Oct. 31, 1950 V. J. TERRY 2,527,599

FACSIMILE DEVICE

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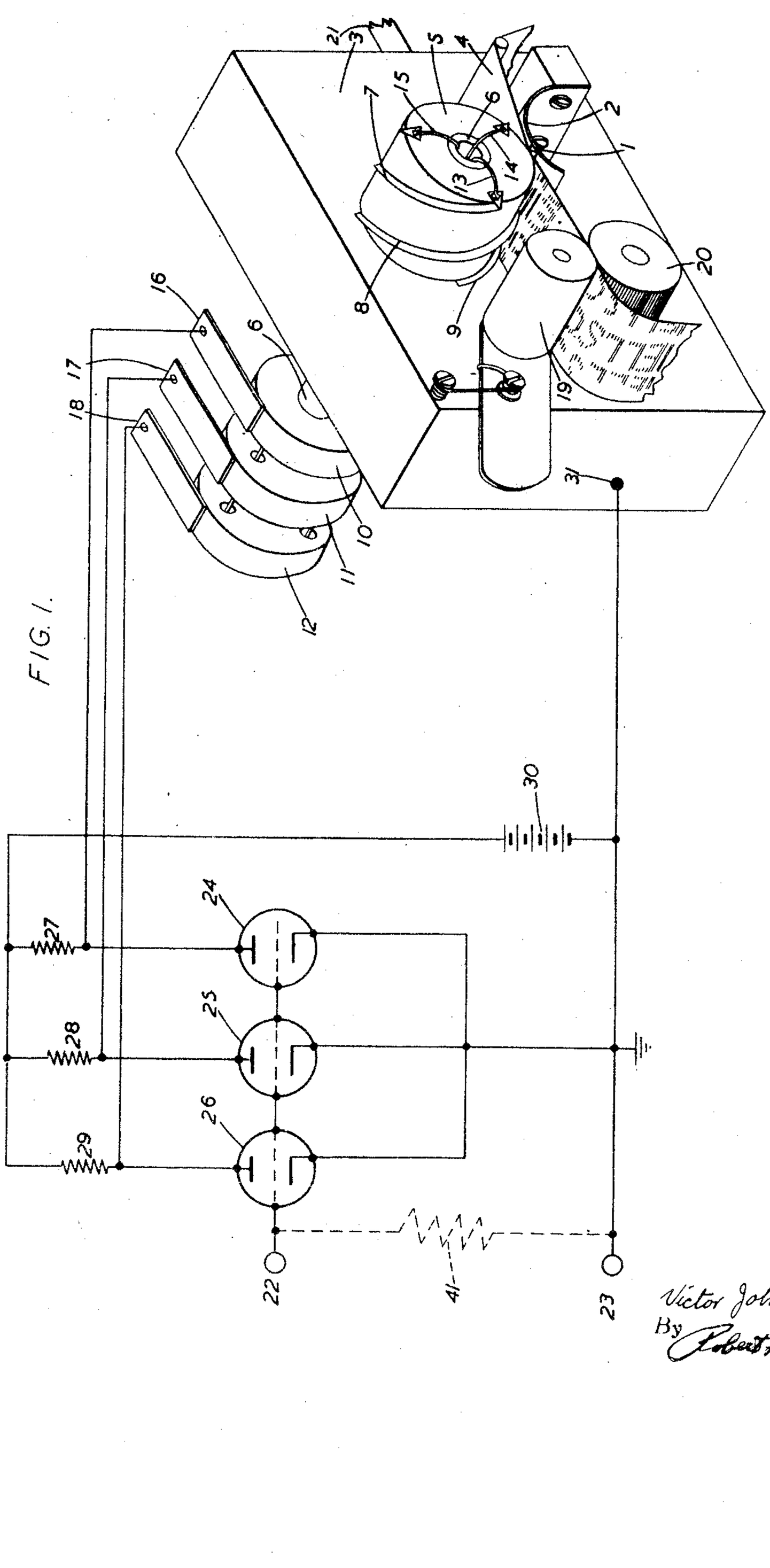

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FIG.2.

