

May 13, 1958

E. G. PICKELS ET AL

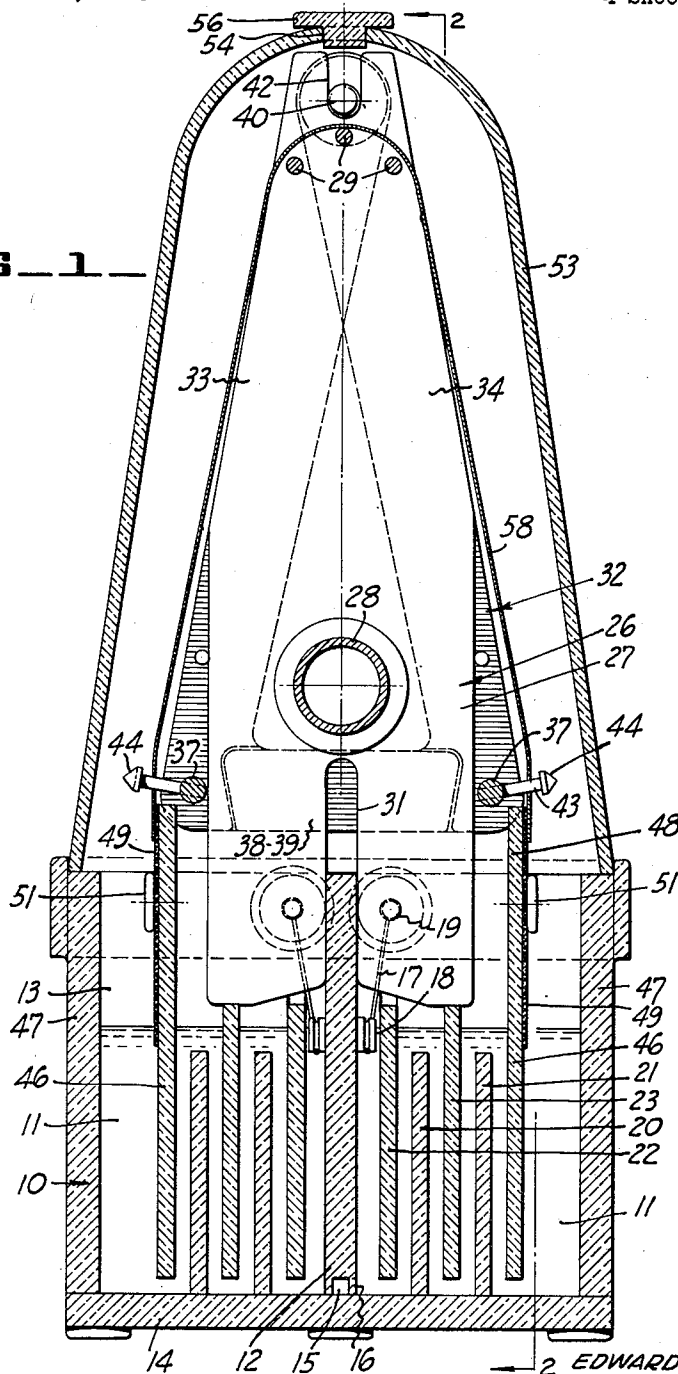
2,834,729

ELECTROPHORESIS APPARATUS

Filed Feb. 24, 1955

4 Sheets-Sheet 1

FIG 1



2 EDWARD G. PICKELS
PHILIP F. SCOFIELD
FRED G. WILLIAMS
INVENTORS

BY

Fleishman Swain
ATTORNEYS

May 13, 1958

E. G. PICKELS ET AL

2,834,729

