THE EFFECTS OF COLOR ENVIRONMENT ON GRADING EFFICIENCY IN FOOD PROCESSING PLANTS

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THESIS

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THE EFFECTS OF COLOR ENVIRONMENT ON GRADING EFFICIENCY IN FOOD PROCESSING PLANTS

By

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THE EFFECTS OF COLOR ENVIRONMENT ON GRADING EFFICIENCY IN FOOD PROCESSING PLANTS

INTRODUCTION

Much progress has been made recently in the field of color in its application to the environment in which people work and live. New theories and principles have been discovered. Exorbitant claims have arisen in industry for decreased absenteeism and happier, healthier, workers through the scientific use of color. A new term, color conditioning, which involves coupling scientifically applied colors with adequate lighting, has come into being.

The food processing plants have been very slow to make changes in this respect. Most factories in this field are operating under almost the same lighting conditions today as they were ten years ago.

The seeing problem in the food processing plants is different and unique. Here the workers must not only have comfortable seeing conditions, but the quality of their product is a result of what they see. Lighting conditions have to be such that the inspectors can readily detect blemishes on the products they are sorting. Their efficiency in doing so is directly related to the type of light they have to work under. If the light strains the workers eyes and if it doesn't show up the blemishes, it can make the task of the worker

a tedious one. The importance of improving the grading of fruit and vegetables is reflected in the food value and quality of the product put out by the packing concerns. Fancy grades of fruit and vegetables command top prices. Many of the operators are interested in improving the quality of their product to the standards of fancy grades, even though there is a demand for third grade products. The improvement of quality means more security to the operators. The producer, the processor, and the consumer are all concerned with increasing the ease and accuracy of grading, as through more accurate selection of premium grades, each can benefit.

Many people, not directly connected with the industry, have expressed the desire for data on the job performed by the workers on inspection work in the processing plants. These people include agricultural workers with the Government and with the colleges and industrial concerns that are making equipment for the processing plants. In some cases, they need efficiency and cost figures to determine the value of their improvements.

The fruit industry in Michigan is mainly concentrated in the counties that border Lake Michigan in the lower peninsula. There is also some fruit grown in the thumb region and in the south central and southwestern regions. The vegetable industry is more widespread. It includes the fruit belt and is more concentrated around the larger cities in the lower peninsula.

The fruit industry in Michigan represents ten percent and the vegetable industry fourteen percent of the state's agricultural income. Together they represent about one quarter of the state's total agricultural income. Michigan ranks fourth among the states in vegetable sales and fifth in fruit sales.[15]

PREVIOUS STUDIES

To date very little work has been done along the line of research for the improvement of lighting conditions in the canneries. The National Canners Association set up a research fellowship in 1947 for studies on the problem of color detection in the different grades of fruit. White[14], the recipient of the fellowship, conducted the study at Stanford University. Most of White's work was on clingstone peaches (cooked) and maraschino cherries in a laboratory. No work was undertaken in the field at the processing plants. He was attempting to differentiate between the grades, e.g. fancy and commercial, by setting up standards for their colors. He established spectral reflective curves for the cooked clingstone peaches.

White mentions the background and surroundings of the fruit being viewed as being more important for color detection than the illuminant. White has been the only one to date who has directly worked with this problem; his pioneer work in the field has pointed the way for other investigators to follow.

In the printing industry, somewhat different results have been obtained with colored lighting for detecting color differences[7]. Restricted wave-lengths of light or colored lights have been used with success on the night shift for checking colors. The checking process consists of two things:

(a) color matching, to see if colors are uniform and holding somewhat to the desired color, and (b) looking for flaws or defects. A booth is used in which the curtains may be drawn to keep out extraneous light. The lights used in the booth include several fluorescent lights, individually controlled, which include all the colors desired for checking work. White fluorescent lights are used also.

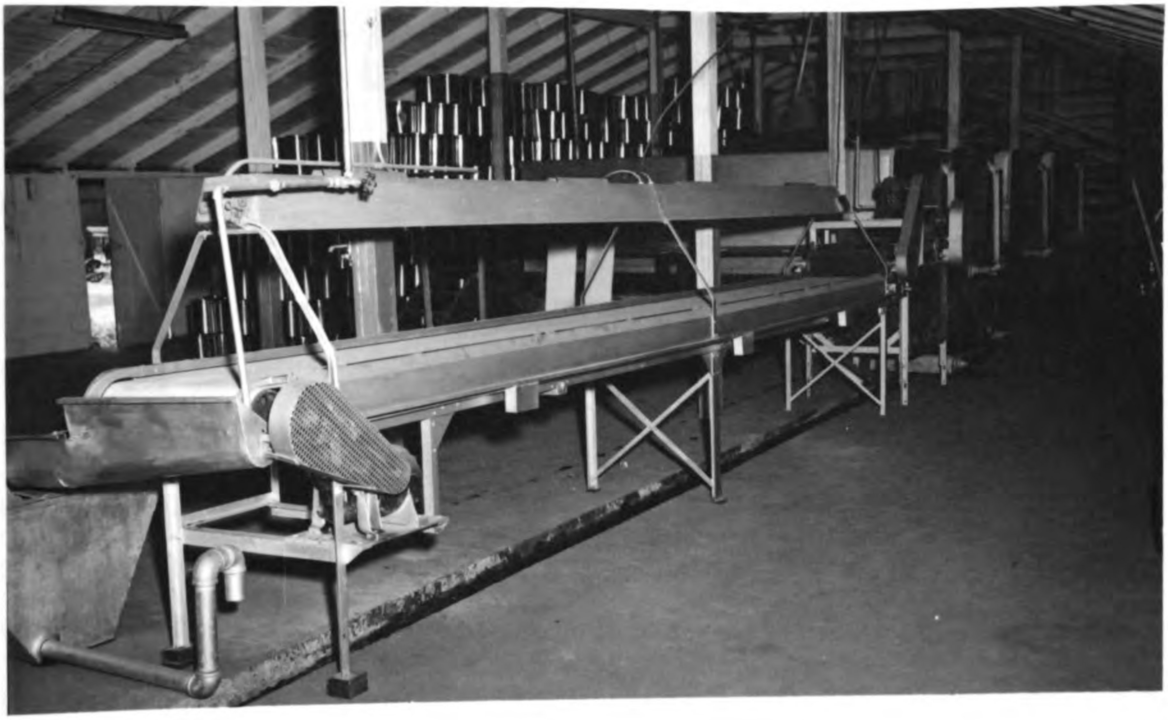
The following table summarizes the individual lights used to check specific colors.

TABLE I

Colored Lights Used to Check Colors in Printing Industry[7]

To check yellow	use blue lights
To check red	use green lights
To check black	use white or amber lights
To check blue	use red lights
To check brown	use green or blue lights
To check green	use red or blue lights

Figure 1, illustrates the set up in a typical small processing plant for lighting. Fluorescent lights are placed directly over the conveyor belts where the sorting out of defective fruit takes place. Other lights either of the filament type or fluorescent type are located near the ceiling for supplementary lighting in the room.



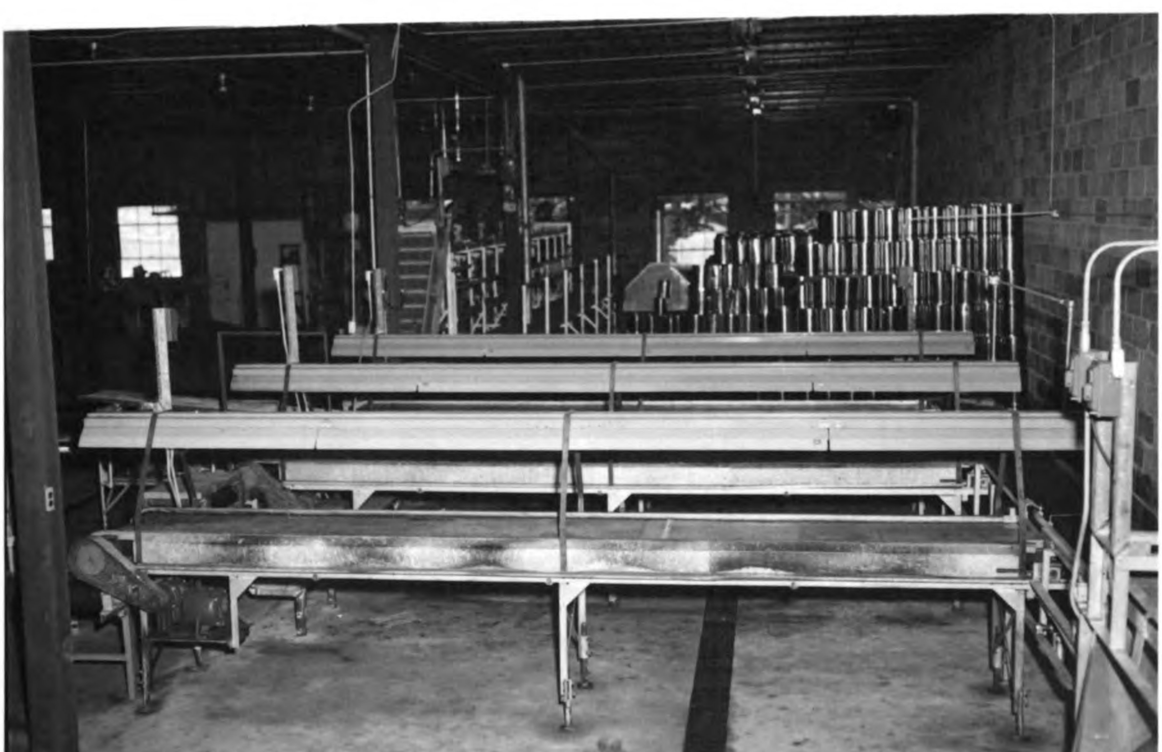


FIGURE 1.

Two views of inspection conveyor belts in small processing plants. Here cherries are processed and placed in 30 pound containers for freezing.

