THE IMPORTANCE OF INTERLACED SCANNING

A television pioneer who, in 1931, set the entertainment world agog when he demonstrated 10 x 10 ft. images on the stage of the Broadway Theatre, New York, discusses in this exclusive article to Radio-Craft one of the most vital developments in television technique.

U. A. SANABRIA

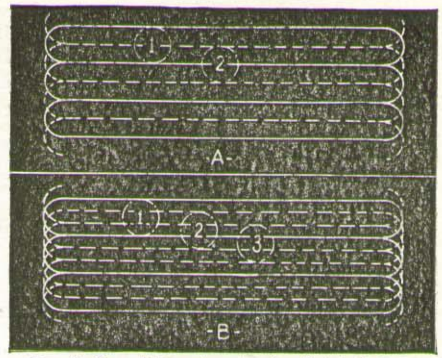

Fig. 2. Two different methods of interlacing.

INTERLACED scanning is a subject about which we today hear a great deal. Those who have not pioneered television would be inclined to think that this is something new, but interlacing has been investigated over a period of many years, and in fact, the quantitative constants have been rather well established.

Those engineers who have concentrated chiefly upon some of the electrical phases of television without much consideration of the scanning system are naturally surprised to find an improvement when they simply interlace the scanning lines alternately with each successive scan. Now, interlaced scanning is an old story to the partially initiated if we call it "offset scanning." In fact, an interlaced scanning system of the type up for consideration at the present time is simply another edition of the old 2-spiral offset scanning disc, which many years ago was shown to be a disadvantage rather than an advantage, for here the picture appeared to "wiggle" within itself at very high scanning speeds rather than to flicker "over all" like a single-spiral scanning disc did.

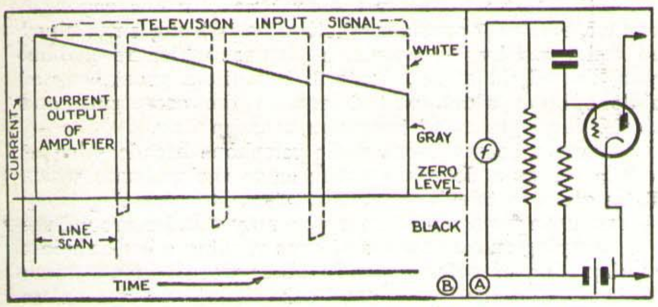

Fig. 1. The effect on the image of current lag in the amplifier.

ADVANTAGES OF INTERLACED SCANNING

In our own laboratory, we first adopted a 3-spiral offset system as part of a system several years ago we called "definition multiplication" and "frequency interposition" although many better combinations were possible, but this one was "framed" easily. These offset systems of scanning, when properly used, contribute much to the art of television. The advantages are listed in Table I.

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TABLE I

1. A much lower scanning speed.
2. A smaller eye strain.
3. A faster permissible motion of the image.
4. The elimination of the picture "flash" when the eye winks.
5. A higher fidelity of the probable image when using a condenser-coupled electrical amplifying system.

In other words, *offset scanning* is an engineering science. It is a very important part of a profound knowledge of television. It can not simply be casually adopted in its most unpleasant form by engineers if it is expected to yield suitable results. It is easy, when scanning electrically, to simply interlace the lines of any 2 alternate picture scans to obtain the well-known "2 spiral effect" (of the mechanical scanner). While such alternate interlacing gives a higher fidelity of the received image, it is only because such observations are being made for the first time by these particular engineers concerning the advantages of the "line waveform interposition of different lines" (or interlaced scanning) in television signals. This simple single offsetting reveals the advantages of a small amount of waveform interposition while suffering an optical disadvantage in the scanning system itself, and therefore these engineers are going to a higher and higher number of scans per second. It has been unpleasant to listen to some engineers speak of the number of scans per second as though television engineers had frequency to "burn"; and fidelity so fine as to necessitate practically putting the image out of focus in order to avoid unpleasant sharpness! Such is definitely not the case, and we must conserve every spot of the television picture and cause it to recur as infrequently as possible as long as we retain a thoroughly acceptable effect. In other words, using ordinary American business intelligence with our engineering, we must make our picture definition cost us as little as possible.

