INSTRUMENTATION FOR OBTAINING SEISMIC ANISOTROPY DATA FROM OCEAN BOTTOM USING MOORED SONOBUOYS

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INTRODUCTION

Using observations by Raitt and Shor, Hess (1964) noted that there was a correlation of compressional wave velocity in the mantle with seismic profile direction, suggesting that seismic anisotropy existed over a broad area of the Pacific basin. This paper describes a system developed and used to look for the existence and extent of this seismic anisotropy.

HISTORY

Measurements by Verma (1960) have shown that many mineral crystals exhibit variations in wave velocities with direction because of the inherent elastic anisotropy associated with the crystalline structure. Studies by Biot (1965) and Thurston (1965) have shown theoretically that an isotropic material becomes anisotropic when subjected to nonhydrostatic stresses. Mechanisms used to account for the details of the earth's crustal structure, such as the moving of the earth's major plates, could produce the nonhydrostatic stresses needed to produce seismic anisotropy.

In January 1965, Scripps Institution of Oceanography carried out its first anisotropy study experiment using the research vessels FLIP, and BAIRD as receiving stations on a 100 Km seismic refraction profile. A second expedition to study seismic anisotropy was carried out in August 1965. These experiments were conducted at two locations centered at 31°N, 121°W, and 35°N, 126°W. Significant seismic anisotropy was observed at these locations. Raitt, Shor, Francis, Morris (1969). The question of how broad an area of the Pacific basin seismic anisotropy existed was not answered. During the summer of 1966 Scripps Institution of Oceanography in conjunction with the University of Hawaii, Oregon State University, and the University of Wisconsin conducted seismic refraction profiles on the Hawaiian Arch. Results from this expedition show that the upper mantle immediately beneath the Mohorovicic discontinuity is anisotropic with respect to compressional waves, in the areas studied. Morris, Raitt, and Shor, (1969). Because of operational considerations and expense it is rarely possible now to obtain seismic anisotropy data using a multi-ship operation. A system using sonobuoys and ballons was, therefore, developed making it possible for a single ship to obtain good data in a reasonable amount of time. Raitt, Shor, Morris, and Kirk (1971).

DESCRIPTION OF THE METHOD

At the time the single ship seismic anisotropy project was started, and most of the time since, funds were quite limited. Nothing seemed to be commercially availalble at a reasonable cost in the way of hardware for the project. The first step in the development work was to establish the availability of Navy sonobuoys. It was found that slightly used SSQ48 and SSQ41A sonobuoys could be obtained for research use. The SSQ41A seemed to be the best of the samples we were able to test for seismic refraction use.

In 1968 the development work was divided into three phases. The first phase consisted of developing a usable sonobuoy for refraction use. The second phase consisted of developing a receiving system capable of receiving seismic refraction data over a distance of 40 miles. The third phase consisted of assembling the shipborad radio and recording system.

Several types of unmodified sonobuoys were tested from the OCONOSTOTA off the coast of California. The sonobuoys were thrown in the water and shots were dropped as we sailed north. An unmodified SSQ38A sonobuoy proved to be the best of the types tested. Unfortunately, these sonobuoys were no longer available in quantity. During these tests it was determined that the sonobuoys could be tracked down and recovered using signals from the air gun and the GDR recorder. A small kytoon balloon was also tested on this trip. It did not have enough lift to raise the antenna high enough to gain any improvement over the channel 7 Television antenna and preamplifer mounted on the flying bridge of the OCONSTOTA. The next step was to test a commercially modified SSQ41A sonobuoy, an SSQ38A and SSQ41A Magnovax sonobuoys with their hydrophones replaced with Brush AX58 hydrophones. Again, the SSQ38A sonobuoy was the best, and the commercial modified sonobuoy the worst. As Magnavox SSQ41A sonobuoys were readily available, it was decided to proceed with our own modifications to make these sonobuoys useable for seismic refraction work. These modifications will be described later.

A firm in San Diego was hired to develop a long range receiving antenna system for use with our modified sonobuoys. Their solution involved flying a rather heavy instrument package and antenna system from a large helium filled balloon tethered to the ship. The object was to have the balloon up high enough to receive data from the sonobuoys, and then retransmit the data down to the ship. The theory was fine, and all worked out by people who had never ventured out to sea. The project was a failure. After a month of trials between San Diego and Honolulu, the system was discarded. Part of the system flew off in the balloon when it escaped one dark night. A rotatable directional ham-radio type antenna and pre-amplifier were installed on the research vessel ARGO while in Honolulu. Between Honolulu and Japan on Leg II of SCAN expedition, April 1969, another complete system was developed using materials on-board ship. The sonobuoy part of the original system was retained. A small raft was anchored to the ocean bottom with scrap iron. SSQ41A modified sonobuoys with AX58 hydrophones were floated out from the raft. The transmitter portions of the sonobuoys and the antennas were flown just below a helium filled Jalbert J2 balloon (Fig. 1). Later a third sonobuoy was added to the raft, and its transmitter and antenna tied to a mast on the raft. If the balloon crashed, we could still get some data, and a signal to locate the raft again. Seismic signals produced by the shooting ship are picked up on the hydrophones, amplified, and sent up a wire to the transmitters near the balloon. These signals are then transmitted back to the shooting ship, thus allowing a one-ship operation with two or three remote balloon receiving stations. Our first attempts to carry out a multi-balloon anisotropy station were hampered by problems of keeping three, or even two stations operating long enough to finish a pattern. Helen Kirk carried out the first successful two balloon station on Leg III of Scan expedition in July 1969. Successful observations were obtained in July and August 1970 extending the anisotropy observations into the North West Pacific Ocean between the Aleutian Islands and Japan. In the Spring of 1972, two locations on the Cocos Plate southeast and northwest of the Tehuantepec Ridge were studied. The data showed that there is significant anisotropy in these areas, Shor, Raitt, Henry, Bentley and Sutton, (1973).

SONOBUOY MODIFICATIONS

Earlier sea tests proved that the standard Navy sonobuoy type SSQ41A was unsuitable for seismic refraction work in its standard form unless very large explosive charges were used from the shooting shop. The attenuation of the low frequencies was too severe, and the battery life too short. Several sets of modifications were carried out in the lab, and tested at sea. The best proved to be to lower the frequncy response of the "Sonic Amplifier", change the AGC, remove the hydrophone system, and put on one of Scripps' standard AX 58 hydrophones. The salt water battery that comes with the sonobuoy only lasts about three hours. When the voltage drops on these batteries, the sonobuoy sinks itself. At least 32, preferbly 48 hours were necessary to carry out an anisotropy station. It may be possible to use seismic refraction patterns allowing a station to be carried out in less than 20 hours. At the time of this writing, there is no reference on the results of these experiments.

Modifications to the SSQ41A sonobuoy are described in detail below. Steps 1 through 6 are to be followed if the sonobuoy is to be modified and reused as a free floating seismic receiver. For use in the raft-balloon system, only the two printed circuit boards are used. For these, the sonobuoy may be carefully sawed open.

1. Remove sink-plug with sharp pliers; or a large screwdriver. Sink-plug unscrews counter-clockwise. Pull the white wire off of the plug.
2. Remove twelve screws in a circle on top of the sonobuoy, and the cage around the antenna.
3. The insides of the sonobuoy should push down through the shell.
   a. If not, unscrew two screws on the antenna plug lock, and carefully pull out antenna plug. Place a piece of heavy pipe over the antenna and pound the whole works on the floor.
   b. Last resort: Hack saw.

4. Unscrew two screws on the bottom of the sonobuoy. Unscrew five screws above the hydrophone cable. The hydrophone and cable, etc., unit can how be carefully lowered enough to reach in and cut the battery leads. Pull off the battery, dye marker, and hydrophone assembly.
5. Remove the 1-3 hour time switch. This can be used later in the battery box.
6. Remove screw from the base of the antenna (on top of the sonobuoy). This is spring loaded, WATCH OUT. Pull out antenna, and remove the spring under it.

The above steps apply only to Magnavox Company sonobuoys. SSQ41A sonobuoys manufactured by several other companies differ slightly in construction.

Steps 7-30 Refer to Fig. 2.

7. Lift one end of R201, a 27k resistor, or remove it. This takes the power off the signal lead. If this is not done it will destroy the pre-amplifier in the AX 58 hydrophone.
8. Remove Q301 and diode Cr 301 from the transmitter board. This is the circuit that controls when the sonobuoy sinks.
9. Add a 100 pf capacitor across the signal input. Remove the black and red wires and connect them to ground. Install a jumper across the two empty holes.
10. Add a one mfd mylar capacitor across C202.
11. Add 4.7 mfd capacitor across C204. Watch the polarity.
12. Add a one micro-henry RF choke in series with R209 using the end going toward Q201.

13. Add a 330 mfd capacitor across C207.

14. Add a 0.01 mfd capacitor from the junction of R209 and R212 to ground, and another 0.01 mfd capacitor across C206.

15. Add a 330 mfd capactior across R215.

16. Add a 20pf capacitor from the base of transistor Q205 to ground.

17. Add a one mfd capacitor across C217.

18. Add a 0.47 mfd capacitor across C210.

19. Add a 330 mfd capacitor across C216.

20. Add a 1 mfd capacitor across C208.

21. Set R213 gain to 50 Db, using a 100 Hz signal.

22. Set R221 AGC control to 90 degrees clockwise.

23. The Deviation control, R234, should be left as it is, unless the peak-to-peak square wave from a strong signal is not 4 volts peak-to-peak.

24. Add a 1/2 watt, 510 ohm resistor in series with the battery lead, if 18 to 19 volts is used as a power source.

25. Add 25 mfd capacitor from the 510 ohm resistor lead going to the printed circuit board. The negative lead of this capacitor goes to ground.

26. Add a 15 ohm, 1 watt resistor in series with the battery lead going to the transmitter board.

27. Add a 25 mfd, 25 volt capacitor from the above resistor lead going to the printed circuit board. The negative lead of this capacitor goes to ground.

28. For balloon use, the transmitter board is removed from the sonobuoy. Cut the extra material from the printed circuit board. Install

this board in some kind of weather, preferably water-proof container. Our first containers were made from the material obtained from used coffee cans. Later, we had the Scripps' machine shop make some simple plastic containers, that could be tied onto the balloon flying line. The antenna with its ground plane is fastened to this container.

29. Set the last coil (white) on the transmitter board for about 1 watt output, and about 130 ma current from the battery (See Fig. 3). It may be necessary to slightly peak each of the tuning slugs. Usually only the last one needs changing when reassembled into its flying line container for balloon use. Recheck the battery current when the transmitter board is installed in the can. A small hole in the side of the can above the tuning slug of the white coil is useful. Seal this when finished tuning the transmitter.

30. Check the audio output of the transmitter under test using an oscilloscope and a receiving radio (See Fig. 3).

BATTERY CASES

The first battery containers were made from the plastic containers that the sonobuoys came in. Later they were made from a piece of PVC pipe. A round end piece is cemented on the bottom. The top end is sealed with an "O" ring and three latches. The connecting plugs and a handle are located on top. As the system evolved in 1970, only the two printed circuits from the sonobuoys were used. The "sonic" amplifier board was placed in the water-proof battery case with the batteries. The diminsions of the battery case depend on the size of the rechareable Gel-cell batteries used, and the size of PVC pipe avaialbe. The battery case contains the 18 volt battery for the sonobuoy transmitter and amplifier, a small 12 volt battery for the hydrophone pre-amplifier, and the sonic amplifier. The batteries and the amplifier must be installed in a manner that does not put any pressure on the amplifier board when the battery case and raft are knocked about by launching and bad weather. The battery cases should have a on-off switch mounted inside, and a 2 to 5 amp. fuse in series with the 18 volt battery. If the balloon crashes the flying line cables will probably short out. The fuse will prevent the destuction of the contents of the battery case.

RAFT

The surface raft for the balloon system is made up from styrafoam billets, 3/4" marine plywood, and threaded rod. A two foot by two foot, by 16" high raft will accommodate one battery case etc. Details of a raft for three battery cases are shown in Figs. 4 and 5. A surface strobe light, and a free floating CB recovery radio transmitter have been added to the raft.