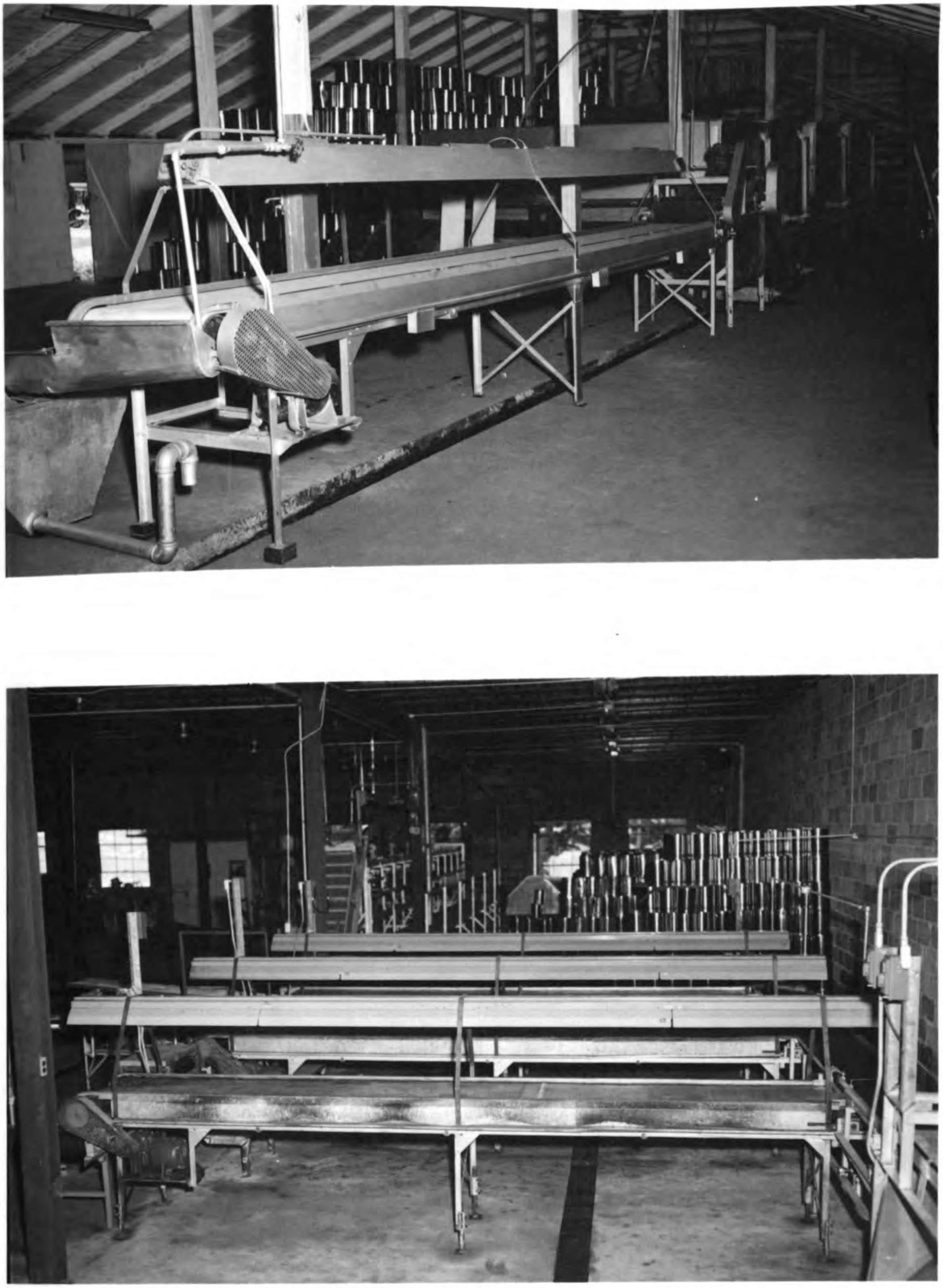


FIGURE 1.

Two views of inspection conveyor belts in small processing plants. Here cherries are processed and placed in 30 pound containers for freezing.

REVIEW OF LITERATURE ON COLOR AND LIGHTING

It is necessary for purposes of clarification to present a definition of the words, light and color. The actual scientific definition of light is the aspect of radiant energy of which a human observer is aware through the visual sensations which rise from the stimulation of the retina of the eye[13]. By definition all light is visible. For this reason, the word visible is superfluous in the common expression, visible light. By the same reasoning, what is not visible cannot be light; hence, we speak of "ultra-violet radiation" rather than "ultra-violet light." Light, which we commonly refer to as white, is actually the combination of all colors of the spectrum.

Color[5] is visual experience depending upon the spectral composition of all the light reaching the retina of the eye and upon its temporal and spatial distribution.

In one meaning of the word color, all light sources are colored. In another meaning of the word, all are colored, except white and achromatic sources. This is one point that has never been clearly defined by the society that set up standards for colors, the Optical Society of America's Council on Color.

The modes of appearance of colors have the following eleven attributes:

1. Brightness
2. Hue
3. Saturation
4. Size
5. Shape
6. Location
7. Flicker
8. Sparkle
9. Transparency
10. Glossiness
11. Luster

For purposes of this study, the first three, brightness, hue and saturation, are of primary consideration.

The perception of color[6] is dependent upon: (a) the source of the light, (b) a modifier, and (c) the eye (brain). From these factors, a formula may be written -

$$C = S\ M\ E$$

It will be noted that, changing either the source, the modifier or the response of the eye, will change the color appearance. Changing the source or illuminant will change the color perceived, even though the material and eye remain constant. If one changes the spectral reflectance characteristics of a material, e.g. from red paint to blue paint, its color appearance will change. Also, if the eye itself changes, due to adaptation to surrounding conditons, the color appearance will change. It is possible to simultaneously change both the source of the light and the material so that the color perceived will remain constant. Since change in state of any one of the three factors will change the color perceived, then obviously this must be considered in any color problem.

Perception of color touches on five fields of investigation; namely, anatomy, physiology, physics, psychology and psychophysics[5,9].

That part of color perception that comes under physics falls in the following categories: (a) the physical spectral distribution of energy in the light and spectral reflectance properties of the objects being viewed; (b) other physical attributes,as the physical make-up of the viewing surface; and (c) attributes of light source as the direction of light.

In the realm of anatomy and physiology are: (a) the parts of the eye consisting of the cornea, iris, lens, retina, optic nerve, optic tract and others; (b) the processes of the retina in converting radiant energy to nerve impulses; and (c) the transfer of nerve impulses to the brain.

In the fields of psychophysics and psychology are: (a) the effects on perceived colors of the arrangement of individual items in the field of view; (b) mental attitudes of the observer at times of viewing; (c) previous exposure to visual stimuli of the observer; and (d) previous training of the observer in the field of color detection.

The retina of the eye[20], which may be related to the film in the camera, is made up of various layers of cells composed of rods and cones. The cones are effective in daytime, when the eye is adapted to light, and produce sensations of hue and brightness. The rods, effective only at night, produce sensations of brightness, e.g. black, white and gray, but no hues. There are seven million cones concentrated in the human retina at its center, the fovea. The fovea has cones, and here images are seen the clearest. Since this is the part of the eye that sees colors and functions only under sufficient illumination, it is the part of the eye that will be of concern in this problem. It is of interest to note that as the vision perceived by the eye is being transferred from the cones to the rods, or the eye is becoming adapted to darkness, sensitivity to red is lost first and to blue and green last. This is known as the Purkinje Effect[5] and accounts for the way the hues at the short-wave end of the spectrum, the blues and violets, seem to become brighter as night falls. The rods function at levels of illumination of .001 foot-candles and below. The cones function at levels of illumination of .01 foot-candles and above. Between .001 and .01 foot-candles, both rods and cones function and this region is known as the Purkinje region.

Associated with the rods and cones is a photo-chemical substance. That substance associated with the rods is known as rhodopsin and that with the cones is iodopsin[19]. These photo-chemical substances convert radiant energy to small electrical impulses in the nerve fibers. It is these impulses, derived from the interaction of the radiant energy with the photo-chemical substances, that travel to the brain to produce visual sensations.

No one knows as yet just how the eye sees color. So far, investigations have isolated only one type of receptor, the cone, and its chemical substance, iodopsin. From knowledge of color in general, it is fairly well concluded that the eye must have at least three color receptors, if not more[13]. These three light sensitive elements of the retina are connected through a complicated nerve network with the brain. The three systems may include one for blue light, one for red and another for green light. Scientists believe that the three systems overlap. It is not surprising with millions of nerve fibers connecting the brain with the eye that most people slightly vary in their vision.

The human eye is considered to adapt itself according to Evans[5] in the following ways: (a) local adaptation, (b) lateral adaptation, and (c) general adaptation. They are considered to come about by separate mechanisms since the adaptions differ both in kind and degree. Evans states that three general observer attitudes have been separated:

1. Toward the mental image
2. Toward the light quality
3. Toward the properties of the object

and that these three attitudes can each lead to three types of results:

1. Knowledge
2. Illusion
3. Hallucination

Judgments of an individual about color under varying conditions are frequently incorrect, just as it is for intensity and the inaccuracy may arise from the effects desired by the individual. This has been investigated by Helson[10] and Judd[12]. When the observer views a scene, his adaptation reaches extreme proportions and strange effects may take place. For example, in using a red light to illuminate a room, the sensitivities of the red receptor, and to some extent the blue, would be depressed in comparison with the green. Also the eye appears to lose all possibility of seeing black. All the areas that would ordinarily appear black now appear as either green or neutral. It is thought that there is some "cross talk" between the nerve cables carrying the impulses to the brain, e.g. current passing through the nerves affect adjacent nerves through which no current is passing. This cross talk must be taken into account in obtaining a desired color result.

The following summarized results from Helson and Jeffers[11] work are particularly applicable to this work on color.

1. Color samples above the adaptation reflectance take the hue of the illuminant color; samples below it take the hue complementary to illuminant hue; while samples near the adaptation reflectance are either achromatic or greatly reduced in saturation.

2. To a first approximation, the chromatic adaptation reflectance can be obtained by taking weighted geometric average of the hues and the saturation of the objects in the visual field.

3. Selective samples have greater constancy in chromatic illuminants than non-selective. Non-selective samples tend to be tinged with the hue of the illuminant or its complementary. Selective samples tend to keep their daylight hue if their dominant wave length is present.

4. Selective samples under a strong non-homogeneous chromatic illuminant tend to take the hue that it had in daylight and the hue resulting from the change in color from homogeneous illuminants.

5. Illuminants having hue characteristics of the ends of the spectrum give the greatest chromatic effects and after-images.

Helson[10] and Judd[12] have worked on shifts in hue and saturation when viewed in complex surroundings. They have expressed their results on the I.C.I. diagram[9]. They have found that by shifting the achromatic point to a new point that predictions can be made as to the hue and saturation of any sample. Formulas for this have been derived by Judd[13] and through extensive testing they have been found to be between 73 and 84 percent accurate. The inaccuracies are due mainly to the small number of devisions Judd used and to observer variation.

Helson and Judd have made it apparent that the perceived color of an object is not determined largely by the spectral composition, but by the reflectance of all the objects in the field of view and their relation to the lightness and chromaticity of the central objects being viewed.

