those of the Bryophytes in which dichopodial development and delay of fructification clearly foreshadow either cladode leaves with distal sporangia (ferns) or a truss of fertile twigs liable to condensation into a strobilus (lepidophytes and arthrophytes). The bracteate cones of the latter are therefore composite in nature.

One wonders if anything but the proverbial provincialism of the British warrants the inclusion in a work of international scope of a chapter on the "Evolutionary Relations of British Ferns." Finally, although Professor Bower makes a consistent case for his ideas in this most stimulating book, I can only repeat the doubts which I expressed in 1927 that the middle Devonian structural material on which the present argument leans so heavily may be merely ancient and simple, rather than that it represents a primitive missing link, although I am bound to admit that it has been made to serve such a purpose in a very admirable way.

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SUBSIDENCE

Subsidence within the Atmosphere. By JEROME NAMIAS. Harvard Meteorological Studies, No. 2; 25 cm × 19 cm, 61 pages. Harvard University Press, 1934. Price, $0.85.

THIS work is a notable contribution to the very limited amount of literature on the subject of subsidence. The paper is divided into two major portions. The first is a discussion of subsidence from the general standpoint, and diagrams are presented which are constructed from the aerological material which is discussed synoptically in the second part of the paper. The second section gives the salient features in connection with three meteorological situations. In the detailed analysis of the aerological material for these periods special emphasis is placed upon the subsidence inversions observed. The maps presented contain only the fronts, air masses, isobars, precipitation areas and positions of aerological stations. The aerological diagrams provide a continuity in the sequence of the weather over the 24-hour intervals represented by the maps. Cold fronts are shown as heavy black lines, warm fronts by double light lines and occluded fronts by broken heavy lines. The air mass notation is that introduced in this country by the meteorological course of the Massachusetts Institute of Technology.

As a mass of cold air (Pc) moves southeastward from the polar regions over North America it spreads out laterally at the surface, and this spreading is probably balanced by a general sinking of the air mass. Subsidence is a stabilizing process which takes place primarily at the upper levels in the atmosphere, and obviously must be non-existent at the surface of the earth. Day-to-day aerological soundings made within one and the same polar air mass often show that not only stabilizing forces are at work, but also sharp inversions develop. These inversions are generally associated with a sharp drop in relative humidity through the inversion, and not infrequently there is a marked drop in the specific humidity. The author claims that the subsidence inversion can generally be distinguished from the frontal (*i.e.,* change of air mass by advection) inversion by means of the moisture discontinuity, since the inversions accompanying fronts almost always have an appreciable increase in the specific humidity upward through the inversion. While this criterion of specific humidity for the differentiation between frontal and subsidence inversions generally holds it should be pointed out that there are cases when a warm front surface may superficially appear as a surface of subsidence, but, the author claims, the opposite case, that of mistaking a subsidence inversion for a frontal inversion, is more common. This error can generally be blamed on the hair hygrometer, since it is well known that the hair behaves erratically under certain conditions and has a particularly large lag coefficient at low temperatures and at low relative humidities.

The temperature and moisture discontinuities through these inversions often are so pronounced that it is necessary to assume that there are other contributing factors in addition to subsidence which are tending to sharpen the inversion. Indeed, even the problem of the original development of these temperature inversions is not yet clear.

The compensating subsidence due to the outflow of air in anticyclones which takes place across the surface isobars because of the frictional effect in the lower layers can not account for the rapid development of subsidence inversions observed in many of our rapidly moving anticyclones of the winter season. Georgii in 1920 showed that the surfaces of subsidence are not horizontal but present a slope. It is generally smaller than that of either the warm or the cold front. It now seems clear that these surfaces of subsidence are extensive domes which may at times reach beyond the 5 kilometer level and at times practically intersect the surface of the earth along their periphery. An example of a subsidence dome in its embryonic stage and later in its development has been given by the author in a previous paper. The difficulty in determining the topography of the subsidence domes should be simplified with the recent increase in the number of aerological (airplane) stations throughout the United States.

Potential temperature is considered a conservative meteorological element because it remains constant during an adiabatic process with unsaturated air.

