Int. J. Heat Mass Transfer. Vol. 17, pp. 1181–1189. Pergamon Press 1974. Printed in Great Britain

MAGNETO-FLUID-MECHANICS FREE CONVECTION TURBULENT FLOW

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(*Received* 19 *May* 1972 *and in revised form* 13 *July* 1973)

Abstract—The present work is an experimental study of the influence of a uniform magnetic field on the structure of a free convection turbulent boundary layer in a conducting fluid. The boundary layer was formed along the heated vertical wall of a cell. The applied magnetic field was normal to the wall.

The measured mean temperature profiles, temperature turbulent intensity distributions, and temperature spectra along the wall, indicated that transition from turbulent to laminar flow occurs at a constant value of the ratio (Rayleigh number)/(Hartmann number).

The study of the recorded spectra indicated that the presence of the magnetic field enhances the mechanism of turbulent suppression due to the buoyancy forces.

Finally, a possible mechanism by which turbulence is suppressed by the presence of a magnetic field is discussed.

NOMENCLATURE

B or B_0, magnetic field;
f, frequency;
g, gravity;
Gr, Grashof number;
Gr_x, local Grashof number;
M, Hartmann number;
Nu, Nusselt number;
Nu_x, local Nusselt number;
Nu_L, Nusselt number based on the length of the heated wall;
P, applied power;
Pr, Prandtl number;
Re, Reynolds number;
Ra, Rayleigh number;
T or t, temperature;
T_0, temperature of adiabatic atmosphere (function of height);
T_w, temperature at the wall;
T_∞, temperature at the bulk of the fluid;
ΔT_w, $= T_w - T_\infty$;
u_i', or u', v', w', turbulent velocity fluctuations;
$\bar{U}_i$, mean velocity;
x, y, coordinates along and normal to the vertical wall;
$y_{0\cdot 5}$, distance from the wall at which the intensity dropped at half of its maximum value;
β, coefficient of thermal expansion;
δ, thermal boundary-layer thickness;
ε_m, eddy diffusivity for mass transfer;
ε_h, eddy diffusivity for heat transfer;
θ' or T', temperature turbulent fluctuations;
Θ, $= \dfrac{T - T_\infty}{T_w - T_\infty}$;
ρ, density;
σ, electrical conductivity.

INTRODUCTION

TURBULENT free convection motions of electrically conducting fluids in the presence of magnetic fields are common in cosmic phenomena and therefore their study is of importance in the fields of Geophysics and Astrophysics. Magneto-fluid-mechanic turbulence also finds application in problems in the fields of Plasma Physics, MHD energy convertion and Nuclear Technology.

The purpose of initiating and conducting the present experiment was primarily directed towards investigating the mechanism of interaction of an electromagnetic field with a shear turbulent flow of a conducting fluid. This study could allow an understanding of the nature of the influence this interaction has on some of the physical processes associated with momentum and heat transfer in the flow. It was hoped that the information gathered would permit the construction of theoretical models explaining some of the above-mentioned phenomena.

In a previous work, results are presented of an experiment concerning the structure of a free convection turbulent boundary layer formed along the heated wall

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of a stainless steel cell filled with mercury (see also [10]). The present experimental study examines the change in the structure of this boundary layer when a uniform magnetic field is imposed on the flow in a direction normal to the wall. The heat flux distribution, which in the absence of a magnetic field provided a uniform temperature on the wall, was kept unchanged during experimentation in the presence of the magnetic field. This, as will be discussed later, created temperature gradients along the wall due to the change of the heat-transfer law in the presence of the magnetic field.

As in the non-magnetic case, the measured physical quantities in the present study were mean temperature distribution, turbulent temperature intensity distribution, and turbulent temperature spectra.

In the remainder of this work, the abbreviations MFM for magneto-fluid-mechanics and OFM for ordinary fluid mechanics will be adopted.

LITERATURE REVIEW

Theoretical as well as experimental work on the subject is very limited and it can be summarized as follows.

The effect of a magnetic field on the heat-transfer rates of a turbulent free convection flow of a conducting fluid along a vertical isothermally heated flat plate was examined by Hopenfeld and Cole [2]. In their theoretical approach they used the integral method as well as the velocity and temperature profiles introduced by Eckert and Jackson [3] for the solution of the corresponding OFM problem. Their results indicated that a similar solution exists when the magnetic field varies in the vertical direction as $x^{-1/4}$. In this case, the reduction in the heat-transfer rates was found to obey the following relation

$$\frac{(Nu_x)_B}{(Nu_x)_{B=0}} = \left[\frac{\{4{\cdot}5+2{\cdot}25\,Pr^{2/3}\}^{1/2}}{1{\cdot}27Z+\{1{\cdot}62Z^2+4{\cdot}5+2{\cdot}25\,Pr^{2/3}\}^{1/2}}\right]^{4/5}$$