CAUSES OF FOGGED IMAGE

Now the reason for picture line frequency interposition in television can be illustrated very simply:— The probable image is a person's face —that is, although we must resolve every conceivable type of image, the human face is the most probable. Therefore, the scanning system producing the *probable frequency* will probably develop this most probable frequency by scanning a face. The face, if traced with an ordinary simple sequence (or non-interlaced) scanning system shows a practically similar waveform sequence in the electrical system, for each line-tracing across the forehead. The low-frequency (or shadow) variation is approximately the same in each case, and therefore, the average voltage developed in an alternating current amplifying system will develop in a general direction which will alter the effective bias on the control-grid in the amplifying system. Therefore, any system using condensers, or a so-called "condenser-resistance coupled" amplifier, will yield spurious shadows in the vicinity of any repeated waveform sequence which is either lighter or darker than that produced at zero signal level. For example, if each successive signal increases the charge in the coupling condenser, which does not have time to completely leak off between signals, then a continuous discharging current will cause a general change in brilliancy in that zone of the picture where these effects occur. Thus, the picture assumes a striped appearance having different zones of light and dark shadings.

By reference to Fig. 1A and B, we can easily see that the successive signals from tracing a forehead of a person will produce a change in effective bias voltage on the control-grid of the electron relay, for the condenser is charged each time, and does not have time to fully discharge, and again balance the circuit to give normal bias on the control-grid. Hence, zones of whiteness will have black shadows, and zones of blackness will have white shadows, and at the end of the zone, gray shadings will appear where white is intended. In photography, we would call this a "fog" on the picture. So let us classify this effect in television as either a "(1) scanning or (2) electrical *fog*," for it is due to either (1) improper scanning or (2) improper amplifying technique.

By the use of a so-called "battery balanced amplifier," or devices that do not involve transformers, inductances or condensers directly in the amplifying system, we can eliminate these undesirable effects from the picture. Such amplifying systems have so far been expensive, and somewhat unstable in operation. To overcome this unpleasant effect with an amplifier is the task of the television engineer *when he is working on amplifiers*, but when the television engineer is *working on scanning systems*, then he should reduce this unpleasant effect with the proper scanning system in order that (1) "scanning fog" may be eliminated; and (2) "electrical fog" isolated and treated by itself.

A noticeable improvement in picture fidelity is immediately effected when a television engineer omits every other line on one scan of the image and inserts it with the next scan, alternately interlacing or off-setting, for then the number of repetitions of "forehead signal" or "hair signal," or "mouth signal" are reduced by 50 per cent and "interlaced" with other signals. Optically, this "shutter" or "lattice work" appears to move within itself, and the scanning system really has to trace very rapidly to effect a pleasant optical sensation. Now, if we off-set *3 times* so that we leave out *every 2 adjacent lines*, then a much more acceptable optical effect is achieved while tracing the picture at a fairly low scanning speed, and at the same time a lesser number of repetitions of the same type of signal occur in sequence; thus, only a few lines have "forehead signal" before they are followed with the signal produced from the eyes, or the teeth, etc.

Visible improvement in fidelity continues as we increase the number of offsets, but the optical advantages of off-setting decrease if we follow too-rhythmic interlacing, for then we appear to see an apparent motion between the coarse-grained pictures that are interwoven. *We have observed* (in our laboratory, where we have exhaustively studied this particular phase of television problems over a period of years) *that the best optical and electrical effect is obtained when we scan sections of the picture as widely separated as possible* with each successive tracing of a line of the picture.

