment and retrieval technique. It is assumed that 5 people are available. Normally either "a" or "b" is the group leader:

a: Niskin hanger
b: Clamp operator and cocker
c: General assistant
d: Winch operator
e: Crane operator

The idea is to hang the barrels as quickly as possible with no mistakes and above all else, no injuries.

2.1 Deployment

Hand signals to the winch operator should be given by the group leader only.

For casts which will approach the bottom, lift the weight and lower until it is just under the surface. For intermediate or shallow casts the weight should be lowered 10 or more meters to stabilize the wire.

Attach pinger to wire. Minimum weight to pinger distance is 5-7 meters except under unusual circumstances. Turn the pinger on and check for strong signal. Check switch operation for double ping. Winch operator lowers until wire out for first barrel is reached. The first barrel should be placed at least 3 meters above the pinger.

Crane operator hooks the barrel which is to be deepest (normally the highest numbered barrel) and moves it into a "ready" position - somewhere near the deployment location. During the move the barrel is steadied by one or more of the deck team. While in the ready position the group leader gives the barrel a final check for loose or non operational parts. There is generally time to do minor repairs in this position, but this quick check is no replacement for a more thorough check inbetween casts.

When the wire stops at the location designated on the cast card, the A-frame is started and brought in far enough to engage the wire in the V-slot on the deployment platform. Once in the slot, the wire is retained with either a spring-loaded capture pin or a chain with a hook. Once the wire is relatively isolated, the crane operator lifts the barrel and moves it toward the wire. As the barrel approaches the wire the taller of a and b guides the trip fork so that it straddles the wire while the other closes the upper and lower wire latches around the wire. The barrel must be hung high enough to allow messenger clearance between barrel and the platform and low enough to allow some member of the deck crew to unlatch the crane hook. After the barrel is latched to the wire, if practical, the crane operator leaves the crane and helps to steady the barrel.

The clamp operator first tightens the main wire clamp then both Klein clamps ("come alongs"). An air wrench helps with this operation. Meanwhile the Niskin person attaches the trip fork bungee cord. The clamp operator then cocks the barrel lid. By this time the assistant should have retrieved the appropriate Niskin, cocked it, and checked the thermometers, air vent, and spigot. Once cocked, the Niskin person attaches the Niskin. The air vent, spigot, and thermometers should be checked one last time at this point. The top and bottom lids of the Niskin should be rotated as far as possible away from the Gerard.

The assistant then hands the Niskin hanger a messenger. The messenger is attached first to the barrel, then to the wire. The messenger should be checked to be sure that it is free to fall. At this point the crane operator returns to the crane.

Finally, the trawl wire securing pin or chain is removed, the crane hook is removed, and the A-frame is extended. Once sufficient clearance is obtained between the barrel and the V-platform, the winch operator can begin lowering. Once fully extended, the A-frame should be turned off.[1]

Under good conditions, the entire hanging operation should take 3-4 minutes per barrel. With the tensions given in the chart in the maintenance section, the barrels can be lowered at up to 60 meters/minute in low seas, 45-50 meters/minute in moderate seas (the definition of "low" and "moderate" is a function of the ship, the deck gear, and the experience of the Gerard hanging team).

2.2 Retrieval

Gerard retrieval is just like deployment, only different. For one thing, these things are heavy when filled. Be careful.

During retrieval at least one member of the deck crew should watch the wire during the last 50 meters before a barrel is due to surface - winch counters are not always precise and winch operators can make mistakes. When the barrel is sighted, the group leader signals the winch operator of the fact and then gives the signal to continue retrieval. Another signal should be given when the barrel reaches the water surface and a continuous signal for "up slow" until the barrel has cleared the V-platform. When the A-frame is brought in the barrel to V-platform separation will increase so it is a bit of an art to signal stop correctly. If the winch is stopped too early, the barrel will not clear the platform; too late and the barrel will either be so high that it is difficult or impossible to attach the crane hook or be pulled into the sheave.

At any rate, the A-frame is brought in and the wire is captured either with the V-platform retaining pin or a chain. Next the crane hook is attached and tension applied. When the crane tension is right, the barrel will either move up very slightly or not move at all when the last clamp in loosened. Extreme care should be exercised during this operation because the barrels often tend to swing around the wire (complete revolutions are very common). People have been launched overboard by a barrel rotation at an unexpected time.

