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ELECTROSTATIC SORTING OF SEEDS BY COLOR

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2 Sheets-Sheet 1

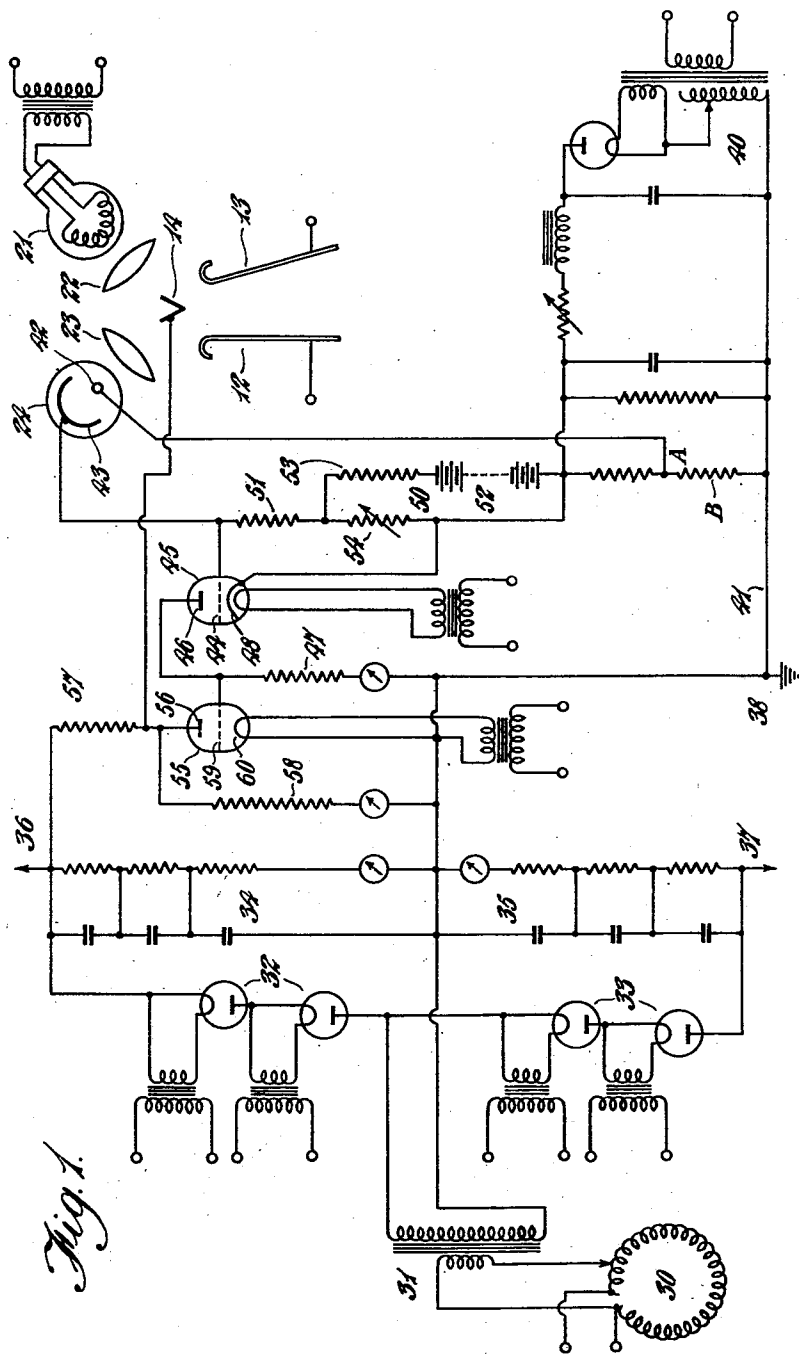


Fig. 1

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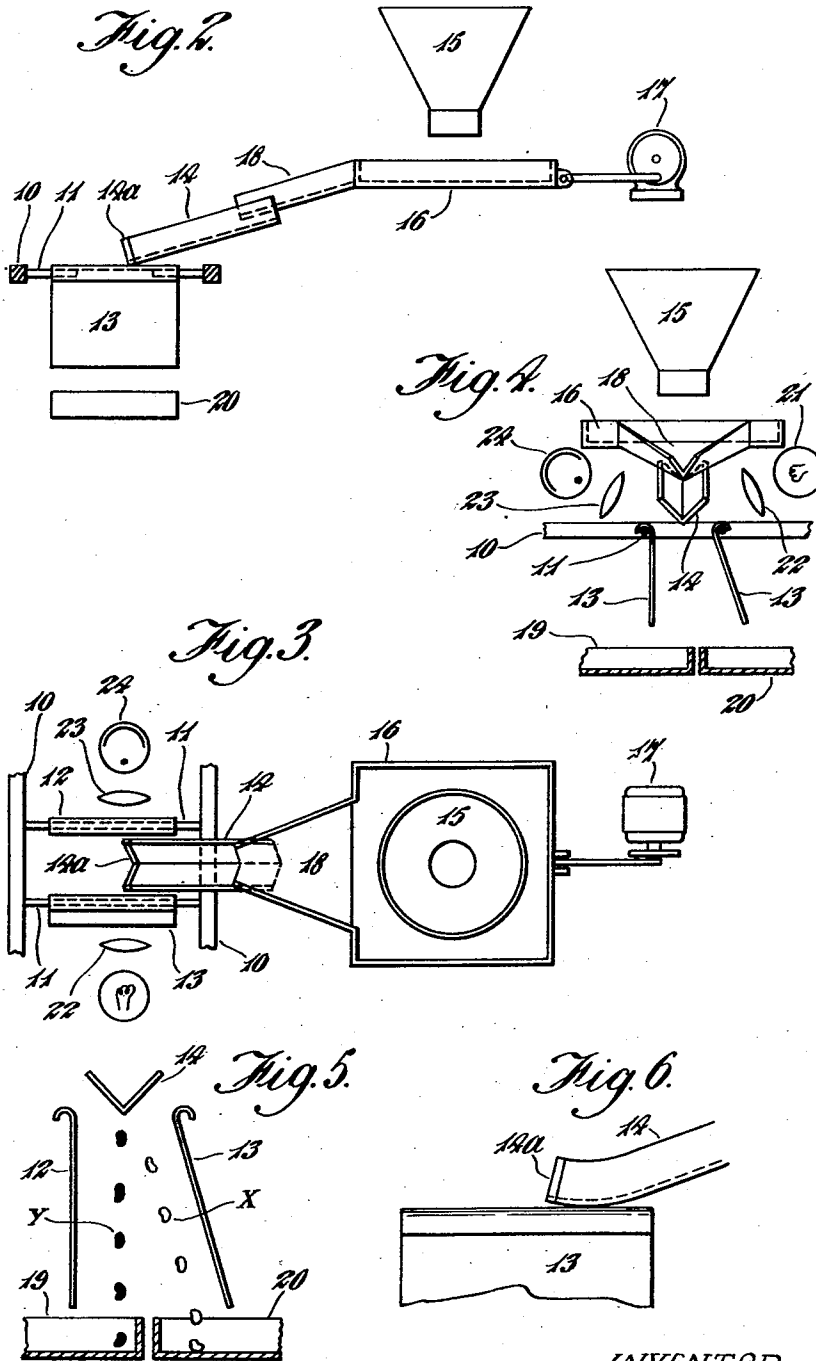
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ELECTROSTATIC SORTING OF SEEDS BY
COLOR

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South Africa, and one-half to R. W. Gunson
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The present invention relates to apparatus for sorting small articles such as peas, beans and similar vegetable seeds, mainly of the botanical orders—Leguminosae and Graminae. It has been discovered that such vegetable seeds can be individually charged electrically and that such charged seeds are deflected when allowed to fall freely through an electric field of suitably high intensity.

It is one object of the present invention to utilise this discovery in the sorting of seeds.

It is well known that defects in individual seeds of these kinds are visually apparent through colour variations or surface configurations, either separately or together on the same seed, and it has been proposed to use these variations to operate a sorting apparatus, by illuminating the articles with light through a suitable optical system, and to receive this light reflected by the article on a photo-electric cell. By means of such suitable optical arrangement it is ensured that the amount of light thus reflected on to the cell from a defective article is different from the amount reflected from a sound article. The resulting difference in photo-cell current has been utilised to actuate some sort of relay, which controls mechanically the sorting operation. A disadvantage is that the relays and associated mechanical devices are relatively costly, need constant adjustment, cleaning and maintenance, and are slow in operation. Furthermore, when it is desired to sort a very large number of articles rapidly, the whole apparatus has to be multiplied to provide a large number of sorting channels, each provided with a separate amplifier.

It is a further object of the present invention to provide a simpler, cheaper and more accurately reliable form of apparatus capable of a much greater sorting speed.

