

April 5, 1949.

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2,466,221

HIGH SPEED FACSIMILE SYNCHRONIZING SYSTEM

Filed Sept. 28, 1945

2 Sheets-Sheet 1

Fig. 1

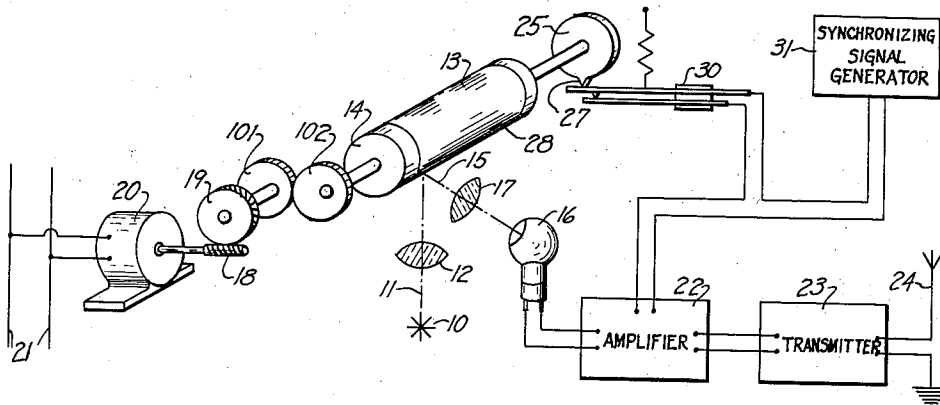
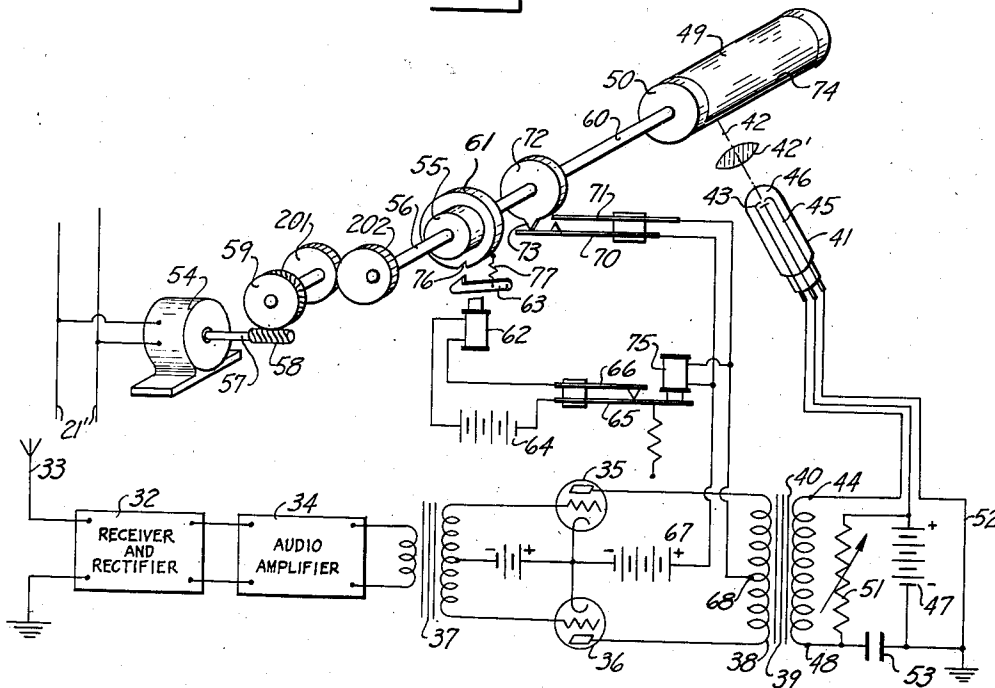