where the parameter Z, introduced first by Lykoudis [4], is defined as follows:

$$Z = \frac{2M}{Gr^{1/2}} = B_0^2 x^{1/2}/\rho(\sigma\beta\Delta T_w)^{1/2}.$$

Emery [5, 6] used a two boundary-layer model to describe the free convection flow in a cell. By applying the integral method and assuming that similarity in the flow is preserved in the presence of a magnetic field, he derived heat-transfer rates for both the OFM and MFM cases in the laminar and turbulent flow regimes. According to his results, the heat-transfer reduction in the cell due to the effect of the magnetic field is a function of the ratio $B^2/(\Delta T_c)^{1/2}$ in both the laminar and turbulent cases (ΔT_c is the temperature drop across the vertical walls of the cell). Subsequently, the change in the overall heat-transfer rates in two cells filled with mercury due to an applied magnetic field was measured. The calculated and measured heat-transfer rates were not in good agreement. Later in this work the results of the present investigation are compared with existing theoretical and experimental work.

The existing information in the literature on the influence of a magnetic field on the turbulent temperature spectra is also limited. Reference is made to the work of Coy [7] who examined theoretically the case of temperature dispersion in a weakly-conducting turbulent fluid for large Reynolds numbers, magnetic Reynolds numbers and Peclet numbers. In his work, the viscous dissipation was neglected and the Joule heating was investigated as an additive effect on an already established turbulent temperature distribution. The case examined by Coy is not applicable to the present investigation in which the calculated Joulean dissipation was found to be negligible compared to the heat rates applied to the cell. Finally, the experimental work of Blum and others [8] should be mentioned. They took measurements in a channel flow with an electrolyte as the working fluid of MFM temperature spectra which indicated that the applied magnetic field preferentially suppresses the low frequencies in the turbulent spectrum.

DISCUSSION OF THE RESULTS, CONCLUSIONS

The experimental apparatus and techniques used in the present work were the same as those applied in the absence of a magnetic field described in [1, 9, 10].

As discussed in the non-magnetic case [1, 10], wall interference prohibited the direct estimation of local heat-transfer rates from the measured mean temperature profiles. Instead, total heat-transfer rates or Nusselt numbers were calculated, based on the length L of the heated wall and on the average temperature difference $\bar{\theta}_w = \bar{T}_w - \bar{T}_\infty$ along the boundary layer. Assuming that thermal losses remain unchanged with varying magnetic field, the change in the heat transfer due to the magnetic field is given as follows:

$$(Nu_L)_B/(Nu_L)_{B=0} = (\bar{T}_w - \bar{T}_\infty)_{B=0}/(\bar{T}_w - \bar{T}_\infty)_B.$$

A first indication of the effect of the magnetic field on the flow pattern in the cell and consequently on the heat-transfer processes in it was obtained from the temperature distribution along the heated wall. The temperature uniformity on the plate, existing in the non-magnetic case, was destroyed in the presence of the magnetic field (Fig. 1). Instead, a temperature gradient developed along the heated wall, becoming steeper with increasing magnetic field.

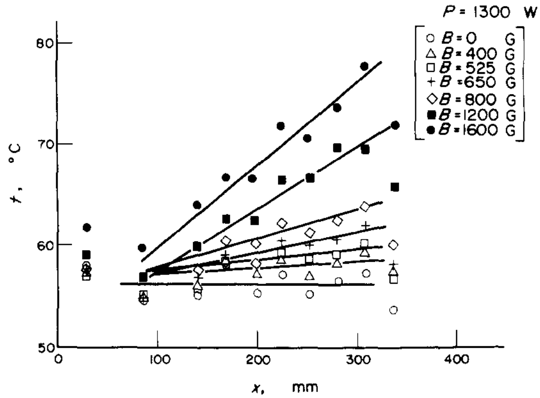

FIG. 1. Temperature distribution along the heated plate for different magnetic fields.

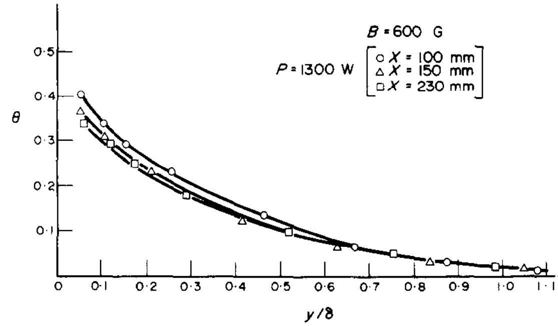

FIG. 4. Destruction of similarity in the temperature profiles along the plate due to the presence of the magnetic field.