There are no data available in literature on what the variation of color differences are with changes in background and surroundings. Certainly this is a very important point and it is unfortunate that such information is not available.

It might be supposed that changes from daylight to night light could be calculated from the properties of the illuminants in question and the properties of the standard observer and those of the reflecting samples. It is very easy to show that this is a false hope, for if we apply only mathematics, we get a different color from the one we perceive. The reason for this anomaly lies in the changed state of adaption of the eye, in sense of the changes involved in the theories of color-constancy or color transformation of Helson[10] and Judd[12].

According to the Kodak Color Handbook[13], a color, judged with comparison to other colors or to its surroundings, never appears to contain gray or black, for we do not compare this color with brighter surroundings. Such an effect may be obtained by looking out toward the light from some distance inside a tunnel or to a lesser degree through a telescope. Thus, in an isolated field, we can never see colors such as brown, olive drab, or navy blue, considered as "grayed-down colors," instead we see orange-red, greenish-yellow and blue, respectively. The amount of gray we see in colors under various viewing conditions is of fundamental importance.

Another concept of color that is important for this problem is the shifting of the achromatic point on the I.C.I. diagram[9] according to the intensity or intensities of lights in consideration. We are all familiar that an incandescent light may appear yellow in daylight and white at night. This same principle will be found to be true to all artificial lights, according to their intensity.

Nickerson[16] has devised a light that is similar to North light. North light is natural daylight from the north. It is considered good for day-time inspection work because it varies the least in intensity. The artificial light used by Nickerson to substitute for North light was a 3000° K illuminant, plus a filter, that gave a combined color temperature of 7400° K. It has been used with satisfactory results in cotton inspection work.

PART II

PRELIMINARY INVESTIGATION OF ILLUMINATION FOR COLOR DIFFERENCES

The work on the importance of illuminants in color problems by Linsday[7] and Nickerson[16] indicates that a relationship exists between color differences and spectral distribution of energy and that the illuminant to use for any given task varies with the spectral reflectance curves of the product. It was decided to use the methods prescribed by Linsday in the printing industry to discover if they could be of any value to the canning industry.

Commercial light sources were obtained in the following types and colors. Fluorescent light sources in blue, gold, red, pink, green and black light. Gelatin filters were obtained from Roscoe Laboratories[18] in Brooklyn to go with the corresponding colored light to give a higher purity of color than could be obtained by the colored light source alone; the only deviation from the corresponding color consisted of a red filter being used on a pink light because the red light had a low efficiency of only 6 lumens per watt. The filters were secured to the lights by means of scotch tape. These lights were tried out individually in a room free from all extraneous light with walls having a very low reflectance factor. The fruit and vegetables used experimentally were: apples, plums, peaches, strawberries, cherries, tomatoes, green beans, and blueberries. First, the lights were used without filters and then, after all possible combinations of light and background were used, the filters were added and further tests made. (Table II.)

The products used in test work were either obtained from the growers or the canners. It was determined very early in the experimental work that the color of fruit changes very rapidly after being picked, if not held under the right conditions. The product may be held at the cannery up to 24 hours before being processed, during which time they are soaked in cool water. It was, therefore, determined that in order to get good results in this type of work that the laboratory work at Michigan State College would be held to a minimum and the bulk of it would be done in the field.

There was also another good reason for doing most of the experimental work on lights at the canneries. The men who are best qualified to say if the lights being tested show up the defects better or not were located there. It will be they who will decide the true value of any new improvements brought out by this work.

The seeing task on the sorting lines is considered the most critical of all the lighting problems in the canneries. It was on the sorting lines that the objective of this problem was pointed out with the purpose of improving the ability to detect defects in fruit. (Figure 2 and Figure 3).

TABLE II

Combinations of Colored Light and Backgrounds Used in Preliminary Work on Cherries, Apples, Peaches and Tomatoes

Light Source	BACKGROUND COLOR						
	White	Black	Tan	Brown	Pink	Red	Green
White	x	x	x	x	x	x	x
Daylight	x	x	x	x	x	x	x
Red	x	x	x	x	x	x	x
Pink	x	x	x	x	x	x	x
Green	x	x	x	x	x	x	x
Blue	x	x	x	x	x	x	x
Gold	x	x	x	x	x	x	x

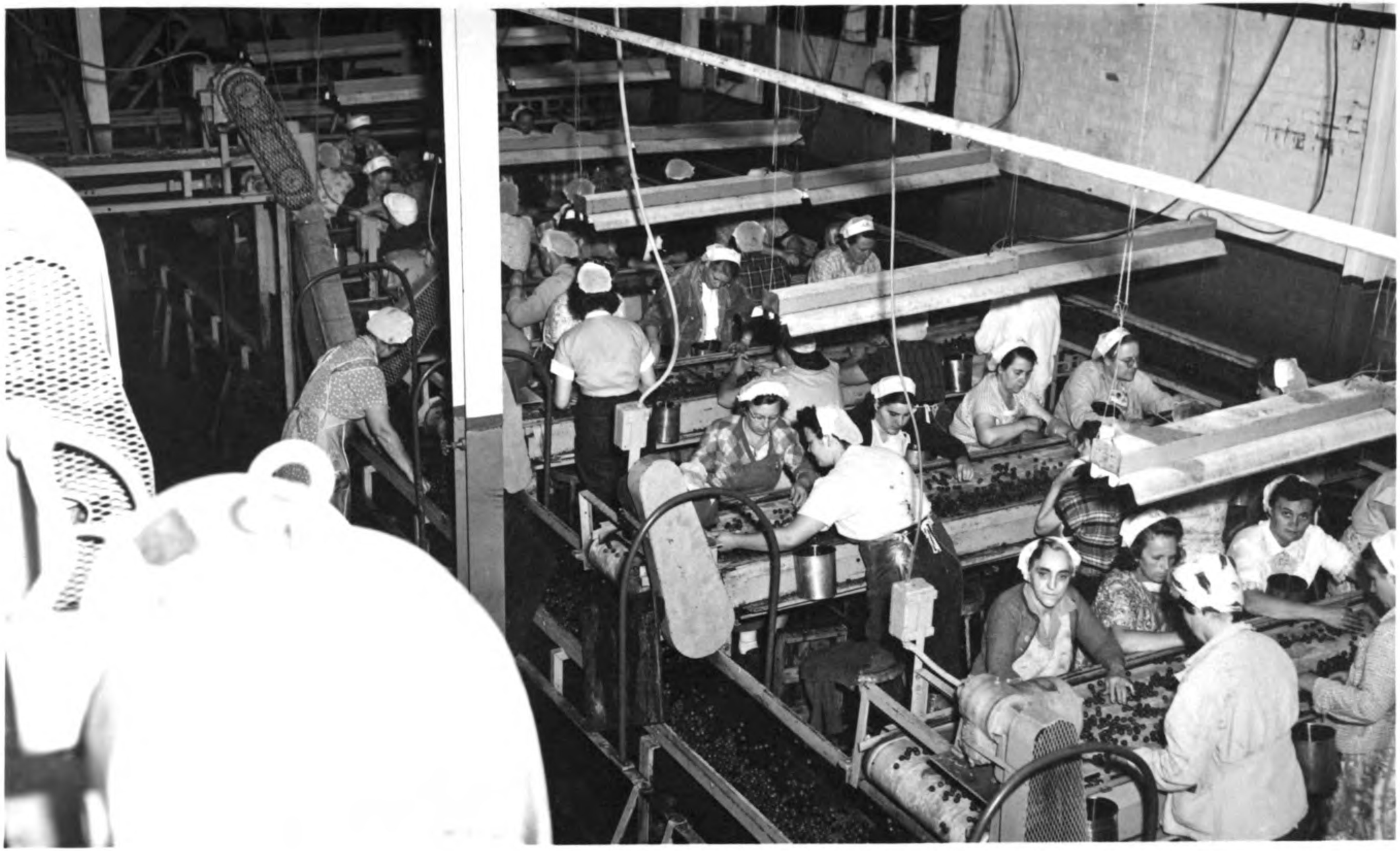


FIGURE 2.

View of night shift workers on the sorting lines in a large cherry processing plant.

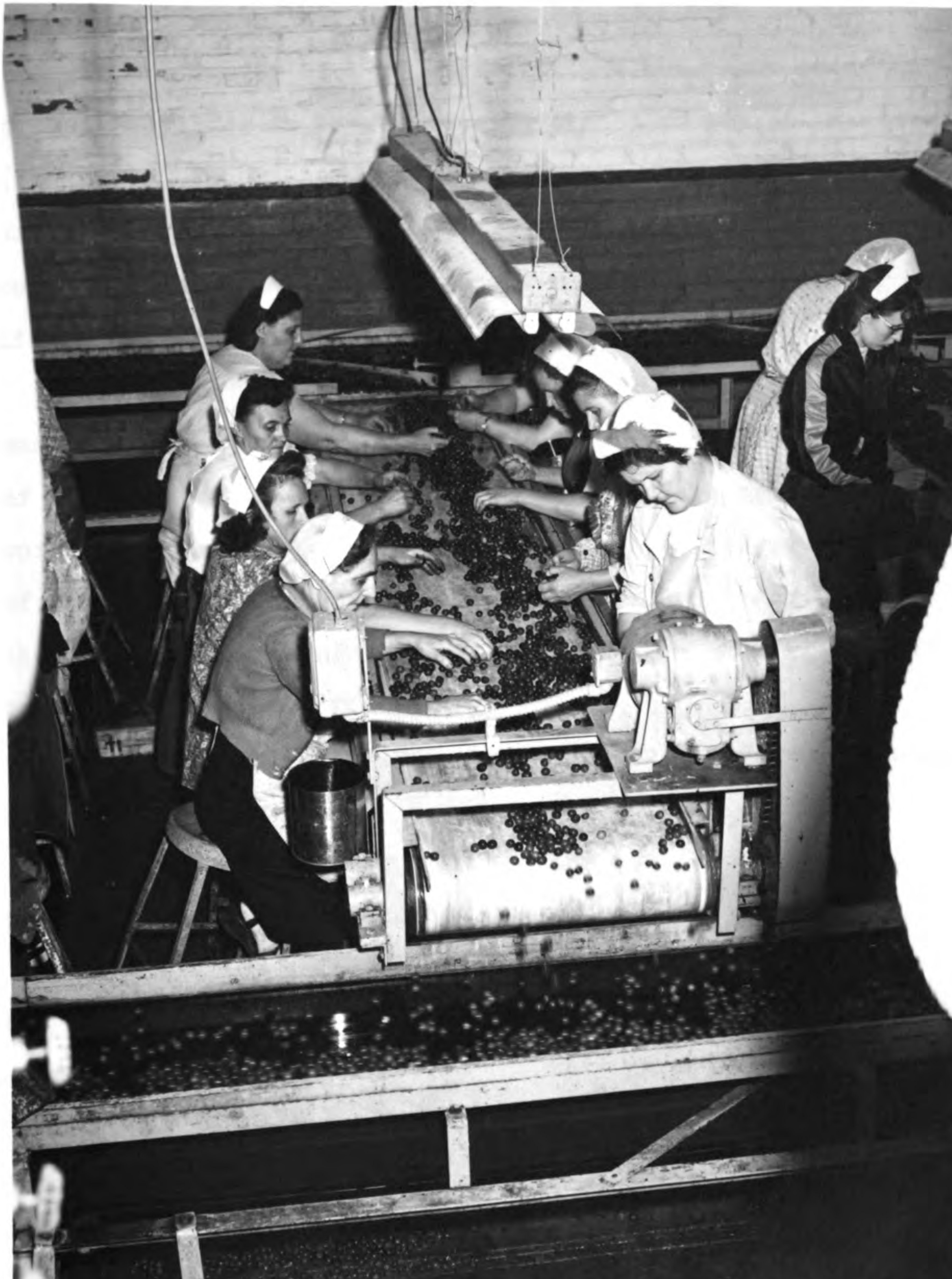


FIGURE 3.