One method of sorting small articles such as beans, peas and similar vegetable seeds, the surfaces of which vary in their light reflecting properties according to the present invention, comprises charging the articles, changing the voltage of at least one member of electrodes forming a field and passing the charged articles through an electric field, whereby they are selectively deflected due to their charge.

Another method of sorting small articles such as beans, peas and similar vegetable seeds, the surfaces of which vary in their light reflecting properties according to the present invention, comprises selectively charging the articles electrically according to the amount or kind of light which they reflect and passing the charged arti-

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cles through a steady electric field whereby they are selectively deflected according to their charge.

Preferably the articles are electro-statically charged, positively or negatively, and are caused to fall through an intense electro-static field.

Apparatus for sorting small articles such as beans, peas and similar vegetable seeds which vary in the light reflecting properties of their surfaces according to the present invention comprises a pair of deflector plates, means for creating an intense steady electrostatic field across said deflector plates, a chute for feeding the articles to a point above the deflector plates such that on leaving the end of the chute they fall between said plates, means for electrostatically charging the articles as they leave the end of the chute, or just prior thereto, means for illuminating the articles as they reach the end of the chute, at least one photo-electric cell to receive the light reflected from the individual articles, the output from the said photo-electric cell being coupled to the means for electrostatically charging the seeds in such a manner as to vary the charge applied to the articles in accordance with the light reflected from their surfaces whereby the articles are selectively deflected in passing between the deflector plates, and means for collecting the selectively deflected seeds.

Several other novel features both of construction and method of operation are provided by the present invention, these features being more fully described hereinafter and claimed in the appended claims.

In order that this invention may be the more clearly understood and readily carried into effect, reference may be made to the accompanying drawings, in which—

Figure 1 is the circuit diagram of a convenient form of seed sorting apparatus according to the present invention.

Figure 2 is a side elevation of a suitable form of apparatus according to the present invention.

Figure 3 is a plan view, and

Figure 4 is a front elevation.

Figure 5 is a diagrammatic view, illustrating the operation of the machine.

Figure 6 illustrates a slight modification to the chute designed to ensure that the articles shall remain longer in the electrostatic field and so be deflected to a greater extent.

Referring now to the accompanying drawings, the apparatus for sorting seeds therein illustrated comprises a framework 10 in which are suitably mounted on insulators 11 a pair of deflector plates 12, 13, across which is created, in a manner

which will be described more fully hereinafter, a steady and intense electrostatic field. As with the apparatus shown in the drawings, the seeds are positively charged, the plate 12, which is connected to the positive pole of the supply, is arranged vertically, or substantially so, whilst the plate 13 which is connected to the negative pole of the supply is inclined as shown so that it is more widely spaced from the plate 12 at the bottom than at the top in order to allow for the deflection of the charged beans.

Located just above the top of the deflector plates 12 and 13 is a fixed chute 14 down which the beans are caused to travel one after the other in quick succession by any suitable means. In the embodiment shown in the drawings, the beans are fed into a hopper 15 from which they fall on to a tray 16 which is vibrated backwards and forwards by means of an electric motor 17. Leading from the tray 16 is an inclined chute 18 adapted to move backwards and forwards in the upper end of the fixed chute 14 so that as the beans are shaken off the tray 16 they slide in quick succession one after the other down the chutes 18 and 14 under the action of gravity. After passing off the end of the fixed chute 14, the beans fall down between the two deflector plates 12, 13 into one or other of the receptacles 19, 20 according to whether they have been deflected or not.

The chute 14 is, in the main, of insulating material but is provided with a metal tip 14a which constitutes an electrode for charging the bean, as will be described more fully hereinafter.

Light from a lamp 21 is focussed by means of a lens, or lens system 22, on to the tip 14a of the chute 14. Light reflected by a bean at the tip 14a of the chute 14 is concentrated by means of a lens or lens system 23 on to a photo-electric cell 24. As stated above, it is the response of this photo-electric cell 24 to the light reflected by a bean in the tip 14a of the chute 14 which controls the charge of the bean, and care must be taken to ensure that a second bean shall not come within the field of the light spot produced by the lens 22 and of the photo-electric cell 24 whilst the first bean is in contact with the tip 14a of the chute 14. If it did, the response of the photo-electric cell 24 would be determined by a combination of the light reflected by the two beans and the first bean would not be correctly charged in accordance with the light reflected by itself alone. In order to overcome any possibility of this fault arising, the lens 22 is adapted to focus the light from the lamp 21 to a spot which is partly on the end of the tip 14a of the chute and partly in the air in front of the tip. By this means light is reflected from a bean into the photo-electric cell 24 only as it is just about to fall off the tip 14a of the chute.