In the OFM case, the temperature profiles showed the existence of a fully developed boundary layer along the plate, obeying the $[1-(y/\delta)]^{1/7}$ law. In the presence of the magnetic field the thermal layer becomes hotter in the sense that heat convection is reduced as would be expected. The influence of the magnetic field on the temperature distribution is shown in Fig. 2. Also, the similarity in the temperature profiles is destroyed as shown in Figs. 3 and 4.

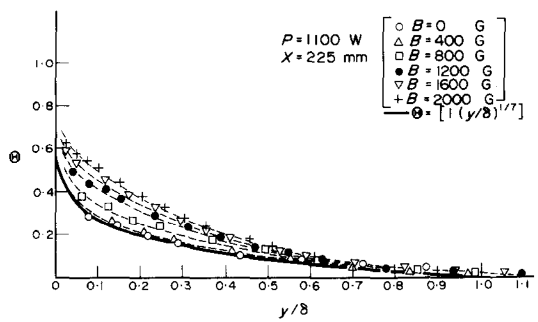

FIG. 2. Nondimensionalized temperature profiles for different magnetic fields.

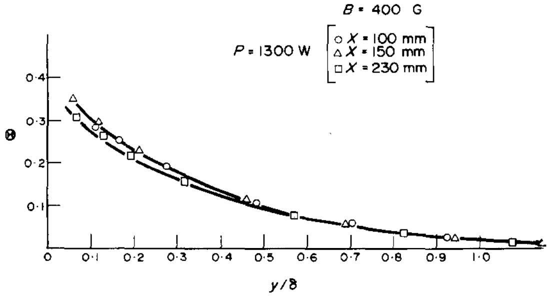

FIG. 3. Destruction of similarity in the temperature profiles along the plate due to the presence of the magnetic field.

Measurements of the thermal boundary-layer thickness indicate that it initially increases with increasing magnetic field. It is important to notice that at a certain value of the magnetic field, depending on the position along the plate and the applied power, an abrupt drop in the thickness occurs (Fig. 5). Further increase in the magnetic field does not change substantially the thickness of the thermal layer until approximately the value of 800 G. Beyond 800 G, the thickness of the boundary layer increases drastically at all distances along the plate. The picture which the temperature profiles and thermal boundary-layer thickness present is consistent with the turbulent temperature intensity and temperature spectra measurements discussed in the following and is due to transition and final laminarization of the flow.

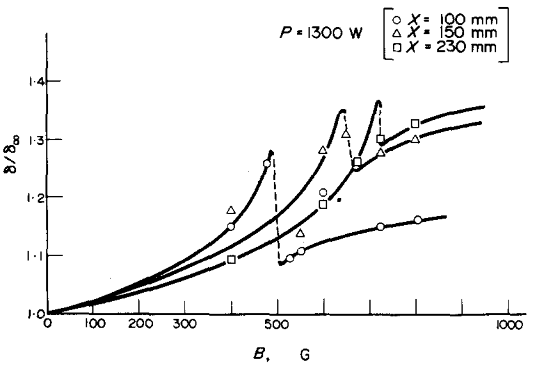

FIG. 5. Change of the thickness of the thermal boundary layer in the presence of the magnetic field.

In Fig. 6 where the effect of the magnetic field on the overall heat-transfer rates is shown, laminarization of the flow can be identified as occurring at a value of the parameter Z corresponding to the point of interception of the two distinct curves representing turbulent and laminar flows in the cell. This occurs at a

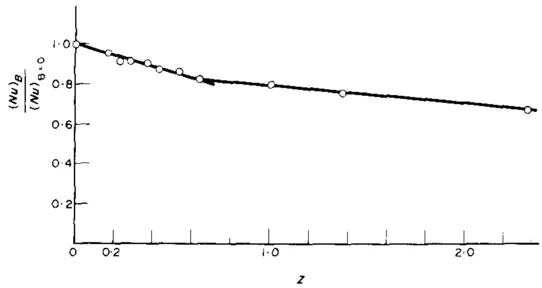

FIG. 6. Change of the overall heat-transfer rates in the presence of a magnetic field, vs the parameter Z.

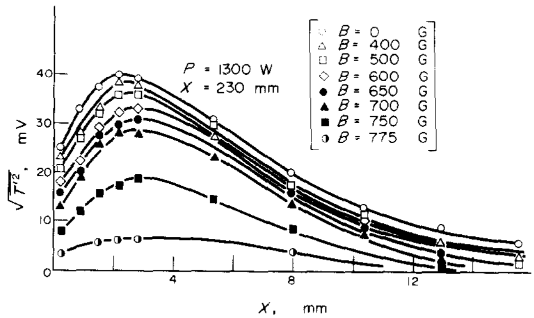

FIG. 8. Temperature intensity distributions for different magnetic fields.