KITE-BALLOON

The Balloons used for this experiment are described in detail in Appendix II. These balloons fly remarkably well under a variety of conditions if directions are followed and nothing breaks. One problem we had in the early experiments was caused by tail pieces breaking. These were originally made of soft pine wood. This plus the fact that we misinterpreted the directions, and installed them under near-breaking stress, caused the crashing of several balloons. If a tail piece breaks, or a briddle becomes untied, the balloon will go out of control. It will do some really remarkable loops up and down to the ocean surface. Eventually something will tear a hole in the balloon, and it will crash and sink. The balloon still may be salvaged. Winch it to the surface. Fasten a hooked knife on the end of a boat hook, or long pole. Lower this under the balloon and cut a hole to let the water out as the balloon is raised out of the ocean. Remove the broken tail pieces etc. Wash the remains with fresh water. Tie it to a blower outlet to dry. Then pull the tore pieces through the filler snout and patch them on the inside surfaces, fill with plain air to test for leaks. We learned that the tail cross pieces must not have much bow in them. The cross pieces are intended to push the back end of the balloon in some. This is supposed to give some reserve helium capacity, according to the manufacturer.

FLYING LINE

The flying line for the balloon is made up from a 500 to 600 foot piece of 3/16" to 1/4" nylon line (See Figs. 1 and 6). The antenna and power cables consist of 1000 foot lengths of shielded cable. These cables are taped loosely in loops to every few feet to the nylon line. As the balloon tension increases, the nylon stretches. The electrical cables have no stength or stretch, so must not be subjected to tension. The sonobuoy transmitters are tied up near the end of the 600 foot line. Above the transmitters another 200 feet of 1/8" nylon line is tied on. The other end of this light line is attached to the balloon bridle. "Granny" knots at these two points have been the cause of the loss of balloons. A small flashing light designed for life jacket use is attached here to help find the balloon at night.

The red wire in the cable is used for plus 18 volts. There will be about 2 volts loss in the cable. The black wire is used for the transmitter input signal. The shield of the cable is used for the battery return, the signal return, and the ground to the ocean. The whole system must be connected to the ocean. It is very unsafe to fly the balloons if this is not done. I was almost killed one night by a static discharge (lightening) coming down the cables. The ground had been left off the raft.

HYDROPHONES

The best hydrophones to use are the Brush AX58-C models. Various companies including Clevite-Brush have tried to design replacements for these hydrophones. They have yet to come up with one as good for seismic refraction work at sea as the AX58. These hydrophones consist of a rochell salt crystal mounted in a metal frame. The frame has two compartments. The one with the crystal is filled with castor oil. The other is air filled, and contains an FET pre-amplifier. The whole frame is covered with a rubber boot. There is no way to take the boot off and on at sea because disassembly must be done in a vacuum chamber. These hydrophones must not be left out in the sun without a wet cloth over them. The crystals will depolarize, rendering the hydrophons useless. The pre-amplifier chamber may be opened at sea if necessary. The pre-amplifier reduces the high impedance output of the crystal to about 600 ohms. The hydrophone is mounted on a two inch diameter float, six feet long, by means of two clamps.

A 250 foot cable drop is made up from Marsh and Marine cable and their XSL plugs. Fifty feet of this cable has small line floats and weights taped to it with friction tape. The hydrophone and this fifty foot leader section is balanced to be neutrally buoyant at a depth of 200 feet. The purpose of the line floats and weights is to filter out surface motion transmitted mechanically down the cable to the hydrophone. A window sash weight or some other weight of about ten pounds is taped and tied onto the cable 50 feet from the hydrophone. This must be one in a manner that does not strain or chafe the cable. The 200 foot section of the cable extends up to the surface to a string of small oval float. These floats act as a spar buoy. The cable from this buoy to the raft has a floating jacket molded onto it. It is important to fasten the float string on the cable in a sort of yoke. Wave action on the cable is severe at this point. Some of the existing cables may have the cable drop and the surface cable all in one piece. Another way is to have the vertical drop, and the floating sections connected with a Marsh and Marine plug set. It is a good precaution to tie a strain line around the plugs. The surfaces float terminates at the battery case which is mounted on the balloon raft.

A cheap substitute hydrophone that works in a pinch can be constructed from the hydrophone elements that come with the sonobuoy. A five to six foot piece of air gun streamer hose is used for the housing. The end pieces can be machined out of PVC on a lathe, and the hose can be filled with fresh water. Some kind of oil that does not attack rubber is better. The ships' fuel is bad because of additives that attack rubber. The sonobuoy pre-amplifier is also installed in the hose. If these are used in the system, it is necessary to put the 27 k resistor, R201 back in the circuit, on the 'sonic amplifier board', and to increase the amplifier gain to about 60 Db. Details of the plug pin connections and pre-amplifier etc. may be found in the MPL Technical Memo 143, (Jones 1964).

SHIPBOARD EQUIPMENT

The shipboard equipment consists of directional antennas (Fig. 7), pre-amplifiers, radio receivers, filters, low frequency amplifiers, and recorders. One of the antennas is fixed and pointed aft. The other two are mounted with rotors on the ends of a yard arm on the main mast. These should be as high off the water as possible. Pre-amplifiers are mounted up near the antennas (Figs. 7 and 8). Power for these is run up the signal lead. Be sure suitable decoupling capacitors and chokes are installed in the pre-amplifiers, and in the lab end of the cables (Figs. 8 and 9). Radio Shack Patrolman II radios are used as receivers for each frequency transmitter used on the balloons. These radios are inexpensive, and seem quite reliable, although they require a slight modification for balloon use (Fig. 10). The signal is taken off the detector. The audio section of the radio is only used to listen to sound from the balloons. Very weak signals can be slightly improved by adding another pre-amplifier to the radio in the lab in series with the antenna pre-amplifier. One Nems-Clarke radio is quite useful; it can be used as a signal strength meter, and tuning aid. The output from the detector of each radio is fed to the high impedance side of a low frequency transformer. The low impedance side goes to the input of the seismic amplifiers (Jones 1964). Integrated circuit operational amplifiers can be used in place of the transformers.

DEPLOYING THE SONOBUOY MOORING

A location with as flat a bottom as possible should be chosen for the seismic anisotropy station. The area should be surveyed first to make sure the moored buoy is not installed on a cliff or near a seamount. Courses and turning points should be worked out in advance if possible. These may have to be changed on the basis of data received from the first buoy station. This data can be worked up as the ship proceeds toward the second station. The bridge must be notified of the plans, including which side of the ship is to be used for launching the raft system and balloon. If it becomes necessary to maneuver on station, the ship should always be turned in the direction that the buoy system is being launched. The balloon raft mooring line is usually made up from 1/4" poly-propylene line. The length should be carefully calculated for the depth of water and desired scope. This length in feet of the rope is the depth from the fathometer in fathoms plus Mathews correction, minus 5% x 6. Set up the reel stand to hold the anchor rope. Rig the line counter and make sure it reads zero feet. Assemble the anchor, chain, and weight on deck.

Lay out the A x 58 hydrophones. Check the floats for water of damage. Cover the crystal part of the hydrophones with wet white rags. Check the cable drop and leader sections to make sure they are not tangled, and that the small floats do not have water in them. The leader section should be on top, and the end with the plug must be accessable. Attach the leader to the hydrophone if it is not already done.

In the lab, check the sonobuoy batteries for full charge. Check the hydrophone batteries. Install the batteries in the battery case. Make sure no wires get pinched in the lid. Seal carefully with silicone grease. A leak here will quickly terminate an anisotropy station.

On deck, insert the battery case or cases into the balloon raft. Plug in the hydrophone cable, and make sure the cable is securely fastened to the raft. Plug in the balloon flying line cable to the battery cases. Use a small battery monitor radio to check the transmitters. High level distorted noise should be heard. Tap the hydrophone, and check for a thump noise in the small radio.

Well in advance of arrival on station, two tarps and the ballon should be brought out on deck. Lay one tarp out on deck, and tie it down. Lay the balloon out on top of this tarp. If there is any wind on deck, lay a second tarp out over the balloon. Loosely tie this tarp down. Run the high pressure helium line out from the supply tanks in the hold. Make sure the pressure regulator handle is in its unscrewed position, and the main valve is shut off before opening the valves on the helium tanks. Tie in the filler pipe opening into the rubber snout of the balloon. Use a strip of balloon material for this. Inflate the balloon at about 38 PSI, until the bungee on the bottom of the balloon is almost stretched out full. If it is cold and cloudy, leave a bit more slack in the bungee for expansion when the sun hits it. If it is warm and sunny, there will be a problem of expansion (See Appendix III). Each balloon will need 800 to 850 cubic feet of helium. Helium tanks containing either 195 or 214 cubic feet of helium are held in place in racks in the hold. These tanks can be connected together in groups of enough helium to fill several balloons. The tanks are connected together with a manifold with a shut-off valve. Detailed instructions for inflating the balloon are given in Appendix III. When the balloon is fully inflated, tie off the filler snout as described in Appendix III. Be sure to use a strip of balloon material, and <u>not</u> nylon line. Several wraps with half-hitch knots, and a plain bow knot seem to work well. The bow knot allows for quick deflation when the balloon is retrieved, as things are apt to be a bit frantic on deck at that time. Fasten on the tail hardware, string and tape. Tie on the flying line to the balloon bridle. Use a good sea-going knot here. Switch on the balloon flasher light. Check the bridle lines carefully. If there is any wind, it is important that there are plenty of hands available to hold lines, launch the hydrophones raft, and anchor line.

Launch the hydrophone, or hydrophones first (See Fig. 10). If the ship has a bow thruster to assist in station keeping it can be used to speed up the launching. If the hydrophone is launched into still water with no drift or headway, let the 200 foot drop down into the water very slowly. This is to prevent the 50 foot section from wrapping itself up around the drop. The hydrophone will be too noisy to use if this happens. Use the small deck monitor radio as the hydrophone is going down. Engine room noise should be clearly heard as the hydrophone goes down.

Next, lunch the balloon (Fig. 11). This can be quite exciting if there is much wind. Make sure the anchor line, and the balloon flying line are secured to the raft. The flying line should be neatly stacked in a garbage can ahead of time, so it will pay out as the balloon rises. Pick the raft up with the deck crane, and lower the raft into the water. As this happens, cast off the hydrophone lines and the balloon line, taking care not to catch them on anything, or with each other. Now, move the ship away from the whole system, and stand by while radio signals are checked for signs of trouble. If all seems well, steam away from the raft paying out anchor line. Various patterns have been tried, the object being to get the anchor and weight etc. on the bottom without pulling the system through the water with the ship or the anchor. A lot of factors enter in here. Wind direction and velocity, surface currents, sub-surface currents, and probably deep currents are some of the factors. Add some weight to the anchor to try to get it to sink at the same rate as the main weight. Two reels of line should be set up at once on the reel stand. As the end of one reel is reached, the end of the spent reel, and the end of the full reel must be pulled forward on the deck far enough to give time to securely tie the ends together while the line is continuously paying out. After the first station, the line can usually be retrieved on the hydrographic winch. The line must then be transfered back onto reels on the after deck reel stand as the anchor line has to be let out at a rate of speed far in excess of that capable of the hydro-winch.

After the proper amount of anchor line is paid out, tie on the chain, the anchor and the weight. Drop these over the stern. The hydrophones may become very noisey for awhile if the anchor drags the system through the water. Ignore this noise, and do not be tempted to sail in close to check for trouble. If the noise persists after the anchor has had time to settle on the bottom, usually 45 minutes to an hour, there is probably an underwater tangle of phone line and anchor line. It may straighten out, but most likely will have to be untangled before proceeding on a seismic run.

SEISMIC ANISOTROPY STATION

When the raft-balloon station seems to be operating satisfactorily, the magnetometer, the air gun, and the streamer are launched. Run back slowly by the buoy to check depth. Start the shooting run as the ship passes abeam, and a seismic refraction profile is run in the direction of the next balloon station to be launched. Data should be plotted as the run progresses to determine if any changes in the pattern must be made before reaching the first turning point. This is also necessary to help determine what size of explosive charge to use. The second station will be the second point on a triangle. Details of the patterns can be found in Raitt, Shor, Morris and Kirk (1971), and in Shor, Raitt, Henry (1973).