After a subsidence dome is once established, the air above the surface of the dome sinks and spreads. At upper levels in the atmosphere, where the effects of turbulent exchange and radiation are small, the process is adiabatic—the potential temperature of each subsiding particle of air remaining constant. A discontinuity of lapse rate within the atmosphere guides the vertical flow of air, since the isotherms of potential temperature represent stream lines of flow. This is evident from the principles of stability. Any horizontal relative movements of the air particles on either side of the inversion will thus be along the particular potential isothermal surfaces on which they lie. The tendency, then, is to maintain a constant potential temperature at the base and top of the inversion. However, small variations do occur, and they may be accounted for by three factors that tend to produce variations in the potential temperature along the surface of subsidence, namely, (1) divergence (and convergence) above and below the inversion, (2) radiation and (3) turbulence.

This comprehensive paper on subsidence should be read carefully by all meteorologists.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

NEW ARRANGEMENT FOR REGULATING FLOW OF LIQUID INTO A CULTURE VESSEL

MAINTENANCE of a specified composition of liquid medium in a culture vessel, as for solution culture experiments with plants, may be satisfactorily accomplished only through employment of some device by which fresh liquid is allowed to flow continuously into the vessel at a suitable rate, with a like rate of waste discharge. This was first emphasized by Trelease and Livingston.[1] Unknown and unpredictable effects of differential absorption by the cultured organisms are thus avoided, as are also the effects of accumulation of substances or ions extruded by the organisms or produced in the vessel. One needs to be able to increase or decrease the rate of flow at will. It should be but little more rapid than is necessary and it needs to be automatically maintained for long periods.

Continuous-flow plant cultures were used by Nobbe as early as 1865,[2] and Schloesing[3] employed an automatic intermittent renewal of solution in some of his experiments. Continuous flow has been increasingly employed for solution cultures and sand cultures of plants since the appearance of Trelease and Livingston's paper; more recent writers on this sort of experimental technique are: Allison and Shive,[4] Prianischnikow,[5] Johnston,[6] Shive and Stahl,[7] Pirschle,[8] Zurbicki,[9] Zinzadze,[10] Pierce,[11] Ungerer,[12] Mehrlich,[13] Trelease and Thompson.[14] Some of these give additional references. Several arrangements for the control of solution flow have been shown at recent annual science exhibitions of the American Association, by Dr. J. W. Shive and by Dr. Sam F. Trelease.

From a comparative study of many different arrangements, the writer has developed the new form of simple continuous-flow apparatus to be described in the present paper, in the preparation of which he has had the benefit of valuable criticism and cooperative help from Professor Burton E. Livingston, Mr. W. Luther Norem, Dr. Theo. C. Scheffer and Mr. Karl A. Grossenbacher, all of this laboratory.

The rate of flow of a liquid through a small orifice is determined partly by the viscosity of the moving liquid within the orifice, partly by the hydrostatic-pressure difference between the entrance and exit of the orifice, and partly by the resistance introduced by the orifice walls. The viscosity of a stable liquid nutrient medium may be satisfactorily maintained by keeping its temperature nearly constant, but this consideration of temperature influence has apparently not yet received attention in the present connection.[15]

The hydrostatic-pressure difference that drives the liquid through the orifice may be satisfactorily maintained if a small constant-level tank is introduced between reservoir and orifice (as in the arrangement of Trelease and Livingston, for example). It is well to equip the reservoir as a Mariotte flask, closed above and with air inlet near the bottom.

This Mariotte arrangement alone, without accessory tank, suffices to maintain a practically constant hydrostatic head excepting that pressure at the entrance to the orifice is somewhat excessive during periods when the temperature of the confined air in the reservoir is rising. For any combination of orifice resistance

1 SCIENCE, 55: 483–486, 1922.
2 *Landw. Verssuchst.*, 7: 68–73.
3 *Ann. Sci. Agron.*, 1: 315–359, 1899.
4 *Amer. Jour. Bot.*, 10: 554–566, 1923.
5 *Ergebn. Biol.*, 1: 406–446, 1926.
6 *Plant Physiol.*, 2: 213–215, 1927.
7 *Bot. Gaz.*, 84: 317–323, 1927.
8 *Planta*, 14: 583–676, 1931.
9 *Plant Physiol.*, 8: 553–558, 1933.
10 SCIENCE, 79: 480–481, 1934.
11 *Ibid.*, 80: 339, 1934.
12 *Ztschr. Pflanzenernärung, Düngung u. Bodenk.*, A, 36: 15–26, 1934.
13 *Plant Physiol.*, 10: 169–177, 1935.
14 SCIENCE, 81: 204, 1935.