ELECTROPHORESIS APPARATUS

Filed Feb. 24, 1955

4 Sheets-Sheet 2

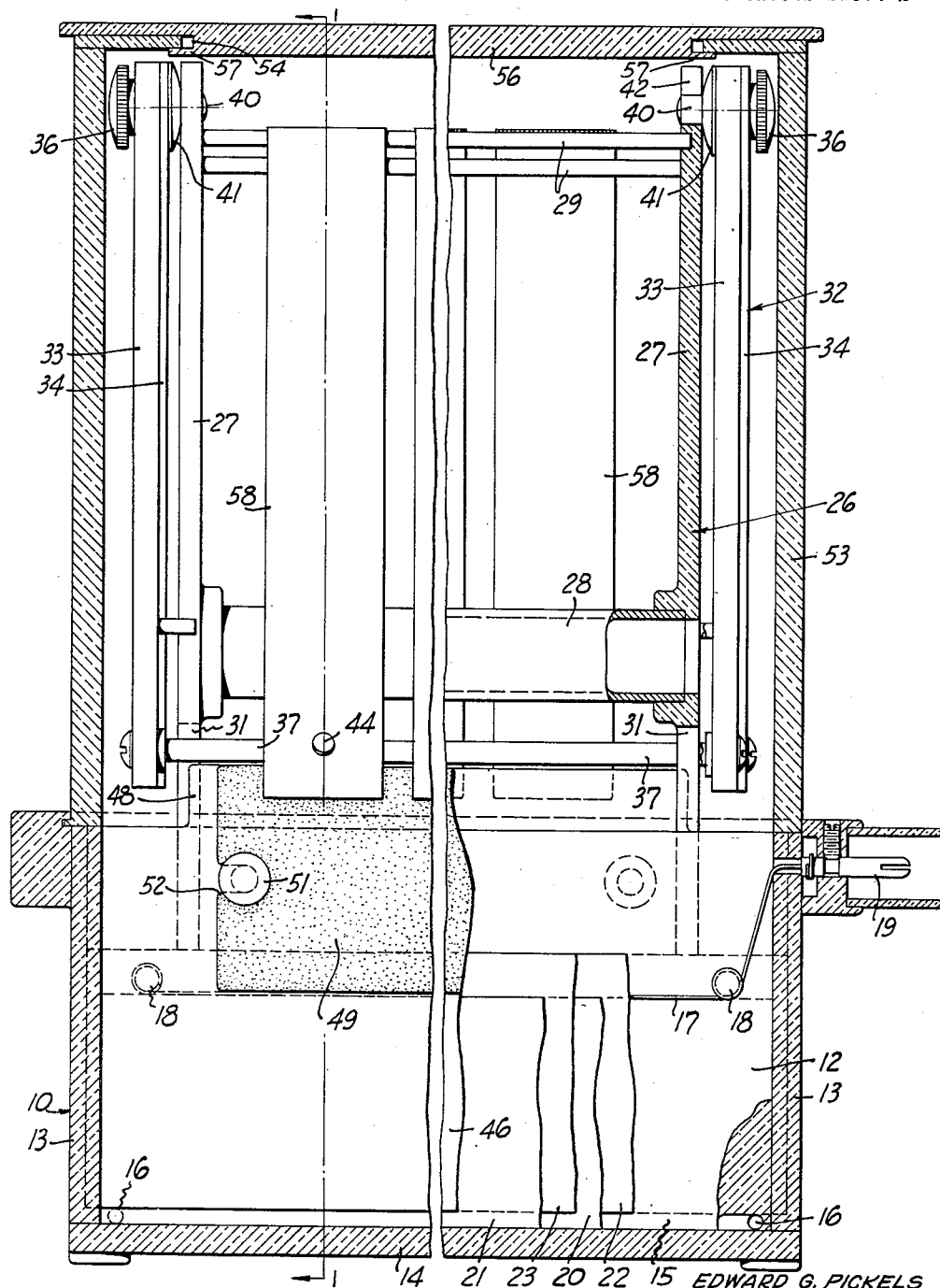


FIG. 2

EDWARD G. PICKELS
PHILIP F. SCOFIELD
FRED G. WILLIAMS
INVENTORS

BY

Fluh & Swain
ATTORNEYS

May 13, 1958

E. G. PICKELS ET AL
ELECTROPHORESIS APPARATUS

2,834,729

Filed Feb. 24, 1955

4 Sheets-Sheet 3

FIG. 3.