"RHYTHMIC—UNRHYTHMIC" SCANNING

Thus, we scan first a line at the top of the picture, and then at the bottom, but now if we should alternately go back to the top and then the bottom and weave in toward the center, the effect would be good in the elimination of electrical fog shadows, but the optical apparent motion or flickering wiggle effect would be rather poor, for the picture parts would appear, at low scanning speeds, to close in toward the center repeatedly in mechanical fashion. Therefore, after we have scanned the top and the bottom line, we move toward the middle of the picture and scan a line there, and since it has been two intervals before we have been near the upper part of the picture, we now scan a line half way between the center of the picture and the top line of the picture, and then we move back to a line mid-way between the center line of the picture and the bottom of the picture. Now we have completed what we call a "cycle in scanning," or in other words, we have skipped as widely as possible over the picture. Now we repeat the same general effect, filling in the lines that have not been scanned, and in this fashion, we continue until we have scanned every line of the picture with the scanning spot. The effect defeats the eye's tendency to follow the scanning spot, so that flicker and apparent motion are practically nullified at very low scanning speeds. Using very high brilliancy, we have been enabled to completely eliminate any serious visible flicker or wiggle or "crawl" with this "rhythmic—unrhythmic" arrangement.

DEFINITION MULTIPLICATION

Now great further advantage is obtained if on the next complete cycle of scanning events, we cause the lines to be "half-offset" so that they trace in the manner shown in Fig. 2A. The center of definition has now shifted to the point where absent lines formerly existed, and this "invisible offsetting" greatly reduces the apparent grain in the picture so that it can be made to appear extremely smooth. We call this "invisible offsetting" *definition multiplication*, for in effect, it takes a fixed lattice work, and puts it into a state of motion. This effect may be improved with two "invisible offsets" in the manner shown in Fig. 2B. Therefore, by operation of these two methods of scanning in co-operation, we achieve both the advantages of *definition multiplication* and line frequency interposition; or in other words the best optical effects *and* the best electrical effects. Hence, by the application of such a system we can say, "we have made television scanning progress."

That is, we can scan and produce the optimum definition with the minimum speed, with the minimum electrical frequency, and the cheapest possible electrical amplifying systems; and with devices which might otherwise have too much inertia for improperly-engineered, higher-speed systems attempting to produce the same definition at the same frequency.

The means by which these methods may be accomplished are numerous. It is not confined to mechanical scanning, and they may be just as easily applied to electrical scanning. If an electrical scanner like the iconoscope has an image-tracing line sequence which traces the lines in a manner giving the best line frequency interposition for the probable image by offsetting, then the cathode-ray receiver may pick up this tracing signal and trace similarly. It is only necessary that they trace in synchronism and the best visible and electrical effects are, therefore, easily obtained. With a mechanical system, this is simply incorporated in the mechanical design. While we hear much of the glory of electrical scanning these days, and the systems are, undoubtedly, attractive, their fidelity "per spot" is far below that of a good mechanical system; and unless electrical scanning systems can reveal more notable advances and improvements, *the mechanical systems still appear to play a serious part in eventual television—particularly, where large pictures are desirable.* Lamb's polarizing film now offers immense new possibilities to large-screen mechanical systems giving extremely high definition, *for the screen itself may be used as the light valve.* It is quite possible that an electrical transmitter like the iconoscope can be made to work successfully with a mechanical receiver, but whatever system is adopted as long as it scans, electrical advantages are obtained by scanning the probable image so as to effect line frequency interposition of the dissimilar waveforms, and to secure improved definition and agreeable effects with the properly coordinated sequence of scanning and invisible offsetting.

Television is a broad science, and it is not "solved" by the contribution of any one type of tube, or a scanner, or any one of its component parts. Like all the other engineering arts, it has many phases. Since the art is young, we are all occasionally inclined to overlook its enormous scope. Therefore, we must choose any standard of scanning at this time with a more scientific attitude than that with which we approached experimental standardization some years ago when single-spiral scanning discs were adopted while now all turn directly to offsetting. Standards unwisely selected will be expensive, and as distressing as the 25-cycle hydro-power systems are in the midst of 60-cycle practice.