Close-up of an inspection line ... Workers must be able to pick off cull cherries from a belt moving at the speed of 30 feet per minute.

In the summer of 1950, observations were made on actual production lines in the processing plants at Ida on tomatoes; (Figure 4) Fennville, Onekema and Traverse City on cherries; and at Scottville on green beans. Plant managers, quality control men and federal inspectors cooperated in checking the lights under test.

The predominant amount of work was done on cherries. It was determined from the initial phase of the project that some of the same principles found to be true on one product still worked in a similar way on other products. Therefore, most of the data and conclusions in this paper are given for cherries only, although some mention will be made of special problems with other products.

From this initial work, the following points were established:

1. The brightness of red cherries and red tomatoes appear highest under red light and much lower under other colors.

2. The brown defects of red cherries and tomatoes appear brightest under a light source with predominate blue spectral characteristics.

3. The greatest brightness contrast in cherries is obtained with a combination of a red filter over a pink light.

4. The most critical seeing of the surface of red cherries and tomatoes is done with a light source with predominant red spectral characteristics.

5. With any equal or nearly equal mixture of saturated

FIGURE 4

The tomatoes in this kodachrome picture are being used for tomato puree. Workers are behind the observer on the same belt. Note the use of a black belt.

lights and incandescent and white fluorescent lights, the eye shifts the achromatic point on the I.C.I. chart so that the end effect is that of a white light.

6. The effect of colored lights in general is to reduce all colors to a monotone, essentially black, white or gray and with certain selective reflectances of the product to increase brightness difference.

The efficiency of all colored lights with the exception of the green is less efficient than standard white. Standard white has an efficiency of 60-65 lumens per watt. Green has an efficiency of 100 lumens per watt. Pink, gold and blue have efficiencies of 25 to 30 lumens per watt; and red, 6 lumens per watt.

The daylight fluorescent 6500° K. has a great deal of blue in its spectral distribution. It gives 55 lumens per watt for general use in viewing cherries and tomatoes. Daylight fluorescent, a harsh light, is not considered easy on the eyes.

Saturated light sources in color may be combined to produce almost any effect desired. Five red light sources and one green source will produce a light very similar to incandescent light[1].

A proportionate part of the effect of a saturated light source is lost if its light is mixed with light from another source.

It is well at this point to consider some differences between the canning industry and the printing industry. Perhaps the chief difference between the printing industry and the canning industry is the difference in the duration of their respective inspection work. In the canning plants, inspection consists of a continuous operation by several individuals assigned to this type of work. Although the printing industry has used colored lighting with success, it is readily apparent that they have different problems than the canning industry in regard to inspection work. It must be added also that at this date the use of colored lighting in the printing industry has not been widely accepted; although there are many printing plants around Cleveland that use colored lighting advantageously, the author found only one printing plant in Michigan that makes use of colored lighting[2]. Apparently the main reason is that colored lighting presents such a radical change that it hasn't been accepted by the industry as yet.

THE EFFICIENCY OF SORTERS UNDER ARTIFICIAL LIGHTS

In the summer of 1951, the work of the previous season was continued. After running tests and making observations of various lights and conditions, it was decided to try out some of these lights under actual working conditions and to test the reaction of the workers to them. Three plants were selected. They will be hereafter referred to as plants A, B and C.

Two of the plants had a higher than normal percentage of culls as the result of severe wind storms in their areas during the first weeks of the season. Because of this, they were especially interested in finding new methods to increase their efficiency in culling out this increased volume of wind-damaged fruit. They lowered their requirements for the grades of fruit they purchased from the growers by 5% and hoped to be able to pick out enough defective cherries to increase the grade that they would sell commercially.

Plant A hires approximately 100 inspectors who work on two shifts. These shifts cover up to 22 hours in a 24 hour day. For purposes of this problem, in order to minimize variables, the number of workers per pitter in each plant will be considered. The reason for this is that the capacity of one pitter is standard everywhere at about a ton an hour. The number of workers per pitter will be an indication of the volume of produce each worker has to handle and will have a direct bearing on the total efficiency of the plant. (Table III).

TABLE III

Number of Workers per Pitter Machine at Two Large Plants and a Small Plant in Southern Michigan (Capacity of one Pitter - One Ton of Cherries per Hour)

	Workers per Pitter	Total Number Pitter Machines
Plant A	4	13
Plant B	6	25
Plant C	16	1

From the preliminary work on lights, there were three colored lights that were thought best to try out on cherries. These included the following color types of fluorescent lighting:

1. Green
2. Blue
3. Gold

At a later date, a fourth was added; red.

Green, as a color of lighting, was eliminated on the first test on a processing line. It gave a dark appearance to the cherries and caused an undesirable sheen on the fruit. Gold was also eliminated because it did not noticeably show up all the defects.

Plant A installed blue fluorescent lights over one of their inspection lines. They illuminated six lines with one white fluorescent and the remainder with incandescent type lighting.

Plant B, with the advent of the first week of the 1951 season, installed blue fluorescent lights on all their lines. This presented a very good place to study blue fluorescent lights for grading work because in a plant using all one type of lighting, there is no interference with lights from adjacent tables that may cause non-uniformities in the room.

Plant C had been using blue coated incandescent type lighting for several years.

The method used to check the efficiency of the workers under the various lights was to check the fruit before and after it passed over the inspection table. A definite area on the belt around the metal clasps was noted and timed so that samples could be taken from this area of approximately the same type of fruit. The samples contained about 100 cherries each. The samples were comparable in size and the same methods of checking them were used, as used by the USDA in their official inspection work. A second method of checking the efficiency of the workers consisted of tabulating the actual weight of the defective fruit picked off the belt. This latter method was deemed more useful in comparing the same workers under different lighting conditions, with at least two test groups working at the same time. The procedure was to have at least two lines set up with two different types of lighting under comparison. After a definite time period, the workers were switched between the two tables. For a larger time period, the total weight of the throw-outs of the two tables were compared. The cherries being run on these tables were taken from the same batch. This method of testing was more readily accepted by the plant operators because of its simplicity.

From the information gathered at Plant A, a calculation was made of the total efficiency of the plant in culling work. It was calculated that, of the total percentage of bad cherries found on a day's run (approximately 22 hours), the sorters had removed 40% of the total defective cherries. To put these figures in other terms, for this particular day's run, there was an average of 15% defective cherries in the total amount brought in from the growers. After the workers had sorted out two-fifths of the bad cherries, there still remained on the average 9% defective cherries to be canned, enough to pass the minimum standards for C grade cherries.

Plant B for a similar calculation averaged 29% for night work during the test period. Plant C, during day-time operation and with 16 workers per pitter, removed 55% of the total defective cherries. Three other plants that were checked fall in the range of 30 to 50%. All of the above plants use artificial lights continucusly for the inspection tables. The amount of daylight falling on the inspection belts is very low, less the 25% of the total light. In all cases, the workers were found by the author to be less efficient on night work. Either the total amount of cherries being processed had to be smaller, or less defective cherries were picked out. The number of workers per pitter influenced the efficiency figures. The higher figures 50 and 55% were obtained from plants using a larger crew per table than the average plant on daytime operation. (Figures 5 and 6).

The processing plants use three different colors for their inspection conveyor belts, black, white or tan. Plants A, B and C use white belts. Generally white belts for cherry sorting are preferred. However, later in the project, it was shown that black belts may be preferred with a bright colored light because of their low reflectance factor. Tan belts are made in place of white belts as the result of a shortage of critical materials in wartime. They are not as well liked. The three different belts are illustrated in Figures 4, 5 and 6.

Tests run at Plant A on various lights are summarized in Table IV. The figures given in the table indicate the percentage of defective cherries remaining after being sorted by the workers. The cherries used during the test periods were from the same batch. They contained approximately 15 percent bad cherries before being sorted. The figures indicate that the workers under blue fluorescent lights only, sorted the highest quality cherries. When blue lights and white lights

FIGURE 5.

Cherry sorting on an extra long tan belt with 12 workers. Most plants use 8 workers per line. White fluorescent lights are being used.

FIGURE 6.

Another view of the same plant as shown in Figure 5. Cherries being sorted on a white belt. Fluorescent tubes (white) are of the 100 watt size.

TABLE IV

Percent of Defective Cherries Remaining After Being Sorted Under Various Types of Lighting at Plant A

Light Source	Average Percentage of Cherries Remaining as Defective After Sorting
Blue and White Fluorescent	10
Blue Fluorescent	6.37
White Filament	8.9
White Filament	10.2
White Filament	10.5
White Filament	8.8
White Filament	12.5

were used together, the end result was no better than cherries sorted from the filament lighted tables.

The blue fluorescent lights installed at Plant B were found to give less light (about 40%) than white fluorescent lights mounted in the same fixtures. (Table V). The blue fluorescent lights made all the cherries look slightly darker. (Figure 7). Blue light increases the brightness of the brown spots making them easier to detect. The black spots on the darker cherries are found to be more difficult to see. The best testimony that can be given for blue lights is that the workers say that blue lights are easier than white lights for the eyes on night work.

Preliminary testing on a weight basis was first done at Plant B on blue and white fluorescent lighting. Figures for these tests showing the total weight of defective fruit thrown out for each test period are given for each type of lighting in Table VI. These figures indicate a slight edge for blue fluorescent lighting over white fluorescent lighting.

