The Sun
Television Data Sheets

Compiled by RALPH R. BATCHER.

SCANNING FREQUENCIES

In describing the process of transmitting television matter from the studio through the various interconnecting mediums many separate frequency ranges must be mentioned. The most important of these will now be outlined.

FRAMING OR PICTURE FREQUENCY (24 to 60 pulses per second)—In order to show moving scenes it is necessary to send a number of complete views successively each second. These scenes differ slightly from each other depending upon the rapidity of the movements of the various subjects. A common standard in the U. S. A. is thirty pictures per second.

LINE FREQUENCY (Proposed value in the U. S. A. is 13,230 lines per second)—As heretofore explained each of these individual scenes is broken up into a large number of strips which are transmitted in a certain order. The proposed standard here is 441 lines per picture. Both of the above frequencies are definite and will become standard for all major transmitting stations.

VISION FREQUENCIES—In the studio scanning camera variations in light intensity reflected from the televised subjects are converted into a continuously varying electric current. As the spot progresses from the start of each line to the end an extremely irregular series of changes is produced. Actually, in one sense, in the average scene there are hardly any definite frequencies present in this series, if the view is taken that at least one complete cycle of a given frequency must be present to be considered as representing that frequency. Periodically, of course, during the transition time from one line to the next or from one picture to the next a larger pulse results. However, the pulses of these two frequencies are usually altered or modified so that they have a definite intensity and duration.

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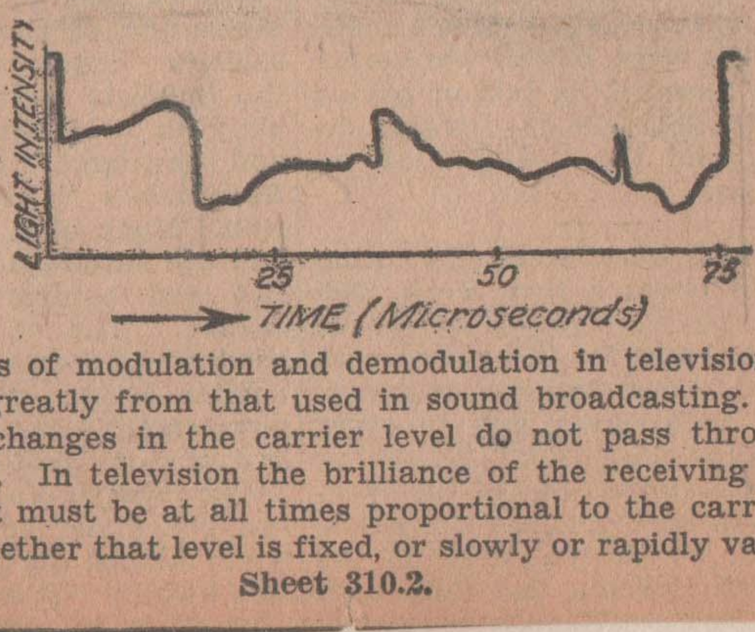
It can be readily seen that while many portions of each picture are being scanned the light intensity may not change for an interval, since in any scene there are certain areas that have a flat tone without detail. If the brilliance of the spot does not change, therefore, during that interval the modulation frequency is zero. In another place a very sharp transition from white to black or vice versa may be encountered. The current may therefore vary between two levels in a very short time, possibly a microsecond. (The factors that determine the actual transition time will be discussed elsewhere.) If we were to modulate the current with, say a 500,000 cycle wave, the change in the current level during a portion of a single cycle of this frequency might vary at the same rate as the variation caused by the change in received light intensity. Thus during that instant we might consider that our current was modulated by a 500,000 cycle wave. The comparison is not exact as the latter has a sinusoidal variation while the former may be more irregular.

It follows that the intensity of the signal may vary in a certain instant at the same rate that it would if it were modulated with a portion of a single cycle of a particular frequency. This frequency may be anywhere between zero and one or more millions of cycles per second. Immediately after that the frequency may change to a radically different value, continuing only for a fraction of a cycle before it gives away to a third value, and so on. In a single line a great many such changes take place. An oscillogram of these changes for a representative scanning line might be illustrated by Fig. A.

