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DESIGN AND CONSTRUCTION OF A MINIATURE, AQUEOU[S] PHASE, LIQUID EXTRACTOR SYSTEM (A.P.L.E.)

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ABSTRACT

An apparatus to remove trace quantities of organic materials from natural waters in the field is described. The apparatus is an improvement on previously utilized equipment and is smaller, lighter, and more portable.

MANAGEMENT PERSPECTIVE

A consequence of analysing water samples to trace levels of parts per trillion is the need to take and store very large samples of water from which organic contaminants are concentrated to a measureable level. Economic and operating benefits are substantial when sample volumes can be reduced in the field. This report gives details of the design and construction of a portable aqueous liquid extraction system A.P.L.E. which concentrates samples in the field.

T.Milne Dick
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June 1982

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1.0 INTRODUCTION

In order to detect trace quantities of organic materials dissolved in natural waters, it is necessary to extract and concentrate them by a factor of over one-thousand. One way of achieving this is to dissolve the trace elements in an organic solvent for which they have a high affinity. It is also necessary for the solvent to have a low solubility in water and either a high or low specific gravity. The apparatus described herein is designed to intimately and repeatedly mix a small quantity of methylene chloride with a large volume of lake or river water for a period of time and then allow the mixture to settle. Since the methylene chloride is denser than water, it rapidly settles out, carrying most of the trace organics with it. It is then drawn off and returned to the laboratory where any last traces of water are separated out and the methylene chloride is reduced in volume under low temperature and vacuum to a fraction of a litre.

The processing of the water through the APLE in the field, achieves a concentration ratio of about 12:1 and the lab step about a further 200:1, thus attaining approximately a 2400:1 ratio relative to the natural concentration. This enables conventional micro-analysis techniques to be used for accurate measurement of the pollutants involved.

Previous versions of the field equipment were sufficiently large that transport was only practical by ship or truck. This precluded the technique from being used in many remote locations.

The apparatus was designed and built for Dr. J. Merriman of Water Quality Branch under Study No. 379.

2.0 DESIGN CRITERIA

Processing capacity - 50 litres
Mass - transportable by two people over rough terrain
Materials - stainless steel and "Teflon"

Special requirements - no organic materials of any sort which would be soluble in water or methylene chloride. All parts to be acid and high purity solvent cleaned.

3.0 DESCRIPTION

With reference to Figures 1 and 2, the liquid extraction apparatus consists of a tank (a), pump (b), drain valve (c), spray nozzle (d), associated plumbing, and support and carrying structure (e).

The tank is a 50-litre, stainless steel drum with welded end seams and "Teflon" gaskets. It is modified by the addition of a 3/8" N.P.T. stainless steel drain port welded into the center of the bottom.

The pump is a "Cole-Palmer" catalogue number C-7010-10, sealless, magnetic drive, centrifugal unit whose wetted parts are all stainless steel or "Teflon". The pump is driven by a toothed belt at a speed increase of 3:1 by a T.E.F.C. electric motor rated at 74.6 W output, 115 V, 60 hz, 1Ø, 1.6 A input. The pump output curve is as shown in Figure 1.

The spray nozzle which mixes the solvent and water is a stainless steel unit with nineteen 1.5 mm diameter holes at three different angles. The jets of mixed fluid emerging from the nozzle cause extremely turbulent mixing throughout the mass of the sample and less than one hour is required to complete the extraction process. Normally the sample used is the effluent from a centrifuge which is removing particulates from the water so that clogging of the jets does not occur. Normal centrifuging times are about eight hours at a flow rate of six litres per minute so that there is plenty of time to divert fifty litres of effluent, extract the solutes, allow the solvent to separate, and bottle the sample while the centrifuge is running.

A 500 W Honda generator supplies power to drive the APLE's pump and the supply pump for the centrifuge and still have power to spare for lights, etc.

Figure 2 shows a schematic diagram of the APLE unit. In operation, nearly pure methylene chloride is initially drawn from the bottom of the tank, through the pump, up to the top of the unit, and discharged through the nozzles into the water at high velocity. This soon forms an emulsion with the water and the pump then recycles the emulsion around and around the system. After a period of time, ranging from thirty minutes to one hour, the pump is stopped and the emulsion starts to break down. This can take between ten minutes and five hours depending on the presence of large quantities of natural organics and humic acids in the water which tend to stabilize the emulsion. When the solvent has fully settled out, it is drawn off at the bottom, along with a small quantity of water, into a sample bottle and returned to the laboratory for further processing.