Fig. 2



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2 Sheets-Sheet 2

Fig. 3

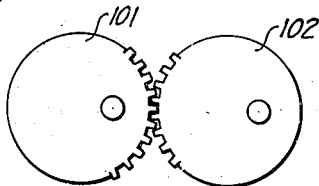


Fig. 4

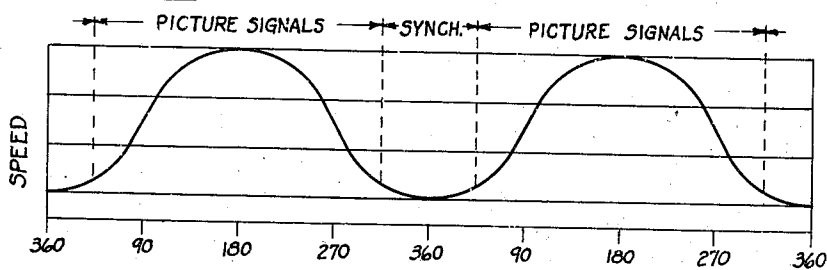
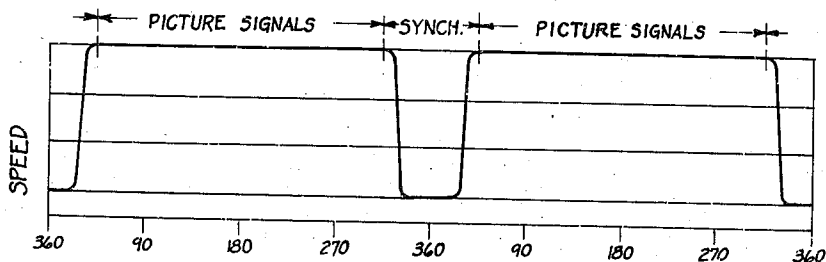


Fig. 5



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HIGH-SPEED FACSIMILE SYNCHRONIZING
SYSTEM

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2 Claims. (Cl. 178—69.5)

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My present invention relates to the transmission and reception of facsimile by wire or radio, and more particularly to novel synchronizing mechanism which will operate efficiently at high speed picture transmission.

Heretofore, in the transmission and reception of facsimiles, it has been necessary, where absolute synchronism was desired between the transmitting and receiving apparatus, to transmit the facsimiles at a relatively slow speed. This relatively slow speed of about one hundred lines per minute has nevertheless been regarded as a rather high speed. For instance, where a drum was ten inches wide and one hundred lines per inch was transmitted, then at this speed a picture ten inches long and having a width only slightly less than the circumference of the drum, was transmitted in ten minutes or less. Modern developments have made it possible, however, to transmit facsimiles by photo-recording or chemical recording processes at a much higher speed. Thus, for instance, it has been found that without any attempt to maintain synchronism, speeds as high as four hundred lines per minute became feasible, and thus the ten-inch picture above described could be transmitted in two and one-half minutes.

Heretofore, synchronizing systems have consisted essentially of stop-start mechanisms of the type specifically described in my Patent No. 2,108,983. The receiving drum was rotated at a slightly greater speed than the transmitter, say, in a ratio of 101:100, so that the receiving drum would reach the synchronizing area first. The receiving drum was then brought to a stop or its rate of speed adjusted practically to zero for an extremely short interval pending the receipt of a synchronizing signal which would permit the receiving drum to start once more. The arrangement of the mechanical elements as well as of the electrical elements used for synchronizing was such that at one hundred lines per minute, the receiving drum could readily be brought to a stop and started once more at a rate approaching twice per second.

Where higher speeds were attempted, the stop-start method could be adapted by various adjustments to work properly at a scanning rate of one hundred twenty lines per minute (exactly two stop-start operations in each second), and even slightly higher, but at speeds of four hundred lines per minute the stop-start mechanism created too much vibration, thus interfering with the quality of the image being recorded, and at times causing the synchronizing impulse to be

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skipped entirely, due to the vibration introduced.

Essentially, my invention contemplates varying the speed of the transmitter and receiver simultaneously, so that a greater time interval will be obtained for the transmission, reception and operation of the synchronizing signal.

Heretofore, the synchronizing signal was arranged to take place over about twenty degrees of the rotation of each of the drums, thus representing about $\frac{1}{18}$ or $\frac{1}{20}$ of the scanning time. Where the transmitter and receiver operated at a rate of 100 R. P. M., the scanning operation took place approximately slightly less than twice a second, and the scanning time occurred over an interval of about $\frac{1}{40}$ of a second. Where the operation of the drums is speeded up to 400 or even 500 R. P. M., then the scanning time is correspondingly reduced to as little as $\frac{1}{200}$ of a second. Since the mechanical elements must be stopped and brought into operation within that time, and since they must operate with accuracy, it has been found that with mechanical systems now known, insufficient time might be given for the synchronizing operation.