The messenger and trip fork bungee are removed. The assistant stows the messenger. While the Niskin hanger removes the Niskin, the clamp operator removes the lower Klein clamp. The assistant takes the Niskin, stows it, and begins taking samples. Once the Niskin has been removed the clamp operator removes the upper Klein clamp and finally the main wire clamp. If an air wrench is used on the clamps, care should be taken to not back the bolts out so far that the pillow block securing screws are sheared off. Again, during this operation, the crane operator helps to steady the barrel.

Finally, the lower then upper wire latches are released, the barrel is freed from the wire, and the crane operator begins moving the barrel toward the ready area or directly to the storage rack. The barrel is initially guided by the Niskin hanger. Meanwhile the clamp operator releases the wire retaining device and takes the A-frame out. Once the wire is clear of the platform, the group leader signals the winch operator to start up.

The deck crew then guides the barrel to the storage rack and secures it with cargo straps. Care should be taken that the messenger trip cable guard is not crushed as the barrel is secured. Sampling can then begin.

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1 Most A-frame hydraulic systems are not cooled. Therefore, the A-frame hydraulic pump should be turned off when not in use for more than 1-2 minutes.

The processes is repeated for each barrel. If you have gotten this far without hurting anyone, you surely will be able to remove the pinger and secure the weight without any help from us. Good luck.

2.3 Relevant Data

The following tables provide data relevant to Gerard barrel deployment and retrieval.

Table 1
Typical Gerard Weights and Drags
(in pounds)

Gerard weight in air	390
Gerard weight in air with accessories	400
Gerard weight in water as deployed	350
Weight of 9-barrel string	3150
Drag per barrel @ 50 m/min	30
Drag per barrel @ 200 m/min	480

Table 2
Typical Values Associated with 3-19 Steel Wire Rope

Data	1/2" (lbs)	9/16" (lbs)
Breaking strength	25,700	32,500
Yield strength	22,600	28,600
Elastic limit	19,275	24,375
Weight in air (km_{-1})	1,286	1,614
Weight in water (km_{-1})	1,118	1,404
Cable drag @ 50 m/min (km_{-1})	32	36

Table 3
Data Associated with Wire and Samplers as Deployed
Percentages are Percent of Yield Strength

Data	1/2" wire (lbs)		9/16" wire (lbs)	
Hydroweight	800		800	
9 barrels, 6 km wire, hydroweight	10,658		12,374	
Drag: 6 km wire, 9 barrels, 50 m/min	462		486	
Total static load + drag	11,120	49%	12,860	45%
Drag: 6 km wire, 9 barrels, 200 m/min	7,392		7,776	
Total static load + drag, 200 m/min	18,512	82%	20,636	72%
Total load with 8 barrels, 200 m/min	17,682	78%	19,806	69%

3 MAINTENANCE

3.1 Tool Kit

3.1.1 Common

Minimum tools for Gerard maintenance

Combination wrenches
- 7/16"
- 1/2"
- 9/16"
- 3/4"

Allen wrenches
- the one for the pillow block set screw
- 3/16" L shape, long arm
- 1/4" L shape, long arm
- optional 3/8" drive butterfly air wrench with set of Allen sockets

Pliers
- 8" slip joint
- needle nose
- 9" water pump pliers (channel lock)
- 12" water pump pliers (channel lock)
- diagonal cutters

Adjustable wrench (Crescent)
- 6"
- 10"

Socket tools
- 2 - 1/2" drive ratchet
- 2 - 3/4" deep socket 1/2" drive
- or

3/8 drive right angle air ratchet with male quick connect
3 - 3/4" deep 6pt 3/8" drive socket
50' 3/8" id air hose with quick connect fittings

Screw drivers (not stubby)
1/4"
3/8"
1/2" long blade

Miscellaneous
0-20lb spring scale (fish scale)
hammer
hack saw
grease gun
WD-40
Corning high vacuum grease or Apiezon M
SS or nichrome seizing wire
1/4" bungee cord
tie-wraps
marlin spike or awl
small fine file
flat file
knife
Teflon tape
tap and die set including 1/8" and 1/4" NPT taps (optional)

3.1.2 Special

2 cocking lever
nicropress sleeves (for messenger lanyards and trip cable)
sleeve crimper

3.2 Pre-Cruise

A significant amount of pre-cruise preparation is necessary to assure that the Gerard barrels are ready for the first station. In general the technicians/scientists who will be using the Gerard samples will be setting up other equipment during loading, departure, and transit. In addition, this preparation is much easier to do on a stable surface.