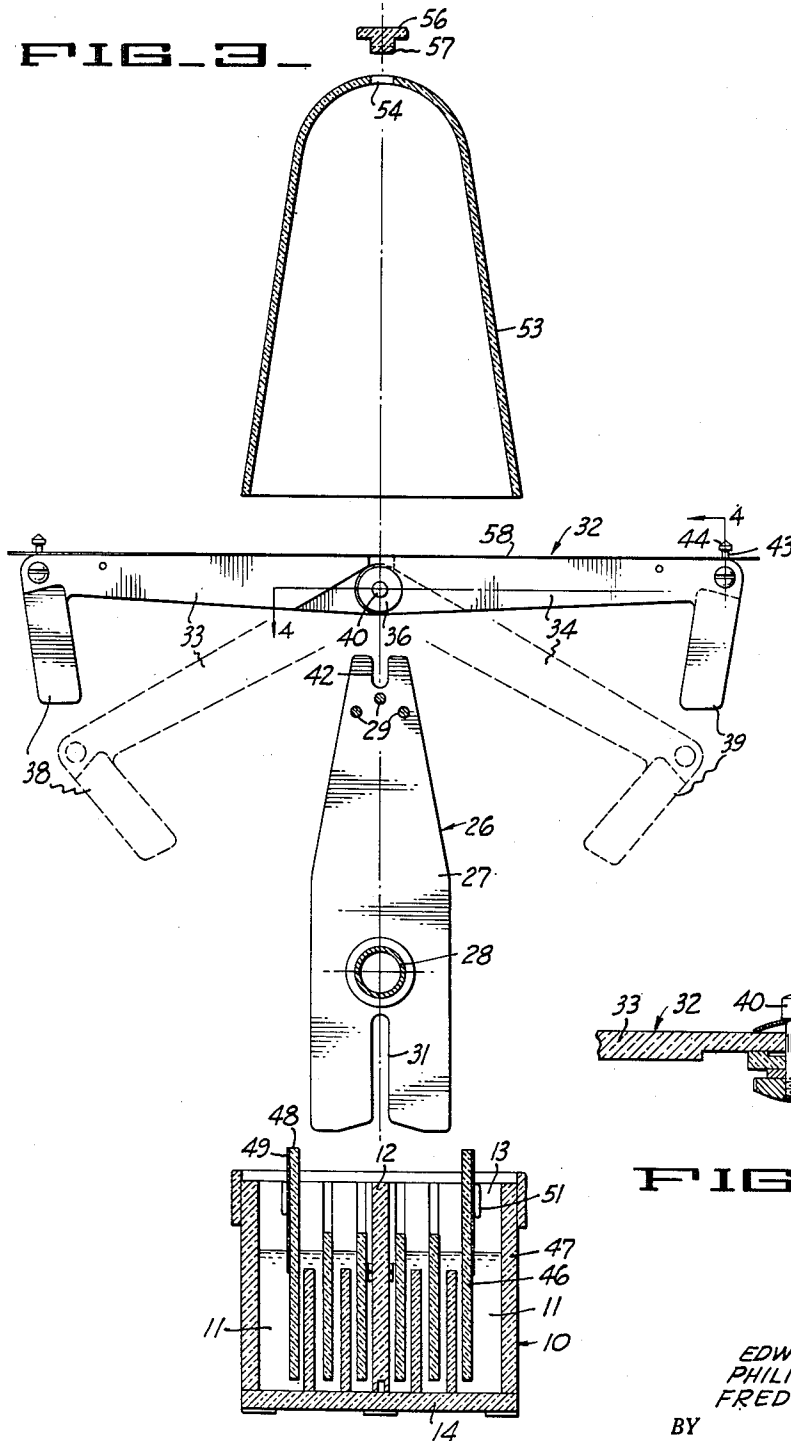
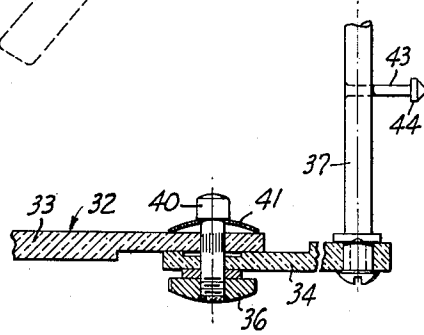


FIG. 4.



