found that with an $f/10$ 20-ft focal-length system we were obtaining resolution from the ground of airborne targets at roughly between 10° and 30° elevation, running from 8½ microradians down to approximately 50 microradians, largely as a function of the differential refraction or heat shimmer which was apparent at the time.

In the course of the study it became quite apparent that if things are to be seen at a considerable distance, you need considerably better than 50 microradians. Consequently we embarked on a feasibility program, at least in terms of what can be done with an airborne camera station. We feel that, based on experience with long-focal-length optics stabilized in gyro-mounts, etc., such a system could very well be described which would attain somewhat better than 8 microradians at all times with focal length up to 20 ft.

Letter to the Editor:
Magnetic/Optical Stereophonic Sound

These comments are in reference to the Discussion published on p. 763 of the December 1957 *Journal*, at the close of the paper "Further Data on Infrared Transparency of Magnetic Tracks," by George Lewin, which was presented at the Society's Philadelphia Convention with a demonstration of stereophonic sound from a magnetic/optical film. In relation to the information set forth by Dr. Frayne and Col. Ranger in the discussion of Mr. Lewin's paper, these comments are submitted on the basis of the technical work done at Telefilm, Inc., facilities to produce the stereophonic demonstration film, when it was my privilege to work closely with Col. Ranger in the technical production of this film.

When these experiments were started, we realized, as Dr. Frayne pointed out, that magnetic and optical are two radically different methods of recording. This in itself does not, of course, mean that the two systems cannot be aurally matched. Disk recording and tape recording are quite different, yet with equipment developed in the last few years, we can now produce a disk recording virtually indistinguishable from its original tape, even when compared under the most critical conditions.

Similarly, we in the 16mm film industry now have available to us new recording galvanometers, new emulsions, and automatic controls over processing and printing, so that we are now making tracks on 16mm release prints that would have been considered adequate for 35mm only a few years ago. Projection equipment is constantly being improved to take advantage of these better tracks.

At the present stage of the art we have little difficulty supplying a 16mm release print track with essentially flat response from 75 to 7000 cycles, and a number of experiments have been conducted demonstrating the possibility of extending the range even further. (I believe Mr. John Maurer has been quite active in these experiments.) Intermodulation and harmonic distortion are still with us, but with modern quality control methods in developing and printing, along with the new recording galvanometers, we are getting quite good results in our attempts to get lower distortion readings. I won't say they are as good as we would like to have them, but, for instance, we can hold single sine wave distortion in the mid-frequencies to about 5%. This certainly leaves room for improvement, and yet, unless you play the track on a very good speaker and in a dead room, you don't hear the distortion at all. Cross-modulation distortion is not a serious problem. With good processing and printing control the cross-modulation distortion on variable-area recordings can be kept well below audibility. I believe most people in the industry are getting about a −38 to −40 db, using the standard test procedures, which is quite adequate.

With magnetic sound primarily in mind, there is no practical reason why the magnetic frequency response cannot be limited to match whatever is available on the optical; and for that matter, we could deliberately introduce a little noise and distortion into the magnetic in order to better match the optical. So I think if we proceed from the standpoint of getting the best possible optical and then matching the magnetic track to it, there is no reason why we cannot get a very acceptable match between the two. I might add parenthetically at this point that since the two tracks are normally played at a lower level when used together than if either was used monaurally, the inherently higher noise level of the optical track is quite a bit less apparent.

An additional advantage of the optical magnetic combination over a system using two magnetic tracks lies in its compatibility. The fact that this is only a two-channel system makes it feasible to use only one track if necessary, in the same way that one can listen to only one side of a two-channel radio broadcast and still hear an acceptable program. Compatibility is going to be a big issue if 16mm stereo is to become accepted production technique. The use of an optical track covered with a halftrack magnetic stripe would allow the print to be played on any 16mm sound equipment presently in use, while machines equipped with lead sulfide cells could play the additional optical track under the magnetic, with corresponding improvement in output and signal-to-noise ratio.

STEVEN A. GUY
Telefilm, Inc.,
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From John A. Maurer

In response to the request to review the comments:

I agree in general with what Mr. Guy has said, but it should be pointed out that he has understated the case as to the quality that can be obtained with 16mm optical sound. During the past few months, I have made a large number of tests by re-recording from ¼-in. magnetic tape records to 16mm release prints using the linearity-compensated variable-density system which I described at the Philadelphia convention, with a frequency response flat to 11,000 cycles. The results have been pleasing even when played in direct comparison with the original tapes.

When properly designed, wide range recording equipment is used, the only really noticeable difference between magnetic and photographic records is the higher background noise of the latter. As film is generally processed in the industry, this difference is of the order of 15 db. Most of the noise of the photographic track, however, is due to suspended matter picked up by the film from the processing solutions, the wash water, and the air used for drying. Photocell hiss and the noise due to the

grain structure of the image are *at least* 10 db lower in level than this noise due to dirt accumulated during processing. If it were considered necessary, therefore, to produce photographic tracks very nearly as quiet as magnetic records, this could be done merely by doing an unusually careful job of filtering the developer, fixing bath, wash water, and air used in the film laboratory.

March 27, 1958

JOHN A. MAURER, President,
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From George Lewin

I greatly appreciate Mr. Guy's comments and welcome the opportunity to acknowledge his contribution to the preparation of the stereophonic demonstration film which accompanied Col. Ranger's and my own presentation at the 82d Convention on October 8, 1957. The credit was recorded on the film but I regret that I neglected to include it in the published version in the December 1957 issue of the *Journal*.

Mr. Guy is certainly correct when he states that it is feasible today to obtain excellent frequency response and low distortion on 16mm prints with optical soundtracks. The regrettable thing is that so many producers do not consider it worth the added expense for equipment and personnel to achieve and maintain optimum quality. The great need is for better printers and constant vigilance to keep exposure, processing and projection within the necessary narrow tolerances. If the proposal to make stereophonic recordings by combined optical and magnetic tracks stimulates the need for better control of optical sound quality in order to match magnetic sound quality, that alone should make it worth while.

The advantage which Mr. Guy points out regarding the compatibility of the optical-magnetic combination is a very good one. Still another advantage derives from the complete absence of crosstalk between the two channels. This is something which will be impossible to achieve in an all-magnetic system because of the necessary close spacing of the heads if both tracks are to lie within the area now occupied by the optical track. Because of the fact that the magnetic halftracks would probably have to be considerably less than 50 mils wide, it is likely that their signal-to-noise ratio would be inferior to that of a good optical track even when completely covered by a magnetic track and reproduced with a good lead sulfide cell.

Incidentally, I should like to acknowledge the assistance which is being given me by the Bell & Howell Co. and the McKay Research Laboratories in my quest for improved photocells which will still further improve the infrared transparency of magnetic tracks.

March 31, 1958

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Editorial Note

Mr. Guy has requested that comments, suggestions and questions be referred to any of the following:

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Errata

William S. Halstead, "The NARCOM Plan for Transatlantic Television and Other Wideband Telecommunication Services," *Jour. SMPTE, 67:* 134–138, Mar. 1958.

On page 134, column 3, line 6 of paragraph 2, *read:* 1951 *for* 1950.

On page 135, column 3, 5th line from the bottom, *read:* . . . at about 22 dba at zero level *for* . . . at about 22 db, etc.

For Reference 6 on page 138, *read:* K. Bullington, "Radio transmission beyond-the-horizon in the 40- to 4000-mc band," *Proc. IRE, 41:* 132–135, Jan. 1953.

Due to the author's isolation by snowstorms on a field trip, the final manuscript and proofs regrettably could not be reviewed before publication of the group of papers on international television.