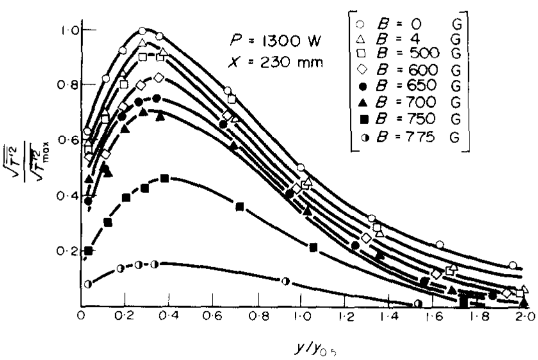

FIG. 9. Nondimensionalized temperature intensity distributions for different magnetic fields.

magnetic field of about 780 G which is in agreement with the results obtained from the turbulent temperature intensity measurements. It can also be concluded from those measurements that the decrease in heat-transfer rates for laminar flow, starting at about 750–800 G, is lower than for turbulent flow. The experimental data pertinent to the overall heat-transfer measurements are insufficient to provide a conclusive answer on the form of the relation representing the reduction of the heat-transfer rates in the presence of a magnetic field.

The assumption that similarity is preserved in the presence of a constant magnetic field, employed in [5], seems to be incorrect even in the case of an isothermal plate. As can be seen in Fig. 3 in the case of an applied magnetic field of 400 G, the measured temperature profiles are not similar, although the imposed magnetic field affects very little the temperature uniformity along the wall (Fig. 1).

The presence of the magnetic field also destroys the similarity of the temperature turbulent intensity distribution existing in the OFM case along the plate. For relatively small magnetic fields, the observed suppression of the turbulent fluctuations is small as shown characteristically in Figs. 7, 8 and 9. At a certain strength of the applied field an abrupt drop in the intensity occurs which is accompanied by the appearance of intermittent flow, indicating that transition from turbulent to laminar flow occurs (see Fig. 10). The previously mentioned abrupt drop of the thickness of the thermal layer at a certain value of the magnetic field can be attributed now to the occurrence of transition in the flow.

In Fig. 11 where the dependence of the occurrence of transition on the position along the plate and the applied power is shown, it can be seen that for $P = 1300$ W transition occurs at $x = 230$ mm when $B \simeq 720$ G while at $x = 150$ mm transition occurs at $B \simeq 640$ G. For $P = 1100$ W, the corresponding values of the magnetic field at the same stations were found to occur at $B \simeq 630$ G and $B \simeq 500$ G.* From the intensity distribution curves it can also be seen that complete "laminarization" of the flow is achieved at $B \simeq 800$ G. This observation on transition suggests that a condition similar to the one found by Murgatroyd [11] for the MFM channel flow might also exist for the MFM turbulent natural convection flow along a

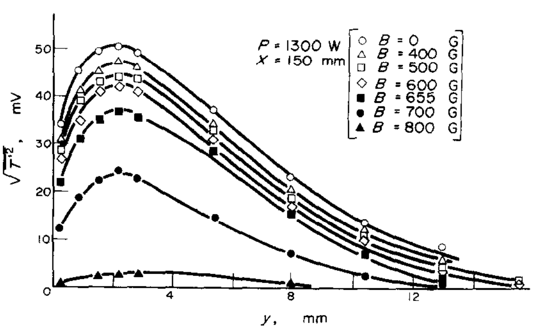

FIG. 7. Temperature intensity distributions for different magnetic fields.

*The occurrence of transition in the flow was also observed visually in the signal displayed on the oscilloscope.

