Disdvantages - unsatisfactory features

- The flow-rate wheel does not turn when the water flow is very low.
- The water flow has to be low for the desired water-tube levels. If the water flow-rate is high, the water wheel turns fast (which is satisfactory), but there is a significant pressure drop across lengths of tubing. Electrically, this is equivalent to placing a 0.5 ohm resistor in a circuit where the resistance of the wires is about 0.2 ohms. When the resistance of the clamp is increased such that it is more than ten times greater than the resistance of the tubing, the flow rate is insufficient to turn the paddle wheel.
- Because the final manometer tube pressure is at ground potential, or just very slightly higher, air enters the water stream, generating large bubbles downstream of the final T-piece. This retards the flow, causing pressure to back up at the final T-piece, and eventually the flow rate to speed up. As a consequence, the water level in the final manometer tube sometimes oscillates between heights of about 3 cm down to zero.

None of the less-than-satisfactory features are sufficiently detrimental as to ruin the general performance. Each is an interesting talking point:

- The ammeter cannot detect low currents.
- Wires have resistance, which cannot always be overlooked.
- The electrical analogue of the third detriment is an LC oscillation. The electrical analogue of inertia is inductance; and, because of the mass of flowing fluids, the system has this characteristic. The manometers store mechanical energy, which may relate to capacitance [1]. The oscillation at the tail-end of the circuit results from the combined effects of the resistance, inductance and capacitance built into the system.

Acknowledgement

Useful discussions were held with Jim Campbell (Lesmahagow HS) and Professor Miles Padgett (Department of Physics & Astronomy, University of Glasgow). Feymann's 'Lectures in Physics' has information on mechanical analogues of electrical properties.

Item	Supplier	Cat. No.	Cost (£)
Flow indicator, ¼"	Cole Palmer [2]	A-06297-05	10.79
Screw clamp x 3		A-06833-10	11.33
Keck clamp, 10 mm x 12		BH-06835-07	38.12
T-connectors, ¼" ID tubing, x 10		A-30610-30	8.06
PVC Bubble Tubing ¼" ID, 50 ft		A-95805-01	27.33
Coupling, Male, Hosebarb, ¼" ID(valved panel connector)		A-06361-71	10.25
Hose Barb, in-line, ¼"		A-06361-51	5.28
Tray, 46 x 34 cm	Local		
Box, plastic, 53 x 34 x 15 cm			
Battery tank, 23 x 11 x 29 cm			
Submersible pump, 12 V	Opitec [3]	224.091	6.48
Hand-cranked generator	PASCO [4]	EM-8090	106.00

Table 1 - Parts list for electric circuit model

[1] Then again, the inverse of capacitance (1/C) is the electrical analogue of stiffness. Water is an incompressible fluid and would seem to have this property.
[2] Cole-Parmer, Hanwell, London W7 2QA; Tel: 020 8574 7556; Web: www.coleparmer.co.uk
[3] Opitec: 7 West Road, Woolston, Southampton, SO19 9AH; Tel: 023 80 44 69 91; Web: www.opitec.co.uk
[4] Feedback, Crowborough, East Sussex TN6 2QR; Tel: 01892 653322; Web: www.fbk.com

Security of radioactive holdings

Introduction

How safe are your sources? Generally they are looked after with great care. Yet, disturbingly, two instances have come to light in the past year of the disappearance of a school's radioactivity cabinet with its entire stock of sources. One occurred during a school closure; the other in the middle of a rebuilding programme – the story was told in a recent issue. They highlight the vulnerability of radioactive materials during irregular working operations. Whereas the security record during normal working procedures has been very good, the chance that things will go wrong increases ever so greatly during school reconstructions or closures.

A new report *Security of radioactive holdings* has been placed on the Members/ Downloads of the SSERC website. Please study it. It will also be on the *Radiological Protection* section of the new *SSERC SafetyNet CD*. Evidence reviewed in the report includes eight instances of the loss of radioactive material and the findings from school audits.

From incidents and audits, there is evidence of simple safety measures not being followed, and some staff failing to recognize that materials being held are radioactive. (Figures 1, 2 and 3 show examples of unmarked cloud-chamber sources. We have found these sources being kept wrongly with their instruments in insecure storage. They should be kept in the radioactivity cabinet.) There seems to be no supervision or monitoring by council officials in some councils. These councils need look at what happens in schools, helping where it is needed. Moreover the security of materials during school reconstruction work must be carefully managed.

Security: the critical points

- All radioactive materials must be kept in secure storage in a locked steel cabinet fastened to the fabric of the building or fixed furnishings.

Figure 1 - Griffin diffusion cloud-chamber source. There is radium-based radioluminescent paint on the bell-end of the source holder.

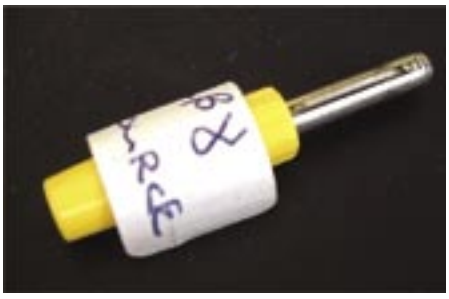

Figure 2 - Irwin diffusion cloud-chamber source. This is the worst example we have met with of an unmarked source. Irwin had drilled into the tip of a 4 mm plug and filled the hole with what we think is a radium-based paint.

Figure 3 - Nicolson Wilson cloud-chamber source. This is a radium source in metal foil wrapped round the recessed end-part of the source holder.

- The only exception is a cloud chamber with non-detachable source. This apparatus should be kept in a locked store.
- Because quite a lot of radioactive artefacts are unlabelled, there is a significant chance that they may be kept in insecure storage with other apparatus. Be on the lookout for such items and test anything suspicious with a GM counter to find out if it is radioactive. Your RPA can help with the identification and tests. An illustrated guide to sources is available.
- Maintain an accurate list of stock, listing every radioactive article or substance held. Don't omit items.
- Maintain a logbook of usage and stock checks.
- Check stock every month (except in the summer vacation) and make a record in the logbook that this has been done.
- Don't keep extraneous stuff in the radioactivity cabinet. The contents should be minimalist for easy checking.
- Radioactive materials are vulnerable to loss during irregular operations. From the historical evidence, losses have occurred during a school rebuild, a closure and a transferral to another site. Arrangements must be made to ensure the security of sources during irregular working conditions.
- If sources are to be transferred from one site to another, then a responsible person must be delegated to remove the material from the originating store and a responsible person must be there to accept the sources at the receiving store.

A sourcespotter's guide

A new catalogue has been written by SSERC to help identify radioactive materials held by schools. Because most of the materials were purchased in the 60s or 70s, there may now be in post no member of staff who knows what is being held. Some of these unknown materials are kept in the radioactivity cabinet because the items are known to be radioactive. Far worse, other unmarked materials are found held in general storage because no one is aware that they are radioactive – and the catalogue lists many items that are not apparently radioactive because of an absence of marking.

The sourcespotter's guide has several related purposes: (1) to help you identify the radioactive materials you are holding, whether in your locked store or not, securing items found to be insecure; (2) to let you draw up an accurate record of stock (another legal requirement); and (3) to facilitate a clearout of waste stock (the means of disposal depend on the type of material to be got rid of).

The guide will be sent to every school by post along with a questionnaire asking for a record of stock. From looking at the returns, we will advise you on what to keep and what to get rid of. Moreover, we should be able to advise the government on how many redundant or aged sources are being held by schools, from which they can assess how much money to budget to undertake a national disposal. The survey is being funded by the Environment Agency and has the support of the Scottish Executive and SEPA.