FIG. A.



The process of modulation and demodulation in television therefore differs greatly from that used in sound broadcasting. In the latter, slow changes in the carrier level do not pass through the audio system. In television the brilliance of the receiving cathode ray tube spot must be at all times proportional to the carrier level no matter whether that level is fixed, or slowly or rapidly varying.

Sheet 310.2.

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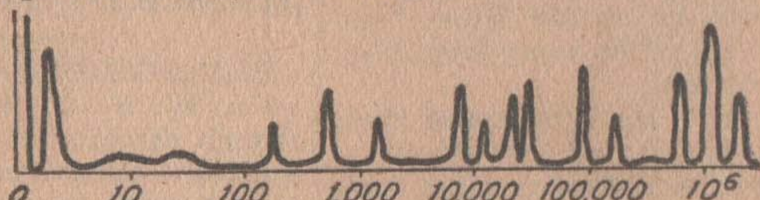
Representative changes in current level during the scanning of a single line was shown in Fig. A, sheet 310.2. An analysis of these changes could be made, using mathematical laws (those of Fourier), but the work would be rather involved due to the complexities of the curve, but if it were done it would show that a certain number of frequencies are present as shown in Fig. B.

FIG. B.

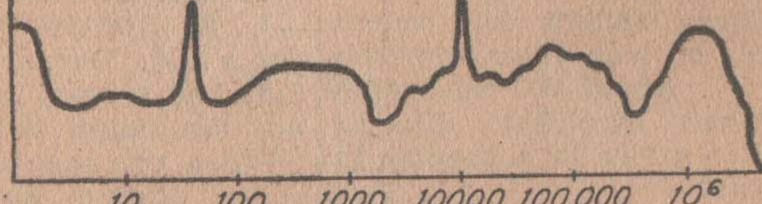


SAMPLE OF FREQUENCIES REQUIRED TO REPRODUCE A SINGLE LINE.

During the transmission of the line following the one just discussed, the same frequencies substantially may be present, but there will be some changes. Further down in the image, however, a completely different series of frequencies will be found, and during the time taken to send one complete picture (one-thirtieth of a second) a more or less complete band of frequencies between zero and one or two million cycles may be utilized.

The summation of these frequencies over a second of time may therefore produce a modulation spectrum somewhat as in Fig. C. The two pulses at 60 cycles and 13,230 cycles are, of course, the above mentioned timing pulses. Here again their envelop is extremely sharp and a considerable number of harmonics of each value must be passed in order that the pulse may be reproduced in the receiver accurately enough to permit correct distribution to the proper interlocking circuits.

FIG. C.



From the studio the whole band shown in Fig. C is sent to the main transmitter and is used to modulate the assigned carrier of that transmitter. For reasons to be described, this transmitter is often located on a high building, which requires special interconnecting circuits from the studio. In some cases this interconnection may be by a radio link, over wires, or over a co-axial cable.

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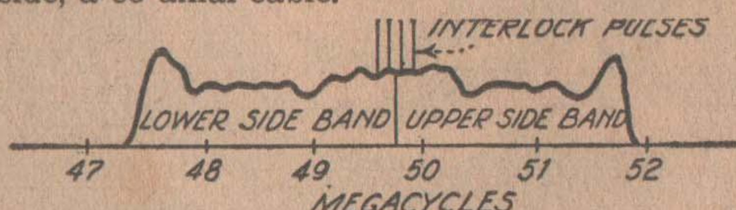
SCANNING FREQUENCIES

As shown in sheet 310.3, the process of translating the scene that appears before the television camera has brought about the generation of a rather wide band of frequencies, a range of from zero to one or two megacycles. During the interval required to scan a single line element we may find only a few definite frequencies spaced at rather irregular intervals within this range, yet over other portions of the picture additional frequencies result so that during a second of time the intervening gaps in the frequency spectrum are filled up, as a comparison of Figures B and C (310.3) will show.

