The Development of the Motion Picture Raw Film Industry

By George A. Blair
Eastman Kodak Company

MANUFACTURING film for all of the many uses to which the motion picture is being daily adapted has always been a technical and precise task, involving great capital outlay and meticulous care and inspection in every stage of the process.

When one considers that each single picture is frequently magnified some 180 diameters or 30,000 times in area on the screen and run through a projector at tremendous speed, an appreciation of the machinery and methods involved in manufacturing film free from any obvious blemishes may be more easily reached.

While motion pictures are now more than thirty years old, no great volume of raw film was produced until about fifteen years ago. With the phenomenal growth of the industry, the demands upon the manufacturers have steadily increased, until now the Eastman Kodak Company turns out more than 200,000 miles of film yearly.

Those who can remember the first crude movies of the nickelodeon period cannot view one of the modern feature pictures and not wonder at the rapid development of this, the greatest of all photographic arts.

George Eastman's Contribution

It was through the discovery of the nitro-cellulose film base in 1889 by George Eastman that motion pictures to-day are possible. Prior to this time Thomas A. Edison was busy eagerly seeking to depict pictures in motion. He lacked, however, the medium of the flexible film to perfect his invention. This the coincidence of the Eastman discovery solved. The nitro-cellulose film base proved to be the "missing link" for which Mr. Edison had been looking.

What Mr. Eastman contributed toward the invention of motion pictures may best be told in his own words from a quotation in a letter which is now a permanent record of the Society of Motion Picture Engineers. In the first part of this letter he tells of his discovery of the nitro-cellulose film support and the establishment of the first factory in Rochester to manufacture this product in 1889. Continuing, he writes:

> While we were engaged in fitting up this factory I received a call from a representative of Mr. Edison who told me of Mr. Edison's experiments with motion pictures and how necessary it was for him to have some of this film. The idea of making pictures to depict objects in motion was entirely new to me, but of course I was much interested in the project and did my best to furnish him film as near to his specifications regarding fineness of grain and thickness as possible.
>
> As far as I know, the film we furnished him then and from time to time later was satisfactory. In the years during which the motion picture industry has been developed, we have made many improvements in the way of fineness of grain, photographic quality and uniformity, but the film made today is substantially the same as the first film furnished Mr. Edison.

All the experimental film which was furnished Mr. Edison was negative film. Special film for printing positives was not made until 1895. The

output of the Eastman factory in that year was 21,663 feet.

RESEARCH WORK OF EASTMAN KODAK COMPANY

As the motion picture industry progressed, the Eastman Kodak Company realized what great dependence the world placed upon its product. In order to keep the art in an ever increasing state of improvement, the Eastman Research Laboratories were established in 1912, and ever since have been the only place in the world where all scientific phases of the industry are continually and carefully studied. The thoroughness with which the field is covered may be gathered from the fact that, while the company makes no professional motion picture cameras or projectors, it tests every known make and offers suggestions for improvement to manufacturers.

Further laboratory researches include the cause of electrical markings on film during exposure, improvements and increased efficiency of developing and printing processes, method of waxing the edges of new prints to prolong their life, optical examinations of screen surfaces, proper illumination of theaters for visual comfort, causes of film mutilation and how to prevent it, data on the photographic efficiency of various light sources and active co-operation in the solution of all problems which have any direct bearing on the art.

MAKING MOTION PICTURE FILM

The two principal ingredients entering into the manufacture of motion picture film are cotton and silver, the former for making the film base or support and the latter for making the sensitive emulsion. Nearly five million pounds of cotton are consumed annually in the manufacture of film base, and, next to the Government Mint, the Eastman Kodak Company is the country's largest consumer of pure silver bullion, the requirements for making sensitive emulsions being in excess of three tons per week.

The cotton is first treated with caustic soda to remove all traces of vegetable gums and other impurities, a preparatory step necessary for treatment with nitric and sulphuric acid. This process is known as nitration and reduces the cotton to what is technically called cellulose nitrate. While not altering the physical appearance of the original cotton, nitration does, however, change it chemically.

Nitrating centrifugals are used for this purpose. These machines consist of "perforated baskets" rotating inside a vat. The cleansed cotton is fed into the basket and acids let into the vat until the cotton is immersed. After allowing sufficient time for nitrating, the acids are drawn off and the basket rotated at high speed for draining.

To rapidly remove the remaining acid the nitrated cotton is then put into centrifugal washers. After washing in these machines it is immersed in large tanks of water and drained and rinsed over a period of weeks. Before dissolving in the solvents it is placed in centrifugal wringers rotated at a high rate of speed to remove the water.

Washing and drying completed, the nitrated cotton is ready for the solvents. These solvents, of which alcohol is the principal ingredient, are contained in "mixers" and the cotton is fed into them through "chutes." In the "mixers"—sometimes called dough machines—large paddles churn the cotton and alcohol together. When thoroughly mixed, the solution is a viscous liquid of the consistency of honey, and in Kodak Park parlance is called "dope."