EDWARD G. PICKELS
PHILIP F. SCOFIELD
FRED G. WILLIAMS
INVENTORS
BY
Flehm & Swain
ATTORNEYS

May 13, 1958

E. G. PICKELS ET AL
ELECTROPHORESIS APPARATUS

2,834,729

Filed Feb. 24, 1955

4 Sheets-Sheet 4

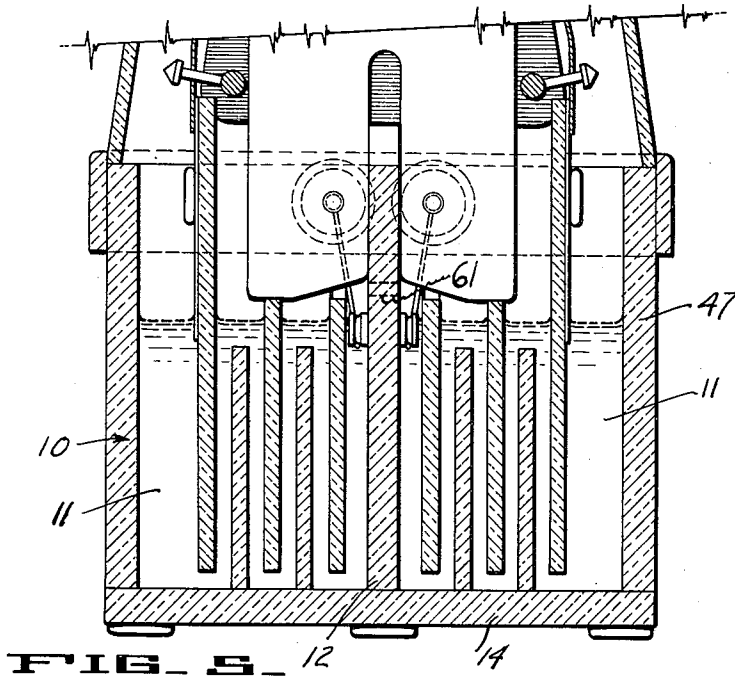


FIG. 5

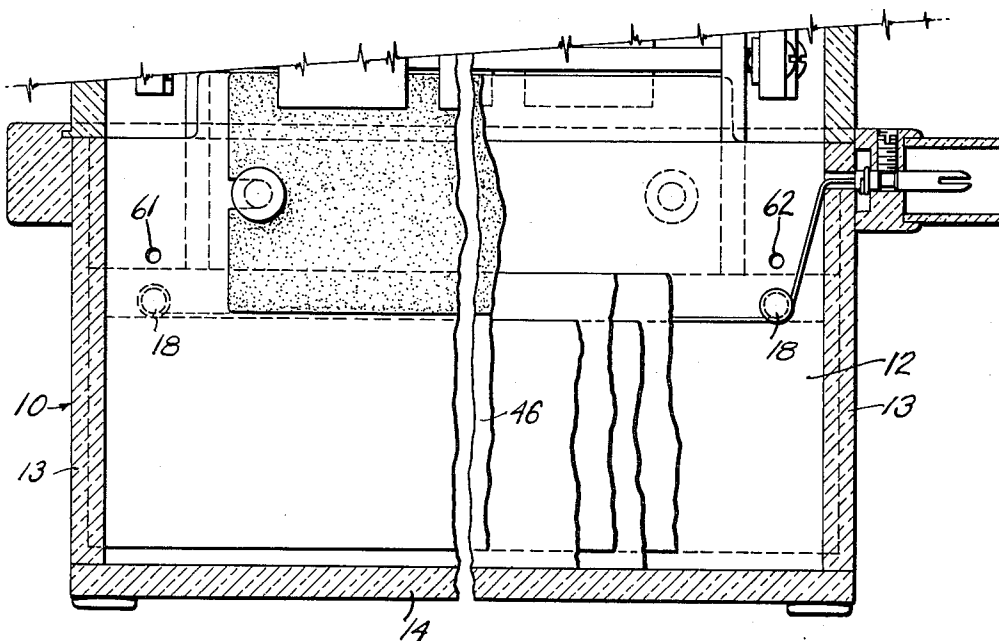


FIG. 6

EDWARD G. PICKELS
PHILIP F. SCOFIELD
FRED G. WILLIAMS
INVENTORS
BY
F. L. Swain
ATTORNEYS

1

2,834,729

ELECTROPHORESIS APPARATUS

Edward G. Pickels and Philip F. Scofield, Atherton, and Fred G. Williams, Redwood City, Calif., assignors to Beckman Instruments, Inc., Fullerton, Calif., a corporation of California

Application February 24, 1955, Serial No. 490,261

8 Claims. (Cl. 204—299)

This invention relates generally to electrophoresis apparatus of the paper strip type.