Check all O-rings for cracks, nicks, and/or flattening. Replace any that are defective. Lubricate all. Check for spares.

Check that lid cocks and closes smoothly. The lid should close on its own when released slowly. Do not free-trip the lid out of water.

Lock-tight zerk fitting on closure and cocking latches if loose. Be sure not to screw the zerk fitting in so far that it interferes with latch function (design flaw).

Lubricate lid hinge, cocking and closure latches, Klein clamps, and cargo strap ratchet. Check all for proper operation. Replace as necessary.

Adjust cocking and closure latches. Check that latch pins are tight.

Check messenger release cable. Adjust if necessary. Make sure that turnbuckle lock nuts are present and tight. The messenger pin should retract fully into it's guides without coming all the way out of the guides. Make sure that double nuts on release pin are tight.

Check pillow block set screws for proper function. Tighten or replace as necessary. Check 1/2" cable clamp bolt for smooth operation.

Clean and check drain valve and pressure relief valve.

Check and/or tighten all nuts, bolts, cap screws.

Check function of trip arm for smooth operation.

Check that all shackles are installed properly and that the shackle pins are seized with non-corroding wire or tie wraps.

Fill with water and check bottom plate for leaks.

Check that there are enough messengers (including spares), that the attachment mechanisms work smoothly, and that the lanyards are appropriately sized and in good shape.

Check barrel racks for bumpers, plastic base, wooden forms, welds, etc. Fix or replace as necessary.

Set trip tension to values similar to those given below. Measure (with a "fish" scale) the force necessary to "trip" the Ger. lid (actually the force required to fully retract the lid latch) and the force necessary to release the messenger. All measurements are made by placing the trip fork in approximately the position it would be on the wire, then applying a downward pull from the bungee cord hook at the end of the fork. The length of the trip lever arm was also measured from the pivot to the bungee hook. There are a few cases below where the messenger would be released before the lid tripped. This indicates that an adjustment is necessary.

Gerard #	Force to trip lid (lbs)	Force to release messenger (lbs)	Trip arm length (in)
81	10.0	11	8.5
82	16.5	11	8.5
83	7.5	16	7.5
84	7.0	13	7.5
85	9.0	17	6.5
87	9.0	10	7.75
88	8.0	12	
89	10.0	15	8.0
90	9.0	20	7.0
91	10.0	8	7.5
93	14.0	11	8.25
94	9.0	12	

3.3 During Cruise

During deployment and recovery the barrels are subject to significant stresses and vibrations. Continued proper function requires regular maintenance. Given the low density of sampling, the time required for a cast, and the number of people involved, it is very expensive to have a barrel failure.

3.3.1 Before each use

Check for any problems during last deployment. Correct as necessary.

Check Klein clamps for smooth operation

Check pillow block set screw.

Check Niskin trip lever for tightness.

Quick visual and "finger tight" check of critical fittings (e.g. latch pins, messenger release cable, bungee cord and springs, etc.)

3.3.2 After 10 casts

Clean and lubricate o-rings for lid, pressure relief valve, and water drain.

Check all nuts and bolts for tightness.

Check for excess slack in messenger release cable.

Lubricate cargo strap ratchets and Klein clamps.

3.4 Post Cruise

The most important thing after a cruise is to get all of the salt water out of the barrels and wash the entire barrel. Washing may require the use of a degreaser as well as detergent.. At the end of a cruise the barrel bottoms should be removed for cleaning. Lubricate Klein clamps and cargo strap ratchets. Make sure that all spares get organized if necessary. If possible, the barrels should be stored inside and covered.

4 PROBLEMS AND SOLUTIONS

The two most common problems associated with Gerard casts are mis-trips and leaking. Both lead to bad, or at least compromised, samples. Fortunately, as long as working conditions are reasonable (*i.e.* sea state), the solutions are generally straight forward.

4.1 Mis-trips

For this discussion a mis-trip is defined as the failure of either the Niskin of Gerard to securely close at the desired depth and/or release the messenger.

