# EMERGENCY BATTERY POWER: TESTING STRINGS IN THE OCEAN.

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We consider here the addition of batteries to the array for powering it during testing, deployment and emergency situations.

## A. FULL ARRAY

The use of storage batteries as emergency power supplies (EPS) has been suggested. A 350v supply consisting of 200 amp–hr automobile storage batteries (an extremely lethal combination) could be placed in the junction box to power the entire array in the event of power failure from shore.

While such a supply could certainly be installed, and would supply power for the array for perhaps 10–12 hours at full load, the question is what its purpose would be. The array is valuable for physics only if it runs for a period measured in months, not hours. One conceivable reason is the possibility of suddenly wanting the array to be active while primary power was unavailable, because some significant astronomical event was in progress for which the array data would be especially valuable; we can imagine no such event.

In the event of primary cable failure interrupting the power, powering the array is of value only if it must be accessed for retrieval or reconnection. If the cable failure were not complete – i.e. at least some of the fibers remained operative – then emergency power at the array might be valuable for diagnostic purposes. However, in the event of power failure in the cable, the fault can be located from the shore end by conventional means (e.g. reflection of an r–f pulse at the fault). In that case the only signal wanted from the strings might be that of an acoustic transponder, so that they could be located for reconnection. Even that might not be needed; when the array is surveyed in, the location of each string in the ocean–bottom coordinate system will be well–known. We cannot see any reason why emergency power would help protect the system or increase its reiability.

In short, it is difficult to think of a good reason for emergency power for the array as opposed to emergency power for an acoustic transponder. Almost all deep–ocean transponders are designed for self–contained battery operation for several years. A transponder on each string is a good idea in any case, and we expect to implement it.

B. INDIVIDUAL STRING SUPPLIES.

The situation is different when we consider EPS for individual strings. If individual strings can be activated for an extended period, there are two applications that suggest themselves immediately. One is to test the completed strings in the ocean before deployment, a highly desirable operation. The other is to track and test the string during deployment.[1]

1. We first consider the cost and feasibility of individual string EPS.

Since each string takes a maximum of 550 watts, or 1.57a at 350v, a battery of 1 amp–hr capacity could run the string for 38 minutes. Such a battery would be of moderate size and cost. Appendix 1 gives a detailed discussion of battery requirements, capabilities and cost.

The question now arises of how to conduct an adequate test of the optical modules from a stored program. Normally test and calibration relies on a CM in another string. It appears likely that the K40 and bioluminescent background of the ocean is sufficient to check optical module operation.

If, after more detailed study, the operation appears feasible, it will be worth while to look into the possibility of recording the operation, at least for the pre–deployment test. The recording medium remains to be determined.

2. During emplacement, before strings are connected to JB.

At this point, acoustic data on string position would be useful. This could be provided, however by a recoverable self–contained acoustic transponder.

More important, however, is the possibility for a final check on string operation before the rope attaching the string to the deployment vessel is released. While a check will be carried out on deck before the string is lowered to the bottom, a battery useful for short–term operation of the string could be very valuable for a final OK before release.

PRE–DEPLOYMENT TESTING.

When the question of how to test the string is answered, it will open up a new possibility: that of testing the operation of the string before final deployment, by lowering it to a somewhat lesser depth – say one or two kilometers. This is something we have always wanted to do, but until now no practical procedure had been suggested. It would check out not only the string operation but the entire technique of deploying the string at sea, thus providing invaluable experience for the crew. If a recording of the test data

1. This use was suggested by Wilkins in the "White Paper" on Dumand Deployment, HDC–4–89

could be made, it would allow more detailed study of the results after the test was completed.

INTEGRATION OF EPS INTO OPERATIONS.

Once a battery capable of operating the string for an hour or so exists, it can be exploited if the string needs to be released – for example if it is being replaced because too many optical modules have failed. It is planned to have an acoustic transponder on the string for emergency release.

Since the presence of both an EPS and an acoustic transponder seems desirable, a symbiosis of the two should be considered in detail. Thus the acoustic transponder might be used to turn the EPS on or off during test, deployment, or recovery operations, thus conserving battery power during the several-hour period of ascent or descent. During operation under shore power the battery can be trickle charged. Further consideration may turn up other useful possibilities.

CONCLUSION.

It appears that individual string battery power is much more useful than a central array emergency battery power supply. The provision of such supplies makes possible full operational testing of the strings, both before and during deployment, and thus will add significantly to the reliability of the operation.