In performing electrophoretic and inophoretic separations making use of an absorbent paper strip, apparatus has been employed comprising two electrolyte cells with means whereby a paper strip is supported with its ends dipping into the electrolyte. Commercially available apparatus of this type has been subjected to certain disadvantages. Particularly many of the manipulations involved have been troublesome and time consuming. In order to equalize the electrolyte levels in the two cells a connecting tube has been employed with a pinch cock. Care must be taken to permit equalization through this tube before a test run is commenced. The practice of permitting the strips to dip into the electrolyte is troublesome in that it tends to provide uneven and excess wetting, particularly at the time the strips are removed for drying. Removal of the strips at the end of a run is troublesome, and requires individual handling to transfer the strips to a dryer.

In general it is an object of the present invention to provide improved apparatus of the above character which will avoid the above mentioned disadvantages of prior equipment.

A further object of the invention is to provide apparatus of the above character having means for equalizing the levels between the electrolyte cells without the use of conventional expedients.

Another object of the invention is to provide electrophoresis apparatus having novel means for effectively connecting the end portions of the strip to the electrolyte, without causing excessive wetting, and without having excessively wet end portions when the strip is removed.

Another object of the invention is to provide an electrophoresis apparatus of the above character in which special means is provided for applying the strips and for removing them for the drying operation.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment has been set forth in detail in conjunction with the accompanying drawing.

Referring to the drawing:

Figure 1 is an elevational view in section showing apparatus in accordance with the present invention, the view being taken along the line 1—1 of Figure 2;

Figure 2 is a side elevational view in section and taken along the line 2—2 of Figure 1;

Figure 3 is an exploded view illustrating various parts of the apparatus;

Figure 4 is a cross sectional detail on an enlarged scale, taken along the line 4—4 of Figure 3;

Figure 5 is a partial elevational view showing another embodiment of apparatus in accordance with the present invention, the view being taken along the line 5—5 of Figure 6; and

Figure 6 is a partial elevational view in section taken along the line 6—6 of Figure 5.

The apparatus illustrated in the drawing consists of

2

a container 10 which forms in effect a base for the apparatus and which provides the separate compartments or electrolytic cells 11. A central vertical partition wall 12 extends between the end walls 13, and is sealed with respect to both the end walls and the bottom wall 14. The lower edge of the partition 12 is provided with a groove 15 which is relatively small in section, and which communicates at its ends through the ducts 16 with the two cells 11. This groove forms an elongated passage filled with electrolyte whereby equalization may occur between the two cells 11 without however permitting any substantial amount of diffusion between the cells. The effective electrical resistance of the electrolyte in the groove 15 is relatively high and therefore the current flow through the same is negligible.

A pair of wire electrodes 17 extend through the cells and are carried by suitable means such as the support knobs 18. At one end of the apparatus the wire electrodes 17 connect with the terminals 19.

Each cell is preferably provided with a plurality of baffles to isolate the region occupied by the electrodes 17, from the regions where electrical connection is being made to the ends of the paper strips. Thus each cell is provided with spaced vertical baffles 20 and 21, which are sealed at their edges with respect to the end and bottom walls 13 and 14. In addition each cell is provided with the baffles 22 and 23, which have their lower edges terminating short of the bottom wall 14. Also the latter baffles have their ends slidably engaged in grooves formed in the end walls 13, thereby permitting their removal.

A paper strip support 26 is removably carried by the container 10. This support consists of spaced vertically extending end members 27, which are attached to the ends of the rigid tube 28. The upper end portions of members 27 are connected by the parallel paper strip supporting rods 29. The lower extremities of the end members 27 are slotted as indicated at 31, to accommodate the end portions of the central partition 12.

In addition to the strip supporting means 26, we provide a special rack 32 which is used for applying and removing the strips. This rack consists of side portions formed by two pairs of arms 33 and 34, having corresponding ends pivotally connected together by the hinge bolts 36. The other ends of the arms are connected together by the rods 37. At the free ends of the arms we provide wing-like extensions 38 and 39, which overlap when the arms are swung together to the position shown in Figure 1. The hinge bolts 36 are provided with studs 40 adapted to engage in the slots 42 provided in the upper ends of the members 27. Also they are provided with Bellville or similar spring washers 41 to provide some frictional resistance to hinge movement. Each of the rods 37 is provided with a plurality of strip engaging studs 43, which are adapted to engage paper strips as will be presently described. The extremities of these studs are provided with enlarged heads 44.