If the balloon stations continue to operate throughout the anisotropy station, it is an easy job to home in on the rafts with the air gun and streamer, plus the radio signals from the balloons. If a balloon crashes, or some other catistrophic event occurs, (i.e. curious fishing boat, large freightor on automatic pilot with man on watch off for coffee), it is useful to have a CB buoy radio operating. These commercially available, run off flashlight batteries, are completely waterproff, and give off reliable warbling tone that can be monitored 10 to 20 miles away. A hand held receiver loop radio will not give reliable directions on most metal boats, although sometimes a spot can be found where satisfactory bearings can be obtained. There is no such spot on the research vessel MELVILLE.

Usually the balloons have to be deflated after a seismic anisotropy station, as they take up quite a bit of deck space, and are very hard to handle if there is a quick change in weather.

SUMMARY

Information in this paper can be used as a guide to adapting Navy Sonobyoys for use on Seismic Refraction runs at sea. A method for extending the useful range of the sonobyoys has been presented. Obviously, this paper does not cover all of the problems that will arise at sea. Even with the best of planning and preparation it will be necessary to be resourceful and make use of material and peoples' skills on hand aboard ship.

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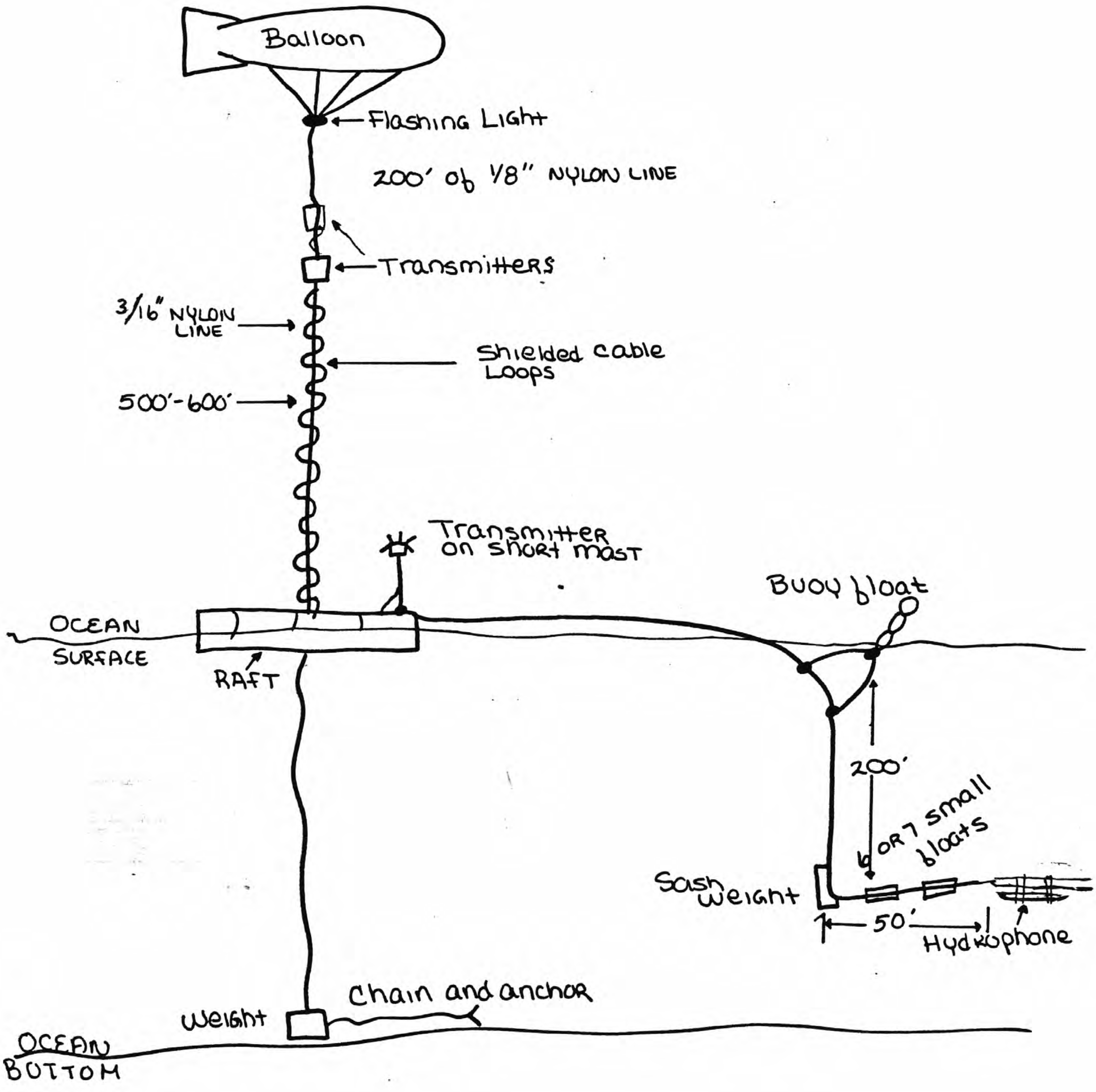
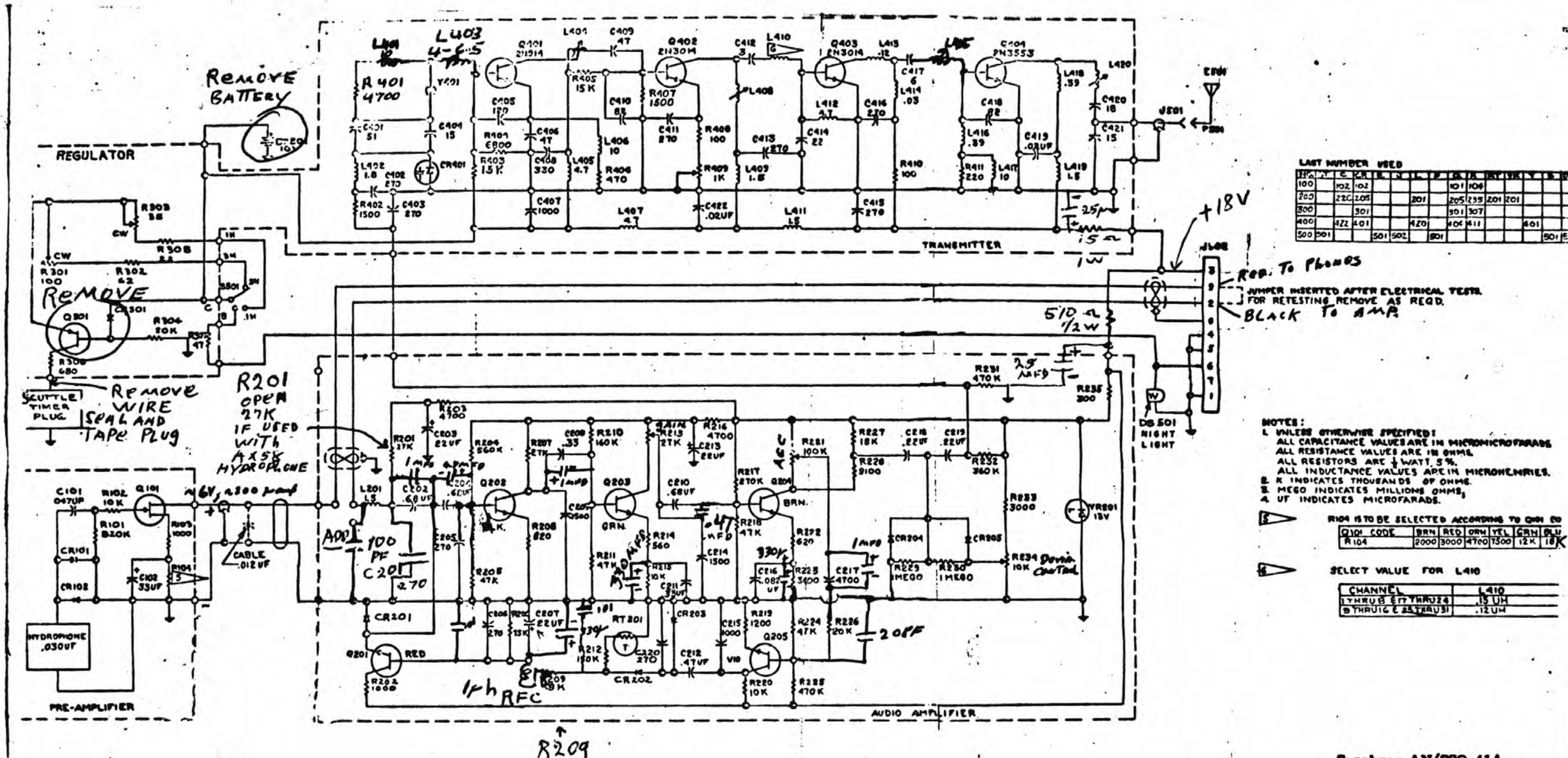
Verma, R. K., 1960, Elasticity of some high-density crystals, J. Geophys. Res., v. 65, p. 757.

FIGURE 1


Balloon
Flashing Light
200' of 1/8" NYLON LINE
Transmitters
Transmitters
3/16" NYLON LINE
Shielded cable Loops
500'-600'
Transmitter on short mast
Buoy float
OCEAN SURFACE
RAFT
200'
6 OR 7 small floats
Sash Weight
50'
Hydrophone
Chain and anchor
Weight
OCEAN BOTTOM