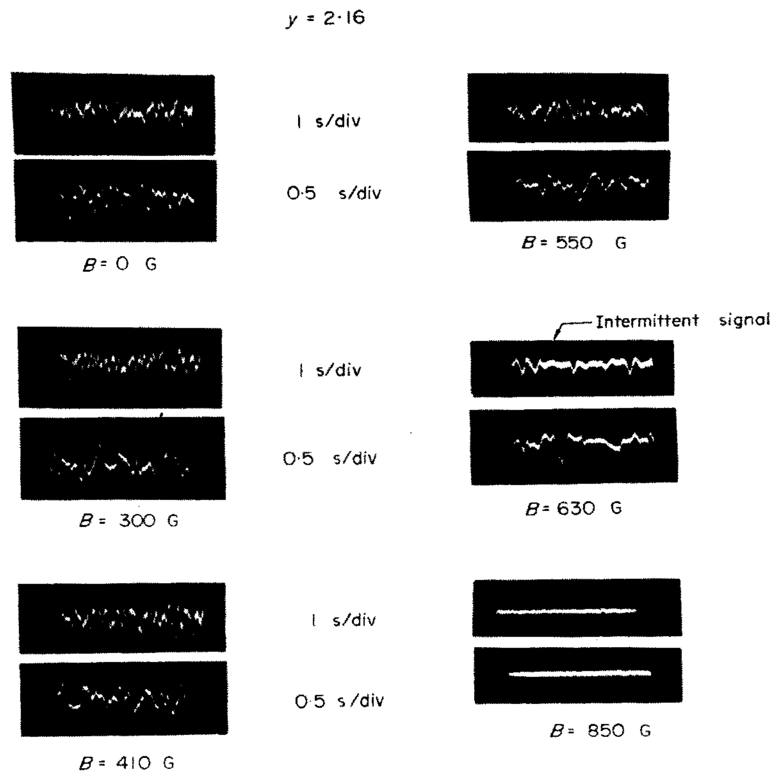

FIG. 10. Oscilloscope traces of the temperature fluctuations in the flow and their damping with increasing magnetic field. ($x = 230$ mm; $p = 1100$ W.)

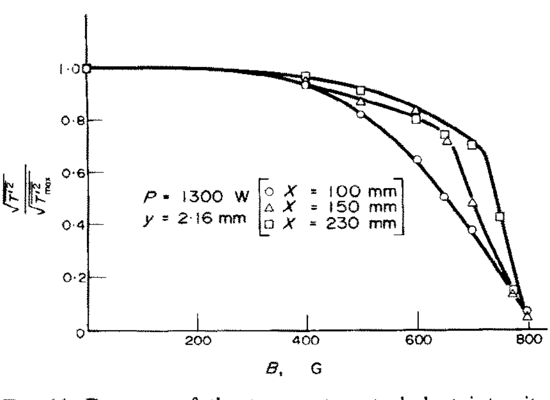

FIG. 11. Decrease of the temperature turbulent intensity with increasing magnetic field at different stations and at the same distance from the wall.

heated plate. In the MFM channel flow, Murgatroyd observed that "laminarization" occurred for a value $Re/M \simeq 225$. A theoretical derivation of this observation has been given by Lykoudis [12] who recognized that the application of a magnetic field exhibits the same effect on the development of the turbulent boundary layer as the mass sucking of the laminar sublayer. Accordingly, the transition of the boundary layer was attributed to the gradual expansion of the laminar sublayer with increasing magnetic field.

In what follows, some physical arguments will be presented in an attempt to explain transition in the MFM natural convection turbulent boundary layer. The flow conditions along the heated wall as well as the final occurrence of transition at a given strength of the magnetic field are determined by the combined effect of the buoyancy, viscous, inertia and ponderomotive forces. The pertinent non-dimensional numbers which describe the relative effect of the above-mentioned forces on the flow are the Grashof number, the Prandtl number and the Hartmann number.

The estimation of a Grashof number for the case of a cell presents certain difficulties. While its usual definition [13] based on the length of the gap between the two vertical plates, gives an overall picture of the flow conditions, it fails to give any indication about the local conditions and the development of the flow in the cell. Also a Gr_x based on the distance from the leading edge seems to be inappropriate, since, as it was discussed in [1, 10], this point does not mark the starting of the boundary layer formed along the heated plate. To resolve this difficulty, an apparent length x_0 was introduced for the estimation of the local Grashof number at the lowest station in the cell where measurements were taken. It was expected, that if a combination of the non-dimensional numbers $f(Gr_{x_0+x}, Pr, M)$ existed to describe transition at each point along the plate, the length x_0 could be estimated by equating $f(Gr_{x_0+x}, Pr, M)$ at two stations along the plate. The use of the calculated x_0 would then give the same constant value for $f(Gr_{x_0+x}, Pr, M)$ for the rest of the stations.

In the free convection case, the value of the product of the Grashof number and the Prandtl number, that is the Rayleigh number, characterizes the flow. A combination of non-dimensional numbers similar to the ratio Re/M found in the case of an MFM channel flow, appropriate for the MFM turbulent free convection flow, would then be the ratio $Ra/M = Gr \times Pr/M$. This ratio was found to have a constant value at all stations along the plate for the values of magnetic field at which transition occurred. The value of x_0 determined by following the above explained procedure was 1200 mm. The Rayleigh number represents the ratio of the buoyancy force and the viscous force [14], whence

$$\frac{Ra}{M} = \frac{\text{(Buoyancy force)}}{\text{(Viscous force)}^{1/2}\text{(Ponderomotive force)}^{1/2}}.$$

A comparison with the ratio Re/M for the MFM channel flow where

$$\frac{Re}{M} = \frac{\text{(Inertia force)}}{\text{(Viscous force)}^{1/2}\text{(Ponderomotive force)}^{1/2}}$$

shows that in MFM free convection the buoyancy force replaces the inertia force appearing in the case of a channel flow. The calculated value of Ra/M at which transition occurs for six cases (three stations for two different levels of applied power) was found to be $1{\cdot}2 \times 10^9$ within 3 per cent.