4.1.1 Gerard barrel

Gerard barrels are susceptible to pre-trips, post-trips, and no-trips. All three types can be either full or partial failure. A pre-trip is when a barrel closes and/or releases its messenger before the desired terminal wire reading is reached. A no-trip is when a barrel does not close and/or release its messenger. A post-trip is when a barrel closes and/or releases its messenger on retrieval. A no-trip is a necessary, but not sufficient, condition for a post-trip.

4.1.1.1 Pre-trips

A pre-trip is probably the worst type of failure. If a barrel closes early and releases its messenger, the operator will usually know it because of the early "double ping". In this case, the barrel that pre-tripped and all deeper barrels can have samples from depths less than desired. If the lid closes but the messenger is not released, the operator does not know and the cast proceeds. The net result of this type of pre-trip can be bending the lid support bar to the point that the barrel no longer functions. The U.S. Gerard barrels can be lowered 500-1000 meters with the lid closed with no permanent damage. Lowering a closed barrel more than 1000 meters will jam the lid closed at the very least and possibly ruin the barrel either permanently or at least for the rest of the cruise. Any time a barrel pre-trips, the lid o-ring should be carefully checked for cuts, gouges, etc.

The most common cause for a pre-trip is insufficient trip tension for the existing sea state. The table of trip tensions in section 3.2 gives values for light to moderate seas. When working during less favorable conditions, these values may have to be increased to prevent frequent pre-trips. The simplest way to increase the trip force is to either add a bungee cord to the trip fork or to tighten ones that are already there. Lid pre-trips can also be caused by having a "hair trigger" setting on the lid open latch. The lid open latch should be adjusted so that it is as low as possible without interfering with the lid rotation.

Pre-trips can also be caused by a hard, sharp snap of the trawl wire or a severe pitch or roll. This sort of snap generally occurs during rough sea conditions or high wire angles when the wire is in or near the V-platform. Wire snap can be severe enough to actually break messenger lanyards. Nothing can be done about pitch or roll, but snapping can be decreased by carefully monitoring wire angle while the A-frame is being moved. The best messenger lanyard material is 1/8" SS cable. Slower wire speed during deployment will decrease rough weather pre-trips.

Messenger release only pre-trips are generally the result of improper messenger release pin settings. Adjustment of the pin travel, messenger release cable length, and/or messenger release tension will generally cure this problem. Messenger release tension should usually be greater than or equal to lid trip tension.

4.1.1.2 No-trips

A no-trip occurs when either a lid fails to close, a messenger is not released, or both. No-trips are not as common as pre-trips. A no-trip can be caused by having the trip tension set too high. More frequently, it is a Murphy's Law effect. If the wire moves down rapidly due to a ship roll or pitch just as the messenger hits the trip arm, the momentum transfer may not be rapid enough to trip the bottle. In general, if a barrel which has been tripping properly no-trips, no action should be taken other than venting expletives at a high decibel level. Multiple occurrences with the same barrel indicate action should be taken.

If the barrel lid closes, but the messenger is not released, it may be necessary to adjust the messenger trip pin travel distance. This is done by moving the double locking nuts on the trip pin. Another possible cause is having messenger lanyards which are too long. It is possible, but rare, to cure a no-trip by yoyoing the wire.

4.1.1.3 Post-trips

Post-trips are uncommon. About the only way they can occur is if subsequent to a no-trip, whatever caused the no-trip is undone by the upward motion or vibration *e.g.* a messenger which has hung up on its lanyard can release tripping barrels below.

4.1.2 Niskin bottle

Piggyback Niskin bottles are subject to all the same problems they have when used on a Rosette. The most common failure is no-trip caused by a lanyard or lid hangup. Other than routine Niskin maintenance no action is generally required.

4.2 Leaking

4.2.1 Air

An air leak on a Gerard barrel can degrade sample quality by atmospheric contamination. Air leaks are especially problematic if the water is analyzed for trace gases (*e.g.* ^{39}Ar or ^{85}Kr) and to a lesser extent for ^{14}C. The simplest way to test for an air leak is to open the water drain valve after the full, closed Gerard arrives on deck. If an air leak is present, water will flow. If a barrel has pre-tripped, the internal pressure is often not completely relieved on retrieval. This can cause an apparent air leak because the pressure will cause flow when the water valve is opened.