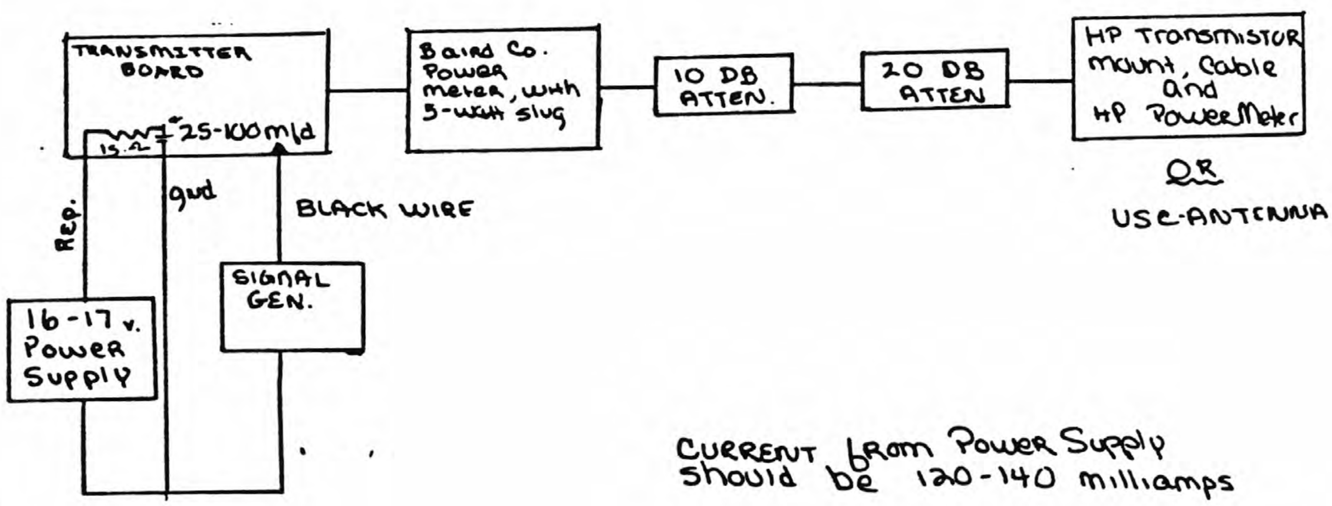
SONOBUOY CIRCUIT DIAGRAM



Sonobuoy AN/SSQ-41A
Schematic Diagram

Figure 2

TEST SET UP



CURRENT from Power Supply should be 120-140 milliamps

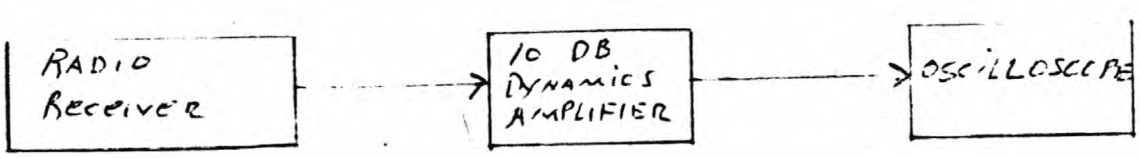
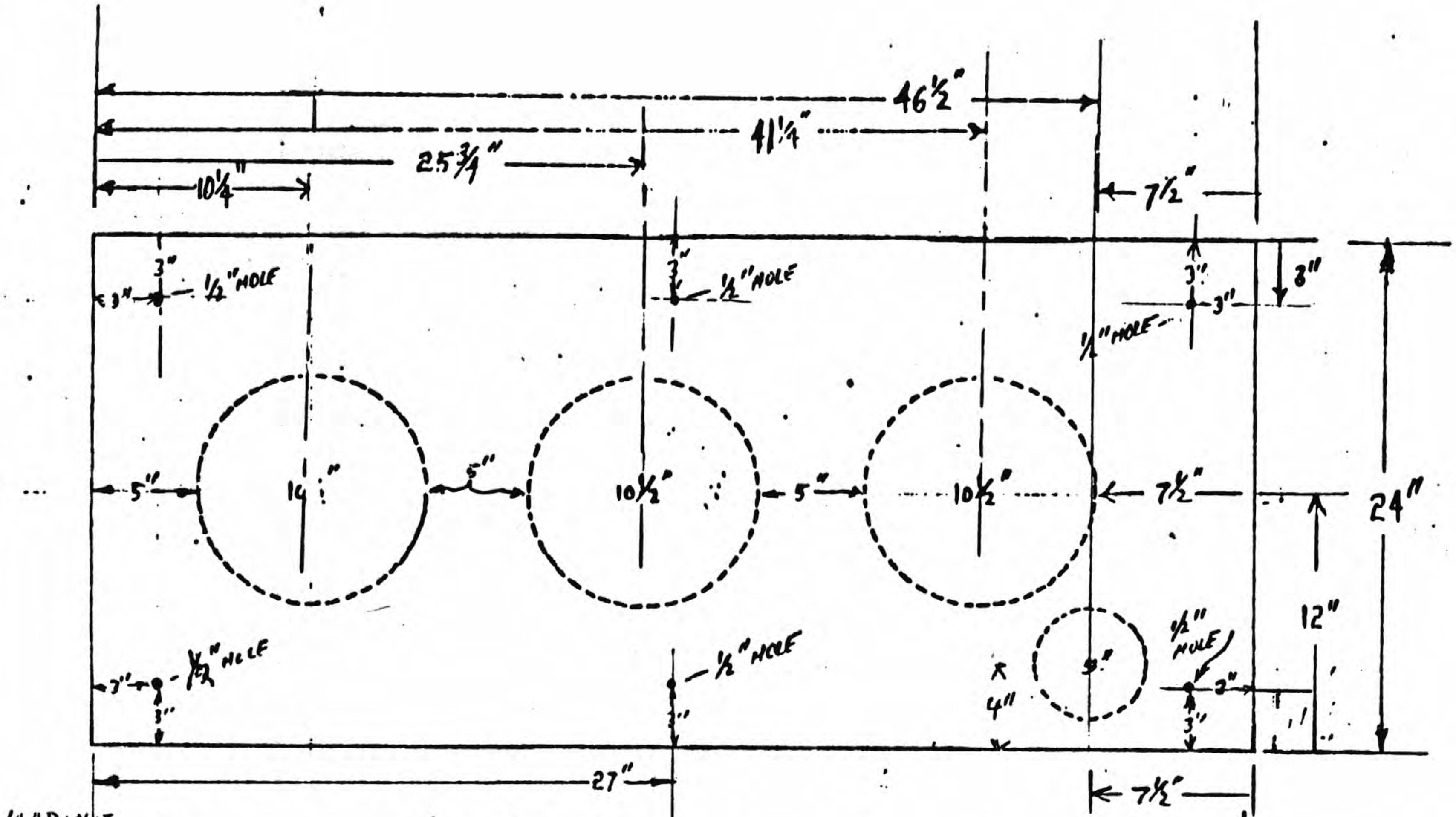


FIGURE 3



MARINE
PLYWOOD BOARDS 3/4" x 54" x 24"

DRILL 6 – ½" HOLES, 3" IN FROM SIDES (LENGTH), SPACED 3", 27" AND 51" FROM ONE END (for bolts)

CUT THREE CIRCULAR PLUGS OF 10½" DIAMETER WITH CTRS. 10¼, 25¾ AND 41¼ FROM ONE END (SAVE PLUGS)

CUT A 3" x 6½ HOLE IN CENTER OF PLUG

CUT A 5" DIA. HOLE 4" IN FROM SIDE AND 7½" FROM END OF RAFT FOR LIGHT.

USED TO HOLD
BATTERY BOX
IN PLACE

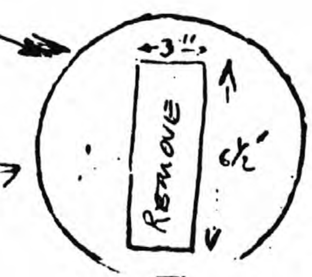


Figure 4

RAFT CONSTRUCTION

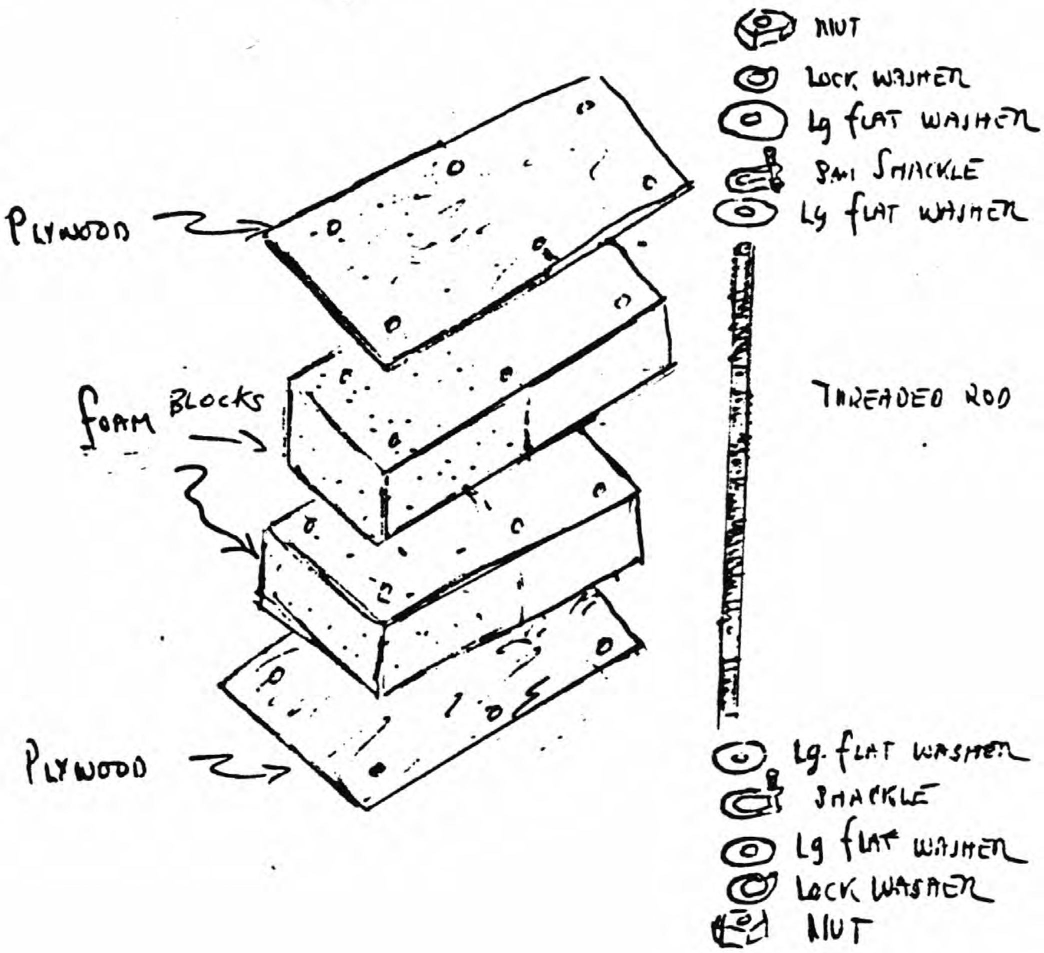


Figure 5

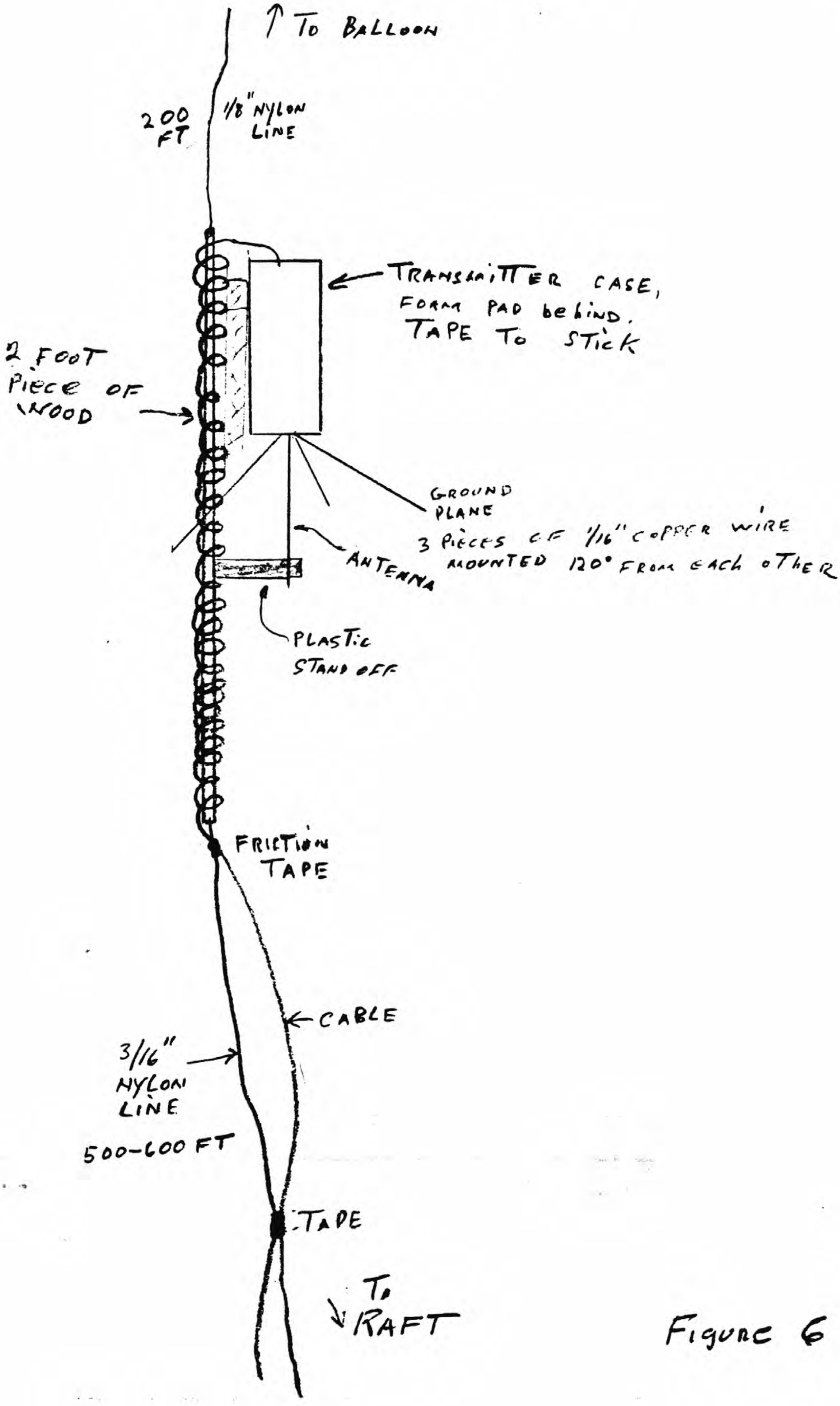
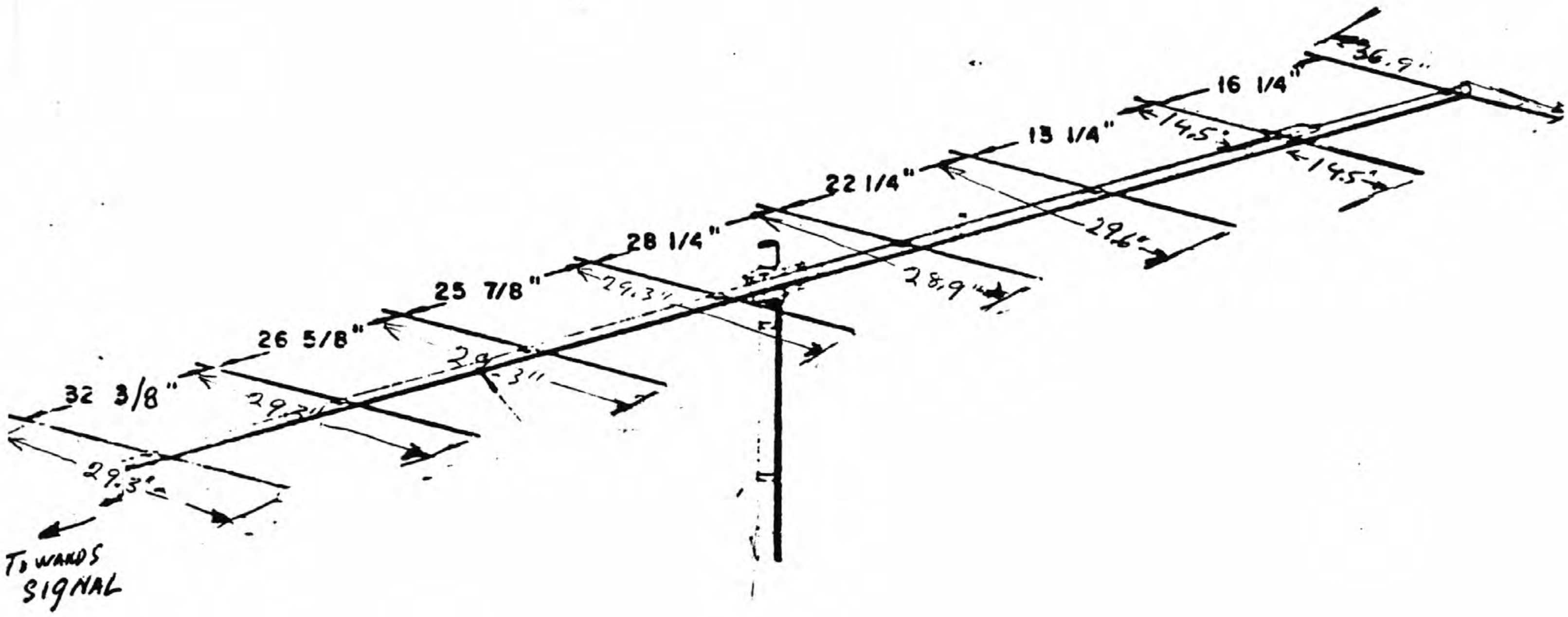