The decrease in the temperature turbulent intensity at different distances from the wall with increasing magnetic field (Fig. 12) shows a much stronger effect on the intensity at the outer part of the layer. This probably is caused by the increase of intermittency in this part of the layer. It can also be noticed that a slightly higher rate of reduction in intensity occurs near the wall which might indicate the expansion of the laminar sublayer with increasing magnetic field. This idea is further supported by the measurements taken at the final stages of turbulent suppression by the magnetic field in which the turbulence persists only in the central part of the boundary layer (Fig. 7).

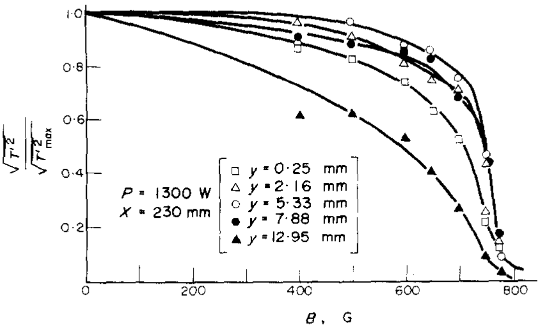

FIG. 12. Decrease of the temperature turbulent intensity with increasing magnetic field at the same station and at different distances from the wall.

In the case of a magnetic field imposed on the flow, the study of the turbulent spectra is expected to throw some light on the mechanism by which the magnetic field is suppressing turbulence. A complete answer to this question can be given by an experimental study of the effect of the imposed magnetic field on every term entering the turbulent energy equation or, in other words, on every process contributing to the balance of turbulent energy. Nevertheless, since different ranges of wavenumber in the spectrum are known to be associated with different turbulent processes, the change of the form of the spectra, or a preferential damping of wavenumber in the presence of a magnetic field, might give indications on the way the field suppresses turbulence.

Characteristic spectra are shown in Figs. 13 and 14. The identification and interpretation of various spectral regions in these spectra in the absence of a magnetic field, has been discussed in [1, 10]. Their study indicates that the magnetic field preferentially suppresses the frequencies situated between the very low and very high frequencies, and especially the region next to the "convection subrange" towards the lower frequencies. From studies of turbulent motions in stratified media [15], it is known that this region is expected to be influenced by buoyancy while still lower frequencies are influenced by both shear and buoyancy. This indicates that in this particular experiment the magnetic field enhances the mechanism of turbulent suppression due to the buoyancy forces. This interpretation is further supported by the development of increasing temperature gradient along the wall with increasing magnetic field, since, as is discussed below, the effect of buoyancy on turbulence is related to the existence of temperature gradients in the direction of gravity.

The effect of the stratification on turbulence is described by the flux Richardson number R_f or the

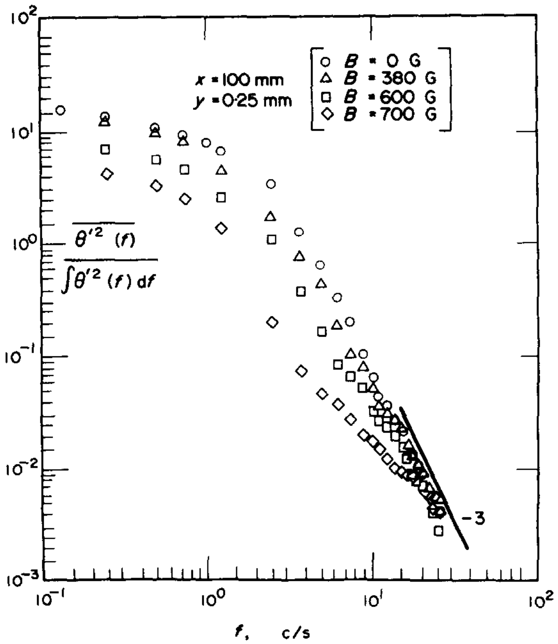

FIG. 13. Change of the temperature turbulent spectral distribution in the presence of a magnetic field.

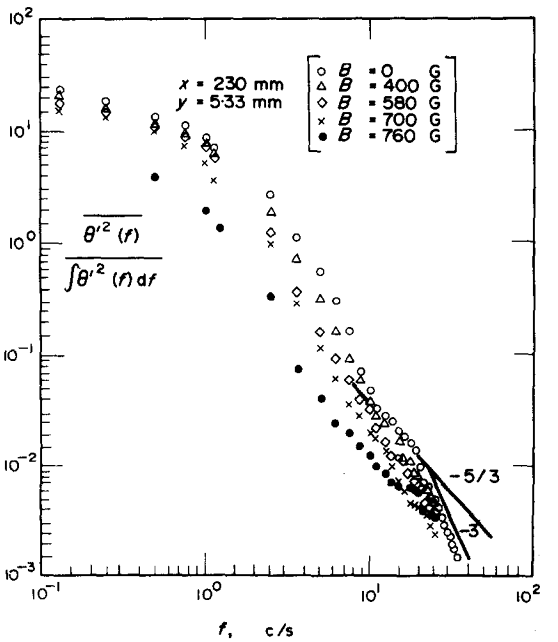

FIG. 14. Change of the temperature turbulent spectral distribution in the presence of a magnetic field.