The most common sources of an air leak are incomplete barrel lid closure or a bad lid o-ring. Incomplete closure can generally be fixed by cleaning and regreasing the lid o-ring and o-ring seating surface. A torn, cut, gouged, or otherwise damaged o-ring must be replaced. With the aid of air tools, a lid o-ring can be replaced in 30-45 minutes. Two people are required to remove the lid spring, but the rest of the procedure can be done by one. Although much less common, air leaks can also occur around the 1" PVC plug in the barrel top and at the mating surface between the barrel top and sides. Tightening the plug or barrel top cap screws will generally fix these leaks.

4.2.2 Water

Water leaks can occur in the PVC fittings and valve which make up the water drain and around the large o-ring in the barrel bottom. The water drain leaks can usually be fixed with Teflon tape and/or tightening; otherwise the part should be replaced. Leaks around the bottom are often more of a hassle. If tightening the bottom marmot clamp does not cure the problem, then the bottom has to be removed. Once removed the o-ring should be cleaned and regreased, or replaced if damaged or flattened. As the bottom clamp is replaced, it helps to set the o-ring if one person hammers on the marmot clamp with a soft mallet while another tightens the adjustment screw. After the clamp is secured, it is absolutely necessary to test for leaks before the barrel is reused.

5 SHIPPING

Avoid if possible unless you are seeking to spread your wealth or launder money. If necessary the barrels can be shipped in individual crates or in the deck racks with each rack containing 3 barrels. The barrels can be trucked on a flatbed, but inside a van is preferably to minimize dirt accumulation. All of the U.S. barrels were made in the U.S. so customs problems are generally not too bad. When shipped by commercial carrier, the barrels should be insured for replacement cost (~$25,000 each). Each empty barrel weighs 400 lbs. Each rack weighs **yyy** lbs. When individually crated the barrels can be air freighted, but it is obviously expensive.

6 REFERENCES

Ewing, M. and R. Gerard (1956) Radiological studies in the investigation of ocean circulation. In: Aspects of Deep-sea Research, *U.S. National Academy of Sciences National Research Council, Publ.*473, 58-66.

R. Gerard and M. Ewing, (1961) A large-volume water sampler. *Deep Sea Res.*, *8*, 298-301.

7 PARTS LIST

The following parts list is broken into major assemblies to facilitate finding a particular part for reference. Given the current state of the barrels it is possible that no barrel contains exactly the parts listed below. This list is what should be there. In most cases the differences are substitution of hex head bolts for cap screws or using a longer screw when a shorter would fit. In some cases lengths substitutions can not be made. Unless specifically stated otherwise, all hardware is 316 stainless steel. ***304 stainless is not an acceptable substitute*** for 316 stainless. Many of the parts names used are simply invented. Hopefully, the names are adequately descriptive. At the end of the list a summary of common hardware and o-rings is given.

7.1 Bottom assembly

1 bottom plate
1 Marmot clamp
1 o-ring (size 2-390)
4 plug 3/8" NPT

7.2 Water drain guard assembly

10 3/4" x 1/4"-20 cap screw
10 1/4" lock washer
10 1/4"-20 hex nut
1 7" 5/16"-18 hex bolt
1 5/16" flat washer
1 5/16" lock washer
1 5/16" hex nut
1 6" sleeve
1 #185 zinc

7.3 Water drain assembly (all parts schedule 80 PVC)

2 1" NPT close nipple
1 1" elbow
1 1" ball valve
1 1" quick connect (Lasco D2464/2467)
o-ring (size 2-124)
1 1" plug

7.4 Main wire clamp assembly

1 2 3/4" pillow block
1 2" 1/2"-13 hex head (3/4" across flats) bolt end tapped .175" for 10-32 1 3/8" 10-32 slotted flat head screw

7.5 Klein clamp (2)

1 2" 1/2"-13 hex bolt end tapped .175" for 10-32
1 1 1/2" pillow block
1 3/8" 10-32 slotted flat head screw
1 1/2" chain shackle
1 1/2" anchor shackle

7.6 Wire latch assembly 2 required

1 latch arm
1 latch arm pivot
Latch arm pivot attachment hardware
  2 1" x 5/16 - 18 cap screw
  1 5/16 lock washer
  1 5/16 - 18 hex nut
1 latch catch
latch catch hardware
  2 1/2" x 1/4"-20 cap screw
  2 1/4" lock washer
  2 1/4"-20 spring retainer 'nut'
  1 1/4" spacer
  1 1/16" spacer
  1 cotter pin
  1 spring

