sity of Amsterdam, has been appointed professor of mathematics; Professor R. von Mises, of the Dresden technical school, has been appointed professor of applied mathematics, and Dr. Issai Schur has been promoted to a full professorship of mathematics. Professor C. Carathéodory has resigned, to accept a professorship at the National University of Athens.

DISCUSSION AND CORRESPONDENCE

EFFICIENCY IN THERMAL CALCULATIONS

THERE is something wrong with the commonly accepted definitions used in calculating efficiency when applied to thermal phenomena.

Take the following case as an example. An ice-making machine is placed in a room that requires heating. Let us calculate the efficiency of the operation of heating the room. Assuming the machine to be operated by an electric motor, the heat supplied to the room consists of two parts, the heat equivalent of the electric current, and the heat withdrawn from the water in making ice. As the entire machine is located in the room, there are no losses, all friction being utilized as useful heat. We therefore have a case where the useful heat is greater than the heat we paid for, or an efficiency of over 100 per cent.

For another illustration, consider the heating of a room by an electric heater. The efficiency is 100 per cent., as all the energy of the current goes into the room. But this same current could have been used to run machinery in the room, such as fans, sewing machines, etc., that would have returned all the heat to the room eventually. Should not this additional work be considered in calculating the efficiency of the outfit?

There is one long established law that gives the clue to more suitable definitions of thermal heat units. Carnot established the fact that the efficiency of an ideal heat engine was equal to $(T_1 - T_2)/T_1$ where T_1 equals the absolute temperature of the source of heat and T_2 the temperature of the exhaust. In other words the work that it is possible to obtain from heat depends upon the difference in temperature as well as upon the calories present.

Our efficiency terms would be of more practical value if instead of using the calories we should use a modified heat unit consisting of the calory multiplied by the ratio referred to above, taking the value T_2 as the lowest temperature of the surrounding air, condenser water, etc.

This would, of course, increase the mathematical difficulties, but why say that a boiler has an efficiency of 80 per cent. when but one third of that 80 per cent. can be used by an ideal engine. This method would also bring out forcibly the tremendous losses in heating houses by coal, without making use of the power as a by-product. The inefficiency of the steam locomotive is frequently commented upon, but the inefficiency of raising the temperature of a house 10° F. is so much greater that it should be made evident to all.

There is one serious objection to the use of a ratio such as that of Carnot's cycle as part of a unit of heat. That is, is Carnot's cycle the best possible cycle? None other has been developed as yet, but we have not established the proposition that none can be developed.

ALLAN W. FORBES
WORCESTER, MASS.

IN Mr. Forbes's interesting communication, which the editor has been good enought to let me see, he has perhaps overlooked the fact that in a reversible cycle, the efficiency being defined as the ratio of work done to heat taken in for a motor, always less than unity, if the efficiency of a freezing machine or heating plant be defined as the ratio of heat taken up to work done, this will be the reciprocal of the efficiency of the motor, and consequently greater than unity. Evidently the efficiency will be greater the smaller the temperature interval to be covered. This was pointed out many years ago by Lord Kelvin, who called attention to the enormous waste in heating a house, the difference of temperature employed being that from the red heat of combustion of the coal to the temperature desired, when all that is needed is the small

range between indoor and outdoor temperatures. Lord Kelvin actually proposed to heat a house by a reversed heat engine or refrigerating machine. I am not aware whether this has actually been tried in practise.

By the efficiency of a boiler we mean the ratio of the energy, contained in the hot water and steam into which it has been converted, to the amount of heat that may be realized by burning the coal. This suffices to indicate the performance of the boiler, while that of the engine is a separate thing, and suffices to compare the performance of the engine with that of a perfect engine, limited as it is by the second law of thermodynamics. Mr. Forbes casts doubt upon Carnot's cycle being the most perfect one, but that was thoroughly proved by Carnot to be the case. In fact the gas-engine and the Diesel, which approach most nearly to the Carnot cycle, have the highest efficiency that has been attained. Mr. Forbes is correct in pointing out the fact that the efficiency of electric heating is unity, a fact which interests the consumer, who in this rare case knows that the meter can not do him an injustice, and yet, for all that, this is not a cheap method of heating. Electricity *can* compete with the ice-man.

Arthur Gordon Webster

REVERSAL OF THE SODIUM LINE

To the Editor of Science: On a recent visit to a large plate-glass factory in the vicinity of Charleston, West Va., I had the good fortune to note the reversal of the well-known sodium line "D." The instrument used was a small pocket direct-vision spectroscope, which I carry with me on technical trips.

The furnace was a 200-ton plate-glass type, gas fired; and the reversal was noted at the peep-hole near the charging end, and shortly after the introduction of a fresh charge of the "mix." The reversal was noted in the case of two furnaces, one of these giving a *steady* reversal, and one giving a *wavering* and *intermittent* reversal. The phenomenon was noted both by myself and also by three distinguished technical friends attendant on the trip. Of course the reversal of the sodium lines is frequently observed in the electric arc, but this is the first instance in my experience that I have noted such reversal in a *fuel-fired furnace.* The temperature of the furance was probably approximately 3,000° F.

The observation may be more common in the experience and observation of others; but if this brief note should prove of value, the writer will be glad to answer any detailed questions regarding this rather unique matter. I have long held the opinion that the spectroscope has not been—and is not yet—used for its full technical worth in the practical arts.

Charles S. Palmer

United Fuel Gas Co.,
Charleston, West Va.

THE CARNEGIE FOUNDATION AND RESEARCH IN THE COLLEGES

In a paper on college government and the teacher's salary, in the 14th annual report of the Carnegie Foundation for the Advancement of Teaching, the statement is made that much of what passes for research in American universities is only imitation research, which is detracting from the quality of the teaching to which the students are entitled. The conclusion is drawn, by inference at least, that the large sums of money spent on this kind of research could be expended much more profitably in strengthening the teaching work. It is unnecessary to debate the correctness of the writer's judgment as to the quality of the research work done in the universities. A large part of the research work done everywhere is mediocre or poor and it would be surprising indeed if this did not imply also to the colleges. No doubt the work done in some institutions is inferior to that of some others just as the teaching is of different degrees of perfection. It seems, however, that the writer has entirely overlooked one aspect of research work which in the colleges should be given the most serious consideration.

For many years the appreciation of the value of research has been growing in this country. This interest has been greatly stim-