The above work indicates that between 8 and 11% of inferior quality fruit would be included in the canned cherries. These cherries would be classified as Grade C.

TABLE V

Percent of Defective Cherries
Remaining on Five Lines at
Plant B Under Blue Lights at Night

Line	Percentage of Cull Cherries Missed by Sorters
1	11.9
2	5.3
3	7.6
4	6.59
5	3.9

Representative Figures for the Percent of Cull Cherries Remaining After Being Sorted Under Blue Fluorescent and White Fluorescent Types of Lighting at Plant B, for the Same Workers and Batch of Cherries

Blue	8.1%
White	9.5%

FIGURE 7.

Two time exposure studies of lighting on Cherries comparing blue fluorescent lighting (top) to daylight fluorescent lighting (bottom). The light intensity is the same in both cases.

TABLE VI

Total Weight of Defective Cherries Removed From the Same Batch of Cherries for Five Tests at Plant B

Test No.	Blue	White
1	79 Pounds	74 Pounds
2	67 "	66 "
3	75 "	71 "
4	61 "	63 "
5	81.5 "	78 "

RED FLUORESCENT LIGHTING FOR CHERRY SORTING

The use of red lights for culling cherries is a very radical change in lighting. At the first thought of using red light, it has been rejected in many people's minds. In the preliminary experimentation, it was shown that the red light increased the brightness of the cherry, making it easier to detect the major culls that should be removed before the product is canned.

After checking with many people in the field on its use, it was decided to try out red lights under working conditions. No comparisons between blue and red fluorescent types of lighting were attempted; only between red and white.

Because of the low efficiency of red light, pink fluorescent lights with a light red filter attached were substituted. The pink light is about six times more efficient than the red. However, it was found that its effectiveness in increasing the lightness of the cherry and showing up the defects was dependent upon the attached light red filter. The pink light alone is considered a bastard type of light containing other colors, such as blue and green. As far as the people who work on the belt are concerned, it does show up the defects that they desire to pick out very well. The minor defects that they want to pass because they will cook out are found to be considerably less noticeable. (Figure 8).

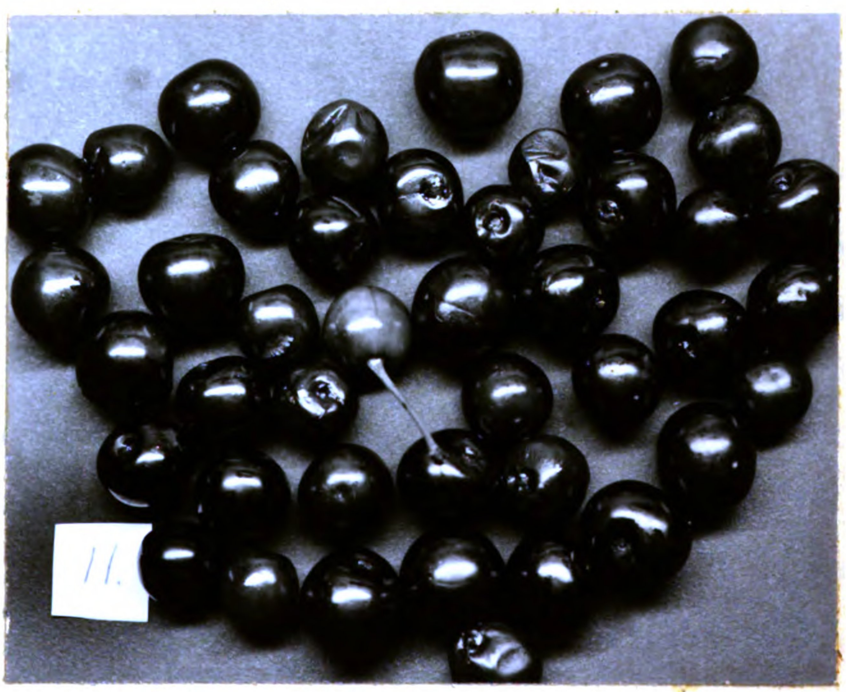


FIGURE 8.

The top picture illustrates the effects of pink lights on cherries for increasing the contrast between the defects and the body of the cherry. Bottom picture shows the same sample under blue fluorescent lighting. Backgrounds are black.

The pink light was tried out first among other lights at Plant C. (Figure 9). Later, a greater number of tests were taken at a new location, Plant D, comparing pink light to white light. The method of checking on the pink light was to take the actual weight in pounds of defective cherries removed from each picking table under test; one of the methods used in working with the blue lights. The lights under test remained in place and the workers were switched around during the test. The same batch of cherries were used for the tables being tested.

Plant D used four workers per pitter. The results of ten tests on pink lights at Plants C and D are presented in Table VII. The test periods were for two hours each.

The light intensity was varied in these tests. In the case of the first column given, the light intensity for the white fluorescent lights was approximately twice that of the pink lights. When the light intensity for both types of lights was increased equally, the efficiency increased proportionally up to a certain point. At this point, the brightness contrast was too great in the case of pink lights, resulting in a drop in efficiency. The light intensity was varied from 10 foot-candles to 80 foot-candles. It may be assumed from these tests that the optimum increase in efficiency was in the range of 50 to 60 foot-candles.

Through repeated use of pink lights, the optimum condition under which they will perform best are noted:

FIGURE 9.

Views of Cherries exposed to pink lighting on a black belt on an actual processing line.

TABLE VII

Total Weights of Defective Cherries Removed by the Same Number of Workers Under Pink and White Fluorescent Lights at Plants C and D

Lights	Total Lbs. of Defective Cherries Picked Out									
Pink	85	70	107	133	116	137	145	154	147	134
White	81	41	74	82	69	74	77	83	81	88
% Difference	5%	70.8%	44.7%	62%	63.5%	85%	88.3%	85.4%	81.5%	59%
Foot-Candles		15	30	30	30	55	55	55	55	70

1. The efficiency of pink lights is only about 50% of that of white lights; therefore, in order to get the same amount of intensity over the tables, one of two methods of mounting is required. Method one - decrease the mounting height of the fixtures above the table so that the intensity of light may be increased on the belt until it is equal to that of white light. Method two - keep the same height as the white lights, but double the number of tubes per fixture.

2. Pink light should be the predominate light on the belts. However, it is necessary to have supplementary lighting in the room to avoid harsh shadows and brightness contrasts. The supplementary lighting should be of the white filament type.

3. It requires several hours for workers to make an initial adjustment to new conditions brought about by use of pink lights. A new set of standards as to just what blemishes are to come out have to be arrived at because the appearance of the product is different.

4. On a dry surface, pink light works better with a black background. The dark background doesn't reflect as much light and it is easier on the eyes. With a wet surface, there is less difference between the black or white backgrounds. (Figure 9).

5. The best background for critical viewing of cherries is on a background that approaches the mean of the colors of the body of the fruit. This is illustrated in Figure 10.

FIGURE 10.

Two time exposures of pink lighting on cherries illustrating different backgrounds. The top picture has a white background and the bottom view a red background.

OTHER RELATED PROBLEMS IN GRADING EFFICIENCY

Background color in the seeing of an object is very important. From the work of White[21], it is thought that background color is just as important as the illuminant, if not more so. Therefore, the color of belting in use should be considered.

The plants now use rubber belts or canvas to convey the product by inspectors. These belts travel at a speed of 25 feet per minute. The color of the belts is either black or white. During wartime white belts are not available and the canners must resort to either black or tan belts. Such is the situation today with our Korean conflict going on. A few canneries use metal rollers in place of belts. Rollers are excellent from the standpoint that they turn the product over allowing it to be seen on all sides, but they are difficult to maintain mechanically. Changing the color of the belts for background purposes by means of paints is not feasible because of sanitary reasons.

One solution to the problem is for the manufacturer to incorporate the desired color in the belt. But, here again most canneries do not specialize in one product and it would not be economical for them to change belts for each product.

The ideal would be to have a transparent belt, then the background could be changed under it as will. This would also simplify the problem because at different stations along the belt various desired backgrounds would be used.

Two ways of constructing a transparent belt were investigated.

1. Using a plastic material for belting.
2. Constructing a belt out of slats of plexiglas or lucite.

The plastic material for a belt was ruled out. Present types of plastic are very thin, the thickest size being about one sixteenth of an inch.

The cost of slatted transparent belts as compared with existing belts is shown in Table VIII.

TABLE VIII

Cost of the Major Material for Slotted Transparent Belts as Compared with Conventional Rubber Belting

	Cost Per Sq. Ft.
Rubber	
Semi White	
4 Ply	$ 3.39
6 Ply	4.65
Black	
4 Ply	3.05
6 Ply	4.19
Plexiglas	
¼"	2.31
½"	4.52

From the initial cost standpoint the use of plexiglas compares favorably with rubber. In all other respects, it also compares favorably with rubber, except for maintenance. However, the benefits to be derived from increased efficiency in culling the produce may more than offset the additional cost of maintenance.

Another factor that has some bearing on the detection of culls on the inspection belt has to do with turning the cherry over in its progress along the belt in order that it may be viewed on all sides before leaving the belt. A series of tests were run on identical samples to show the importance of turning the fruit. The results of these tests are presented in Table IX. The figures indicate the number of defects that are visible without any turning. Each sample for the test contained twenty-two cull cherries per one hundred cherries.

Every cherry has a flat side from which it is harder to dislodge than if it is lying in some other position. Usually it is found that the flat side is where the stem has been attached or a defective spot.

The workers do roll the cherries a little as the product passes them on the conveyor belts. How much they turn the product and how effective this is, needs to be investigated by further research.

A few of the processing plants do attempt to turn the product at the halfway point on the inspection belts by mechanical means. These methods include wooden pegs, a trip wire

TABLE IX

Total Percent of Defective Cherries That Were Detected Without Manually Turning Them Over

Samples Contained 22 Percent Cull Cherries

Test	Fresh Cherries	Soaked Six Hrs.	Under Red Light
1	4	6	11
2	9	4	6
3	7	5	8
4	5	8	6
5	5	7	7
6	7	6	6
7	7	6	8
8	8	8	7
9	7	9	8
10	5	5	6
11	2	8	9
12	4	6	8
Average	5.83%	6.5%	7.5%
Percent of Total Defects Visible Without Turning	26%	30%	35%

or a square roller. The wooden pegs are set so that they come down vertically, very close to the belt. They are staggered in two rows the width of the belt. The trip wire method is to string a piano wire across the belt below the center of gravity of the cherries. The latter method, the square roller, is a wooden roller that turns in a direction opposite to the direction the belt is traveling. The disadvantages of the above methods are that the first two will jam up when squashed cherries come along and the latter method may do mechanical damage to the product.