Turning now to the electrical equipment of the apparatus, and referring to Figure 1 of the accompanying drawings, there is provided a variable transformer 30 fed from the A. C. mains, this transformer 30 feeding a transformer 31, the secondary of which has an output of the order of 15,000 volts R. M. S. The output of the transformer 31 is rectified by a voltage doubler bridge rectifier comprising series-connected rectifiers 32 and 33 in the two arms of the bridge and condenser-resistance networks 34, 35 in the other two arms of the bridge so that we have at the points 36 and 37 D. C. voltages which are of the order of 21,000 volts respectively positive and

negative with respect to earth 38 to which the one lead of the secondary of the transformer 31 is connected as shown. The point 36 is connected to the positive deflector plate 12 and the point 37 to the negative deflector plate 13 so that we have a potential difference of approximately 42,000 volts across the plates 12 and 13 creating an intense steady electrostatic field in the space between the plates.

A conventional power pack 40 is provided, the output of which may be of the order of 600 volts, and the positive line 41 is earthed as shown. The anode 42 of the photo-electric cell 24 is connected to a suitable point A on a potential divider B shunted across the output of the power pack 40 and the cathode 43 is connected to the grid 44 of an electronic valve 45. The electronic anode 46 of the valve 45 is connected through a resistance 47 of the order of 60,000 ohms to earth and hence to the positive line 41 of the output of the power pack 40, whilst the cathode 48 of the electronic valve 45 is connected to the negative line of the output from the power pack 40.

The grid 44 of the electronic valve 45 is biased negatively with respect to the cathode 48 by means of the biasing network 50 which is connected to the grid 44 through a high resistance 51 which may be of the order of, say, 20 megohms. The biasing network 50 comprises a battery 52 and fixed resistor 53 shunted by a variable resistance 54 by means of which the bias applied to the grid 44 may be adjusted. The photo-electric cell 24 is of the high vacuum type having a very small dark current and in use the standing bias on the grid 44 of the electronic valve 45 is adjusted by means of the biasing network to the cut-off point in the absence of current flowing through the photo-electric cell 24. The result is that until such time as light is reflected into the photo-electric cell 24 from a bean in the tip 14a of the chute 14 the electronic valve 45 is cut off and no current will flow in the anode circuit 46, 47, 38.

The electronic valve 45 is used to trigger a charging electronic valve 55, the anode 56 of which is connected, firstly, directly to the metal tip 14a of the chute 14, secondly, to the positive point 36 of the high voltage supply through a high resistance 57 of the order of 20 megohms and, thirdly, through a very high resistance of the order of 200 megohms to earth. The anode 46 of the electronic valve 45 is connected directly to the grid 59 of the electronic valve 55, as shown, and the cathode 60 of the electronic valve 55 is earthed.

We have so far considered the state of affairs in the absence of illumination of the photo-electric cell 24. Let us now consider the operation of the electronic valve 55 under these conditions. As the electronic valve 45 is biased to the cut-off point no current will flow in the resistance 47 and the grid of the electronic valve 55 is effectively at earth potential. Hence the electronic valve 55 will conduct and current will flow through the same. The internal resistance of the electronic valve under these conditions will be negligible compared to the resistance 57 and the anode 56 so that the voltage drop across the electronic valve 55 will be very small and only a very small potential will be applied to the tip 14a of the chute 14. For all practical purposes, the tip 14a may be regarded as being at earth potential and a bean in contact therewith will not be charged.

Let us now turn to the case in which light

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falls on the photo-electric cell 24 which thus conducts current. The cell current flowing through the resistance 51 sets up a potential which opposes the standing bias on the grid 44 of the electronic valve 45 so that the electronic valve 45 is no longer biased to the cut off point. The electronic valve 45, therefore, conducts and current will flow through the resistance 47. There will be a potential drop across the resistance 47 which will be applied to the grid 59 of the electronic valve 55 and the value of the resistance 47 is so chosen with respect to the internal resistance of the electronic valve 45 under these conditions that the electronic valve 55 will be biased well beyond the cut off point. Consequently no current will flow through the electronic valve 55 and the potential of the anode 56 will be substantially that of the point 36, which, as above stated, is connected to the positive deflector plate 12, since the value of the resistance 57 is small compared to the value of the resistance 58. A high potential, of the same order as that applied to the positive deflector plate 12, will, therefore be applied to the tip 14a of the chute 14 and a bean in contact therewith will be highly charged positively.