## APPENDIX I

An investigation of possible storage batteries for this purpose has yielded useful information. Standard 12-volt batteries of capacity in the range of a few amp-hrs are made for motorcycles and other uses. Since the string power supplies are all regulated and capable of operating with input voltages from 250–400 volts, the battery supply can be designed with the constraint that it can be recharged at the normal operating voltage of the array, i.e. 350 volts. It turns out that for batteries in the size range required – to operate a string for about 2 hours – a battery designed to yield 300v will recharge at 350 to 360v. Thus we design for a 300v battery supply; at 2.0v per cell, this requires 25 12-volt batteries.

The lead-acid battery has properties that make charging it in a confined space an operation requiring care. Charging may produce both hydrogen and oxygen gas. At high pressures these will remain in solution. It may well be that we will find no need for recharging the batteries, if their sole function is to aid deployment. In that case the following considerations on the problems caused by gas generation during charging will be irrelevant. If we do want to recharge them, then we have to take into account those problems, as follows.

We distinguish two cases: batteries operable at high pressure, and batteries that are not. We will also assume that the battery will be located within the string anchor, and therefore will not be retrieved when and if the string is.

1. If the battery is operable at high pressure no gas will be generated until the pressure is released, which would occur only if the battery is brought to the surface. HIG has had experience with conventional automobile storage batteries at depths comparable to DUMAND. They were modified slightly to introduce an oil whose specific gravity was intermediate between that of the electrolyte (ca. 1.28) and seawater (1.05 at depth). This kept the seawater out and the battery worked perfectly. They did not try either recharging the battery at depth (which would have been indeed remarkable) or retrieving it.

2. If the battery is not operable at high pressure, it will require a sealed pressure container, in which the gases will slowly accumulate. Filling the vessel with nitrogen at the maximum allowable pressure (e.g. 4 atmospheres for the Sonnenschein batteries described below) would greatly delay any venting from the battery into the container. It will of course be necessary to design carefully to avoid any chance of igniting the accumulating explosive mixture. We would hope to avoid this by using batteries operable at high pressure. If we must provide a pressure–sustaining container for the battery, its cost will very likely exceed that of the battery; thus the economic advantage of pressure–tolerant batteries is considerable.

Since the primary purpose of the battery is to operate the array before and during deployment, the number of charging cycles will be small, once the strings are connected to shore. Thus problems connected with recharging, such as gassing, are probably not of primary concern. One could limit the number of recharges to a value at which the produced gases would be negligible. It is more likely that unless special care to exercise them is taken, the batteries will deteriorate (by sulphation) for lack of use – a common problem for lead–acid cells.

The quotations that follow are based on the maximum string power assigned as an upper limit to our power requirements. It is quite likely that the eventual power consumption will be considerably less, in which case the battery requirements will be correspondingly reduced. We have at present quotations as follows (both for lead–acid):

1. Sonnenschein: Model A212/6S, 12v., 6 amp-hr. Wt 2.185 kg. Price $31.25 each, or $815. for 25. Total wt. ca. 125 lb., volume 0.83 cubic ft. Will operate string at 300v 1.84a for two hours at $4^{o}$ C. Max pressure 4 atm; above this, the battery gas vent distorts. This will require a pressure vessel, with an escape valve. There is not expected to be much gas buildup. As with other batteries, the battery top can be removed and modified to remove the valves; then the battery can probably be made pressure-tolerant. Testing would be required to verufy this.

2. Globe Dynasty: Model GC670, 6v., 7 amp-hr. Wt. 1.2 kg. Total Wt. for 50 units 132 lb. Volume 1618 cu. in = 0.936 cu. ft. Will operate string at 300v 1.84a for just over 2 hrs. Pressure tolerance not known – will be tested. Cost quoted by Honolulu Electronics at (unavailable).
Battery is sealed, maintenance-free. Gas recombination advertised as 99%. As with the Sonnenschein battery, this one also can probably be made pressure-tolerant; again, testing will be needed.

The combination of pressure-tolerant batteries and abandonment at the ocean bottom essentially eliminates the problem of accumulation of explosive gas mixtures; this path is therefore one to be highly prized.

The size and cost of the battery supply will decrease if the string power requirement turns out less than the maximum value assumed. If the string takes 300w instead of 550, the current drain will be just 1 amp. A 4 amp-hr battery that will run the string 2 hours will weigh 92 lb instead of 132, and take .565 cu.ft. rather than .94. The cost will probably not decrease proportionally in these small sizes.