The apparatus is supported by an aluminum framework, as show in Figure 3. It is equipped with a tubular aluminum carrying pole for ease of transportation by two people. If the tank is full of water and solvent, the apparatus is best carried "coolie" fashion on the shoulders, but if empty, it can be carried by hand. The mass of the complete unit is 17 kg when empty, and 68 kg when full.

All plumbing is stainless steel, type 304, and the only other material to contact the water or solvent is "Teflon" which is totally inert.

Cleaning is done by circulating two lots of ultra-high purity methylene chloride through the unit between uses.

4.0 CONCLUSIONS

This mini version of the APLE is a useful and sensitive system for extracting organic materials present in the ppb to ppt range found in natural waters. The system is sufficiently portable to be carried by hand, small boat, light aircraft or small off-the-road vehicle to almost any desired sampling site.

All design criteria have been met.

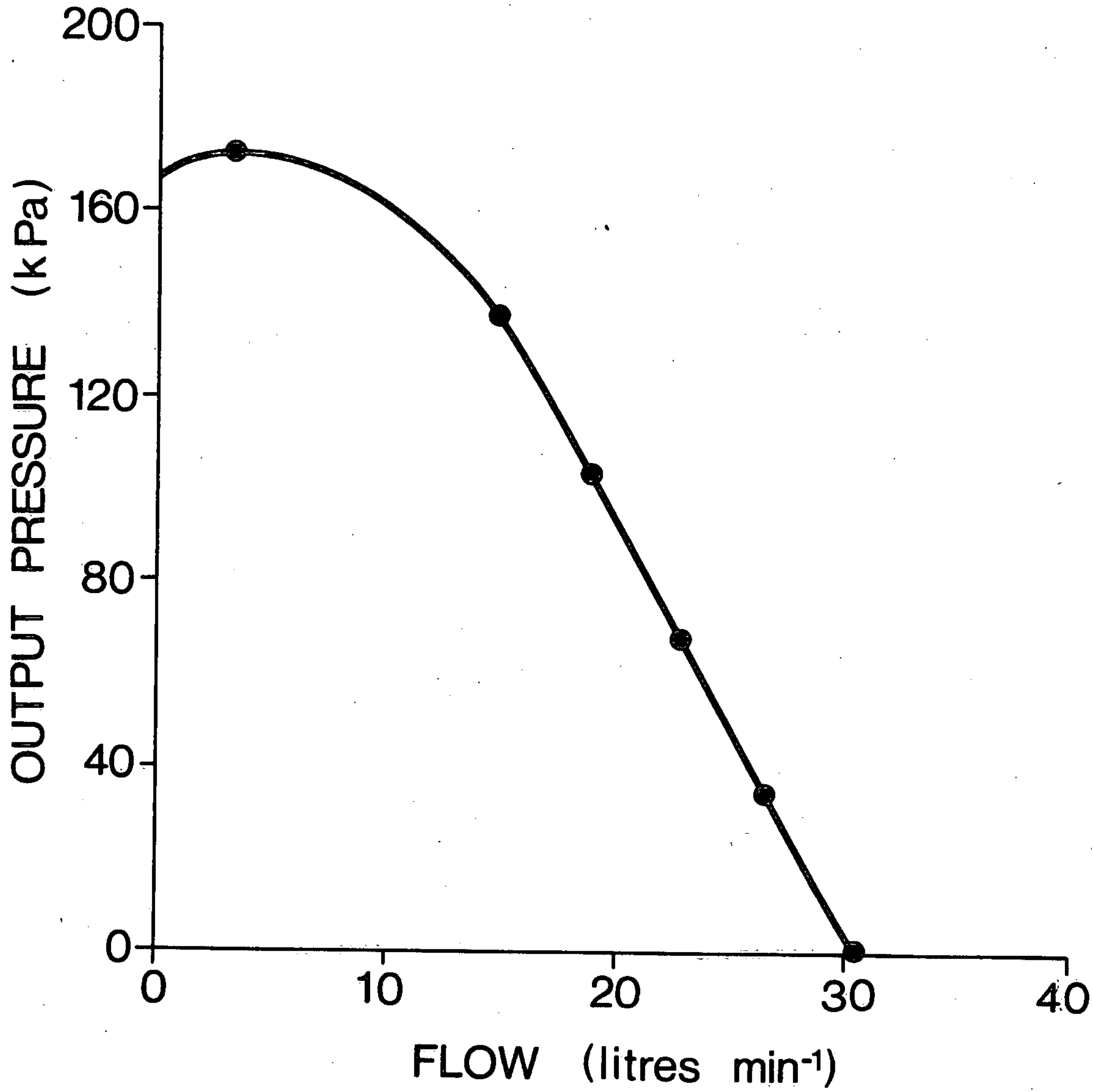

Figure 1. OUTPUT CURVE FOR COLE-PALMER PUMP MODEL C-7010-10.