A new method that made use of foam rubber fingers was tested. The foam rubber was cut into strips or fingers which are clamped securely to the underside of the table above the belt. This method was 80 percent effective in turning the cherries. It is very similar to the method of using wooden pegs, but it is better from the standpoint that it doesn't jam up.

Transparent Covers for Lights Over Inspection Tables

Along with belting and methods of turning cherries, it is well to mention a safety precaution in regards to the lights over the tables. The author suggests that the lights over the sorting belts should have protective covers. (Figure 11 and Exhibit I). Accidents have been known to happen in which tubes have been broken when the plant was in operation. This

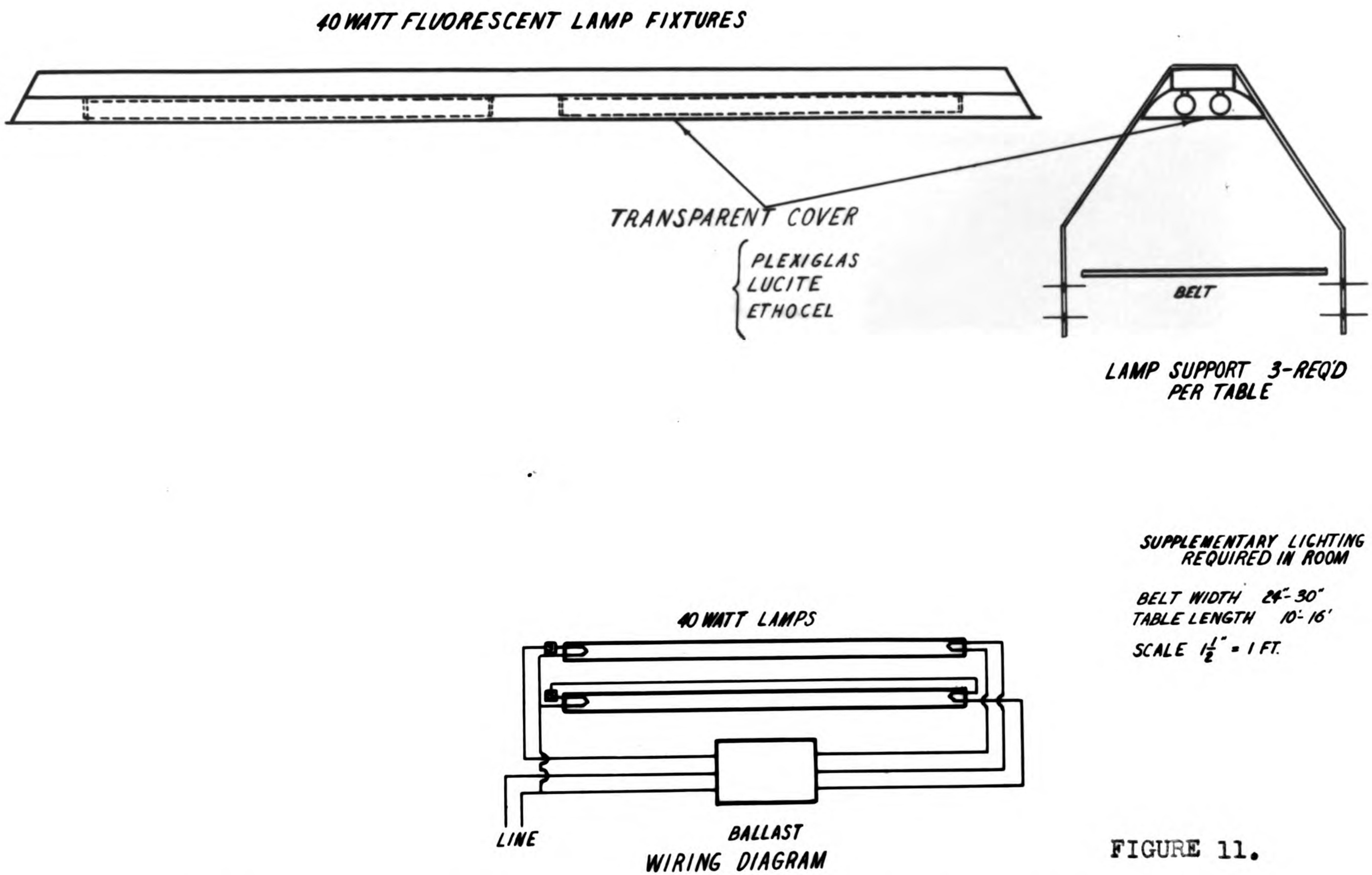


FIGURE 11.

Sketch showing the location of protective covers on fluorescent light fixtures over inspection belts

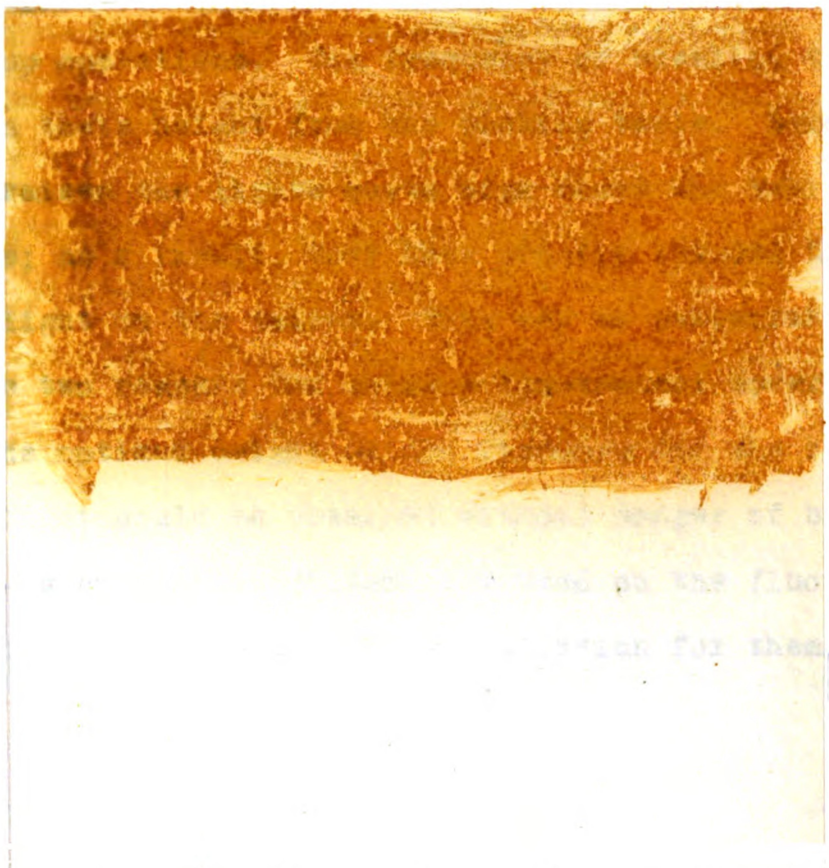
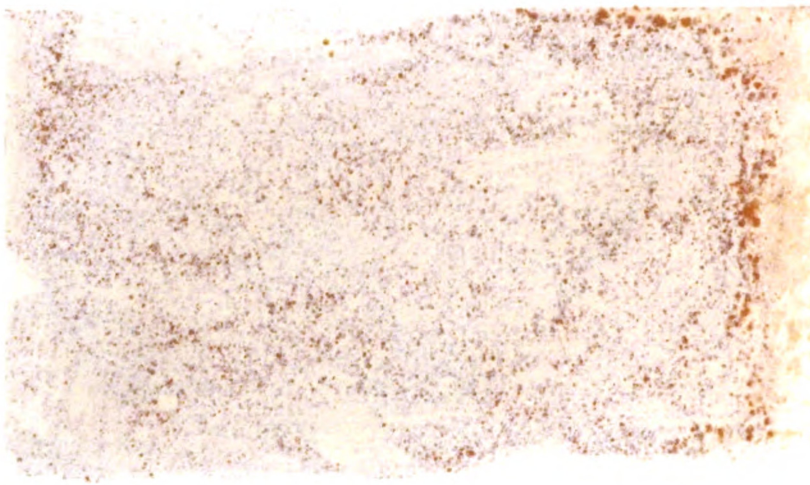


EXHIBIT I

A sample of a clear plastic material that may be used for a transparent cover for lights over sorting tables and belts.



held up production for a matter of hours until the machines could be cleaned and the contaminated product thrown away. More frequently fluorescent tubes have been broken during the cleaning-up operations. The frequency of breaking them is dependent upon their height from the picking table. Some canners have raised the lights quite high above the tables to avoid breakage; as a result, they have greatly reduced the intensity of light on the tables. This may be undesirable.

There are two reasons for using a transparent cover. One is that the optimum height of the fixtures for the best intensity of light could be obtained without danger of breakage; and two - when gelatin filters are used on the fluorescent tubes, the covers would provide protection for them.

SURVEY OF THE CANNING FACTORIES LICENSED IN MICHIGAN

In the spring of 1951, a survey was undertaken of the one hundred and seventy two licensed canneries in Michigan. The purpose of the survey was two-fold. First, it was to ascertain the interest in the lighting problem in the canneries; secondly, the plants that indicated an interest in the project were to be sounded out as a follow-up for experimental work at their plants when they would be in operation.

The main points of the questionnaire were as follows:

1. To find what products were processed by Canning Factories in Michigan.
2. To find to what extent artificial lights were being used.
3. To find what types of lights were used.
4. To find what types of inspection work were done by the plants.
5. To find what types of inspection equipment were used by the plants.
6. To find if professional eye tests were given to inspectors.
7. To find interest or concern of using background color or lights for inspection work.

RESULTS OF THE LIGHTING SURVEY IN MICHIGAN CANNING FACTORIES

1. Major products processed by the Canning Factories:

Cherries	Raspberries
Frozen Foods	Tomatoes
Asparagus	Pickles
Apples	Mixed Vegetables

Other products include:

Peaches, strawberries, dewberries, blueberries, tomato puree, mushrooms, green peas, green and wax beans, lima beans, string beans, kidney beans, carrots, red beets, onions, potatoes, apple juice, blackberries, pickled peaches, crab-apples, apple sauce, squash, succotash, corn, horse-radish, salad dressing, mustard, vinegar, broccoli, grapes, cauliflower, rhubarb, spinach, plums, sauerkraut, and relish of all kinds.

