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LETTER TO THE EDITORS

COMMENTS ON SPALDING'S PAPER "A TRANSFORMATION OF THE MOLLIER *i–x* DIAGRAM"

D. B. SPALDING, *Int. J. Heat Mass Transfer* 7, 3 (1964)

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IN HIS paper [1] published in the Mollier commemoration January issue of this Journal, Spalding presents an enthalpy-composition diagram on a "nole"-fraction basis, where he in the Fig. 1 [1]—as an example—defines "1 nole" of air as 25 lb of air and "1 nole" of H_2O as 1 lb of H_2O. The advantages thus achieved are firstly, in comparison with Mollier diagrams on a mass-of-air basis, that all compositions, "pure air" and "pure H_2O" included, can be represented by points on a finite scale, and secondly, in comparison with a diagram on a mole-fraction basis, that suitable choices of the units, named "noles" permit often very desirable expansions of the region of the scale, where slightly moist air is represented, of course at the cost of the region for perhaps less interesting highly moist mixtures where accurate readings are less important. He also points out the fact that such transformations of the representation are related to various central-projective transformations of Mollier's diagram.

After having read the paper I informed Professor Spalding about the fact, that I have lectured about these same things for a long time—as a matter of fact for at least 20 years—in my courses for chemical engineering students at the university "Åbo Akademi", Åbo, Finland. He then kindly suggested that I write a "letter to the Editor" concerning the projectively transformed diagrams, which I had sent to him. Now obeying his kind invitation, I must, however, explain why I have arrived at a somewhat different solution of the problem of a practical representation than his nole-fraction-based diagram.

The transformation of a Mollier *i–x* diagram into a diagram of the nole-fraction type shown in Spalding's paper can be considered as the result of two successive procedures: (1) a central projective transformation, which for every state-point of the former diagram determines a corresponding point, representing the same state of the mixture, in the plane of the new diagram, and (2) a change of the state variables *i* and *x* (referred to the mass of dry air) into new variables, referred to noles of mixture, giving new co-ordinate lines, now belonging to a co-ordinate system of the Cartesian type, as shown in Spalding's paper.

The first of these procedures brings the two essential practical advantages already mentioned. The second procedure may simplify the construction and appearance of the new diagram, owing to the equidistance and parallelism of the co-ordinate lines, but from the point of view of a user of the diagram it will in general cause more disadvantage than advantage, at least in calculations concerning drying, dehumidification, cooling towers and other such cases, where the quantity or flow of the mixture contains a constant quantity or flow of dry air. This is simply because the variations of quotients of the type enthalpy/noles of mixture and noles of H_2O/noles of mixture, where both numerator and denominator vary, as a matter of course are more difficult to follow in imagination and also to compute, than the variations of quotients where only the numerator varies, as in the case of using quotients of the type "enthalpy and mass of H_2O/mass of dry air".

It is thus certainly possible to improve the practical usefulness of Mollier's *i–x* diagrams by means of suitable projective transformations, applied also to all lines and curves of his diagrams and resulting in such transformed, and to my knowledge new, diagrams as that included in this letter,* but there is in my opinion no necessity to reject Mollier's well-judged choice of the variables. (Perhaps this defence of Mollier's choice of variables may also be considered as a small contribution to the Mollier commemoration.) The projectively transformed, alternative scale for *x* in Spalding's Fig. 1 can of course also be

* The diagram is with due permission reprinted from the calendar for 1964, published by EKONO, Assn. for Power and Fuel Economy, Helsingfors, Finland. The units of the quantities, represented by the several groups of lines, may give sufficient explanation of the diagram. More detailed diagrams (size 22 in. × 33 in.) have been constructed with both kcal and kJ as units for the enthalpy. Diagrams have also been constructed by such a central projection, that the lines for $x =$ const. converge ([3], p. 628). I am indebted to my former assistants M. Soininen, N. Westerberg and J. Lindell for their computations and practical constructions of the diagrams.

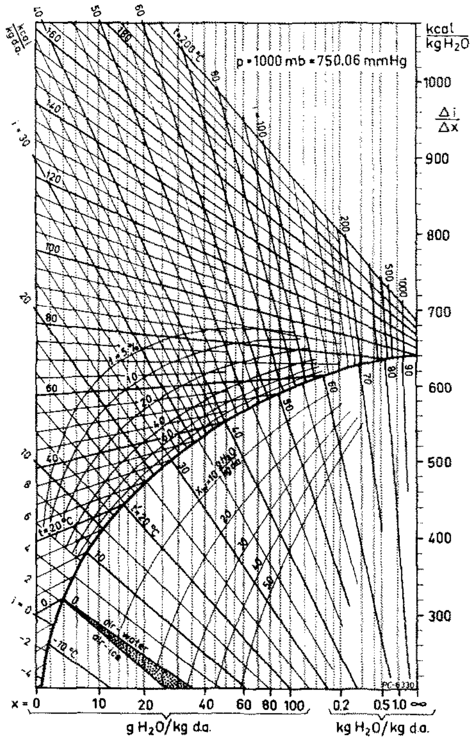

FIG. 1.

considered as a step in the direction of reintroducing Mollier's variable.

These comments—from the practical point of view of the users of the diagrams—should, of course, not hide the interesting fact, discussed by Spalding in his papers, that different projective transformations of the diagrams are closely related to different choices of unit quantities—by Spalding called "noles"—of the components in question. As this fact can throw light on the possibilities of describing the thermodynamics of processes, where more than two components are involved, there is surely good reason to draw attention to this and related facts in lectures and research at the university level. An introductory study of the applicability of projective geometry as a part of modern linear algebra to such problems was made by one of my pupils a few years ago [2]. The use of diagrams for quantitative descriptions is of course restricted to cases with only very few components in the mixtures. More general methods of description must thus operate with formulas in terms of numbers and symbols of units. Whenever the units can be chosen arbitrarily, as Spalding shows in his example, the right of option should of course be preserved in the development of the system of expressions.

REFERENCES

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3. S. HEINIÖ, Editor, *Tekniikan käsikirja* (Technical Handbook, in Finnish) 7th ed., vol. 1. Chapter 10, Lämpö (Heat), by J. SALIN. Gummerus Oy, Jyväskylä, Finland (1951).