difference being that the darker the color of the grapes the more concentrated the solution of pigment obtainable from their skins. The same is true of the

Fruit source	Color change	pH range
Apples	Red to yellowish-green	6.2– 7.2
Blackberries	Red to dark grayish-blue	6.0– 7.4
Blueberries	Reddish-purple to greenish-purple	6.2– 7.2
Cactus	Red to faint purple	9.0–12.0
Cactus	Faint purple to reddish-brown	12.0–13.0
Cherries	Red to bluish-purple	6.0– 7.2
Cranberries	Red to yellowish-green	6.2– 7.2
Grapes	Red to purple	5.0– 6.6
Grapes	Purple to green	6.6– 7-6
Plums	Red to yellowish-green	6.2– 7.2
Pomegranates	Red to purple	6.0– 6.8
Pomegranates	Purple to green	6.8– 7.6
Strawberries	Red to yellowish-green	6.2– 7.2

class of fruits consisting of blackberries, dewberries, loganberries and raspberries. We have not had time to purify these fruit pigments and study their chemical composition, but from the colors they show and the pH range they cover we judge that most of them are derivatives of anthocyanin or similar compounds.

Any of the pigment solutions, except that of cactus fruit, can be used in the titration of acids. As kept in the form of alcohol preserved solutions, they have stood for several months without showing any signs of deterioration. They can not be used in titrating bases, for in a solution which is no more than moderately alkaline they soon decompose, all of them producing a brown color which does not change when acid is added. The faint purple and reddish-brown colors of the cactus pigment are comparatively resistant to alkalis, but the pH range of the color change is too far over on the alkaline side to make the pigment of much use in titration work. Since, however, it is not poisonous, has but little odor or taste and holds its deep red shade over so wide a pH range, one can easily see why certain housewives in parts of the United States where prickly pear cactus grows have found it so satisfactory a coloring agent in jelly-making.

The most practical use that we have found for these indicators is in making test papers. Soaking a cheap grade of thin filter-paper in the crude decoctions—it is not necessary to clear with alcohol for this purpose —and then drying the paper, gives a satisfactory neutral-tinted product in most cases. The natural acid of apples, cranberries, plums and pomegranates is sufficient to cause the production of red papers. When such papers are dry it is best to wet them with .2 per cent. ammonium hydroxide, rinse quickly and dry again. This treatment changes the color to a neutral tint. The fact that these fruit pigment test papers have a definite neutral tint, as well as an acid tint and an alkaline tint, is an advantage. Their color changes, however, are in some cases a bit different from those of the corresponding pigment solutions. For this reason we add a brief table to show what may be expected of the papers.

Fruit source	Neutral tint	Acid tint	Alkaline tint
Apples	Grayish-purple	Red	Green
Blackberries	Purple	Red	Bluish-green
Blueberries	Purple	Red	Blue
Cherries	Reddish-purple	Red	Bluish-green
Cranberries	Faint purple	Red	Light green
Grapes	Purple	Red	Bluish-green
Plums	Faint purple	Red	Light green
Pomegranates	Purple	Red	Bluish-green
Strawberries	Reddish-purple	Red	Light green

SUMMARY

(1) Solutions of many fruit pigments act as indicators.

(2) These solutions are easily prepared and stable, and the pH range of their color changes is in most cases conveniently near the neutral point.

(3) As liquid indicators they can be used in titrating acids, but not bases.

(4) Their greatest usefulness depends upon the fact that very satisfactory test papers can be made with them in a simple and inexpensive way.

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THE SPOTTING METHOD OF WEED ERADICATION

IN the eradication of ragwort, reported by Grimmett,[1] mention is made of placing about an ounce of dry mixture of equal parts of finely crystallized sulphate of iron and sodium chloride on the crown of the individual plants. A later examination of the area so treated showed 100 per cent. killing. The plants were rotted and could be pulled out easily. In no case did regrowth occur from the roots. In most cases a ring of grass from a few inches to a foot in diameter was also killed.

Some years ago the writer, while considering methods of eradicating plantain and dandelion in a young blue grass lawn, conceived the idea of using a fer-

[1] B. E. R. Grimmett, "Chemical Eradication of Ragwort," *N. Z. Jour. of Agr.*, 34, 4: 256.

tilizer instead of a toxic salt to plasmolyze the weeds. By so doing the surrounding grass would be stimulated after the weed was killed and after the fertilizer had been washed away sufficiently from the point of application to reduce it to a concentration that is non-plasmolytic.