My invention provides cyclical speed-changing means for the transmitter and receiver, which will slow up the transmitting and receiver drums just prior to the synchronizing operation, maintain this slower speed during the synchronizing operation, and speed up the drums during the second cycle.

It has been found that scanning operations must be performed at extremely high speeds, while the synchronizing operation nevertheless should be slowed down. By this cyclical varying of the speed of the receiving and transmitting drums, the entire scanning operation may be made to take place in $\frac{1}{3}$ of a second rather than the half-second per line scanning operation of prior devices, while at the same time the speed of the drums at the time of the synchronizing operation is maintained at from $\frac{1}{40}$ to $\frac{1}{100}$ of a second, depending on the ratio of the cyclical speed-changing mechanism which is used.

In the specific embodiment here shown, I have used elliptical gears between the driving motor and the transmitter drum, and exactly similar elliptical gears between the driving motor and the receiving drum. Other speed-changing gear mechanism may, of course, be used to the same effect.

Accordingly, the primary object of my invention is the provision of novel synchronizing methods and means for use in high-speed transmission of facsimiles by wire or radio.

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Another object of my invention is the provision of novel speed-changing apparatus in connection with the drive for the transmitting and receiving drums, so that the transmitter will send to the receiver, picture impulses at extremely high speed, while the synchronizing signal will be sent at low-speed operation of the drums, thus affording sufficient time for operation of the synchronizing elements.

The foregoing and many other objects of my invention will become apparent in the following description thereof and from the accompanying drawings, in which:

Figure 1 is a schematic view of my novel facsimile transmitter showing the incorporation therein of novel speed-changing mechanism which will permit proper synchronizing operations to take place at high speed transmission;

Figure 2 is a schematic view of my novel receiver showing the incorporation therein of novel speed-changing mechanism which will permit proper synchronizing operations to take place at high speed transmission;

Figure 3 is a schematic view of the elliptical gear drive for my transmitter and receiving drums;

Figure 4 is a graph showing the speed characteristics of the transmitting and receiving drums for the sending of picture signals and synchronizing impulses; and

Figure 5 is a graph showing an optimum curve for the speed characteristics of the drums during the sending of picture and synchronizing signals.

The schematic diagrams, Figures 1 and 2, of a telepicture transmitter and receiver respectively, are described to more clearly set forth the function and relation of the synchronizing mechanism of my present invention. It is to be understood that the telepicture system and circuits described are by way of example only, and that the synchronizing mechanism to be hereinafter described in detail is applicable to other telepicture or facsimile systems.

Referring to Figure 1, a source of light 10 generates a beam 11 focused to a point by a lens system 12 upon the picture 13 to be transmitted, which is mounted on the cylindrical drum 14. If the picture is scanned one hundred lines per inch, the diameter of the light spot focused upon the picture should be .01 inch. The refracted beam 15 from the picture is focused upon the photoelectric cell 16 by lens system 17. The intensity of the refracted beam 15 is proportional to the shading of the picture elements which are successively moved past the light beam 11.

The picture drum 14 is rotated by worm 18 and worm gear 19 which suitably reduce the speed of the motor 20. Motor 20 is preferably a synchronous motor connected to a commercial electrical supply line 21, for example, a sixty-cycle, 110-volt system. The drive from the worm gear 19 to the drum 14 is through the eccentric gears 101, 102, which may be elliptical, or have any other appropriate eccentricity to provide a high speed operation over most of the rotation of drum 14, and extremely low speed operation at the underlap region 28 hereinafter to be described, in order to provide slow-speed operation of the drum during the synchronizing impulse, so that synchronization can take place over a relatively much longer interval than would be possible if the speed of the drum were cyclically constant.

The refracted picture light beam 15 impinging on photoelectric cell 16 produces corresponding electrical signals which are amplified by ampli-

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fier 22. A light "chopper" or an audio frequency carrier wave may be employed with the amplifier 22 to facilitate transmission of the vary uni-directional picture signals, as is well known in the art.