The usual pair of wires in a telephone cable will not carry these high frequency currents; there is too much energy lost due to radiation and dielectric absorption, &c. A countrywide network of television programs where a large number of transmitters at various parts of the country are all fed by a single studio program, is therefore not possible with present facilities. Special "pipe lines" can be installed, however, that will handle these currents efficiently, but they are rather expensive, consisting of a hollow electrical conductor with the paired (return) conductor accurately spaced along the exact center inside, a co-axial cable.

FIG. D.



For the present discussion it will be assumed that the studio and the transmitter are both located in the same city. The band of frequencies shown in Fig. C (310.3) is used to modulate the radio carrier, which is located in one of the assigned television bands between approximately 3.5 and 7 meters corresponding to 42 and 86 megacycles, between which limits several television carrier bands have already been allotted for experimental purposes. The modulated carrier is then represented by Fig. D, based on the assumption that the carrier of 49.75 megacycles was used. In some experimental tests, however, the system is modified, in that one of the side bands is eliminated by appropriate filters. This matter will be described elsewhere. The picture Fig. D may also be modified in some cases, in the matter of the interlock pulses, particularly in cases where the carrier level is automatically reduced to a low level during the intervals where the scanning spot reaches the edges of the scene.

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INTERLACED SCANNING

The question is often asked as to why the elaborate processes associated with interlaced scanning have been selected since it would seem that simpler methods would be found with consecutive scanning. Some advantage must be found with the interlaced method since both systems were given a practical trial in Great Britain last year, where alternate television broadcasts were on one or the other scanning system, yet finally the interlaced method was chosen.

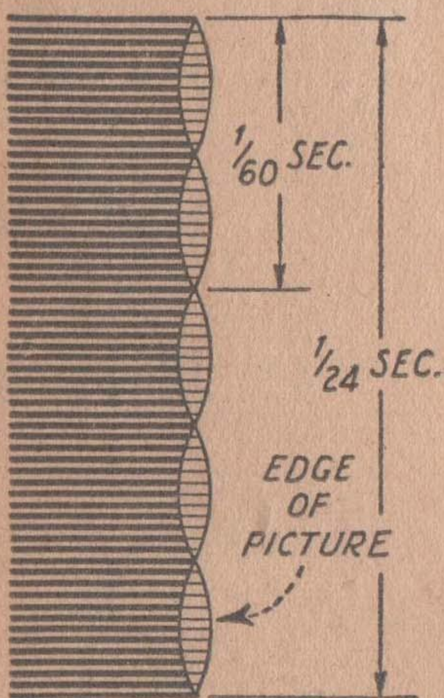

FIG. 1.

It is evident that a number of scenes must be transmitted each second in order to obtain the illusion of motion. A considerable proportion of the material to be broadcast over television will doubtless be from moving picture film sources, for many events take place where direct pick-up is not possible and when it is not convenient for the public to look on. The present standards for film projection is twenty-four pictures per second, so that this rate would seem to possess some advantages. Tests have shown, however, that there are some disadvantages with this picture framing rate, so that the matter was reopened for further investigation. Of these the main obstacle is due to the inevitable power line hum which appears to a greater or less degree in any apparatus which operates from power line voltage sources: While this hum can be substantially eliminated by heavy filtering of each power supply, it is found that a certain amount is retained which is not easily eliminated. This amount would not be great enough to affect the usual sound broadcast receiver, but is particularly annoying in television receivers.

(To be continued.)

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INTERLACED SCANNING

(Continued)

In sheet 320.1 the effect of a superposed hum on the scanning potentials was analyzed. It might be interesting to study the same problem under the assumed condition of a 24 cycle power line frequency, that is equal to the framing frequency that matches the projection rate of an ordinary moving picture film. In Fig. 2, it is seen that the edges of the picture due to the ends of the horizontal scanning lines are still curved, since nothing was done to cut down the amount of hum. Still each line falls directly upon the corresponding line of the preceding frame. Thus the edges coincide although they may be slightly curved. Vertical lines appearing in the pictures, such as from flagpoles, buildings, &c., would appear curved a small amount, but this curvature would scarcely be noticed. It might seem that this would provide a solution for the hum problem, but unfortunately it would be impossible to change the frequency of all power systems to 24 cycles. The next possibility therefore would be to increase the framing frequency to 60 cycles since it is seen that the hum problem is satisfactorily eliminated if the framing frequency and the power line frequency are equal.

