with spherical top molecules. The impetus for such studies is given by non-linear photophysical procedures used presently to separate isotopically substituted species of spherical symmetry, such as SF_6.

The reports on high resolution optical and microwave apparata proved the steady tendency in the USSR to create a home experimental basis. The most intriguing instruments were the spectroscopic laser devices and the now famous Gorky mm-wave spectrometer with an acoustic detector. The impact of laser technology upon spectroscopy is demonstrated by the twenty-odd papers given in this field.

Since the Symposium was organised by the Tomsk Institute of Atmospheric Optics numerous papers were devoted to atmospheric molecules, such as water, CO_2 and ozone. The physics of these studies is centred on intermolecular interactions influencing the shape of individual spectral lines. Future needs are for more experimental and theoretical work on line-contours.

The Novosibirsk Symposium fits well into the European series of high resolution spectroscopy meetings in Tours, France and Prague, Czechoslovakia. These conferences represent a turnabout from chemical spectroscopy towards the more quantitative methods of physical spectroscopy. The rigorous principles and procedures of atomic and diatomic spectroscopy find a broad field of application for the polyatomic molecules. The greatest contribution of the Novosibirsk meeting is the promotion of this kind of change of philosophy for polyatomics.

Finally let me add that Akademgorodok Novosibirsk had a display of young talent and enthusiasm, both important and promising for the future of this discipline.

I. Kovacs

Dilution Refrigeration and Its Applications

It is now more than a decade since the first dilution refrigerators were built and in the mean time these machines have become standard for reaching temperatures between 10 and 300 mK in a continuously operating mode. Moreover, the technique has spread beyond the area of purely low temperature physics and is now widely used in a number of fields.

Dilution refrigerators operate on a mixture of liquid ^3He and ^4He making use of the property that at low temperatures the liquid separates into two phases, usually known as the concentrated phase and the dilute phase according to the ^3He concentration. The thermodynamic properties of the two phases being rather different, cooling can be obtained by forcing ^3He atoms from the concentrated phase to the dilute phase, somewhat analogous to a simple evaporation refrigerator but in fact more similar to the Peltier cooling achieved by forcing electrons across the boundary between two dissimilar metals. The operation of the conventional dilution refrigerator, in which ^3He is drawn out of the dilute phase by a heated still and the cooling caused by the balancing flow from the concentrated phase, is sufficiently well understood that machines reaching 10-12 mK are available commercially.

However, in the past two or three years, a number of improvements and innovations have been made which have allowed continuous operation to temperatures of 3-4 mK, in other words not far above the liquid ^3He superfluid transition. Since a great deal of this recent work has been done in Europe it seemed both timely and appropriate for the EPS Low Temperature Division to sponsor a study conference on dilution refrigeration this summer.

The study conference format suited the subject admirably. Session leaders introduced the topic under discussion with short 30-40 minute talks, sometimes followed by one or two ad hoc "contributed" comments of a few minutes. Since refrigerators continue to be temperamental creatures, both in operation and concept, lively argument filled the greater part of the time.

The conference which took place in Lancaster from 25-27 September, was roughly divided into, day 1, the conventional refrigerator, or as the first session leader described it the "General Motors, rear-wheel-drive refrigerator": day 2, applications: and day 3, new or unconventional cycles.

Day 1 began with a historical introduction to dilution refrigeration and the basic thermodynamics of the cycle using the concept of the enthalpy balance to calculate the behaviour. The optimization of performance was then discussed with particular reference to the successful Grenoble machines that routinely reach 4 mK. One of the most significant results reported was that using very fine sintered silver heat exchangers these temperatures can be reached and, as important, that the performance of each section of the machine agrees reasonably well with calculations. The day finished on a second high note with a discussion of multiple mixing chambers which have been developed in Eindhoven and more recently at Grenoble. These devices allow with very little extra effort, final temperatures two to three times lower than the single mixing chamber to be achieved.

Day 2 saw the discussion of applications of refrigerators both for the relative beginner and the expert including a number of sophisticated uses in nuclear physics, and there was some discussion of the problems of making thermal contact to the mixing chamber. The day finished with a discussion of practical thermometry and there was lively argument here too, especially over the problems of dehydration of CMN and of local moments in platinum used for pulsed nuclear resonance thermometers.