The telepicture signals may be directly transmitted to a remote station over wire lines or may be transmitted by radio transmission means. Figure 1 illustrates a transmitter 23 connected to the output of amplifier 22 for converting the audio frequency telepicture signals into corresponding radio frequency signals which are radiated by antenna 24.

Synchronizing signals are cyclically transmitted for effecting synchronization of the transmitter scanning apparatus in a manner to be described. The synchronizing signals have heretofore been transmitted once per scanning operation. When a drum is used as in the preferred embodiment, the "underlap" period of the rotation cycle is employed to transmit the synchronizing signal. The underlap period corresponds to the portion of the picture drum where the opposite ends of the picture 13 are gripped or otherwise fastened into position on the drum.

A cam 25 is mounted upon the shaft 26 of the telepicture drum 14. A projection 27 of the cam 25 is positioned angularly corresponding to the underlap portion of the drum 14. The edge 28 of the picture sheet 13 determines one side of the underlap zone and is gripped by clamping means internal to the drum 14, in a manner preferably as described in my prior patent No. 2,051,511.

The synchronizing cam switch 30 is cyclically closed by the cam projection 27 to impress suitable synchronizing impulses upon the amplifier 22 from the synchronizing signal generator 31. Synchronizing switch 30 is connected in series with the synchronizing signal generator 31 output to a suitable portion of the telepicture amplifier 22 schematically indicated in Figure 1. The synchronizing impulse effective during the underlap period is preferably of intensity somewhat greater than the maximum or "white" telepicture signal intensity in order to readily distinguish the synchronizing signals from the telepicture signals at the receiver.

The synchronizing signal generator 31 may be a direct current source which produces a unidirectional impulse at each closure of cam switch 30, or may be an audio carrier frequency signal which is unmodulated during the synchronizing period and is suitably modulated by the picture signals during the remaining period of the cycle. A preferred embodiment of such a method for signal generation forms the basis of my prior Patent No. 2,069,061.

Figure 2 is a schematic diagram of a telepicture receiver used in conjunction with the transmitter of Figure 1, and employing the synchronizing mechanism of my present invention. A radio receiver and rectifier 32 is connected to a receiving antenna 33 for receiving the radio transmitted signals from the radio transmitter 23. If a wire line is used, suitable amplifying and line equipment are instead employed. The output of the receiver and rectifier 32 are connected to an audio amplifier 34. The output of audio amplifier 34 is coupled to a class B push-pull output stage 35-36 by an interstage coupling transformer 37. The output of the push-pull stage 35-36 is connected to the primary 38 of the output transformer 39. The output of the secondary 40 of transformer 39 is connected to a photo-lamp 41 containing a

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gas such as neon, for producing a light beam 42 output in accordance with the telepicture signals received. The light output 42 from lamp 41 is suitably focused upon the record sheet 49 on the receiving drum by a lens system 42'.

I have here used a neon crater-photo-lamp 41 having a control electrode 43 which is connected to one terminal 44 of the transformer secondary 40, and an auxiliary or striking electrode 45. The crater plate 46 of lamp 41 is connected to the positive terminal of a suitable direct current source 47, the negative terminal of which is connected to ground. The other terminal 48 of the transformer secondary 40 is connected to the crater plate 46 through a variable resistance 51. The auxiliary or striking electrode 45 is connected to ground by lead 52. As is well known in the art, the auxiliary electrode 45 maintains a striking or discharge condition at the photo-lamp crater plate 46, so that it will always be in readiness to respond to telepicture signals introduced between the plate 46 and the control grid 43. A by-pass condenser 53 is connected between the output terminal 48 and ground.

The receiver drum 50 is driven by a synchronous motor 54 connected to supply lines 21'. The lines 21' are, where possible, from the same alternating current supply lines 21 as those of the transmitter, although such condition is not essential. The synchronous motor 54 drives drum 50 through the schematically indicated synchronizing phase adjusting mechanism 55. The synchronizing phase adjusting mechanism is more fully described in detail in my prior Patent No. 2,108,983.