The operation of the seed sorting machine can now be explained. Let us take first of all the simple case of sorting light beans from dark beans, i. e., beans, the surfaces of which have good light reflecting properties from those whose surfaces have practically no light reflecting properties. The beans are fed down the chute 14 and reach the tip 14a, one by one, and are illuminated by the light spot from the lamp 21. When a light bean reaches the tip 14a light is reflected from its surface into the photo-electric cell 24 which thereupon conducts current. The result is that the electronic valve 45 conducts, the electronic valve 55 is cut off and a high potential is applied to the tip 14a to charge the bean positively, as above described. The highly charged bean falls off the end of the chute and down between the deflector plates 12 and 13 under the action of gravity. Being highly charged positively it will, when it enters the electrostatic field between the plates 12 and 13 be repelled by the positively charged plate 12 and attracted by the negatively charged plate 13 and will consequently be deflected so as to fall into the receptacle 20. It can be proved mathematically that the path of a bean within the electrostatic field, provided it does not approach too closely to the negatively charged plate 13, is a straight line and not a parabola as would appear at first sight. By suitably proportioning the deflector plates 12 and 13, therefore, adequate deflection can easily be obtained.

When a dark bean reaches the tip 14a of the chute 14 no light (or insufficient light to activate the photo-electric cell 24) is reflected from its surface and the photo-electric cell is, therefore, non-conducting. In these conditions, as explained above, the electronic valve 45 does not conduct, the electronic valve 55 conducts and the potential applied to the tip 14a of the chute is effectively zero. A dark bean is, therefore, not charged and after leaving the chute falls straight down between the plates 12 and 13 under the action of gravity into the receptacle 19.

The path of the light beans is shown at X in Figure 5, and the path of the dark beans at Y in that figure.

It is interesting to note that it is not the relative potentials between the plates 12, 13 and the

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beans which matter. The plate 12 is positively charged to a high potential above earth, whilst the plate 13 is highly charged negatively with respect to earth. Nevertheless, the dark bean which is at earth potential falls undeflected through the field.

Effective separation of the light beans from the dark beans is thus secured.

The above case of separating light coloured beans from dark coloured beans has been chosen merely for the sake of simplicity and ease of explaining the way in which the present invention operates. It will be seen that so long as it can be arranged that the light reflected from the surface of one kind of bean or other article activates the photo-electric cell 24 to such a degree as to reduce the bias on the grid 44 sufficiently to cause the electronic valve 45 to conduct, whilst the light reflected from the surface of another kind of bean or other article does not activate the photo-electric cell to this degree, separation can be effected.

Where the beans, peas or other articles which it is desired to sort differ in the intensity of the light reflected by their surfaces, a control is provided by the variable resistance 54. The resistance 54 is adjusted so that the light reflected by the article of lower light reflecting power is just insufficient to enable the current in the photo-electric cell to overcome the standing bias and to take the grid 44 of the electronic valve 45 over the cut off point. Sorting or separation is then effected, as above described.

The present invention may also be employed to sort or separate articles which differ in the colour of light they reflect irrespective of its intensity. All that is necessary in this case is to provide between the tip 14a of the chute 14 and the photo-electric cell 24 a colour filter which will prevent the passage of the light of one colour whilst allowing passage of the light of the other colour. The bean reflecting light which is passed by the filter then becomes a "light" bean, and the bean reflecting light of the colour which is absorbed by the filter becomes a "dark" bean, and sorting is effected as above described.

Whilst it is convenient when separating mixed small articles such as beans, peas and similar vegetable seeds into two sorts to charge one sort and not the other prior to allowing them to fall through the electrostatic field, this is by no means essential as with suitable modification of the electrical equipment the same result can be obtained by charging both sorts provided they are charged differently. One sort may, for example, be charged positively and the other negatively.

Also the present invention is not limited to separating the mixture into two sorts. It can easily be applied to the sorting of a mixture into three or more sorts. In this case, each sort is arranged to activate the photo-electric cell 24 to a different degree and the article is charged according to the degree to which it activates the photo-electric cell. This may easily be done by amplifying up the photo-electric cell output appropriately to charge the bean or the like.