To BALLOON
200 FT
1/8" NYLON LINE
TRANSMITTER CASE, FOAM PAD behind, TAPE TO STICK
2 FOOT PIECE OF WOOD
GROUND PLANE
3 PIECES OF 1/16" COPPER WIRE MOUNTED 120° FROM EACH OTHER
ANTENNA
PLASTIC STAND OFF
FRICTION TAPE
CABLE
3/16" NYLON LINE
500-600 FT
TAPE
To RAFT

Figure 6

SHIPBOARD ANTENNA



Cut elements of standard HY-GAIN CO. Model 341, 28 eight element, twO metter band Beam Antenna to the values shown above.

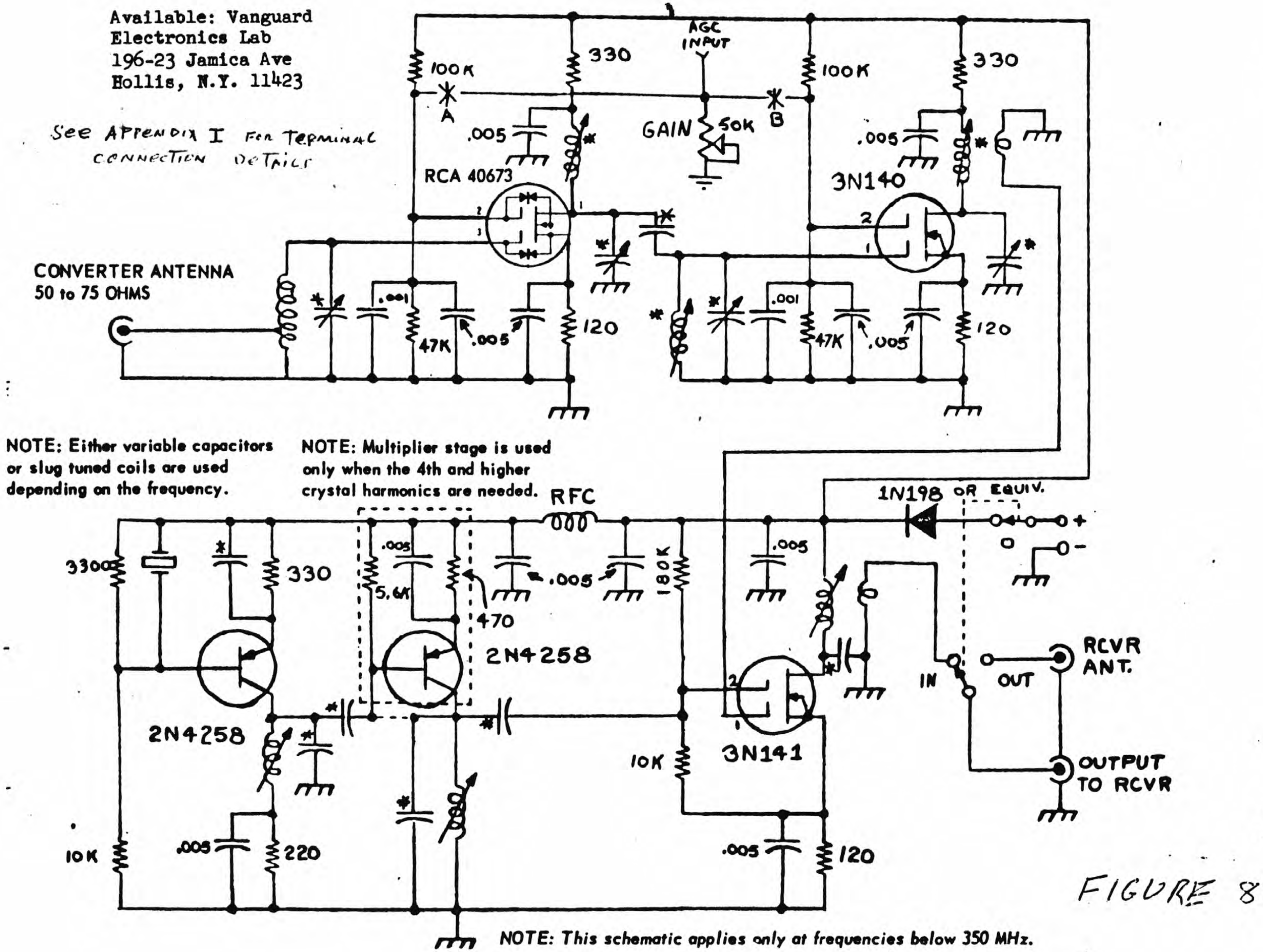
Figure 7

VANGUARD dual-gate MOSFET PRE-AMP

Power requirements for the pre-amp are 12 volts @ 8-15 ma.

Available: Vanguard
Electronics Lab
196-23 Jamica Ave
Hollis, N.Y. 11423

See Appendix I for terminal connection details



NOTE: Either variable capacitors or slug tuned coils are used depending on the frequency.

NOTE: Multiplier stage is used only when the 4th and higher crystal harmonics are needed.

NOTE: This schematic applies only at frequencies below 350 MHz.

FIGURE 8

SHIPBOARD ANTENNA AND RADIO SYSTEM

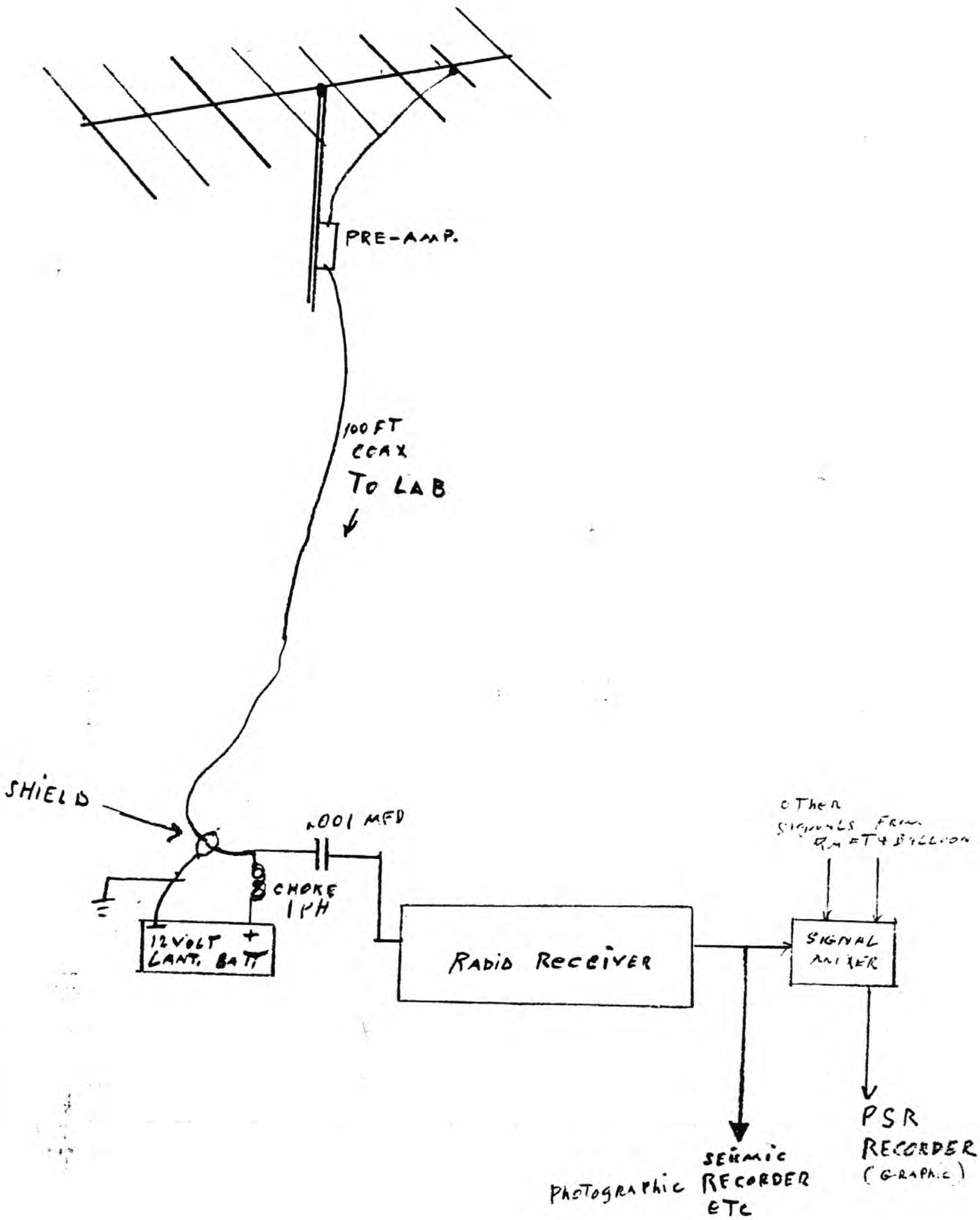
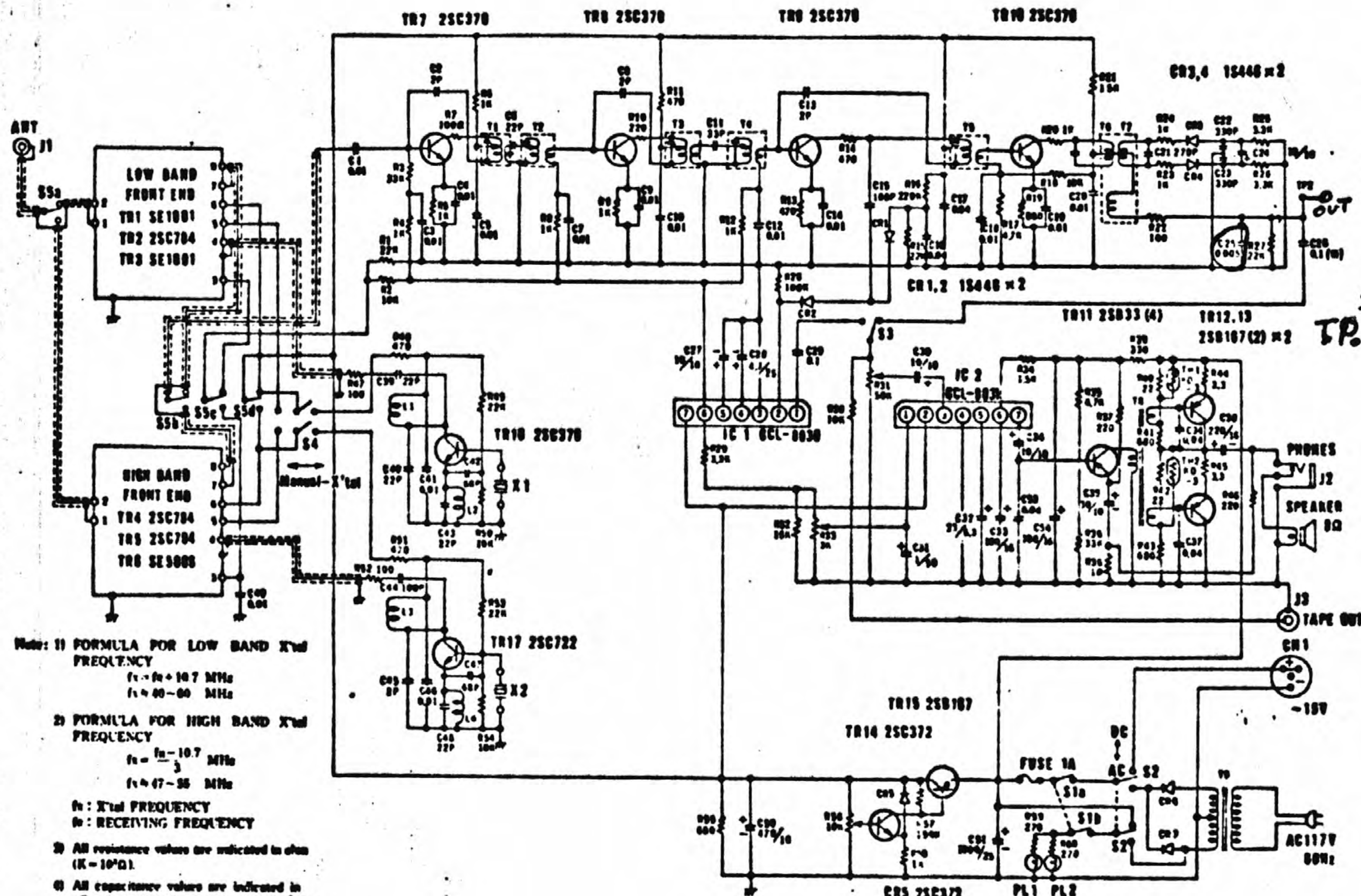