The drum phasing mechanism 55 maintains a driving connection between the shaft 56 which is driven positively from the motor shaft 57 through worm 58 and worm gear 59, and the shaft 60 directly attached to the receiver drum 50.

The drive from the worm gear 59 to the phasing mechanism 55 is through the eccentric gears 201, 202, which may be elliptical or have any other appropriate eccentricity to provide a high-speed operation over most of the rotation of drum 14, and extremely low-speed operation at the underlap portion 28 hereinafter described, in order to provide slow-speed of the drum during the synchronizing impulse, so that synchronization can take place over a relatively much longer interval than would be possible were the speed of the drum cyclically constant.

The control plate 61 cooperating with the phasing mechanism 55 is actuated by the synchronizing magnet 62 through its armature 63. Drum 50 is preferably driven at a slightly faster speed than the corresponding transmitter drum 14, for example, in a ratio of 401:400.

The phasing mechanism 55 is under the control of the synchronizing magnet 62 to maintain the drum 50 in phase synchronism with the transmitter drum 14. A direct-current potential source 64 supplies the synchronizing magnet 62 through its relay contacts 65—66.

The anode potential source 67 for the push-pull amplifier stage 35—36 is supplied to the center tap 68 of the primary 38 through the synchronizing cam switch 70—71. A cam 72 is connected to the shaft 60 adjacent the drum 50. The projection 73 of the cam 72 is in the same angular position on shaft 60 as the underlap or "dead" zone 74 of the drum 50. The cam switch 70—71 is normally maintained closed during the major portion of the rotation of cam 72, and the anode current from source 67 normally directly flows

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to the push-pull amplifier stage 36—35 during the reception of the telepicture signals.

The cam switch 70—71 is opened by the projection 73 of the cam 72 during the synchronizing period of the receiver at an underlap portion thereof. The anode current from source 67 is accordingly directed to the amplifier 35—36 through the synchronizing relay 75, which relay 75 is otherwise short-circuited by switch 70—71.

The synchronizing signal, as hereinabove described, occurs during an underlap period of the picture transmitter, and is preferably of greater magnitude than the telepicture signals. Synchronizing relay 75 is preferably a marginal relay responding only to the increased magnitude signals so as to avoid the possibility of interference of the synchronizing action by any of the telepicture signals. The push-pull amplifier 35—36 rectifies an alternating current synchronizing impulse in the anode lead if such is used, and the actuation of the relay 75 is by rectified or unidirectional current, as will be understood by those skilled in the art.

Although I prefer to use synchronizing signals of increased intensity, and a marginal synchronizing relay, I have also successfully employed synchronizing signals of intensity equal to the maximum intensity picture signals to operate an ordinary relay. It is also to be understood that the synchronizing magnet 62 may be directly energized by the synchronizing signals, displacing the relay 75.

The receiver drum 50 is prepared for the synchronizing signal during its underlap period by cam 72. The synchronizing signal will flow through to energize the synchronizing relay 75 which then closes the relay contacts 65—66, locally energizing the synchronizing magnet 62. The synchronizing magnet 62, when energized, will attract the armature 63 away from control plate 61 to permit the phasing mechanism 55 to continue to normally drive the receiver drum 50, i. e., if the drum 50 were in phase synchronism and in proper phase, the release of armature 63 away from the plate 61 would avoid phasing or angular correction by the mechanism 55.

The control plate 61 of the phase-correcting mechanism 55 has a notch 76 on its periphery; the angular position of notch 76 corresponds to the angular position of the underlap zone 74 of drum 50 and that of the projection 73 of cam 72. The armature 63 is normally mechanically biased by spring 77 against the periphery of the control plate 61. Armature 63 accordingly engages the notch 76 of control plate 61 and holds it against rotation. By preventing the rotation of control plate 61, the angular or phase correcting mechanism 55 is actuated to effect the phase synchronism of drum 50 with transmitter drum 14 in a manner to be described in detail hereinafter.

