All of you appreciate the value of quality seed and are familiar with the many factors that determine the quality of a seed lot: the percentage of pure seeds, other crop seeds, weed seeds, and inert matter; percentage of germination; the rate of occurrence of noxious weeds; and freedom from disease and disease organisms. You also know that testing procedures for checking a seed lot for quality have been standardized to the extent that results obtained on a sample in one laboratory can be repeated within accepted tolerances by another laboratory. It is visual inspection of a representative sample that determines the percentage of pure seeds, other crop seeds, weed seeds, inert matter, and in many cases, if there is deterioration of a fraction of the seed due to adverse conditions during the growing, harvesting, processing, or storage period, this also is evident in the appearance of the seed. Certainly extensive insect and mechanical damage changes the appearance of the seed, and there is a difference in seed color when there is deterioration due to other factors.

Since so many quality factors are reflected in the appearance of seeds, uniform appearance can mean uniform quality. If it were possible for you to visually inspect and sort the millions of seeds that make up a lot of seed on the basis of the difference in their appearance, you could be sure of uniform quality -- electronic color sorting machines do this! Models now available have capacities that make this kind of separation economically feasible. The E.S.M., Type B-350, which we have here in the laboratory, is able to inspect and sort individual seeds, in single file at the rate of more than a million per hour. Newer models have capacities of more than 3 million seeds per hour, viewing the seeds from both sides while in single file. These machines utilize the miracles of electronics to rapidly and accurately process, automatically, free flowing objects to obtain an acceptable product of uniform color.

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Some separations that can be made on the basis of a difference in color or appearance to improve quality are obvious, others need investigation to determine the correlation. The problems that remain are more in the area of determining the relationship of seed color and seed quality than with making a machine that will sort accurately and continually. Regardless of how automatic and consistent a machine is made to do a job, human decisions have to be made in programming the machine.

Two manufacturers of color sorting machines have units here in the laboratory. We have been working with the Sortex Model G414 and the E.S.M. Type B-350. In both machines the objects are classified by comparing the quantity of light reflected from their surface with that reflected from a selected standard. An electro-air device rejects those objects from the product stream that are classified by the machine as different in color from the standard chosen for an acceptable product.

Illustration No. 1 shows the B-350 machine. Illustration No. 2 shows the arrangement and identification of some of the features incorporated into the machine. This design makes it possible to classify and sort the product in single file, one particle at the time, viewing it from both sides, and making a bichromatic sort by utilizing four separate optic circuits.

**Description of the Operating Cycle**

The objects to be sorted are fed by gravity from the hopper into the feed chute. A sidewise, shaking motion of the chute drops the product into a disk shaped, rotating, conveying device called the bowl.

The quantity of product in the bowl is kept within the limit necessary for the most efficient operation by being continuously controlled at the point of entry into the bowl by the quantity of product already present in the bowl. This is accomplished by a latch control circuit that controls the feed chute shaking mechanism. A light is directed on a circular path of holes in the bowl near its periphery. When the quantity of product in the bowl is insufficient to prevent the light from passing through these holes, the light falls on a photocell causing the latch control circuit to activate the feed chute shaking mechanism until sufficient product has been shaken into the bowl to block the light from shining through the bowl's perforated control path.

The bowl is used to form a single row of product moving at a speed at which it can be transferred to a nearly tangent rotating disc-shaped conveyor called the drum.

The drum is a hollow disc fitted with projecting openings equally spaced in a single row around its circumference. Vacuum suction from inside the drum on these openings, called ferrules, is used to lift the objects from the bowl and hold them in a single row, a fixed distance apart, for their passage through the viewing
Figure 3.

Figure 4.
chamber.

The viewing chamber consists of a hollow lighted sphere through which each object in turn passes for viewing by four phototubes each of which is optically connected by a lens system to the viewing station in the sphere. Each object is viewed from both sides as it passes through the sphere. The light reflected from each side of the product is divided by a 50% mirror so that one-half the light is passed through the mirror to one filter while the remaining half of the light is reflected through a second filter. The first view inspects one side of the product; the second view inspects the other side. The filters are selected to pass only the desired critical wavelengths which are projected on the phototubes. The difference in reflectivity between the object being viewed and a selected standard, called a background, is translated into a signal by each of the phototube circuits. These signals are amplified and used to deflect a cathode ray tube electron beam, one signal deflecting the beam parallel to a horizontal coordinate axis charted on the tube face, the other signal deflecting the beam parallel to the vertical coordinate axis charted on the tube face. Each time an object is viewed the beam is deflected from a coordinate position representing the reflectivity of the background to a coordinate position which is a resultant of the two measure reflectivity signals applied to the deflecting plates of the cathode ray tube.

An opaque paper mask (see illustration No. 3) is fitted over the tube face covering that area of the coordinate chart into which the accepted color objects deflect the beam, as well as that point where the beam is set by the background color. A photo multiplier tube acts as a sentinel to watch the cathode ray tube face by means of a mirror for tell tale traces of the beam appearance of an off color object in view. When a trace appears, the sentinel phototube detects its presence and a signal is sent through the sentinel amplifier. This output signal calling for ejection of the object in view is then recorded on a time delay device called a timer. This time delay is necessary in order to physically separate the viewing position from the ejection area.

At a fixed point after an object-bearing ferrule leaves the viewing chamber the vacuum suction on the ferrule is removed thus allowing the object to fall free of the ferrule. Its tangential downward course carries it into the ejection area.

As each object enters the ejection area the related timer section is connected to the ejection circuit. If a signal for ejection was recorded, (either the right or left amplifier signal can cause the ejector to fire) it is now picked up and used to activate the ejector which strikes the object.
with a blast of compressed air, deflecting it into the rear outlet chute for rejects. Objects not rejected fall without deflection into the front outlet chute for accepted product.

**Product Analysis**

In order to cut the proper sorting pattern for a given separation, it is usually necessary to produce a field chart (Illustration No. 4). A number of pieces of the product, both bad and good, are viewed individually with the cut-off shoe removed, and their co-ordinates as shown on the grid of the C.R.T. are plotted on the field chart. By gluing the particles on the field chart at these points, we may make a more intelligent evaluation of what is taking place as we are cutting our chart blanks. After the pattern is cut to make the desired separation, the machine is programed to make the millions of visual inspections that will result in a product of uniform color. What color would you prefer?

Editors Note: Shown below is another color separator located in the Seed Technology Laboratory. This machine, Sortex G414, was manufactured by the Sortex Company of North America.