gradient Richardson number Ri.* The Richardson number enters in the turbulent energy equation for stratified fluids as part of the production term which in this case takes the form $\overline{u_i'u_j'}\,\overline{U}_{i,j}(1-R_f)$. It is obvious that the presence of buoyancy forces could enhance or suppress turbulence, this depending on the value of the Richardson number. Positive temperature gradients $\overline{T}_z$, along the direction of gravity (corresponding to positive Ri), indicate an unfavorable influence of the buoyancy forces on the turbulent production while negative temperature gradients indicate that buoyancy forces add to the turbulent production.

An abrupt drop in the total area of the spectra is observed at transition in accordance with the boundary layer thickness and intensity measurements. Also a redistribution of the quantity $\overline{\theta'^2}$ occurs in the spectra at transition, resulting in a substantial increase in the level of high frequency fluctuations (Fig. 15). This increase in the level of high frequency fluctuations at high magnetic fields might indicate that the final stage of turbulence suppression takes place through dissipation.

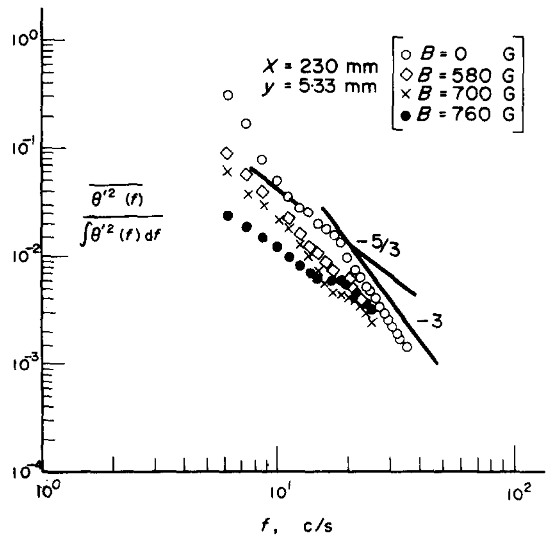

FIG. 15. Increase of the level of high frequency fluctuations at high magnetic fields.

*The flux Richardson number represents the ratio of the work of buoyancy forces and that of the Reynolds stresses and is expressed as follows:

$$R_f = \frac{g}{T_0} \frac{\overline{w'\theta'}}{\overline{u_i'u_j'}\,\overline{U}_{i,j}}.$$

The gradient Richardson number can be obtained from the above expression by introducing eddy diffusivities ε_h and ε_m to express heat and momentum transfer. It is expressed by the relation

$$R_i = \frac{g}{T_0} \frac{\overline{T}, z}{(\overline{U}_{i,j})^2}$$

where z is the direction of gravity.

The effect of magnetic field on the flow can be qualitatively described as follows. As the magnetic field increases, it reduces the velocity, and as a result, the convection heat transfer along the plate is reduced. This means that the thermal layer becomes hotter and that its thickness increases in order to accommodate the applied heat. This phenomenon is clearly shown in the measurements of the thermal boundary-layer thickness and the temperature drop across the layer. Also the temperature gradients in the thermal layer become less steep as shown in the measured temperature profiles. One can surmise that the same effects of increasing-boundary-layer thickness, decreasing velocities and velocity gradients must also occur in the velocity distributions. This should result in a reduction of turbulence production in the flow. From the above discussion we can conclude that possibly the mechanism by which the magnetic field suppresses turbulence is by reducing the production term. It has been previously suggested that the presence of the magnetic field increases the draining of turbulent energy through the action of the buoyancy forces. This does not contradict the idea expressed above, since, as already has been discussed, this draining process exclusively affects the production term.

Acknowledgements—The authors gratefully acknowledge the financial support of the National Science Foundation (Grant GK-23694).