This "dope" is piped to large air-tight tanks, where it is kept ready to

be converted into sheets. This is done on what are known as coating machines, on which sheets 2000 feet long and three and one-half feet wide are formed. These sheets, when dry, become the familiar transparent film backing or base on which the sensitized coating is spread.

The accuracy of these machines is such that the mean variation in thickness of a sheet of base from end to end, when coated, is not more than 1/8000 of an inch.

Silver is the active element in the sensitizing material of the emulsion. It comes in bars of pure bullion weighing about forty-two pounds each. The bars are dissolved in nitric acid in porcelain dishes and after crystallization, pure crystals of silver nitrate are obtained. Other ingredients in the emulsion are potassium iodide, potassium bromide and gelatin. The gelatin, extracted from the bones and hides of cattle and necessarily of the purest possible grade, is dissolved in water, after which the bromide and iodide solutions are carefully mixed with it. To this mixture, heated to the correct temperature, is added silver nitrate solution. The precipitate of the sensitive silver salts is then held in suspension by the gelatin.

This motion picture film base is usually coated with either one of two kinds of emulsion. Negative emulsion is highly sensitive to light and is used in the camera, while positive emulsion, which is purposely much less light sensitive, is used for printing the pictures as they are viewed on the screen.

The actual operation of emulsion making is conducted in silver-lined steam jacketed vessels provided with suitable agitators. Soluble salts formed during the reaction must be washed out of the emulsion. This is accomplished by chilling it to a jelly and then shredding it by pressing the mass through a chamber with a perforated bottom and sides and washing the spaghetti-like strands many times with pure cold water. The shredded emulsion is then melted and coated on the film base.

THE FINISHED PRODUCT

For this operation special delicate machinery is necessary in order to carefully control the thickness. As the film is coated, it is carried in large loops to the chilling rooms of regulated temperature to set and harden or become "conditioned." When thoroughly dry, motion picture film in rolls three and one-half feet wide and 2000 feet long is automatically cut in strips of the standard width of $1\frac{3}{8}''$ and wound in rolls varying from 100 to 1000 feet in length.

The final operation is perforating the film, where accuracy is of the utmost importance. This is accomplished at Kodak Park only by constant vigilance on the part of experts who keep the machines at the highest point of precision and who are constantly on the alert for possible improvements.

Even such an apparently small detail as the shape of the perforation has been minutely studied, with the result that the Eastman type of perforation allows the film to pass through the projector so smoothly that projection is immeasurably improved and wear and tear on the film considerably lessened.

After perforating, the rolls of film are taken to the packing room to be wrapped in selected chemically pure black paper and are then packed in metal cans carefully sealed to keep the contents air- and light-tight. The cans are stamped with the emulsion number and footage and are then placed in straw-board containers ready for shipment to the motion picture studios and laboratories of the world.

The Eastman Kodak Company has

thus pioneered the manufacture of motion picture film, and has been intimately identified with every step in the photographic development of motion pictures since their inception.

COLOR PICTURES

Among these developments is panchromatic negative film, which records all colors in their true black and white relationship, as the emulsion is sensitive to reds and yellows as well as blues and violets. Its use is invaluable when photographing colored sets or costumes and for accurately rendering flesh tints in close-ups.

A large proportion of the more elaborate screen productions of recent releases were made on panchromatic film entirely, and could not have been so pretentiously produced without it.

Although panchromatic film is strongly sensitive to red, yellow and green, it remains more sensitive to blue and violet, especially when photographing by daylight. To correct for this extra sensitiveness to the blue and violet, color filters are used before the lens. These filters consist of thin sheets of dyed gelatin cemented between two pieces of optical glass. Yellow filters are most commonly used with panchromatic film, as they absorb a definite portion of the violet and blue light to which the emulsion is most sensitive, thereby equalizing the exposure for all colors. The result is a more accurate rendering of the tone values of the subject.

Panchromatic film under special treatment can be made hyper-sensitized, which increases the red and green sensitiveness of the film three to four times. By using this hyper-sensitized panchromatic film and a deep red filter, exterior effects closely resembling those obtained at night can be secured by daylight, thus avoiding the use and expense of elaborate lighting equipment.

In order to obtain more pleasing effects on the screen, prints were often colored in the laboratories by treatment with various chemical solutions. It is now rarely necessary for the laboratories to assume this extra operation, since positive film on tinted support or base has been supplied by the Eastman Kodak Company for several years. This tinted stock is printed and processed in the usual way and is supplied in nine standardized colors.

USE OF "SAFETY FILM"

Another development is that of cellulose acetate film, commonly known as Safety Film, for use when pictures are to be projected in homes, schools, churches, factories, lecture and assembly halls. The use of Safety Film does away with the necessity of an enclosed booth and trained projectionist.

Eastman Safety Film is also used in the portable amateur motion picture cameras, where its width is 16 mm. instead of the standard 35 mm. In this amateur size it is known as Ciné-Kodak Safety Film, and is processed in such a way that the exposed film is first a negative and then, by reversal of the image, a positive ready for projection in the home. The use of this film by amateur cinematographers is growing rapidly, and the resultant familiarity with cinematographic problems by a larger proportion of the public will, it is believed, tend to secure an even greater appreciation of the professional offerings.