PHYSICS

Films Improve Lenses

Thin Invisible Coatings Increase Efficiency of Glass By Reducing Light Reflected; Will Now Withstand Wear

See Front Cover

THROUGH a paradoxical treatment of glass—adding an invisible coating in order to let more light through—the cameras, windows, binoculars, movie projectors and other light-handling instruments so useful to us are having their efficiencies greatly increased.

Latest achievement in this suppression of optical reflections is the making of the thin films so rugged and permanent that they will stand scratching with a knife without harm. They can be soaked in sulfuric acid for a week without impairing their amazing optical properties.

A rush to put these amazing thin films to use is underway. Scientists are working hard to produce the best effects in the easiest ways. The properties of thin films, only a few molecules thick, only a fraction of the lengths of the light waves themselves, take on intensely practical meaning. A few months ago study of such coatings was considered merely "pure," unapplied research.

Like many developments this latest achievement of optics has a past. Nearly 50 years ago, in 1892, the British scientist, Dennis Taylor, found, surprisingly, that some of his camera lenses appeared to be faster (quicker in light-gathering power and hence needing a shorter exposure time) if they had a thin layer of tarnish on them. Ever since, science has realized that if such films could be made durable a new world of optical tricks and applications could be opened.

And now this 48-year-old dream of scientists has been realized.

Dr. C. Hawley Cartwright, scientist of Massachusetts Institute of Technology, has described and displayed pieces of glass covered with a circular thin film of magnesium fluoride. The edges of the glass, uncoated, reflected light in the ordinary, annoying way but the circular opening in the center, where the film was present, was at the same time clear and transparent. In some cases the film makes glass look as though it had a hole right through it.

New uses of a permanent film of the kind which Dr. Cartwright showed are immediately apparent and are, even now, being explored to the fullest.

One man certain to be interested is Dr. Julian S. Huxley of the Zoological Society of London who wrote to Science Service last year asking if the films were permanent enough to be used on the glass windows of London zoo cages. Foresighted Dr. Huxley well realized that with rugged, thin film coatings on the glass the visitor would have a much better view of the exhibit objects. Everyone probably has noted the annoying reflection on windows, show cases and glass-covered paintings.

Large commercial uses for transparent display windows, with amazing transparency, is foreseen. They would show the goods within as though they were in the open air, not behind glass.

Camera lenses that are "faster"—require less light to take comparable pictures—are already being perfected. On a small scale Dr. Cartwright is coating such lenses at M. I. T.

All manner of intricate optical equipment, with many different kinds of glass and air-to-glass surfaces, can be greatly improved by the use of the new rugged, thin films. The Navy, particularly, is interested in the application of thin films to periscopes which contain intricate "trains" of optical prisms and lenses.

As it is now, a periscope will bring about a total reduction in light that it will transmit by some 80%. Rays of light originally entering are partially reflected at each prism and lens surface. While the loss is small for any one reflection—about 5%—the cumulative effect of these 5%'s adds up into an amazing loss of light and a truly inefficient optical system. In practice this means that a submarine using a periscope at dawn or dusk becomes "sightless" long before it would otherwise need to if its periscope were more efficient in transmitting light.

The rugged, thin films now possible for glass surfaces are a splendid example of the often unforeseen ramifications of scientific research. They owe their origin —if one must pick a single factor—to man's desire to learn more about the universe and, in fact, grew out of research in which rugged, highly reflecting coatings of aluminum and chromium were deposited on telescope mirrors to make them reflect ultraviolet light better.

The fragile, temporary nature of silver coatings for telescope mirrors had long been realized. In the first half of the last decade, several groups of scientists were seeking to correct this trouble by perfecting techniques of evaporating onto glass, in a vacuum, a thin layer of aluminum or chromium metal.

At Cornell University, there was a group, consisting of S. L. Boothroyd, H. C. Ketcham, R. C. Williams and G. H.

DURABLE FILM

The shadow on Dr. C. Hawley Cartwright's chin shows how the durable thin film on the glass he is holding reflects less sunlight than does the plain glass around it.

Sabine. At California Institute of Technology were Drs. John Strong and C. Hawley Cartwright and at the University of California at Los Angeles was the group headed by Dr. H. W. Edwards.

With its close connection with nearby Mt. Wilson Observatory and the newly-created Mt. Palomar Observatory where the giant 200-inch diameter mirror telescope will some day be installed, the scientists at the California Institute of Technology vigorously pushed their researches, developing larger and larger vacuum chambers for the evaporation technique. It is virtually decided that the great 200-inch mirror of Mt. Palomar will receive an evaporated coating by Dr. Strong when it is finally ground to its needed accuracy.

With his background of evaporation methods learned at Caltech, Dr. Cartwright moved to Massachusetts Institute of Technology, across the continent, and with Dr. A. F. Turner has been adapting the method of evaporation of thin films to the old problem of cutting down light losses on lenses and optical parts by the application of a thin film whose thickness is only one-quarter that of a wavelength of visible light.

The recent step in this research has been to increase the hardness of the film by baking the films with heat. Dr. Turner has carried out many of the experiments which have perfected this method. A final advance has been the application of oil to the completed film. This not only increases the waterproofness of the film but also lubricates the film so that it is less likely to be scratched in service.

The astounding story of thin films and their ability to cut reflections on glass has a parallel chapter in the work of Dr. Irving Langmuir, Nobelist of the General Electric Research Laboratories and Dr. Katherine Blodgett on films of stearates, made by dipping glass into a bath on which floated the thin films which will be made only one molecule thick if necessary. Drs. Langmuir and Blodgett had for some years been studying these two-dimensional films and their properties. They then decided to build up a multiple film of these materials which would have multiple layers but whose total thickness would be only one quarter a wavelength of light.

They, too, obtained amazing pictures showing the decrease of reflection from glass treated in this manner and showed that the transmission was increased from 92% to over 99%.

It is most difficult to obtain rugged, permanent films from the stearate compounds, but research and added effort may some day produce the needed permanence which will make these films, too, widely useful.

The evaporated films of the fluoride compounds which Dr. Cartwright uses, in contrast, can now be made so tough that one may scratch the films with a penknife and leave the film unharmed. The potential uses of these films are many.

Dr. John Strong on the West Coast, it is understood, is working with the motion picture studios coating their camera lenses. Dr. Cartwright, likewise, has been working with the motion picture industry which is keenly interested for color photography.

Color photographs require longer exposures to get pictures, as any amateur photographer knows who has tried to take such pictures for home movies. Any increase in camera "speed" due to the coating represents a real, tangible gain for the professional cameraman who can "shoot" scenes in color under conditions of lighting which they could not tackle before.

Television, too, is a very new field which would be extremely interested in getting "faster" lenses for the television cameras, new eyes for broadcasting.

Another new, suggested usefulness of coated "non-reflecting" glass, which should interest women particularly, is for eye glasses. While not available commercially such glasses are being studied experimentally and they have much less reflection. It is this reflection which makes one's glasses visible to another person.

Many men and women wear glasses but dislike to do so because the glasses betray their appearance. Such people will be keenly interested in this development when it is perfected. The goal—perhaps a long way from realization—would be to have "invisible glasses" which would be as unseeable, without frames, as anything which could be devised.

A major task which Dr. Cartwright has set for himself is to perfect his thin film, evaporation method so that it can be carried out in air and not, as now, in a vacuum.

If this goal can be realized it will mean the day when whole store windows and other large glass surfaces can be coated with thin films and bring greatly increased realism to the products displayed behind them.

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