REFERENCES

1. D. D. Papailiou and P. S. Lykoudis, Turbulent free convection flow, *Int. J. Heat Mass Transfer* **17**(2), 161–172 (1974).
2. Y. Hopenfeld and R. R. Cole, A similar solution of the turbulent, free convection, boundary layer problem for an electrically conducting fluid in the presence of a magnetic field, *AIAA Jl* **1**(3), 718 (1963).
3. E. R. G. Eckert and T. W. Jackson, Analysis of turbulent free convection boundary layer on a flat plate, NACA, TN 1015 (1951).
4. P. S. Lykoudis, Natural convection on an electrically conducting fluid in the presence of a magnetic field, *Int. J. Heat Mass Transfer* **5**, 23–34 (1962).
5. A. F. Emery, The effect of a magnetic field upon free convection, Ph.D. Thesis, University of California, Berkeley, California (1961).
6. A. F. Emery, The effect of a magnetic field upon the free convection of a conducting fluid, *J. Heat Transfer* **85**, 119 (1963).
7. B. E. Coy, A theoretical investigation of temperature dispersion in magnetohydrodynamic turbulence, Ph.D. Thesis, School of Aeronautics, Astronautics and Engineering Sciences, Purdue University (1968).
8. E. A. Blum, M. V. Zakya, Y. E. Euanov and V. A. Michailov, Heat and mass transfer in magnetic fields, Riga, USSR (1967).
9. D. D. Papailiou and P. S. Lykoudis, Magneto-fluid-mechanic-laminar natural convection—an experiment, *Int. J. Heat Mass Transfer* **11**, 1385–1391 (1968).
10. D. D. Papailiou, Magneto-fluid-mechanic turbulent free convection, Part I of Ph.D. Thesis, School of Aeronautics, Astronautics and Engineering Sciences, Purdue University (August 1971).
11. W. Murgatroyd, *Phil. Mag.* **44**, 1348 (1953).
12. P. S. Lykoudis, *Rev. Mod. Phys.* **32**, 796 (1960).
13. G. K. Batchelor, Heat transfer by free convection across a closed cavity between vertical boundaries at different temperatures, *Appl. Math.* **12**(3), 209 (October 1954).
14. E. A. Spiegel, *The Solar Atmospheric Convection Zone*, I.A.U. Symposium No. 28, p. 348. Academic Press, New York (1967).
15. J. L. Lumley and H. A. Panofsky, *The Structure of Atmospheric Turbulence*, Interscience, New York (1964).

ECOULEMENT TURBULENT DE CONVECTION NATURELLE EN MAGNETO-FLUID-MECANIQUE

Résumé—On présente une étude expérimentale de l'influence d'un champ magnétique uniforme sur la structure d'une couche limite turbulente de convection naturelle dans un fluide conducteur. La couche limite se forme le long de la paroi verticale chaude d'une cellule. Le champ magnétique appliqué est normal à la paroi.

Les profils de température moyenne, de distribution de l'intensité turbulente de température, du spectre de température le long de la paroi, indiquent que la transition se produit pour une valeur constante du rapport (nombre de Rayleigh)/(nombre de Hartmann).

L'étude du spectre indique que la présence du champ magnétique renforce le mécanisme de la suppression de turbulence due aux forces d'Archimède.

On discute enfin un mécanisme possible par lequel la turbulence serait supprimée par la présence d'un champ magnétique.

MAGNETO-FLUID-MECHANIK TURBULENTER STRÖMUNGEN BEI FREIER KONVEKTION

Zusammenfassung—Es wird der Einfluß eines zur Wand senkrechten Magnetfeldes auf die Strukturen der turbulenten Grenzschicht an einer beheizten, senkrechten Wand bei freier Konvektion eines elektrisch leitenden Fluids experimentell untersucht.

Aus der Messung der Temperaturprofile und der turbulenten Temperaturschwankungen ergab sich, daß der Umschlag von turbulent in laminar bei einem konstanten Wert des Verhältnisses aus Rayleigh-Zahl und Hartmann-Zahl auftritt. Die Auswertung der Meßergebnisse ergab, daß die Verringerung der Turbulenz infolge von Auftriebskräften durch ein Magnetfeld verstärkt wird.

Eine mögliche physikalische Erklärung der Turbulenzverringerung durch ein Magnetfeld wird diskutiert.

МАГНИТОГИДРОДИНАМИЧЕСКОЕ ТУРБУЛЕНТНОЕ ТЕЧЕНИЕ ПРИ СВОБОДНОЙ КОНВЕКЦИИ

Аннотация — Экспериментально исследуется влияние однородного магнитного поля на структуру турбулентного пограничного слоя свободной конвекции в проводящей жидкости. Пограничный слой образуется вдоль нагретой вертикальной стенки ячейки. Магнитное поле приложено по нормали к стенке.

Измеренные профили средней температуры, распределения температуры в турбулентном потоке и спектры температур вдоль стенки показывают, что переход от турбулентного течения к ламинарному происходит при постоянном значении отношения числа Релея к числу Гартмана.

Анализ записанных спектров показывает, что наличие магнитного поля усиливает подавление турбулентной свободной конвекции.

И, наконец, обсуждается возможный механизм подавления турбулентности за счет магнитного поля.