Frozen food products processed by canneries:

Asparagus	Succotash
Peas	Corn
Lima Beans	Cherries
Squash	Peaches
Mixed Vegetables	Strawberries

2. Proportion of total operating time that the plant uses artificial light for inspection work. Number of plants answering this question were 47 or 98% of the 48 plants.

	Number	% of Total
Full time	35	74.5
Half time or less	5	10.6
Misinterpreted question	7	14.9

3. Type of artificial lighting used by the plant for inspection work. All 48 plants answered this question.

	Average watts Per lamp	Number	% of Total
Incandescent	100	10	20.8
Fluorescent (white)	40	18	38.5
Both types		20	42

4. Type of inspection work carried out by plants. The number of plants answering this question were 43 or 90% of the 48 plants.

	Number	% of Total
Grading	3	6
Eliminating defects	15	31
Both of above	25	52

5. Types of equipment used by the plant for inspection work; as stationery table or a moving belt. Number of plants answering this question were 47 or 98% of the 48 plants.

	Number	% of Total
Inspection table	2	4
Conveyor belt	12	25
Both of above	32	67
Other combinations	1	2

5a. Additional comments on particular types of inspection equipment were made by 16 of the 48 plants.

6a. Are professional eye examinations required of inspectors by the plant? All 48 plants answered question.

6b. Relationship of professional eye examinations to elimination of inspectors with seeing deficiencies.
Number of plants indicating their policy totaled 45 plants.

	Number	% of Total
(a) Requiring professional eye tests to inspectors	5	10
(b) Attempting elimination of workers with seeing deficiencies	39	81

7. Interest or concern of the plant operators for a different background color or light other than now in use for sorting and grading work. Plants answering these questions were 43 in number.

	Number	% of Total
Indicated need for some other type of background color or light for the inspection job	34	71
Particular comments made for a background color or a light	24	50
Of those making comments on background color, a white belt was indicated	13	27

The results from the survey indicate the following points:

1. Individuals from the canneries and particularly those in deep-freezing and cold storage work are very interested in improving the seeing task in sorting and grading work.
2. Although only about ten percent of the operators require professional eye tests, eighty-one percent of the operators attempt to eliminate individuals with visual deficiencies.
3. A large majority of the plants use artificial lights most of the time.
4. Many of the operators think a definite background color is needed when sorting and grading work is being done. Many of them think that a white sorting belt is helpful.

From this and other sources, it is understood that the color grading and inspection work in the freezing operations are more critical. This does not take away from the fact that some of the canners are just as interested in grading efficiency as the freezer people. A few of them expressed the desire to have research work done on colored lighting. They also thought that what they had now in the way of lighting was inadequate. The manager[17] of Stokely Foods was especially anxious to have proper lights for beets for which he claims they have been unsuccessful in providing adequate lighting.

The requirement of professional eye tests for graders and sorters is a recent development. It is anticipated in the future more operators will resort to this method to make sure of efficiency on the grading line. From the standpoint of color blindness, eye tests are not important. An article in Fortune magazine,[3] entitled, "Color in Industry," states that only one-half of one percent of adult women are found to be color blind, against eight percent of the male population, though most can distinguish some colors. From the standpoint of visual acuity, it is very important, however, because many people of advancing years need the advantages of refraction. The bulk of grading work done in the canneries is accomplished by middle aged or older women.

Of those questionnaires that indicated use of other types of equipment for conveyors, a few were found to use rollers. Although rollers are more expensive than belts, they are most efficient from the standpoint that the product is repeatedly being turned over while it is being inspected.

EVALUATION OF THE SURVEY

In spite of the fact that the questions were clearly stated, they were in some cases misinterpreted by the recipients. The question on the amount of time that artificial lights were used was misconstrued more than any other question. In the revised questionnaire, the writer would not only make sure that the question was in its clearest form, but that the units that the writer wanted the answer to be in, be stated also.

From reports from other sources, individuals who work with the canneries, and also in actual contact with some of the canning factories, the writer believes the answers to the questions to be a fair representation of the situation in Michigan.

ELECTRIC SORTING OF CHERRIES

The work of maximizing the difference of appearance of the body of the fruit and its defects, points to a method of easier selection by means of an electric eye. Such a machine or electric eye would have to accurately select the good from the bad on a speed basis. There are machines in existence that will sort beans, coffee beans, peanuts, peas, potato chips and lemons. (Figures 12 and 13). They are being manufactured by the Electric Sorting Machine Company of Grand Rapids[4] and are leased to the processing plants throughout the world. The total number of machines in operation numbers around 1300.

The use of an electric sorting machine for cherries presents a complex problem. A machine that will meet the requirements of the job has not been built. The machine would have to simultaneously pick out two extremes; the lighter immature cherries and the darker blemishes on the cherries. Furthermore, careful checking on the reflectances of different cherries seems to indicate that more than one operation would be involved. If run as one batch, the cherries that were light with dark spots and the darker cherries without any spots would overlap in their amount of reflectance, and both good and bad cherries would be rejected. One solution to this problem may be that shown on the flow diagram in Figure 14.

FIGURE 12. View of Electric Sorting Machines working on beans at Lowell.

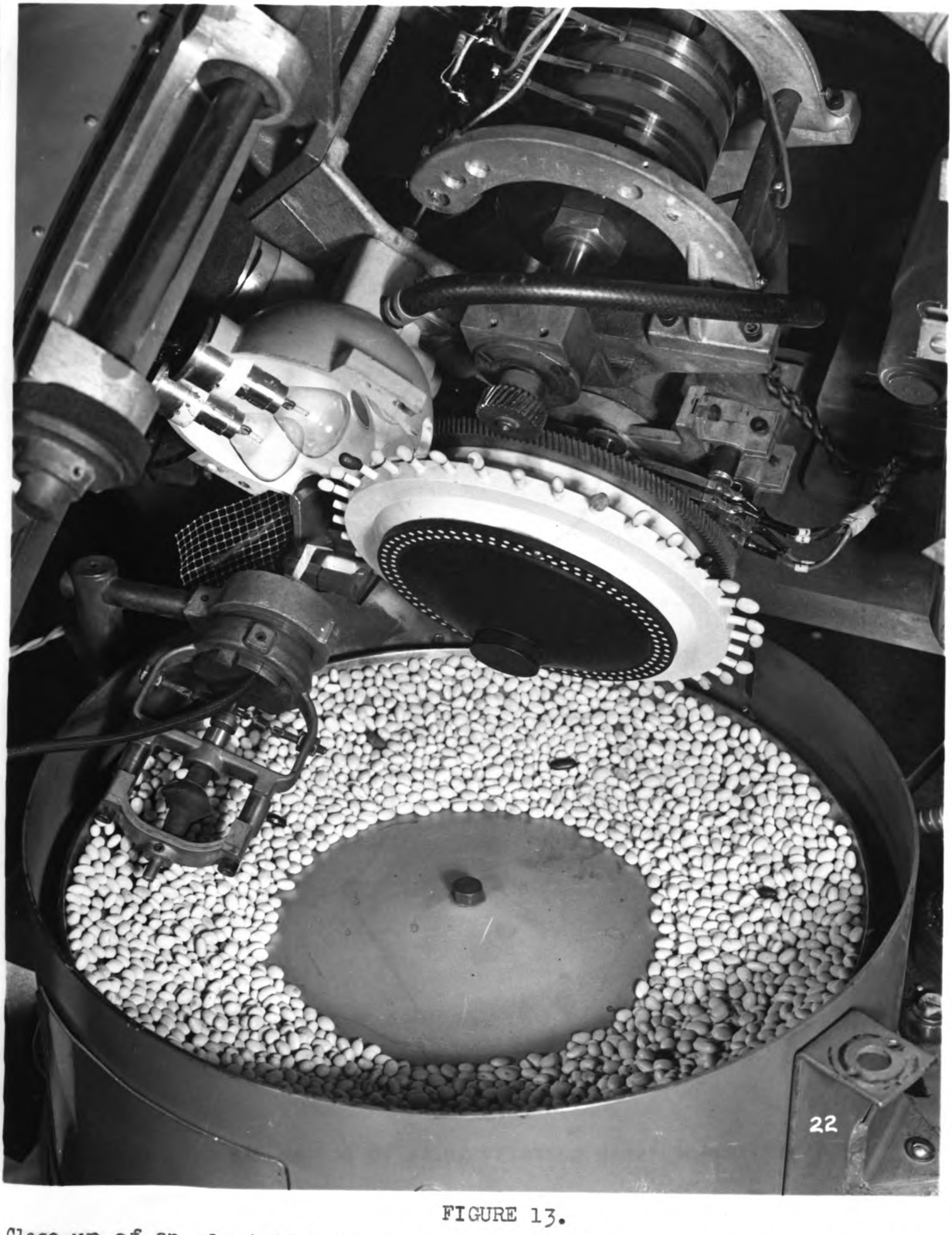


FIGURE 13.

Close-up of an electric sorting machine, rotary type, with the cover removed. Electric eye and [illegible]

