lished the Hinds Fund for Agricultural Research. This fund will be used, in cooperation with the Soil Conservation Service, for the study of soil erosion.

THE California Commission, a body created by the governor of the state to aid the recent Golden Gate Exposition, has presented exhibits valued at $80,000 to the University of California. Among exhibits sent to other institutions, two went to the Buffalo Museum of Science in Buffalo, N. Y. These were the Demonstration of Human Heredity and the Migration of the Races of Man. The Museum of Science and Industry in Chicago received the model of the San Francisco-Oakland Bay Bridge. The Griffith Observatory, a part of the Los Angeles City Park System, received the exhibit on Nuclear Charge, otherwise known as the Soap Bubble Gun, and Stanford University acquired the exhibit of the Embryology of the Salamander, which was prepared in cooperation with Dr. V. C. Twitty, of that university.

IN an article in *Industrial Standardization* R. P. Anderson, chairman of the American Standards Association, states that despite the war situation in Europe, the American Standards Association has continued its support of the International Electrotechnical Commission and also of the International Standards Association. While much of the international work is at a standstill and the future situation is uncertain, it is maintaining contacts with a number of foreign standardizing bodies and continuing to obtain copies of their standards wherever possible. So far, the association has encountered no great difficulty in sending and receiving communications from these groups abroad and its file of foreign standards has been invaluable to American firms filling orders for export. Even the British Purchasing Commission has found it necessary to call on the association on numerous occasions for standards and specifications which they did not have themselves. Recently the American Standards Association has received copies of the second edition of the International Electrotechnical Vocabulary, which is being distributed in the United States.

DISCUSSION

PERCEPTUAL DISORIENTATION DURING LANDING OF AIRPLANE

UNDER the above title in SCIENCE, November 22, A. D. Moore described an illusion which he had noted during landings of airliners, and he raised a question on the possibility of trouble in case a pilot was confronted with unusual conditions that might make him subject to this illusion. Writing partly as a pilot with a thousand-and-some hours, but more as a physicist, I feel sure the illusion will not cause any such trouble, but I should like to add a point to Moore's explanation.

Briefly, the illusion is this: Looking across the ship from a seat in the passengers' cabin, when the ship had "started to skim along the runway," the field "appeared to slope down forward at an angle of about 15 degrees." This illusion continued after the wheels touched the ground, even though Moore turned his head repeatedly between that window and one on his own side, through which the ground "remained horizontal." But, "when the plane, with a low remaining speed, wheeled through a short turn to taxi back, the phenomenon abruptly ceased."

In explanation, Moore notes that during each flight before such an observation he had got accustomed to the fact that the window frame lines were horizontal and vertical, so it was natural to persist in thinking of the horizontal ones as horizontal even when the ground seen through the frames was no longer parallel to them. This is indeed natural, as I can testify in terms of a memory from age 10 or 12, of exploring the hold of a schooner, which had been wrecked on a beach and lay heeled over some 10 or 20 degrees, and feeling seasick, apparently because of the conflict of such evidence with that of my semicircular canals and other internal senses.

There is more to it, however, in my opinion. Airline pilots use their controls and throttles with most expert smoothness. In their hands the ship changes its attitude and its speed with none of the bumps of a railroad train or an automobile. And the cruising speed is so high that in stopping the ship with a backward acceleration of the order of 20 per cent. of gravity there is time to build up this acceleration very gradually and then maintain it for a long time.

Let us apply these principles to the approach and landing. In the straight glide, for perhaps a mile or two, the ship is nosed down and the passenger gets used to the downward slope of the floor and of the "horizontal" frame lines of the windows. The speed is almost constant, the propeller thrust and the forward component of gravity being balanced by the drags of the ship and its flaps, which are usually down for most of this time. Nearing the airport boundary the throttles are closed smoothly, reducing the propeller thrust to zero and thereby introducing a considerable backward acceleration. But during this change the nose is rising and the flight path is becoming more level. So, as the backward acceleration grows, the forward component of gravity fades out. The passenger, however, so long as he keeps his eyes within the ship, has no way to tell backward acceleration from forward gravity. If the changes are smooth enough, and properly correlated as to time and magnitudes,

his visual illusion of the cabin as a fixed frame of reference may be corroborated by false evidence from his semicircular canals and all other physiological means of sensing what is horizontal. With all these senses combining to mislead him, it is no wonder that he may discredit the little glimpses of the ground through these small and distant and apparently stationary windows.