Figure 9

SCHEMATIC DIAGRAM



Note: 1) FORMULA FOR LOW BAND X'tal FREQUENCY

$f_x = f_R + 10.7$ MHz

$f_x \doteq 40 \sim 60$ MHz

2) FORMULA FOR HIGH BAND X'tal FREQUENCY

$f_x = \frac{f_R - 10.7}{3}$ MHz

$f_x \doteq 47 \sim 55$ MHz

f_x : X'tal FREQUENCY
f_R : RECEIVING FREQUENCY

3) All resistance values are indicated in ohm ($K = 10^3 \Omega$).

4) All capacitance values are indicated in pF unless otherwise specified ($P = 10^{-6} \mu F$).

Remove C-25

Take Seismic signals From TP. point 2

Printed in Japan

Figure 10.

BALLOON AND RAFT LAUNCHING

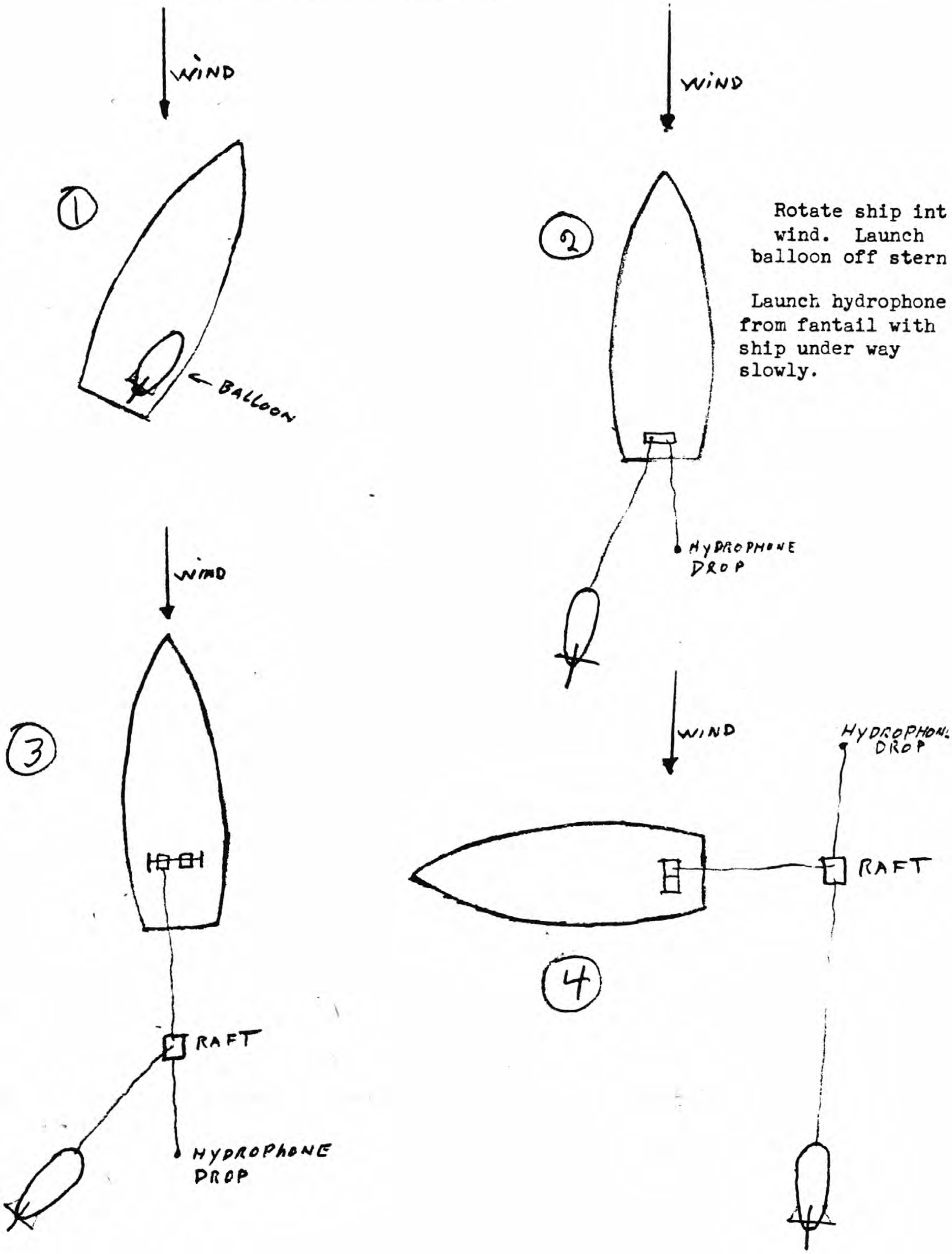


FIGURE 11

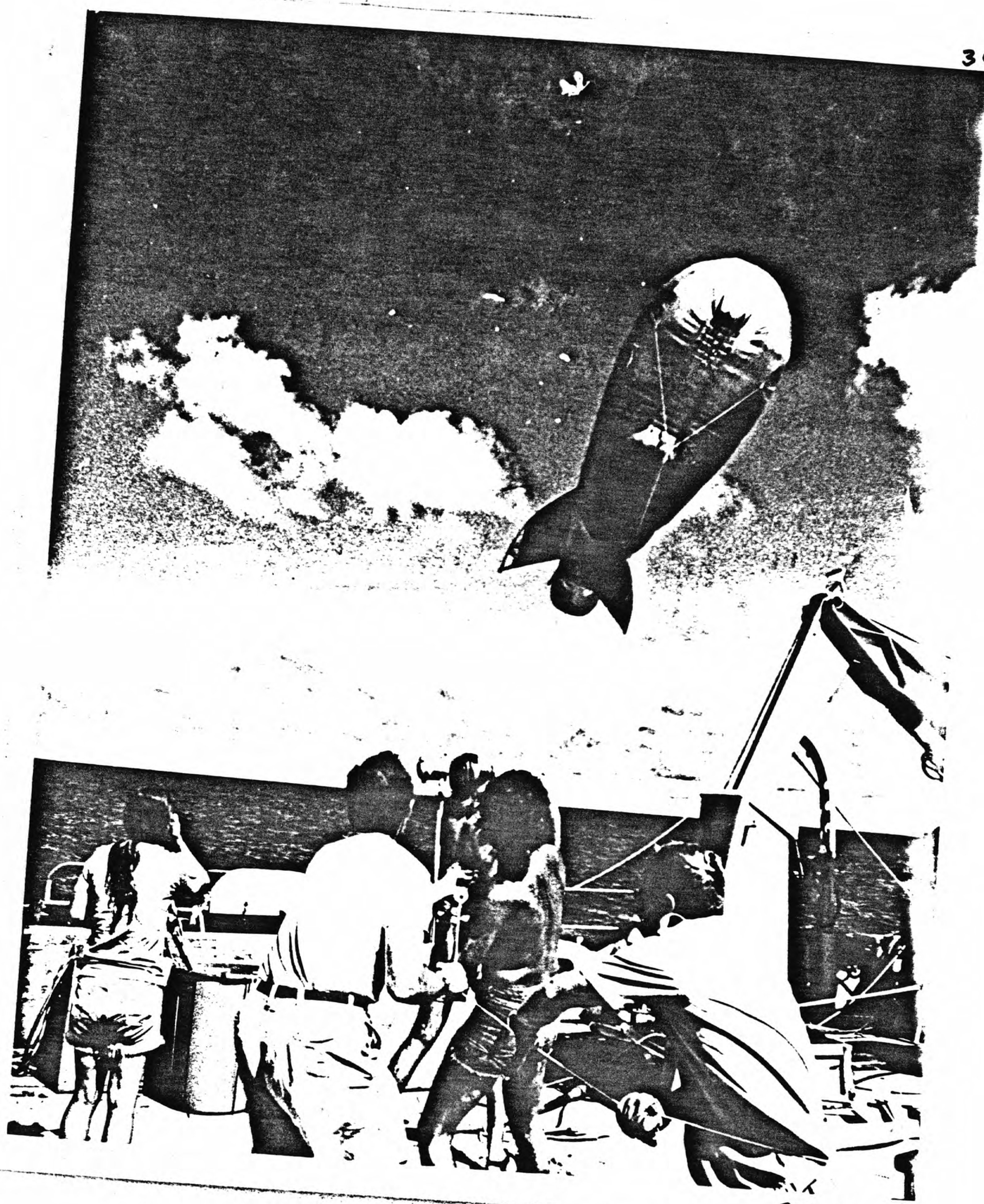


FIG. 12

Masthead pre-amplifier

MODEL 407 TERMINAL CONNECTIONS

C.ANT. – Converter antenna.
R.ANT. – Outside receiver antenna.
RCVR. — Receiver antenna input.

Binding post + to 12 volts positive.
Binding post grounded to case is negative.

The power source for the converter may be any 10-14 volt DC supply capable of supplying 25 milliamps. Do not use battery eliminators unless they are transformer operated. For maximum signal transfer, the receiver's antenna trimmer should be adjusted with the converter connected. To minimize losses, use the shortest cable connections possible.