FIG. 2

The 60 cycle framing rate has several disadvantages over the 24 frame rate. In the first place it is not necessary to send as many pictures per second to secure a smooth reproduction of fast actions. With the same number of lines per frame the video signal frequency band would be just 2.5 times as great, increasing the cost of the system considerably without improving the clarity and detail in the scenes. In fact, it accomplishes nothing except the elimination of distortion due to hum. Sending only half as many lines per frame would cut the video band width in two, at the expense of picture detail since 220 lines per frame would result in a very coarse reproduction.

(To be continued)

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Scanning conditions that result when a twenty-four frame per second system is used with a 60 cycle power line when perfect filtering is not present, was illustrated in Fig. 1 (sheet 320.1). The combination of hum potential with the ordinary saw-tooth scanning wave causes lines on alternate frames to shift slightly to right or left, so that successive frames blur each other. The effect shown in Fig. 1 (although greatly exaggerated) shows how one edge of the picture would appear. In addition the lines may also shift up and down, so that line No. 321, for instance, might fall on line 326 of a previous picture. This results in confusion and a lack of detail. The improvement due to keeping the framing frequency and the power line frequency the same was shown in Fig. 2 (sheet 320.2). On account of the extravagant use of the frequency band when using this high framing rate, a compromise plan has been developed. This consists of a scheme by which the lines in one frame spread out so that a gap exists between them, using only half as many lines per picture as before. The missing lines are filled in during the next scan so that a full set appears for each two frames. A complete picture appears only thirty times a second, which is still more than actually necessary, but not extravagantly so. This method, it will be seen, corresponds to the interlaced scanning method previously referred to (sheet 010.11).

The hum problem is also gone since the lines in successive frames will all be superimposed, as in Fig. 2. Some complications are found in sending standard moving picture films, such as news reels, &c., during the television program, but these problems are concerned solely with the transmitting equipment, which is not so serious as systems which add extra apparatus to each receiver.

There are two possible systems for adding the interlaced scanning system, which depend upon whether an odd or even number of lines per frame are used. In this matter it is necessary to define a frame as a complete picture which includes two of the interlaced sections. Odd line interlacing, now considered standard, was illustrated on sheet 010.11.

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SCANNING WAVE TRANSMISSION SYSTEMS

As mentioned in sheet 300.7, it is possible to transmit the scanning wave signals with exact wave form and timing characteristics so that at the receiver it is only necessary to amplify these signals for scanning. Several variations in this system have been suggested by Von Ardenne, Dumont and others.

Von Ardenne (Germany), suggests the use of scanning oscillators which are under the direct control of incoming scanning signals. The local oscillators therefore have no inherent frequency settings of their own.

The condensers in the timing circuit of each scanning "amplifier" charge up until the pulse is received. The gas discharge tube is arranged to operate only when a particular type of pulse is applied to its grid. In the ordinary circuit if the synchronizing pulses fail to arrive the scanning oscillators continue to operate although possibly not on the correct frequency. In the above arrangement, however, the deflection stops whenever the driving pulses are missing. Provision has to be made in this case to hold the spot off the screen so that the fluorescent material is not burned.

In the Dumont system the two signals having the scanning wave form are superposed on the sound signals, or upon carrier frequencies which are above the range of sound signals.

At each receiver these frequencies are thereupon filtered out of the amplified and applied to the deflection plates of the cathode ray tube.

In practice it is necessary to transmit a rather wide band of frequencies in order to reproduce a saw tooth wave, that is, the fundamental and the harmonics of those frequencies, at least up to the tenth. Therefore, in the Dumont system, the plan is to transmit sinusoidal waves having the exact frequencies of the transmitted standard. These waves are then converted into the saw tooth wave form by a type of wave form distorting network. Two circuits of this type are therefore essential parts of each receiver.

These networks are connected through filters to the sound channel part of the television receiver, and the resulting pulses, suitably amplified are connected to the deflection system of the cathode ray tube.

(To be continued.)