Each spring, for several years, this spotting procedure has been practiced. As much sulphate of ammonia as can be held between the fingers and thumb is placed on the crown of the weeds. As Grimmett reported, weeds so treated die quickly and completely. The grass surrounding the weed dies also, but in no case is the circle of dead grass so large as one foot across, as Grimmett reported sometimes occurs from the use of the toxic salt. Shortly the growth of the grass bordering the circle is tremendously accelerated so that within a few weeks the whole bare spot is covered with a thrifty growth of grass.

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SPECIAL ARTICLES

CAPACITY OF CONDENSERS IN SERIES

THE object of the present note is to show that the conventional formulation for the total capacity of electrical condensers joined in series or cascade is unnecessarily inexact. The formulation referred to is: The reciprocal of the total capacity of any number of condensers connected in series equals the sum of the reciprocals of the discrete capacities of all the individual condensers. The cause of the inexactness of the formulation lies in the fallacious idea which is brought out typically in the following quotation from a generally excellent book: "Since the outflow from one condenser constitutes the charge on the next, the charge *Q* on the positive coating of each must be the same and equal to that communicated to the first condenser." This premise was found by me to be involved, either explicitly or implicitly, in all the relevant books, save one, which were accessible in two libraries. By no means are all these books elementary texts; on the contrary, the names of several of the most noted living Dutch, English and Russian physicists are to be found on the respective title-pages. The exceptional book is by E. Mascart and J. Joubert (tr. by E. Atkinson), entitled "A Treatise on Electricity and Magnetism." A qualitative hint at the correct state of electrical distribution is given on page 72 of the first of the two volumes.

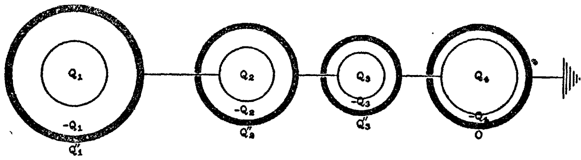

FIG. 1

It will be sufficiently general for the purposes of this note to outline the proof of the rigorous formula for the case of four spherical condensers connected by ideal wires of infinite length and zero capacity, as suggested by the accompanying diagram. The radii of the central sphere, of the inner surface of the concentric shell and of the outer surface of the shell will be denoted respectively by r_i, r_i' and r_i'', for the i th condenser ($i = 1, 2, 3, 4$). The corresponding charges on these three surfaces are Q_i, Q_i' and Q_i''. $1/C_i = \kappa(1/r_i - 1/r_i')$ and $C_i'' = r_i''$. The charge Q_1 is at the potential V_1 and the outside of the fourth condenser is "earthed." Then the following conditions must be fulfilled:

$$\begin{aligned} V_1 = Q_1/C &= Q_1/C_1 + Q_1''/C_1'' \\ -Q_1 + Q_1'' + Q_2 &= 0 \\ -Q_2 + Q_2'' + Q_3 &= 0 \\ -Q_3 + Q_3'' + Q_4 &= 0 \\ Q_1''/C_1'' &= Q_2/C_2 + Q_2''/C_2'' \\ Q_2''/C_2'' &= Q_3/C_3 + Q_3''/C_3'' \\ Q_3''/C_3'' &= Q_4/C_4 \end{aligned}$$

Elimination of all the Q's from the preceding equations leads to the following general type of continued fraction:

$$\frac{1}{C} = \frac{1}{C_1} + \cfrac{1}{C_1'' + \cfrac{1}{\frac{1}{C_2} + \cfrac{1}{C_2'' + \cfrac{1}{\frac{1}{C_3} + \cfrac{1}{C_3'' + C_4}}}}} \tag{1}$$

The way in which the various capacities are involved in formula (1) is instructive and interesting. Formula (1) can not reduce rigorously to the conventional equation

$$1/C = 1/C_1 + 1/C_2 + 1/C_3 + 1/C_4 \tag{2}$$

unless $C_i'' = 0$, and this is impossible since the outside radii of spherical condensers can not vanish. Incidentally

$$Q_4 = Q_1 - (Q_1'' + Q_2'' + Q_3'')$$

so that Q_4 can not equal Q_1, since the parenthetical trinomial is always finite.

Although the goal of this note has been reached already in the above theoretical deductions, it seems desirable to give some numerical data in order to show the order of magnitude of the charges and errors.

Let all the condensers be identical with $r_i = 10.00$