The final day saw the introduction of the new cycle in which, instead of extracting ^3He from the dilute phase in the mixing chamber using a still, ^4He is pumped in through a superleak. This cycle offers the great advantage that the dilute and concentrated phases counterflow in the same tube, rather than in separated tubes and no heat exchangers are needed. The simple Leiden machine which reached 8mK very soon after having been commissioned was discussed. Hybrid machines in which a "Leiden" mixing chamber is piggybacked on a conventional refrigerator, and both ^3He and ^4He are separately circulated, as developed at Philips and Grenoble, were also considered. The meeting finished with an all-too-short session on running problems and trouble shooting including a very scientific look at leak detecting.

The meeting was held at the University of Lancaster, no great distance from the English Lake District and the

(Right) Participants looking down Gaping Ghyll Pot in the Yorkshire Dales during one of the hill walks.

Yorkshire Dales. Sessions were held in the mornings and in the evenings after dinner. The afternoons were left free and most participants availed themselves of the opportunity to enjoy some hill walking in some of the most beautiful countryside in England. We would like to acknowledge financial support from Oxford Instruments, Elscint (GB) Ltd., and Schaefer Instruments.

G. R. Pickett and D. Thoulouze

SQUIDS

The International Conference on Superconducting Quantum Devices, held in Berlin from 5-8 October, 1976 was the first devoted primarily to the superconducting devices known as SQUIDs. An attendance of over 125 persons from the Western European countries, the USA, and Japan (hardly anyone, unfortunately, from eastern Europe and the USSR), plus displays of SQUID magnetometers and other instruments by representatives of three commercial firms, showed that these simple, highly sensitive devices have become part of the way of life of a large and diverse group of scientists and engineers.

The nature of the contributed papers demonstrates that SQUID technology is approaching maturity. The operation and limitations of DC and RF biased SQUIDs were analysed and presented in considerable detail. One unexpected prediction was a negative input resistance of an RF biased SQUID in the hysteretic mode. It would be useful to have a simple qualitative explanation of this, since it differs radically from the Manly-Rowe relation. Both the theory and the fabrication technology of tunnel junctions, microbridges, and point contacts seem to be maturing rapidly, although the theory of microbridges is not nearly as far along as the others. Also, much remains to be done on the very-high-frequency (above 100 GHz) operation of Josephson junctions.

The intrinsic limit of SQUID sensitivity to low-frequency magnetic fields was estimated to be of the order of 10^{-32} J/(Hz)$^{1/2}$. Practical instruments now have sensitivities in the range of 10^{-28} to 10^{-30} J/(Hz)$^{1/2}$. Roughly speaking, these figures are the amount of field energy that must be coupled into the SQUID to give an observable response. In summarizing the conference, John Clarke listed two applications in which greater sensitivity would be useful. One is in gravity-wave detection: the other is in the general area of magnetic-gradient measurement. A third is in biomagnetism, specifically magneto-encephalography, where any significant increase of sensitivity would be very gratifying.

There were several reports and an ad hoc session on computer simulation and analysis of SQUID operation. While it is clearly useful to work out in precise detail the consequences of our simple models, the real world is more complicated, and I suspect that many of us would be better served if some carefully-worded intuitive or qualitative explanations were presented along with the computer results. Our love affair with the electronic computer reminds me of the recent experience of watching a younger colleague use a pocket calculator to multiply 40 x 60, and I wondered if he would have been dubious if the result had been 480.

As a tutorial document, the conference preceedings will be deficient in certain areas, a defect for which we, the programme committee, must be assumed responsible. First, some of the potential major applications of SQUIDs, namely geomagnetism (geothermal prospecting by earth conductivity measurements, for example) and biomagnetism (measurement of magnetic signals of the heart, brain, and other organs) were not mentioned or reviewed. Second, the mechanical analogue of the Josephson junction and associated circuit elements was not used or discussed. This important intuitive aid is easily worth ten thousand words.

The exciting and potentially enormous application of SQUIDs in computers was covered in an invited and several contributed papers. Several unique and interesting applications of SQUIDs to magnetic susceptibility, RF power and attenuation, and other laboratory measurements were given in contributed papers. The papers demonstrate the almost revolutionary impact of SQUID technology on DC and low-frequency laboratory measurements. There was one paper on an important technology that usually is not even mentioned in papers on SQUIDs, namely refrigeration.

In short, this conference proceedings will be useful to specialists in the field, but will not be as useful to a broad spectrum of potential SQUID users as it might have been. If, as has been suggested, the conference is held again in three years or so, we should try to do better for the latter group.

Our German hosts earned our praise and admiration for the excellent facilities and smooth operation of both the technical and non-technical events. They set a standard that will be difficult for others to match.

J. E. Zimmerman