DUAL-GATE MOSFET PRE-AMP CONNECTIONS

IN – Pre-amp input to outside antenna (see note below).
OUT – Pre-amp output to receiver antenna input.
Binding post + to 12 volts positive.
Binding post grounded to case is negative.

NOTE: *When used with a transceiver the pre-amp must be connected between the receiving section input and the antenna relay or the entire pre-amp will burn out the moment you transmit.*

Dual-gate MOSFETS produce less cross-modulation than any other type transistor however the greatly increased gain can overload some receivers and cause spurious responses. If this occurs reduce the gain of the pre-amp with the gain control.

The gain control on our pre-amps is now wired to the gate of the 2nd stage only, so as not to deteriorate the signal-to-noise ratio when the gain is reduced.

PRECAUTIONS

1. Do not discharge the UNISEP battery at currents greater than 20 amperes. DO NOT SHORT THE BATTERY.

2. Do not overdischarge the UNISEP battery as indicated by a voltage of less than 4.5 volts.

3. If by accident, some of the sulphuric acid battery electrolyte is spilled, flush the battery thoroughly with water promptly. If the electrolyte is spilled on clothing, or similar material, flush thoroughly with water, then neutralize with a mixture of baking soda and water (one tablespoon to a glass of water) until bubbling stops, and rinse with water. If spilled on one's person, flush with water and see a physician.

Electromite Corporation
2117 South Anne Street
Santa Ana, Calif. 92704

ELECTROMITE CORPORATION

OPERATION INSTRUCTIONS FOR "UNISEP" MAINTENANCE FREE LEAD/CALCIUM BATTERIES

MODEL 12CP820-6 VOLT

GENERAL INSTRUCTIONS

The UNISEP Model 12CP820-6 volt battery is a 6 volt, 8 ampere-hour, rechargeable lead calcium battery. This battery is designed for applications requiring a maintenance-free, spill-proof, portable DC power source. The battery will provide long term, maintenance-free service if operated in accordance with the following instructions.

OPERATION & SERVICE

The UNISEP battery is shipped in the fully charged condition ready for immediate use. However, it is recommended that this battery be charged prior to use for maximum performance.

The battery may be operated in any position, although inverted charging is not recommended.

BATTERY CHARGING

1. An adaptor plug is provided with each battery. Remove this plug from the connector on the top of the battery and attach to the input cord from the battery charger. The large pin of the 2 pin plug is positive. Additional plugs are available from Electromite Corporation if required.

2. Charge the battery using a constant voltage charger set at 7.0 to 7.1 volts. The maximum current rating of the charger should not exceed 2 amperes nor be less than 0.5 ampere. The initial charge should be applied for a 16 - 24 hour period. Caution: Use only a REDOX SYSTEMS constant voltage charger available from Electromite Corp. (or equivalent).

BATTERY SERVICE

The UNISEP battery should be used in a manner which will give the best service for your application as follows:

1. STANDBY - The UNISEP battery can be used as a standby energy source without charging for a period of one year maximum. Capacity loss will be approximately 1% per month. The UNISEP battery should be recharged as described above, discharged to 4.5 volts, and again recharged at least once each year when used as a standby energy source.

2. FLOAT SERVICE - The UNISEP battery can be used as a line regulator on float service. The battery should be floated continuously at 7.0 to 7.1 volts. It will not require water addition. However, should the charge regulator fail or be set too high causing excessive water loss, the UNISEP battery can be maintained by adding water through the top cover. Specific directions should be obtained from the manufacturer before attempting this type of service.

3. CYCLE SERVICE - The UNISEP battery can be used as a rechargeable battery for many applications requiring repeated discharging of the battery. After each discharge, the battery should be recharged at 7.0 to 7.1 volts for 8 to 16 hours depending on the current rating of the charger used.

JALBERT'S NEW FIN JACKET ASSEMBLY* GIVES DEPENDABLE KITE BALLOON OPERATION IN 40 KNOT WINDS

In a sense, a balloon flying in an ocean of air can be compared to a boat sailing on an ocean of water. The boat, however, can shelter behind an island or in bays, harbors, etc., in case of bad weather. Further, it can operate safely on lakes or rivers in weather which would be hazardous at sea. The more rugged its construction, the more severe weather it can withstand. The balloon, in its ocean of air, hasn't the advantage of shelter, but, like the boat, a more rugged construction enables it to withstand more severe weather.

The Jalbert Aerology Laboratories, Inc., have designed a rugged reuseable fin jacket assembly, entirely independent of the gas envelope, except for sockets. It maintains stability in winds over 40 kts -- does not depend on internal pressure of the gas envelope -- does not require fin rigging or patches.

A balloon's performance, with fins, is based on three major factors:

1. Proper inflation of the gas envelope.
2. Proper rigging to keep the body at the right attitude and the fins well aligned with the body.
3. In winds over 15 kts., proper weight is needed at the stern (ballast) to overcome the increased catenary and to keep the balloon overhead.

Generally, a well designed captive balloon, with a PSI ranging from .5 to 2.5, will have enough pressure on the envelope for normal operation in winds up to 20 kts. The pressure indicated is of a manometer (water) reading.

Under these conditions, fins dependent on pressure inside the gas envelope to maintain the proper position and stability, will perform beautifully, provided the three above factors are applied.

With a 20 kt. wind velocity, the belly of the kite balloon, coupled with the horizontal fins, will develop a great dynamic force which keeps the unit overhead by overcoming the pressure on the nose. Otherwise the flight angle would be reduced with a consequent loss of needed altitude.

When the pressure on the horizontal fins becomes greater than the pressure inside the envelope, three hazards are created:

1. The light rigging lines holding the fins in position may snap.
2. The lines holding the patches may pull out.
3. Added dynamic force applied to the horizontal fins will cause them to develop a greater pressure on the envelope and be pushed into

* Patented

it. This causes the horizontal fins to change position, develop a dihedral, spill the needed dynamic force which keeps the balloon overhead and into the wind and the whole unit will go out of control.

Even if both fins developed the same dihedral at the same time, which is highly improbable, the stability and angle of flight would be lost and the nose would probably cup.

The overhead angle of 60° or better in winds of 15 kts. and over is entirely dependent on the dynamic force created by the relative winds on the belly and the horizontal fins. The amount of dynamic force is also controlled by the attitude of the balloon. A good attitude for the body of the envelope is about 12° from the center of the nose to the center of the stern in relation to the horizontal fins. As the wind rises, unless proper ballast is added to control the required attitude to maintain the kite balloon overhead, the unit will drift downward, develop a bad catenary and the altitude will be lost. Wind pressure on the flying lines also imposes a pressure which sometimes is greater than the gravity of the lines.

Jalbert's Fin Jacket Assembly solves these problems. In the event of a calm, the kite balloon flies without the added weight -- providing the needed additional free lift. No relative winds, no motion, no direction controls are required and no dynamic force is created. If the wind rises, the assembly is put on and the wind offsets the extra weight so ballast is not required.

Jalbert's airfoil kite balloons are all equipped with a dilation system, except when otherwise requested. This provides an expansion or contraction of gas to approximately 12% of the volume of the fully inflated unit and a pressure hazard is thus eliminated.

An independent fin assembly offers many advantages over one whose fins depend on the rigidity or pressure of the balloon envelope (especially in winds over 20 kts). It eliminates rigging lines and patches. It is easily -- quickly -- put on or removed. The plain panel fins may be of any color or at any location for easy identification. Still another plus factor of the Fin Jacket Assembly is its use on a new envelope if the first one is lost. Since most losses are caused by damaged envelopes only, saving the fins and rigging saves a large part of the cost. AND GOOD FLIGHT PERFORMANCE IS MAINTAINED IN WINDS WELL IN EXCESS OF 40 KNOTS at better than a 60° angle.

Domina C. Jalbert

Domina C. Jalbert

JALBERT AEROLOGY LABORATORIES, INC.

BOCA RATON FLORIDA

Tel: 395-0644

1. Jalbert's K. B.'s are delivered in Kits in compact packages, with the necessary flying line and repair kit enclosed.

2. Hydrogen or helium is used to inflate these K. B.'s and can usually be purchased from your nearest compressed gas manufacturer or distributor.

3. Select a clear space on the roof of a building or ground, with about 20 square feet which is not surrounded by high tension wires, poles, or other obstructions upon which the flying line might chafe.

4. Cover the ground or roof with a ground cloth, a tarpaulin, or cardboards to prevent the balloon from chafing while being inflated. Spread the K. B. on the covering and examine it for possible damage during shipping.

5. Obtain any type of plastic rubber hose of which the inside diameter is the same as the outside diameter of the nozzle of the gas tank. Slide the hose over the nozzle of the tank and secure it there with an ordinary hose clamp. A hose of about 4 feet is sufficient.

6. Before turning on the hydrogen or helium, be sure that the K. B. is as nearly empty of air as is possible and that neither balloon nor appendix is twisted. Check that all the ropes are on the same side and not fouled.

INFLATION

Hydrogen or helium coming from the bottle and going into the K. B. is very cold and it expands quite rapidly as the temperature rises in the envelope. Therefore, carefully follow the subsequent instructions in order to avoid over-inflation. This is particularly important if the K. B. is inflated in bright sunlight or on a hot day.

Insert the inflation hose about half way up in the appendix and have one man hold the appendix about the hose so no air will be drawn in with the gas; this man will also hold the K. B. down by the nose bridle to keep it from rising.

Turn on the gas and allow the K. B. to rise slowly until it is inflated to the point that the hydrogen or helium is coming down into the appendix just beginning to fill it out.

The K. B. should be filled until it is plump but not tight. If it is inflated too tight and tied shut you risk having the K. B. burst if gas expansion takes place due to flying in a warmer air than in which it was inflated.

If possible, inflate the K. B. under the same temperature conditions in which it will be flown. Gas comes out of the tank cold and expands rapidly as its temperature rises in the K. B. Remember this particularly if you are inflating in a cool shelter and releasing into a hot atmosphere. When you inflate in a warm place for cold air flight leave the K. B. on the ground a few minutes after inflation. Allow the gas to shrink and add the necessary amount before flying.

When the K.B. has reached the proper point of inflation, shut the gas off and remove the hose from appendix. Double the last six inches of the appendix back on itself and then put two wraps of rubber band around the appendix, which is furnished with the K.B.

The purpose of this band is to act as a valve, and when properly applied it will stretch sufficiently to permit gas to pass out of the appendix whenever the gas in the K.B. expands to the extent which makes loss of gas through the appendix necessary in order to avoid bursting of the balloon.

WARNING: The K.B. appendix must not be tied shut with a cord or string.

ANCHORING THE K.B. DOWN WHEN IT IS NOT IN FLIGHT

When the K.B. is taken down without deflating, as at night, or for any other reason, the proper means of bagging down the K.B. is by placing a ground cloth or other smooth surface under it. Remove fin struts. Attach weights to the loose lines, provided for this purpose, on the suspension patches and on the nose. After the weights have been attached to the ropes, pull the ropes until they are just taunt without forcing the K.B. down too tight upon its bed. Fin struts should be taken off when the K.B. is not in flight.

This is a safe and secure means of anchoring the K.B. when it is left out of doors. Anchored in this manner, it will resist any normal wind. It is also advisable to select a sheltered place from the wind if at all possible in which to anchor the K.B. down. An indoor shelter is always preferable. Nose the K.B. into the wind, if possible, when bedding it down outside and make sure that the total weight of all the sand bags will be at least 300 pounds.

REPAIRING

To repair your K.B., (this is done when it is deflated) pass your hand through the appendix and pull out the damaged area so that it can be repaired from the inside. Wash around the torn place with gasoline, throughly cleaning fabric. Apply two coats of cement on both the patch and K.B., and allow to dry between coats. Apply the patch and press it on firmly like you would a tire patch.

STORING WHEN NOT IN USE

To store the K.B., roll all of the air or gas out, having it throughly dry. Wrap it in paper or cloth and store in a cool dry place.

WHEN IN DOUBT 'DON'T FLY THE BALLON'. IT IS BETTER TO BE CRAZY SAFE THAN CRAZY SORRY.

GENERAL INFORMATION AND CAUTIONS

The following are a few general rules which should be strictly adhered to during inflation and flying of the K.B.'s.

1 - No smoking or open fire should be permitted near the K.B.

