Correspondence

An Unidentified VLF Station

SIR,—During a search of the VLF portion of the radio spectrum for transmitting stations which might serve as sources of "whistler-mode" signals, we observed a transmission on 14·9 kHz which presented some puzzling propagation effects.

Its origin is unknown, and we have been unable to identify the operating agency or the location of the transmitter itself.

We have plotted the diurnal phase variations of the transmitted frequency for about six months, and, by correlating this information with the sunrise and sunset terminators which produce the major phase variations, we have determined that the signals arrive from the direction of the Gulf of Alaska (about 30° true). The great circle distance from Lower Hutt is indefinite, except that it is more than 8,000 kilometres.

Variations of signal strength suggest that at least a portion of the path is subject to PCA events. The station cannot be in Europe or Africa, or its signals would be received along the short great circle path, which can be readily identified by means of the sunrise–sunset phenomena.

There is some evidence that the frequency is controlled by an oscillator which is corrected daily by reference to an atomic standard.

The station is using one of a group of six frequencies used by an unidentified agency during 1969 to transmit a repetitive sequence of short dashes, similar to the well known Omega format, except that the pattern consisted of six intervals over 3·6 seconds, as against the Omega pattern of eight intervals over ten seconds.

No information on the transmission described, or its "navigational" predecessors, which ceased transmission in January 1970, has been noted in the technical or scientific press, and any information on the existing transmissions on 14·9 kHz known to other scientific workers in this field would be welcomed by this laboratory.

Yours faithfully,

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Topology and Metallurgy

SIR,—In a recent publication[1], L. Barrett and C. Yust review the applications of topology to metallurgy. From it, it is clear that metallurgists have been laggard in using topology: after a pioneering paper by C. S. Smith in 1951 (ref. 2) on the analysis of grain shapes in a polycrystal, only some 15 to 20 of the papers which have been published up to now on this problem, on the sintering process and on the study of interfaces in a two-phase material, have applied topological theorems.

This lack of enthusiasm is really surprising because, by its very nature, topology seems to be a very appropriate tool to deal with metallurgy, a brand of science that proposes the "wary analysis of non-living complexity"[3], "a perpetual balancing act between the realistic and the tractable"[4]. As Barrett and Yust put it: "Often mathematics, particularly applied mathematics, is thought of in terms of analytical formulae yielding quantitative results. (Topology) is of a more qualitative nature, offering newer concepts as the means of describing physical phenomena. . . . These concepts yield a fresh viewpoint and unifying relationships among apparently diverse structures". In typical metallurgical problems as complex as work-hardening, recrystallization, creep and the like, metallurgists have been so busy—and not very successfully as yet !—looking for analytical formulae that they have overlooked the possibility that perhaps topological relationships were more apt to answer their questions. I do not see any epistemological reason why nature must abhor topology. And in fact I would like to suggest that perhaps nature loves topology, as is shown by what I would call the "topological structure" of one of the most important relationships in physical chemistry, very well known, respected and used by all kinds of metallurgists: Gibbs's rule of phases.

Gibbs's rule possesses a striking similarity with Euler's theorem (which gave rise to the discipline of topology): If we call V the number of vertices, E the number of edges and F the number of faces of a polyhedron, then Euler's theorem states that $V-E+F=2$. But if V is now the number of phases, E the number of independent components and F the number of degrees of freedom of a physico-chemical system, Gibbs's rule states that $V-E+F=2$.

It can, of course, be said that this similarity is merely an accident, a formal curiosity without any further consequence, and that, besides, Gibbs's rule is not more than a useful "recipe", deduced from a system of analytical equations establishing the equilibrium conditions of a system of V phases and E components with F degree of freedom. But the important thing to realize is not how the "recipe" is usually deduced, but its very nature: just as Euler's theorem makes possible a "geometry without metrics", Gibbs's rule permits one to analyse equilibrium without measuring anything. It provides a powerful means of dealing with the many variables of the equilibrium of any complex system. To evaluate how powerful it is, it is enough to try to imagine metallurgy without Gibbs's phase rule.

Are there many other topological relationships in the realm of metallurgy ? According to Barrett and Yust, there are very few, and these do not seem to be as important as Gibbs's phase rule. This paucity is not strange, because it seems that metallurgists have not been looking very hard for applications of topology to their science.

Yours faithfully,

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[1] Barrett, L., and Yust, C., *Metallography*, 3, 1 (1970).
[2] Smith, C. S., *Metal Interfaces* (Amer. Society for Metals, Cleveland, 1952).
[3] Smith, C. S., *A historical view of one area of applied sciences: metallurgy, Applied Science and Technological Progress* (National Academy of Science, USA, 1967).
[4] Cahn, R. W., *Discovery*, 41 (July 1965).

Abortion Act in Action

SIR,—Since the publication of my letter on May 16 (*Nature*, **226**, 673; 1970) more recent official figures[1] have shown that abortion deaths in 1969 were in fact a little up on 1967, the last full year under the old law.

In England and Wales, 10 deaths were directly attri-