DESPITE the manifold advantages of alfalfa as a forage crop, its use directly for pasturage has been seriously limited by the danger of losing animals from bloat. If the bloat hazard could be eliminated it is probable that hundreds of thousands of additional acres would be used for pasturage, with a carrying capacity considerably greater than that of some of the pastures now in use.

The nature of rumen bloat remains undetermined, though agreement seems general that pasture bloat is always accompanied by the formation of a stable foam by the contents of the rumen and reticulum. Since movement in the rumen is more or less continuous, a foam that persists would be expected to have considerable resistance to mechanical stress and considerable ability to retain entrapped gases (8). Consequently, several measurable properties of foams, foam strength might be most pertinent to the role of foam in bloat.

The nonbloating properties of birdsfoot trefoil as a pasture legume are well known. The possibility of developing a nonbloating alfalfa is highly intriguing, and it would seem profitable to explore differences in the foaming properties of alfalfa materials and their correlation with bloat-producing potential, with the hope of selecting within alfalfas for the low-bloat characteristic, if such exists. The present report describes a foam-measuring apparatus used in determining the foam strength properties of expressed alfalfa juices, and presents the effects of foam strength of centrifuging, pH range, dilution rates, methods of preservation of the plant material, and plant maturity.

REVIEW OF LITERATURE

Johns (8) reported two main schools of thought on the basic cause of ruminant bloat: that bloat is due primarily to a foaming of the contents of the rumen and reticulum, and that it is due to a toxic substance that inhibits rumen movements and/or the evacuation mechanism. Perhaps it is a combination of these factors. It is evident that both plant and animal factors are implicated. Bloat research in New Zealand (6, 13) has supported the first school of thought, indicating that legume bloat is caused by foaming of the rumen ingesta, with fermentation gases being retained in the form of a stable foam that cannot be eliminated by the normal evacuation mechanism. Foamy bloat has been reported by many investigators in other localities (1, 3, 5, 12).

Many studies have attempted to correlate the foaming properties of plant extracts with bloat. Weiss (14) found no significant variation in foaming capacity when freshly expressed alfalfa sap was shaken each day over a considerable growth period. Ferguson and Terry (3) considered the foaminess of alfalfa sap during preparation to be a fair indication of its bloat potential. Hunsperger et al. (5) found, from incubation of rumen liquor in Warburg vessels, some correlation between foam production and bloat. Mangan and Johns (11) devised a serial-dilution method for comparing the foaming properties of fractionated extracts of bloat- and non-bloat-plant species and failed to demonstrate any relation between foaming properties and the bloat-promoting potential of the clover. Conrad et al. (2) suggested that the combined effects of the natural structure of green alfalfa fiber, pectic substances of alfalfa plants, galacturonic acid obtained on hydrolysis of pectic substances, and reducing sugars normally present are capable of causing the formation of stable foam found in pasture bloat.

Surface-active agents may be of two types: (1) high viscosity compounds and (2) compounds whose solutions exhibit low viscosity (7, 13). The foam in the rumen appears to be of the stable high-viscosity type. A number of properties of high-viscosity foams can be measured, though many of the determinations are difficult to carry out in routine handling of a large number of samples (9). Mangan (9) described an apparatus for estimation of the expansion, dynamic stability, and strength of foams formed by surface-active compounds. He indicated that the last measurement would be the most useful. In studies by Mangan (9, 10) the foam strengths of saponin foams were found to have a pH optimum, those from red clover and alfalfa being between pH 4.5 and 5.0. The presence of calcium in the saponin preparations greatly increased the formation of rigid foams. Foams from red clover cytoplasmic protein showed maximum strengths at pH values ranging from pH 5.4 to 5.6, and the foaming properties were found to depend markedly on salt concentration. It was found that salivary mucoprotein had the greatest foam strength above pH 7.5, but some samples had a secondary peak at pH 6.5. Rumen liquor from cows fed on red clover had a pH optimum for foam strength at pH 5.4 to 5.7, similar to that for cytoplasmic protein. Although the optimum pH for foam strength with red clover saponin and salivary mucoprotein is outside the range concerned in bloat, these compounds do form foams at pH 6.0 and, together with cytoplasmic protein, may give foams with greater foam strength than either alone. The evidence indicated that cytoplasmic protein is of major importance as a foaming agent in causing bloat in cattle (10).

FOAM-MEASURING APPARATUS

The foam-measuring apparatus described by Mangan (9) for estimating the expansion, dynamic stability, and strength of foams formed by surface-active compounds was modified for this investigation. Figure 1 illustrates one of two identical units constructed. A 25 mm. O.D. X 1.219 m. glass tube (A), selected by trial and error for uniformity with a similar tube used in the second unit, was closed at the bottom with a rubber stopper fitted with a 12 mm. M gas dispersion fritted cylinder tube (C), and fitted near the bottom with a 8 mm. O.D. side-arm inlet tube (B) for the solution to be foamed. Tube A is mounted in a larger (51 mm.)