7.7 Top plate

8 1 1/4" 5/16"-18 cap screws
8 5/16" lock washer
1 pressure release vent (PVC)
  o-ring (size 2-325 or 2-012)
1 latch plate
3 1" 5/16"-18 cap screw
3 5/16" lock washer
1 plate o-ring (size 2-464)

7.8 Lid assembly

1 lid
1 o-ring (size 2-453)
1 1/4"d-3/4"l lid cocking pin
1 cock bracket (open)
  2 1" 1/4"-20 cap screw
1 latch assembly
  1 latch body
  1 latch pin
  1 latch throw bolt
  1 zerk
  4 1/2" 1/4"-20 cap screw
  4 1/4" lock washer

7.9 Lid hinge bar assembly

1 hinge bar
1 cocking ring
3 1 1/2" 5/16"-18 cap screw
7 5/16" lock washer
3 5/16" flat washer
3 5/16"-18 hex nut
8 1" 5/16"-18 cap screw
hinge bracket assembly
  1 left
  1 right
  4 3/4" 1/4"-20 slotted flat head screw
  2 zerk
1 hinge block
1 Niskin trip assembly
  1 actuator lever
    1 1/2" 1/4"-20 cap screw
    2 1/4" flat washer
    2 1/4" lock washer
    1 spacer/pivot
    1 1 1/4" 1/4"-20 cap screw
  1 plunger bar
    1 1" 1/4"-20 cap screw
    1 1/4" flat washer
    1 1/4" lock washer
    1 1/4"-20 hex nut

7.10 Hood end plate assembly

1 hood end plate
1 latch assembly
  1 latch body
  1 latch throw bolt
  1 latch pin
  1 zerk
  3 3/4" 1/4"-20 cap screw
  3 1/4" flat washer
  3 1/4" lock washer
  3 1/4"-20 hex nut
1 latch trip arm assembly
  1 latch trip arm
  1 spacer/pivot
  1 3/4" 1/4"-20 cap screw
  2 1/4" flat washer
  2 1/4" lock washer
  1 1/2" 1/4"-20 cap screw
4 3/4" 5/16"-18 cap screw
4 5/16" flat washer
4 5/16" lock washer
4 5/16"-18 hex nut
4 "L" mounting bracket

7.11 Hood assembly

1 hood
1 #185 zinc
3 3/4" 5/16"-18 cap screw
1 1 1/4" 5/16"-18 cap screw
4 5/16" flat washer
4 5/16" lock washer
4 5/16"-18 hex nut
2 support arm
  2 1" 5/16"-18 cap screw
  1 1 1/2" 5/16" cap screw
  3 5/16" flat washer
  3 5/16" lock washer
  3 5/16"-18 hex nut

7.12 Trip assembly

1 trip fork
1 trip lever
1 2 1/4" 5/16"-18 cap screw
2 5/16" lock washer
1 5/16"-18 hex nut
1 1 1/4" 5/16"-18 cap screw
1 spacer
trip lever spring(s) and/or bungee
1 3/16" turn buckle with locking nuts and cable loop ends
1 5" 3/8"-16 rod (drilled one end turned down other)
2 3/8"-16 hex nut
1 spring
1 3" 1/2"-13 cap screw
1 1/2"-13 hex nut

7.13 Messenger release cable guard

1 upper guard
1 lower guard
4 3/4" 1/4"-20 cap screw
4 1/4" lock washer
4 1/4" flat washer
4 1/4"-20 hex nut

7.14 Miscellaneous

1 1" anchor shackle

7.15 Common hardware summary

1/4"-20
  cap screws
    8 1/2"
    22 3/4"
    3 1"
    2 1 1/4"
  12 flat washer

28 lock washer
17 hex nut
5/16"-18
cap screw
7 3/4"
13 1"
10 1 1/4"
4 1 1/2"
1 2 1/4"
1 7"
15 flat washer
33 lock washer
17 hex nut
3/8"-16
2 hex nut
1 5" threaded rod
1/2"-13
cap screws
2 2"
1 3"
1 hex nut

7.16 O-ring summary

All nitrile "Buna N" 70 durometer compound 674 (674-70)
lid 2-453
top 2-464
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