After the wheels touch, the aerodynamic drags weaken gradually, but the wheel brakes take their place and the backward acceleration may not change much. So it is reasonable that the illusion should persist sometimes nearly to the end of the run. Then, when the ship wheels around and the engines start up for taxying, the acceleration is quickly changed from backward to forward; so in the cases observed by Moore, "the phenomenon abruptly ceased."

To create this illusion, and to maintain it during the change from aerodynamic drags to wheel brakes, the ship must indeed have to be handled very smoothly. But these airline pilots are smooth!

On the practical question of the possibility of a pilot being misled by this illusion, it must be noted that experienced pilots are already disillusioned as to their sense of level, and they are also well trained on how the ground should look in a landing.

This does not mean any lack of use for the sense of level, but only that its use is not what the layman would expect. The principles applied above, to explain Moore's phenomenon, apply also to turns. In them, centripetal acceleration acts like the backward acceleration in a landing, to mislead our sense of level. The only difference is that in the turn it is not through the side windows, but ahead, that the horizon appears not horizontal. If the ship is correctly banked for the turn, however, she seems level to all senses but that of sight. So the pilot uses his internal senses of level to find the correct angle of bank, well knowing that what he senses is not really level, and he uses his eyes to find the true level.

This separation of the internal and visual senses of level, and their concurrent but independent uses for different purposes, is therefore a very important part of piloting. The ability to separate them has to be acquired in learning to fly, because flight is the only activity in which accelerations can grow so smoothly and with so little angular velocity as not to warn us of the difference between acceleration and gravity. Having acquired this ability, however, and having had to put some real effort into its acquisition, the experienced pilot can be counted on to apply it in landing on any airport that he can see. So there is no appreciable chance of his being misled by Moore's illusion.

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SPATIAL DISORIENTATION DURING LANDING FROM AIRPLANE

THE type of spatial disorientation reported by Professor A. D. Moore[1] in connection with the landing of an airplane is by no means unknown to experimental psychologists, although too little attention has been paid to it in the literature on space-perception. The basic principle, as Professor Moore suggests, is that of the conflict of two spatial frames of reference, both of which reside in the visual field of the observer, but one of which is more closely related to the directional system of the observer's body. The ground, as seen through the near window, occupies a sufficiently large visual angle to dominate the perceptual process and consequently to provide a "true" system of horizontal and vertical directions. As seen through the far window it is imbedded in the framework of the interior of the plane, and is consequently seen as tilted. The underlying principles have been discussed, although with different examples, by Koffka,[2] Wertheimer[3] and others, and the phenomenon has even crept into at least one elementary text-book.[4]

Whether or not this is a newly discovered phenomenon is, however, of no importance. What is to be emphasized is that this type of "illusion," and the underlying psychological principles, may too easily be overlooked, not only in aviation but in any field of activity in which the perception of space is an important factor. In seeking for the determinants of our perception of spatial directions we are apt to concentrate on the vestibular functions to the neglect of visual organization. In the example which Professor Moore cites, the problem is essentially visual. I am inclined to think that the solution which he proposes will not prove satisfactory. It might be noted, however, that a sub-committee on problems of perception has recently been organized in connection with the program of the National Defense Research Committee. The problem might well be referred to this committee.

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THE HEAT OF SEROLOGICAL REACTIONS

THE only attempt to measure directly the heat of an antibody-antigen reaction known to us is that of Bayne-Jones.[1] It is generally admitted that his result is much too high.[2] We have recently completed mea-

[1] A. D. Moore, SCIENCE, 92: 477, 1940.
[2] K. Koffka, "Principles of Gestalt Psychology," 1935.
[3] M. Wertheimer, *Zsch. f. Psychol.*, 61: 161–265, 1912.
[4] E. G. Boring, H. S. Langfeld, H. P. Weld, "Introduction to Psychology," 1939.
[1] S. Bayne-Jones, *Jour. Immunol.*, 10: 663, 1925.
[2] F. C. Smith and J. Marrack, *Brit. Jour. Exp. Path.*, 11: 494, 1930.