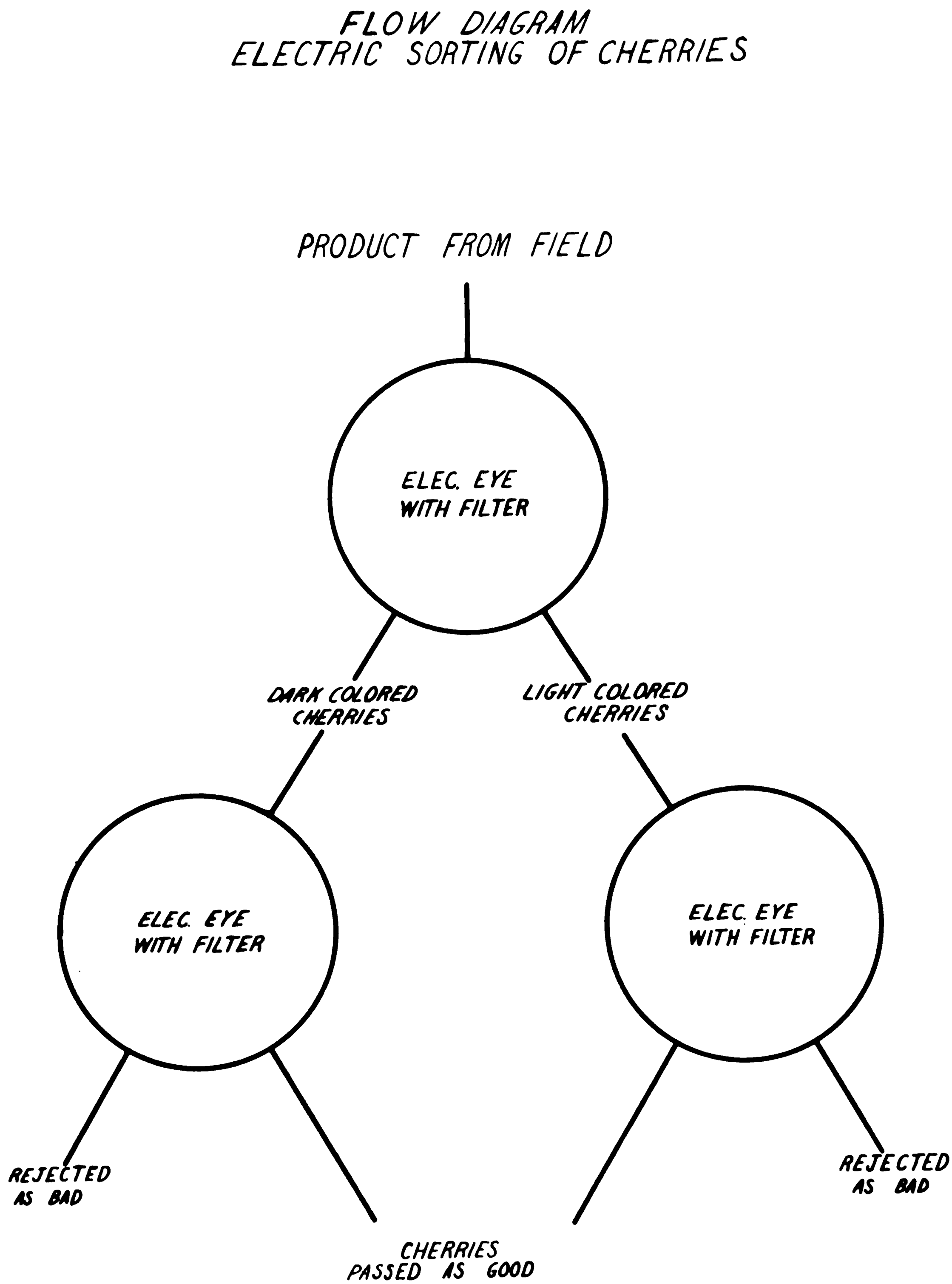


FIGURE 14.

A proposed method of using existing electric sorting machines on cherries. Assuming that different methods of conveying are needed.

The objectives of using an electric sorting machine would be to increase the accuracy of picking out defective cherries and to reduce the cost of processing. It costs one plant $2200. for labor per day to have the product manually picked over, and as previous tests show, the labor force removed only from 30% to 50% of the defective fruit.

The cost of developing a machine for cherries is not known. It is anticipated that, if such a machine were developed, it could be adjusted to do as good a job as desired for picking out the defects and do it accurately. If the packer wanted to can the fruit for a grade of C, he could do so, or if he wanted to adjust the machine to pack a fancy grade, that also could be accomplished.

Another feature of the machine that would be required for cherries is that the amplifier and certain other parts of the machine would have to be water-proofed. With cherries coming from the soaking tanks, this is a necessary requirement. The machines now in use for pea processing are waterproof. Similar waterproofing would work for the cherry industry.

The plant operators have expressed much interest in having such a machine for sorting work. Individually they are not able to finance the development of the machine.

This much can be said about a machine for electric sorting of cherries; there is every indication it is within the realm of possibility that a machine could be developed that would do the job accurately. There is a possibility that present types of machines may be used as shown in Figure 14 with the exception of mechanically conveying the product. Therefore, the two important phases of the problem are that more sensitive red or infra-red filters will have to be used and the mechanical feature of conveying the product past the electric eye fast enough to keep up production will have to be considered.

It is the hope of the author and many plant operators that more research work will be done on developing a machine to do the job.

PART III

DISCUSSION OF THE PROBLEM

The majority of the work done on the problem was accomplished at the processing plants. Doing the work in the field involved many things. First, it meant that contacts had to be made with the plant operators to gain permission to do experimental work in their plants. Secondly, the continual approval of operators had to be met in order to continue the work.

The operators on the other hand, once the initial permission had been gained, did not usually favor lengthy experimentation because it interfered with the normal routine of the plant. For this reason very few of the tests taken on lighting in the plants can be considered as conclusive, but only as an indication of what the results might be and where further research is needed. To prove reliability, a series of tests should be made under actual working conditons on the colored lights over a period of at least two seasons. Since the research work done at each plant was kept down to a minimum and several plants were used instead of one, the experimental conclusions presented will, in the final analysis, give a cross section of the problem for all the plants. The experimental work did not lack for trained personnel or reality, for the checking was done on the actual production lines with people who do this job year in and year out. The experimental data does lack breadth because of the above reasons. It is hoped that the experimental results presented will cover enough problems about culling work that it can be used as ground-work for other projects in this field.

Another factor that limited the amount of work that could be done in the field was the length of the season. In Michigan the annual cherry season lasts six weeks.

During the 1950 season, observations were made on several different types of lighting at the various plants. A few tests included the use of blue fluorescent lights for cherry sorting work. Also observations and tests were run on other products as green beans, peas and tomatoes. In 1951, the work centered on cherry sorting and grading, and blue fluorescent lights were tried out further. Work done on pink lights and the electric eye were carried on in the 1951 season only. During the six weeks that the plants are operating on cherries, four of them involve both day and night work. During this time, it was possible to put in long days on the experimental phases of the problem.

The use of blue lights and pink lights are new to the industry. Pink light, and to a lesser degree, blue light, brought about an improvement in efficiency in culling work, but this was measured on a short time basis. Because all of the aspects of using this type of lighting are not known, it will not be possible to say if they are better. Psychologically they have not been accepted by everyone in contact with their use. At the end of the 1951 season, there were two plants that were using blue lights and these planned to continue their use until a better type of lighting could be found. The chief advantage they claim for blue lights is that they are easier on the eyes during night work. The workers get less tired under them and are able to perform their duties better. Whether they do a better job under these lights on a long time basis, remains to be investigated.

Pink lights present a greater problem psychologically. When shown to observers with the light source clearly showing, they were not as acceptable as when the light source was concealed and the attention of the initial observer was called first to the effects of light on the product. Very few people have seen the pink lights in operation and yet there is one plant that already has them installed partially on a trial basis and another one plans to do so with the advent of a new season. It will be here on a long time basis that their true worth can be determined. It is for these plant operators concerned to ascertain their true value.

The plant operators should use judgment about the opinions of the workers concerning this type of light. The workers have on occasion complained about changes in lighting even though the lights were known to be better. In connection with the pink lights, the author has been informed of the possibility of lawsuits, by the workers and also the operators, if the workers become blind or were harmed through their use in experimental work. The first time the author tried pink lights on individuals was at the State Prison in Jackson on the prisoners. Tests were run over a period of time to determine approximately the right intensity of light to use and to note if any harmful effects resulted. Then observations and later actual trial runs were made at two widely located plants in the State. The latter plant, a very progressive processing plant, decided to keep the lights as they were pleased with the initial results and wanted to determine the further importance of them.

In using the blue and pink lights, and the same holds true for other nearly saturated colors, the plant operators should be cautioned about light intensity measurements. The light sensitive cells in foot-candle meters and in other light measuring equipment are adjusted for white light. The light cell is more sensitive to blue and pink light, and in the case of pink light, the light cell registers twice as much as it should. Almost the same results will be obtained with blue light.

The multiplying factors to use to correct light meter and exposure meter readings for colored light are given in Table X.

Some of the principles of lighting that have been used with success with cherries may apply to other products. The product that comes to mind first is beets because of the operators' difficulty in culling out the beets that have worm

TABLE X

Approximate Multiplying Factors to Correct Light Meter Readings for Fluorescent Colors[8]

(White = 1.00)

Daylight	0.80
Green	1.50
Gold	1.30
Blue	0.50
Pink	0.90
Red	0.70

holes. It is anticipated that, if lights were used with appropriate filters that would approach the chromaticity of the beet, the worm holes could be very readily spotted.

Of the two methods of testing the efficiency of the sorters, the procedure of taking absolute weights is considered by the author as the more reliable. This method could be used as an absolute check rather than as a spot check. It also had the advantage that it could be made without the workers knowing that any check was being made, as the throw-outs were carried out, as they normally were, and the weights recorded in another part of the building. This type of testing involves more than one shift, and more than one day. Actually, the test periods were usually shorter and the workers were switched around between the tables under comparison.

An attempt was made by the author after the 1951 season was over to record the various effects produced by the various lights that had been experimented with on film. Some of the better views may be seen in Figures 7, 8 and 10. These illustrations represent by no means an accurate picture of the effects of this light in the proper surroundings, however they do give some indication. The main disadvantage in regards to the pictures was in keeping the fruit fresh until the pictures could be taken. This proved to be impossible. The color of the fruit changes to brown very rapidly in the laboratory, if not refrigerated, and this was the reason that a majority of the work on the lights was accomplished in the field. The extremes in lighting effects are recorded in Figure 15. Other illustrations by the author are presented for those who are not too familiar with processing lines in order to show the inspectors at work in the processing plants. (Figures 2 and 3).

The results of this project point the way to two possible major paths of future research work. One line of research could be on effective methods of mechanically turning over the product during the inspection process. There is some indication that the reason some of the defects are missed is not entirely the fault of the seeing conditions, but the fact that the fruit hasn't been turned over adequately.

The other path of research consists of the development of a machine to do the culling work. The possibility of using an electric eye on cherries holds a definite challenge for some future research worker. It is entirely within the realm of reason that such a machine can be made, but at present no electric sorting machine in existence will do the job.

FIGURE 15.

Color views of cherries illuminated by pink fluorescent red filtered light and daylight fluorescent lighting. (Color by Ansco).

CONCLUSIONS

1. The efficiency of the inspectors on culling work, at three cherry processing plants that were studied, ranged from 30% to 50%.

2. The following three factors influence the efficiency of the workers:

   A. Type of Light

   B. Type of Background Color

   C. Method of Turning Fruit

3. Under short time investigations, a pink fluorescent light with a red filter was shown to increase culling efficiency approximately 80% on cherries.

4. Blue lights do make all cherries look darker, and on darker cherries, it is harder to pick out the defects.

5. Both pink and blue lights are less intense than white light, and either the number of fluorescent tubes has to be doubled or the fixture mounting height lowered accordingly to obtain the same intensity of light as with the white.

6. Blue fluorescent lights have to be used without a filter; with pink fluorescent lights, it is necessary to use a filter.

7. The amount the fruit has been turned over on the sorting belts reflects on the over-all efficiency of the inspectors. Without any turning, about 30% of the defects are visible.

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