In addition to the baffles previously mentioned, we provide the baffle walls 46 which are interposed between the baffles 21 and the side walls 47 of the container. The lower edges of the baffles 46 terminate short of the bottom wall 14, and the upper portions 48 extend a substantial distance above the normal electrolyte level. The portions 48 serve to accommodate wick-like members 49 which can be formed of absorbent material like blotting paper. Normally the lower edges of members 49 dip into the electrolyte as illustrated in Figure 1. As convenient means for retaining the wick-like members 49 upon the baffles 46, we provide button-like member studs 51 which engage slots 52 in the ends of the corresponding wick member 49. This arrangement permits ready application and removal.

It is desirable to provide the apparatus with a suitable removable cover 53. The lower edge of this cover seats upon the upper edges of the container, and the upper end is provided with an elongated access opening 54 (Figure 2). A closure 56 is provided for the opening 54, and is shown provided with inner locking lips 57, whereby upon sliding the closure in one direction or the other, it can be removed.

Suitable materials can be used for the various parts. The container and the various baffles can be made of a plastic insulating material, such as a material that is transparent. The same material can be used for the side members of the support 26, and the arms of the rack 32 and the cover.

Although the apparatus has been described with reference to electrophoresis apparatus of the paper strip type, it is to be understood that other media such as silk cloth, glass fibers, gelatinous sheeting and other materials having the desired capillary action may in special circumstances be employed. It is further noted that the paper as well as the other materials may be so proportioned as to be considered sheets, bars, rods or tubes rather than strips.

Operation of the apparatus described above is as follows: A suitable quantity of electrolyte at the required pH is introduced into the cells 11, and the wick members 49 applied. The level of electrolyte in the two cells equalizes through the groove or duct 16. A number of absorbent paper strips 58, each provided with an aperture adjacent its end, are engaged with the studs 43 of the hinged rack 32, while this rack is extended on a suitable supporting surface. The hinge rack 32 is now applied to the support 26, with engagement of the studs 40 in the grooves 42, after which the two sides of the rack 32 are swung downwardly to the final position illustrated in Figures 1 and 2. As the two sides of the rack are swung downwardly the central portions of the paper strips bend over the strip supporting rods 29, substantially as shown in Figures 1 and 2. In addition the extremities of the paper strips come into contact with the wick members 49, and are caused to be spaced from the rods 29 (Figure 1). By means of a suitable syringe all of the paper strips are wet with electrolyte. By virtue of such wetting, and also because of absorption from the cells, the wick members 49 become thoroughly saturated, together with the strips. The extremities of the strip are caused to lay into even close contact with the wick members 49. After a predetermined interval the strips are in condition for application of a sample for electrophoretic or ionophoretic separation. This operation involves the removal of the closure 56 followed by application of a predetermined amount of the sample to each of the strips, the sample being carefully and evenly applied to a narrow region immediately overlying the uppermost one of the rods 29. An electrical current of a predetermined value is now applied to the terminals 19, whereby current flow occurs through the electrolyte of each of the paper strips. This results in separation of certain constituents of the sample in a manner well known to those familiar with electrophoresis equipment. After a period of time sufficient for completion of the separation desired, the current is discontinued, the cover 53 removed, and the sides of the rack 32 swung upwardly followed by removal of the rack 32. Initial outward movement of the two sides of the rack 32 causes a shearing away of the extremities of the strips from the wick members 49. When the two sides of the rack are swung out to a common plane as shown in solid lines in Figure 3, the strips are taut, the pattern area hanging free from contact with any support. The extended rack can now be introduced into a suitable drying oven, to hold the strips while they are being dried. The drying can be followed by application of dyeing solutions, followed by final drying, all while the strips are supported upon the rack 32.

Referring to Figures 5 and 6, we have shown an em-

bodiment of our apparatus which does not employ a groove 15 and communicating ducts 16 for equalization of the liquid level. Instead, the ducts 61 and 62 located at opposite ends of the cell and above the level of the liquid provide means for equalization of the liquid level. Prior to commencing a run, one end of the cell is lifted to allow the liquid to cover one of the ducts 61 and 62. When the liquid level is equalized, the cell is then lowered and the run is commenced. Thus, any possibility of diffusion between the cells is eliminated. Further, there is no current path between the cells other than the one which includes current flow through the electrolyte of the electrophoresis strips.