In all cases it will be appreciated that the extent to which a charged bean or the like is deflected is a function of the time during which it is within the electrostatic field. With the object of increasing the time the bean or the like is within the electrostatic field, the end of the chute 14 may be turned up slightly, as shown in Figure 6, so that the bean or the like follows a path as shown in that figure rather than starting to

fall immediately it leaves the end of the chute. It will be seen that the bean will be within the field for an appreciably longer time and hence, other factors being equal, its deflection will be greater.

More than one chute with its bean charging tip may be provided to each pair of deflector plates if desired but in general this will be unnecessary. In all cases a separate amplifier such as the electronic valves 45 and 55 will have to be provided for each charging tip and a single high voltage generator can be used to supply any number of pairs of deflector plates since the potential is not varied so that a great saving will be effected by feeding more than one stream of the differently charged mixed articles through a single pair of deflecting plates.

Although it is preferred to secure the separation of the differently charged beans or the like by allowing them to fall through a steady electrostatic field, the same result may be secured by passing the differently charged beans or the like through a steady magnetic field.

I claim:

1. Apparatus for sorting small vegetable seeds which vary in the light reflecting properties of their surfaces comprising a pair of vertical deflector plates, means for creating an intense steady electrostatic field across said deflector plates, a chute for feeding the articles to a point above the deflector plates such that on leaving the end of the chute they fall between said plates, means for electrostatically charging the articles at about the time they leave the end of the chute, means for illuminating the articles as they reach the end of the chute, at least one photoelectric cell to receive the light reflected from the individual articles, the output from said photo-electric cell being coupled to the means for electrostatically charging the seeds in such a manner as to vary the charge applied to the articles in accordance with the light reflected from their surfaces, whereby the articles are selectively deflected in passing between the deflector plates, and means for collecting the selectively deflected seeds.

2. Apparatus for sorting small vegetable seeds according to claim 1, in which the photo-electric cell is fed to an amplifying electronic valve, a further electronic valve controlled by said amplifying electronic means, said further electronic valve controlling the means for charging the electrodes.

3. Apparatus for sorting small vegetable seeds according to claim 2, in which the grid of the amplifying electronic valve is so biased that for the amount of light reaching the photo-electric cell from one sort of article the amplifying electronic valve is cut off, the anode of the amplifying electronic valve being connected to the grid of the control electronic valve and through a resistance to earth so that in the said conditions the control electronic valve conducts and the article is not charged, whereas for conditions of greater light reflection the amplifying electronic valve conducts and biases the grid of the control electronic valve beyond cut-off point, whereby a high charging potential is applied to the article.

4. Apparatus for sorting small vegetable seeds

according to claim 3, characterized by the provision of means for varying the standing bias on the grid of the amplifying electronic valve.

5. Apparatus for sorting small vegetable seeds, according to claim 4, characterized by the provision of a colour filter between the point where the article is illuminated and the photo-electric cell or cells.

6. Apparatus for sorting small vegetable seeds according to claim 5, in which the anode of the control valve is connected direct to the charging electrode and in which the anode circuit of the control valve includes a resistance very many times greater than the internal resistance of the control valve under conducting conditions, whereby when the control valve conducts the charging electrode is practically at zero potential.

7. Apparatus for sorting small vegetable seeds according to claim 6, characterized by the provision of a resistance, the value of which is many times greater than the value of the resistance in the anode circuit of the control valve, connected between the anode and cathode of the control valve.

8. Apparatus for sorting small vegetable seeds according to claim 1, in which the end of the chute is made of metal and forms an electrode for charging the articles as they pass over the same.

9. Apparatus for sorting small vegetable seeds according to claim 1, in which the end of the chute is curved slightly upwards so that the articles leave the chute with a velocity which has a vertical component, whereby the articles remain within the electrostatic field for a longer time than would otherwise be the case.

10. Apparatus for sorting small vegetable seeds according to claim 1, in which the articles are illuminated by a light spot focussed partly on the end of the chute and partly in the air immediately in front of the chute.

11. Apparatus for sorting small vegetable seeds according to claim 1, in which the means for creating the electrostatic field across the deflector plates comprises a transformer, and a voltage doubler bridge-connected rectifier for rectifying the output of the transformer connected to the deflector plates in such a manner that one deflector plate is charged positively with respect to earth and the other deflector plate is charged negatively with respect to earth.

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