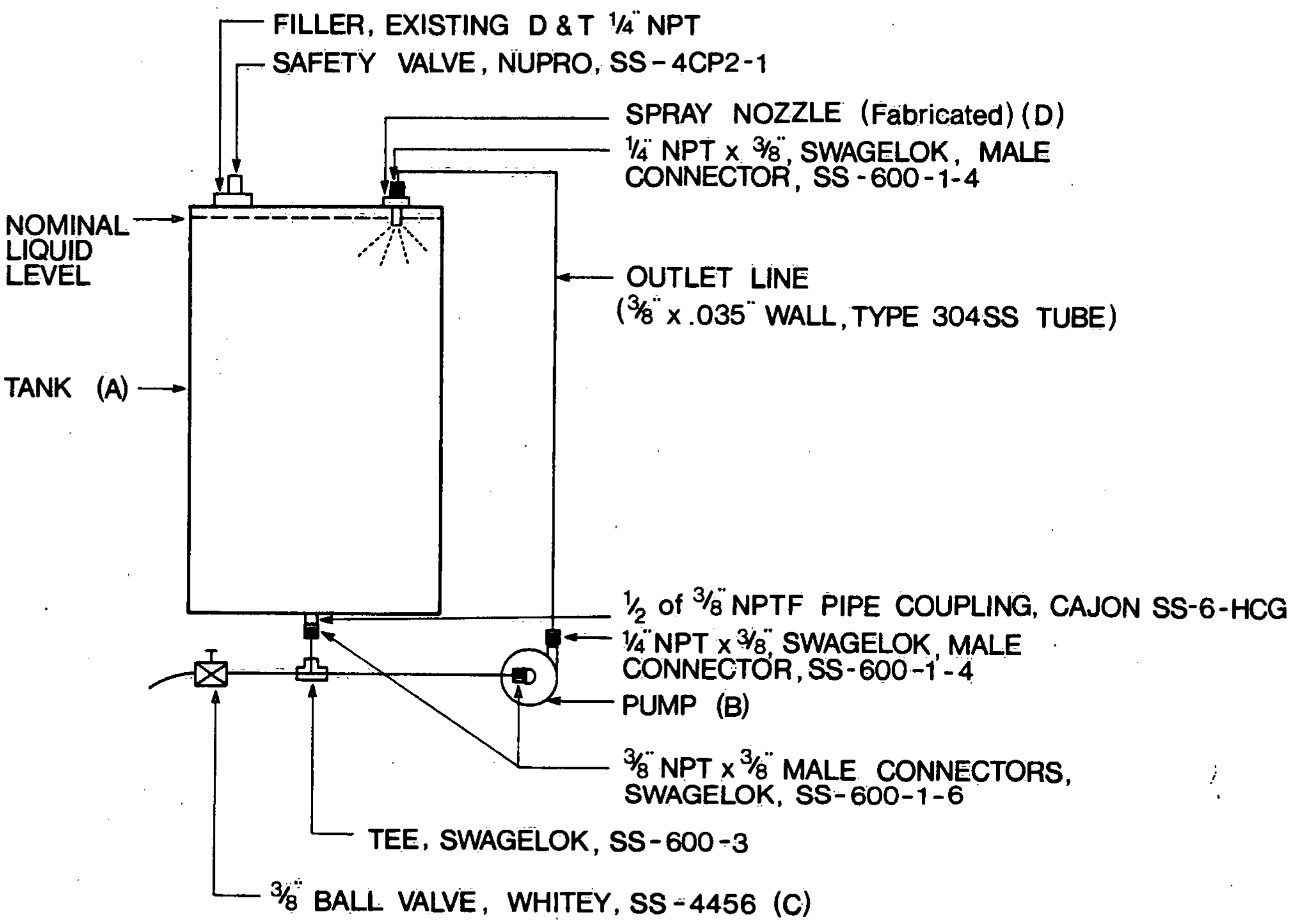

Figure 2. SCHEMATIC DRAWING OF