It will be evident from the foregoing that we have provided apparatus having many advantages over the conventional equipment previously described. The two cells are self-equalizing with respect to the electrolyte levels. There is no excessive wetting of the lower ends of the paper strips because they do not dip directly into the electrolyte. There is a shearing away action as the strips are removed from contact with the wick members 49, and as a result the strips do not have excessive amounts of electrolyte at their extremities. The hinged rack 32 greatly facilitates both application and removal of the paper strips, and also the handling of these strips during drying. Further, because the strips are horizontal and taut they dry with practically no shift of the resolved zone.

We claim:

1. In paper strip electrophoresis apparatus, container means forming two cells for electrolyte, a rack comprising two side portions hingedly connected together, said side portions having means thereon for engaging end portions of paper strips, support means carried by the container means for supporting said rack and said strips with the side portions of the rack swung downwardly to thereby establish electrical contact between the extremities of the strips and the electrolyte of the cells, said hinged rack being readily removable from said supporting means at the end of a run.

2. Apparatus as in claim 1 in which the means for attaching the end portions of the paper strips to the hinged rack include studs loosely engaged in apertures formed in the strips.

3. In paper strips electrophoresis apparatus, container means forming two cells for electrolyte, rack supporting means carried by the container means, a hinged rack removably carried by said supporting means, said hinged rack comprising two side portions hingedly connected together and having means thereon for engaging the end portions of paper strips, said supporting means including elements adapted to engage the bent middle portions of the strips for supporting the same when the hinged rack with the strips is applied to the apparatus, and means for establishing electrical connection between the extremities of the strip and the electrolyte of the cells.

4. Apparatus as in claim 3 in which said last-named means comprises wick members formed of absorbent sheet material having their lower edges adapted to be immersed in the electrolyte and their upper edges adapted to form overlapping contact with the lower extremities of the paper strips.

5. In paper strip electrophoresis apparatus, container means partitioned by a dividing wall to form two cells for electrolyte, rack-supporting means carried by the container, a hinged rack removably carried by said supporting means, said hinged rack comprising two side portions hingedly connected together and having means thereon for engaging the end portions of paper strips, said supporting means including elements adapted to engage the bent middle portions of the strips for supporting the same when the hinged rack with the strips is applied to the apparatus, and means for establishing electrical connection between the extremities of the strips and the electrolyte of the cells.

5

6. Apparatus as in claim 5 in which said last-named means comprises wick members formed of absorbent sheet material having their lower edges adapted to be immersed in the electrolyte and their upper edges adapted to form overlapping contact with the lower extremities of the paper strips, and wherein said means for equalizing of the liquid level in said cell comprises ducts formed in said wall, said ducts being positioned in said dividing wall at the ends of said cells and above that portion of said wall adapted to be covered by the electrolyte.

7. In paper strip electrophoresis apparatus, container means forming two cells for electrolyte, means for supporting the paper strip in a region generally overlying the cells with the extremities of the strip depending toward the cells, at least one wall mounted in each cell, and wick members of absorbent material removably carried by said walls, the lower edges of said wick members adapted to be immersed in the electrolyte carried by the cells and the upper edges terminating short of the uppermost extension of the paper strip and adapted to form an overlapping contact with the lower extremities of the paper strip.

8. In paper strip electrophoresis apparatus, container means forming two cells for electrolyte, means for sup-

6

porting the paper strip in a region generally overlying the cells with the extremities of the strip depending toward the cells, and a wick member of absorbent material supported in each of said cells and adapted to form an intermediate portion between the ends of the strip and the electrolyte, the lower edges of said wick members adapted to be immersed in the electrolyte carried by the cells and the upper edges being spaced apart and adapted to form an overlapping contact with the lower extremities of the paper strip.

References Cited in the file of this patent

FOREIGN PATENTS

647,630	Great Britain	Dec. 20, 1950
1,057,440	France	Oct. 28, 1953
842,863	Germany	July 3, 1952
865,379	Germany	Feb. 2, 1953

OTHER REFERENCES

Durum: Journal American Chem. Soc., vol. 72 (1950), pages 2943 to 2948.