2 - Keep the K.B. cable away from high tension wires, trees, and high buildings.

3 - Care should be taken to prevent the envelope of the K.B. and appendix from becoming twisted during inflation.

4 - Clean the ground cloth or other smooth surface before spreading the K.B. before and after inflation.

5 - Always see that the anchor rope is securely tied to the bridle of the K.B. and building or another anchor point while inflating and before letting the K.B. up.

6 - The man operating the K.B. should be within distance of it at all times.

7 - Never leave the K.B. in the air all night without someone watching it.

8 - Make it a habit to inspect the K.B. before launching it.

9 - To get more pull on the flying rope just shorten the stern bridle by making an overhand knot in it.

10 - Do not allow anchor rope to chafe against building or other object when it is flying.

11 - Inspect the anchor rope and the flying bridle periodically for weak spots or chafed places.

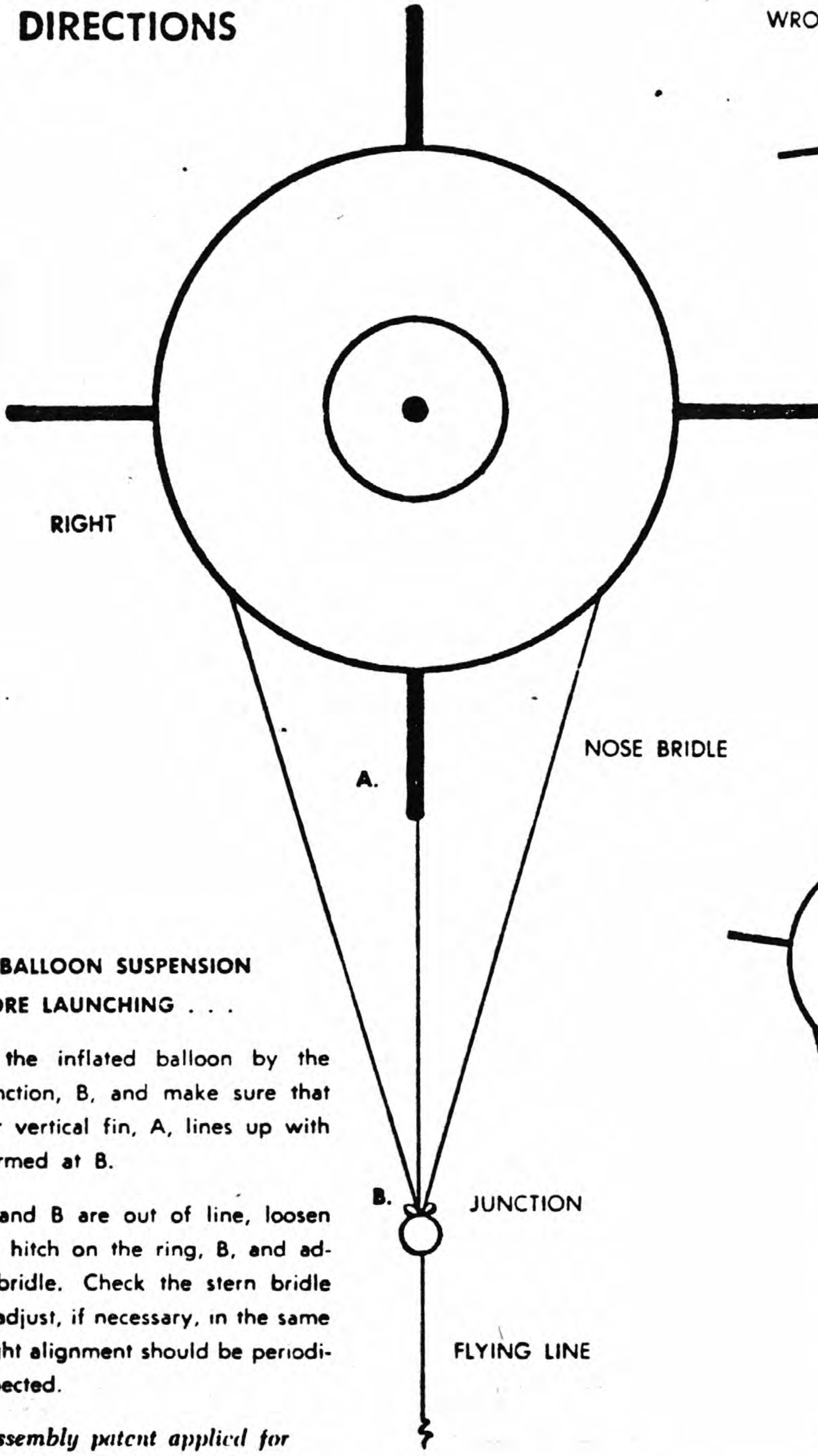
12 - Painting must be done with a rubber base paint.

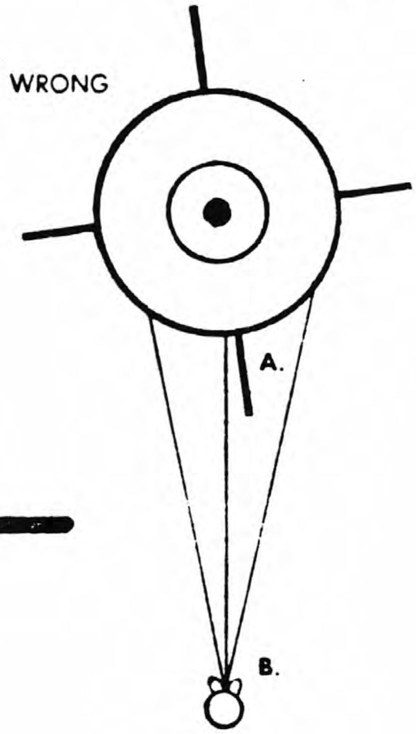
13 - Do not apply signs on the K.B. with gummed tape, when these tapes are removed it damages the coated fabric and will cause the K.B. to develop leaks, because it removes the coating from the fabric.

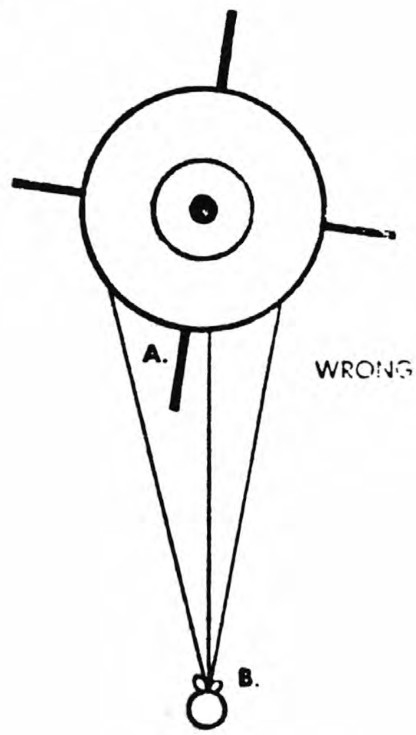
14 - After the initial inflation, it will be necessary to add a small amount of gas daily to offset the seepage of the gas except when the following day is warmer than the previous one, in which case the expansion of the gas will maintain the K.B. taunt for practical flight. The free lift of the gas will last from three to four weeks after which time the K.B. should be entirely drained and fresh gas put in as in the original inflation.

15 - It may be necessary to obtain a waiver from the Aviation Safety District Office in your locality. These K.B.'s are flown most all of the time below 300 ft. elevation and we have found the Aviation Safety District Office very cooperative.

FLIGHT ALIGNMENT DIRECTIONS







LINE UP BALLOON SUSPENSION RIG BEFORE LAUNCHING . . .

Hold the inflated balloon by the bridle junction, B, and make sure that the lower vertical fin, A, lines up with crotch formed at B.

If A and B are out of line, loosen the clove hitch on the ring, B, and adjust the bridle. Check the stern bridle and also adjust, if necessary, in the same way. Flight alignment should be periodically inspected.

Fin assembly patent applied for

JALBERT AEROLOGY LABORATORY

Phone 9094

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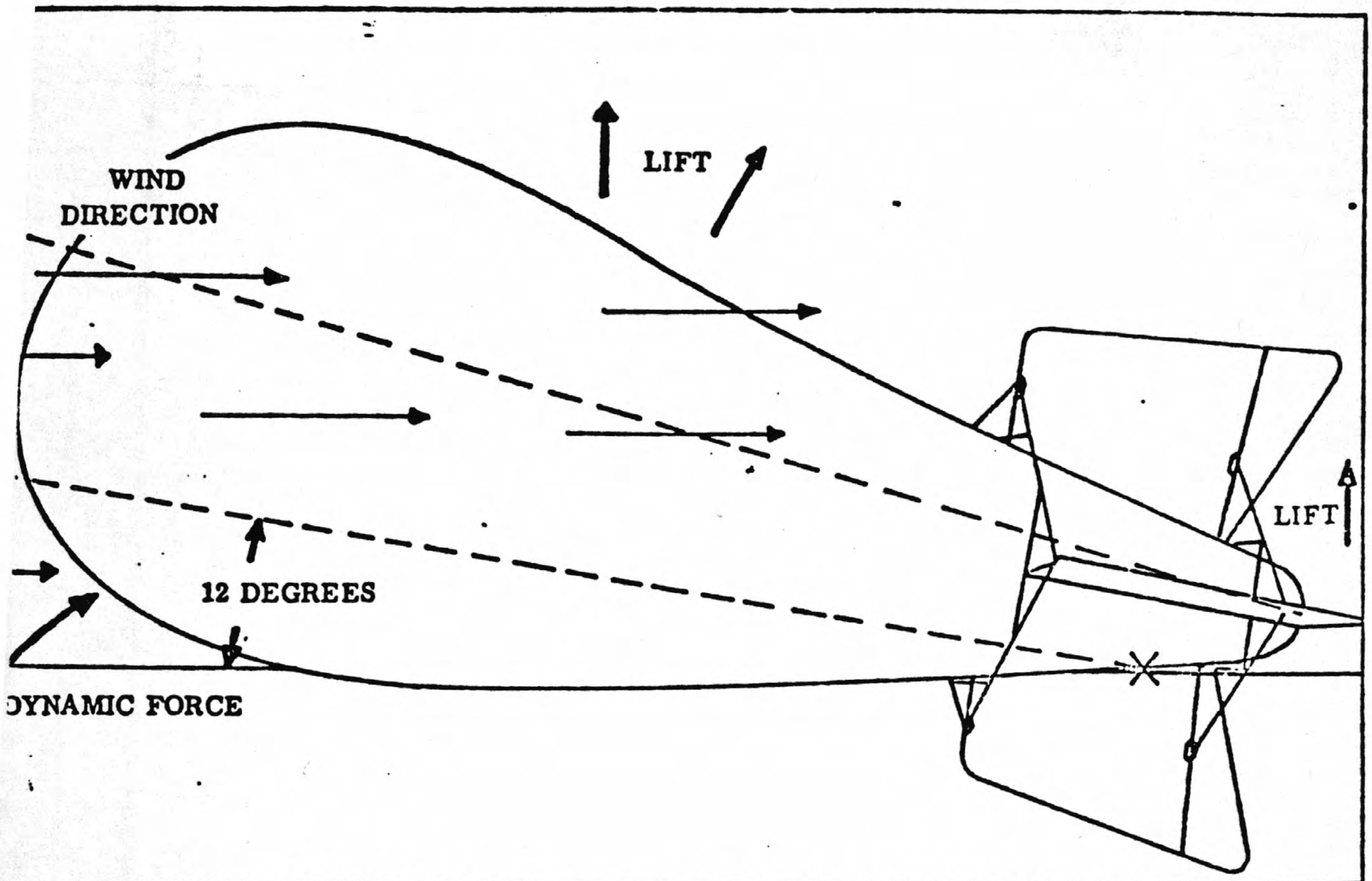
4.1.3 Flight Attitude. - The balloon shall maintain a flight attitude as indicated (figure III) at any relative wind speed within the test range.



4.2 Inspection. - The completed balloon shall be inspected to assure its conformity with all material and manufacturing specifications set forth herein.

4.2.1 Leakage. - The completed balloon envelope shall have no greater leakage rate than the leakage rate of the fabric employed in its construction. Test pressures shall be held within the range of 0.5 to 2.5 psi as indicated on a water manometer.