MINI A.P.L.E. UNIT

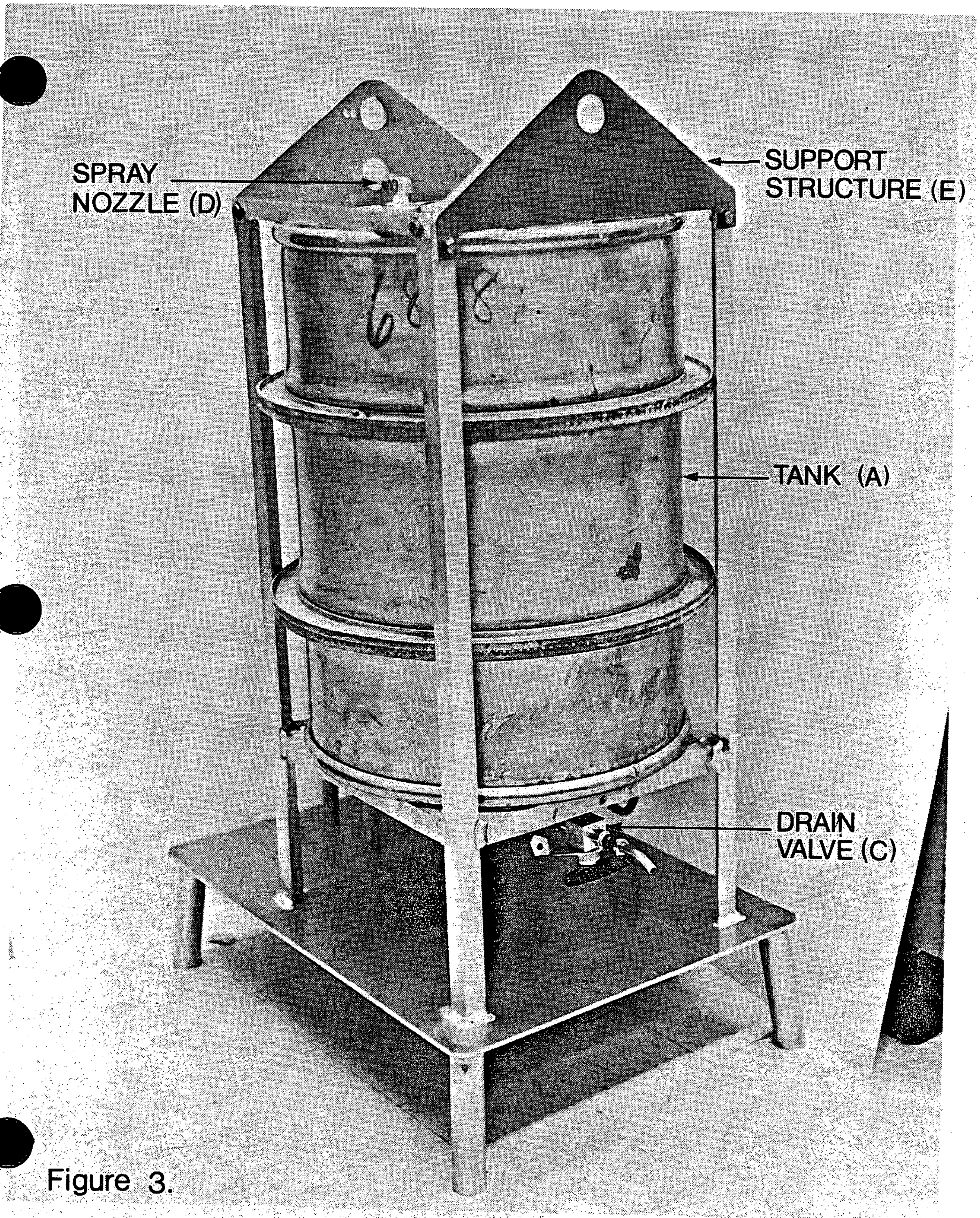

Figure 3.