Clive Coogan's nephelometer.

The following account is reproduced from Kannegiesser H, 1996, "*Ever the Clever Country? Innovation and Enterprise in Australia"*, McGraw-Hill, Sydney, pp 89-90.

A nephelometer measures the cloudiness or turbidity of a liquid. Many chemical and physical processes in science and industry are marked by a change in turbidity. For example, Coogan's nephelometer has been used to monitor:

- the treatment of sewage,
- the concentration of the yeast culture in fermenting wine,
- the purity of drinking water,
- the onset of solidification in the making of cheese and
- the coating of the inside of surgical gloves with talcum powder.

New applications are appearing all the time, the most recent being the measurement of acid rain in the northern hemisphere.

Like most inventions, the nephelometer leapt at Coogan out of the dark when he was working on something else. During the 1970s he had been using nuclear magnetic resonance to study the microstructure of crystals. During that project he often wished he had some device that would automatically follow a line drawn by a recorder, some form of optical device that would "see" the difference between the dark line and the white paper and perhaps represent it as a change in voltage in an electric circuit that could be used in some form of feedback device to control the recorder itself. Coogan was also interested in the problem of the control of the heating of furnaces where the temperature had to be increased with time in a predetermined fashion. Again, a device that could follow a line on a graph would help solve that problem. Finally, he had developed an interest in optical fibres, then a CSIRO specialty, as early as 1970 when he was the head of the Solid State Chemistry Section of the Division of Chemical Physics.

Clive Coogan AM

Coogan began to play with optical fibres and lines drawn on paper in his office using rubber bands to hold two fibres together and a desk lamp as the light source. The light was shone down one fibre onto the graph. If it struck white paper, the light was reflected up the second fibre. If it struck a dark line, it wasn't. Eureka? Not quite. The device to track a graph was never made. Suddenly, in a "blinding flash", came the idea of measuring cloudiness in liquids. Why not use reflected light to measure turbidity, thought Coogan? If you shine light on particles suspended in a liquid, some would be reflected, like dust in a shaft of sunlight. The greater the number of particles, the brighter the reflection. No particles, no light. What a good idea.

He tested the idea by setting up in his kitchen a crude device similar to the one he had earlier used in his office. However, this time he experimented with clear water and water clouded by a few drops of milk instead of white paper and black lines. His expectations were amply fulfilled and "*a new, robust and particularly sensitive"* type of nephelometer was born.

Now, why did Coogan jump from an optical device for tracking lines on sheets of paper to measuring the cloudiness of liquids? He has no idea. Nobody he knew of in CSIRO was conducting studies in the area and he had never shown interest in it himself. His brain made the leap quite spontaneously. However, once the idea emerged he knew what to do with it. Having been trained by Lloyd Rees [Chief of the CSIRO Division of Chemical Physics] to always seek a commercial application for a discovery, Coogan took his working model to Selby Scientific and Medical Company, a long-established firm trading in scientific instruments and a onetime manufacturer of instruments themselves.

In the past, Selby had often helped CSIRO. Coogan thought that his nephelometer might now help it to re-establish itself as a manufacturer. Like Rees, Coogan was keen to see an Australian scientific instrument industry come into existence.

Selby did not respond with much enthusiasm but it did respond. It asked one of its recently retired and highly experienced technicians to turn Coogan's working model into a prototype for a commercial instrument. Success was not immediate. The first attempt was a total failure, giving the same reading for milk as for water because a bubble had been trapped between the optical fibres and the liquid.

The next instrument eliminated the bubble and worked as expected, except that it covered a far wider range of turbidity than anticipated(from milk to nearly pure water) but showed a lack of sensitivity at the lower end (that is, nearly pure water). A disappointing result, but promising. After some thought, Coogan decided that they should "code" the light emerging from the nephelometer and look for a signal coming back along the other fibre that exhibited this "code", rejecting extraneous signals. This system worked well, improving the sensitivity at the lower end, and was incorporated into n instrument that was small, cheap and easy to use, requiring only that the probe from the nephelometer be inserted into the liquid under test to obtain a reading.

The patent describing this invention can be viewed at: Optically based measurement of fluid parameters - Patent 4690560 *[external link].* The instrument was put on the market in 1986 and recorded $ 2 million in sales over the next three years, being substantially superior to its commercial rivals.