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In the Dumont system outlined on sheet 320.5 a four-times interlaced picture with a 441 line frame is shown. Actually only fifteen pictures per second are transmitted, although it is claimed that flicker is eliminated by the rapidity of the interlace.

Certain advantages are claimed for this system such as the elimination of elaborate scanning oscillators in each receiver, together with the synchronization filters and their attendant controls, in favor of simplified amplifier circuits. It is also claimed that less time is lost between lines or frames since the flyback interval can be speeded up. Also, being inherently synchronized, even more than a four-time interlace per frame can be used. This feature is of some interest since it would permit a reduction of the number of frames transmitted per second from thirty to fifteen or less. The band width requirements are thus automatically reduced to one-half or less. This permits either a simplified video amplifier or the use of a greater number of lines per picture if the same six megacycle band width (see sheet 200.4) is retained.

In the diagram on the preceding sheet (320.5) showing the circuit used at the transmitter the two basic scanning frequencies are generated by oscillators G and H. G is maintained in synchronism with the power line frequency and H is held to the correct multiple of that frequency. The sinusoidal wave form output is converted to a saw-tooth wave form by "modifier" circuits which introduce all harmonics both even and odd. It is necessary, however, that the amplitude of each harmonic be inversely proportional to the harmonic number. That is, the second harmonic should be one-half as strong as the fundamental; the third harmonic, one-third as strong, &c. In addition it is necessary that all harmonics be in phase, that is, all must cross the axis at the same time.

The success of this system depends upon the ability of the modifier circuits to do this correctly. The resulting saw-tooth waves are applied to a camera tube of any type, such as the Iconoscope and the sinusoidal waves themselves are broadcast by modulating their own particular superaudible tones, which for simplicity are selected as 15,000 and 25,000 cycles respectively.

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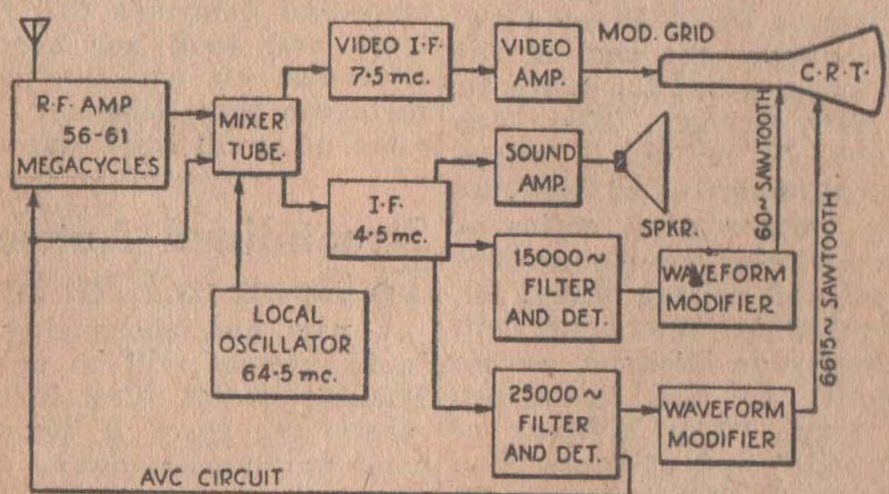
SCANNING WAVE TRANSMITTER SYSTEMS

(Continued.)

In the transmitted scanning wave system advocated by DuMont the receiver is in some respects the converse of the transmitter. The video channel is unhampered by any synchronizing pulses or pedestals, and so the video I. F. delivers its output directly into the modulation grid of the cathode ray tube through a rectifier (and video amplifier if needed). As shown in the diagram below the output of the sound I. F. channel contains several band-pass filters to separate the sound broadcast, the 15,000 cycle framing wave carrier, and the 25,000 cycle line frequency carrier, from each other.



Inasmuch as the amplitude of the deflections are proportional to the received signal strength of the carrier that contains the scanning wave frequencies it is necessary that the amplitude of this carrier be maintained constant. For this reason it is necessary to have an automatic volume control arrangement, or else the pictures will expand or contract with every change in signal amplitude. This matter is one of the most serious drawbacks of the system. The a. v. c. circuit may be a part of the 25,000 cycle filter and detector, as shown in the figure.