By rotating drum 50 at a slightly faster rate than the transmitter drum 14, for example in the ratio of 401:400, the underlap period of the drum 50 will reach the predetermined position corresponding to the engagement of armature 63 of notch 76 slightly before the normal reception of the synchronizing signal from the transmitter. The cam 72 will accordingly open cam switch 70—71 by the projection 73 and permit the energization of synchronizing relay 75 by the synchronizing impulse as it is received. The energization of synchronizing relay 75 by the synchronizing impulse will close contacts 65—66 to correspondingly energize the synchronizing mag-

net 62 to attract the armature 63 away from engagement with notch 76 of control plate 61. The drive connection between the motor 54 and the drum 50 is continuously maintained and the synchronizing signal in attracting the armature 63 from the control plate 61 permits the drum 50 to continue rotating with the positive driving connection intact and in accurate phase synchronous relation with the transmitter drum.

In Figure 3 I show the eccentric gears 101, 102 of Figure 1 with a variable speed ratio of approximately 3:1. The ratio and arrangement of gears 201, 202 of the receiver of Figure 2 is exactly the same. The gears are arranged as shown in the graph of Figure 4, so that high-speed operation takes place during the transmission of the picture signals, but the operation is slowed down materially at the time of transmission of the synchronizing signal. In other words, the position of the gears 101, 102 shown in Figure 3, is the position the gears should assume at the central portion of the interval over which the synchronizing impulse is sent.

It will be seen from Figure 4 that while the drums are slowed up during the synchronizing operation, the speed of the drums varies materially during the transmission of picture signals. This variation is identical for both the transmitter and receiver, resulting in no variation in the picture signals; but since for certain signals the drum will be moved at a much slower speed than for other signals, those signals may be recorded darker than they otherwise might be. For ordinary transmission of black and white facsimile impulses by use of stylus recording, this will not make any noticeable difference. In the case of photoelectric reception of picture signals, the light will impinge more strongly on the receiver drum, due to the slower travel of the receiver drum at the areas adjacent the underlap portion 74. Using a photographic sheet, however, of appropriate latitude and contrast, this too will not make any appreciable difference.

In Figure 5 I have shown a graph giving the optimum speed variation curve which should be obtained, if possible, during the cyclical variation of the speed of the drums, i. e., the synchronizing signal is sent during a constant low-speed, relatively short portion of the cycle, and the picture signals are sent along a constant high-speed, relatively long portion of the cycle.

While I have described my invention in connection with the use of drum-type transmission for photoelectric recording, it will be obvious that the same kind of drive can be used for stylus recording. It will also be obvious that my novel synchronizing system is adapted for continuous sheet recording of the type shown in my prior Patent No. 2,296,274, for oscillating arm recording, and for spiral or lawn-mower type scanners.

Since many variations and modifications of my

invention will now be obvious to those skilled in the art, and since I have illustrated my invention solely in connection with an illustrative embodiment thereof, I prefer to be bound not by the specific disclosures herein contained, but only by the appended claims.

I claim:

1. In a high-speed facsimile system comprising a high-speed facsimile transmitter and a high-speed facsimile receiver; said transmitter and receiver each comprising cyclically rotating members and means for operating the same; means at the transmitter for generating a synchronizing signal at a predetermined point in each cycle; means at the receiver for receiving said synchronizing signal and responsive thereto; and additional means at the receiver for varying the speed of the cyclically movable member during each cycle of movement thereof; said speed-varying means imparting a relatively slow speed to the cyclically movable member at the receiver during the portion of the cycle immediately before and after the receipt of the synchronizing signal, and a relatively high speed thereto during the remainder of the cycle, said cyclical speed-varying means comprising a pair of eccentric gears between the driving means at the receiver and the cyclically moving member.

2. In a high-speed facsimile system comprising a high-speed facsimile transmitter and a high-speed facsimile receiver; said transmitter and receiver each comprising cyclically rotating members and means for operating the same; means at the transmitter for generating a synchronizing signal at a predetermined point in each cycle; means at the receiver for receiving said synchronizing signal and responsive thereto; and additional means at the receiver for varying the speed of the cyclically movable member during each cycle of movement thereof; said speed-varying means imparting a relatively slow speed to the cyclically movable member at the receiver during the portion of the cycle immediately before and after the receipt of the synchronizing signal, and a relatively high speed thereto during the remainder of the cycle, said cyclical speed-varying means comprising a pair of elliptical gears between the driving means at the receiver and the cyclically moving member.

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