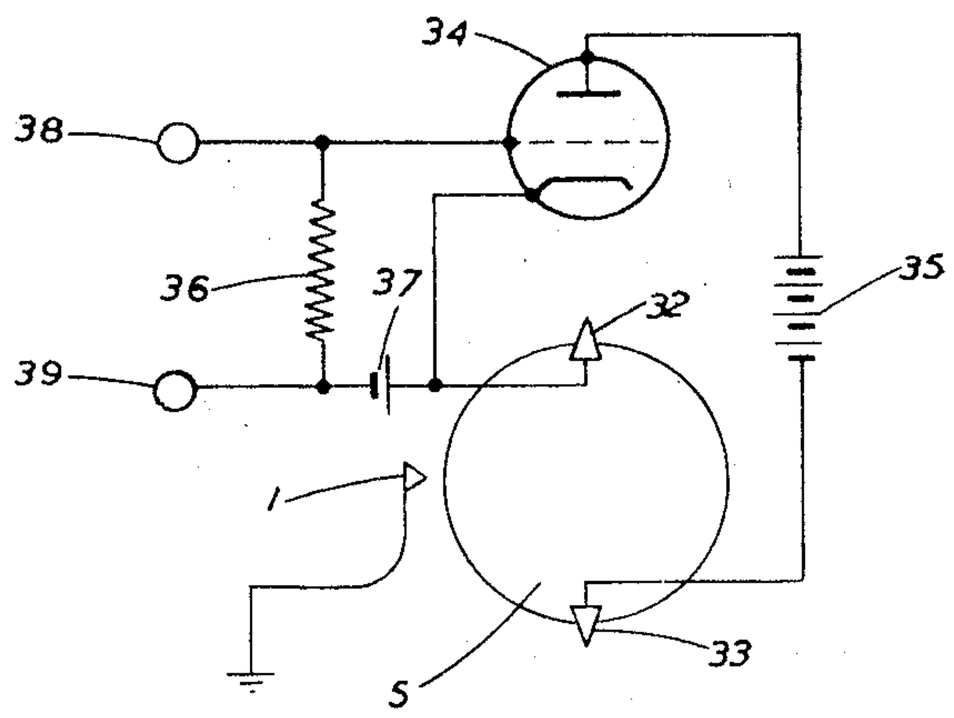
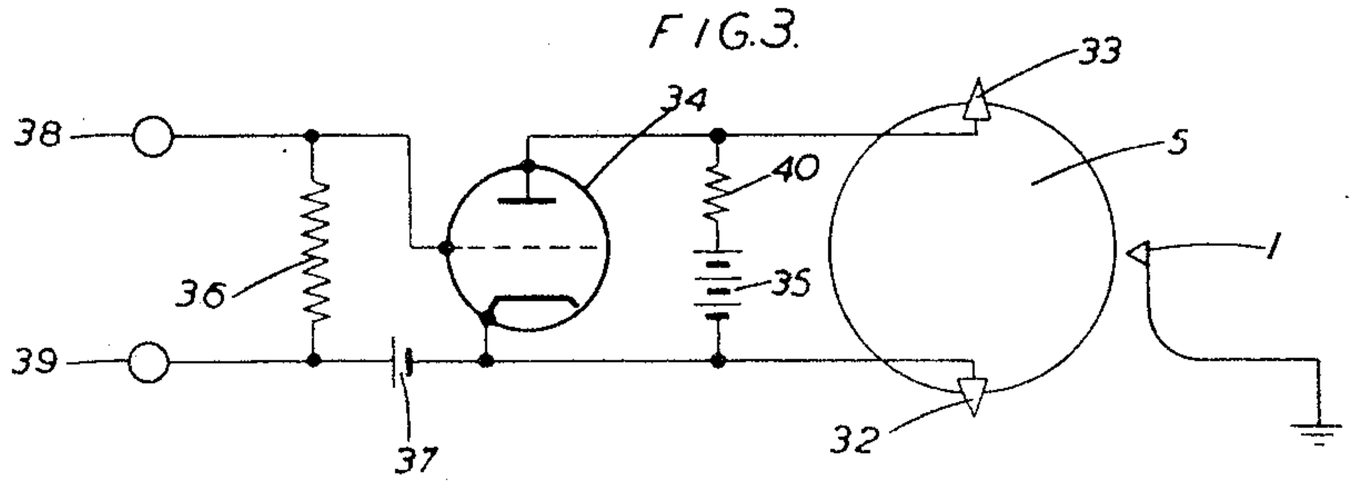


FIG.3.



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FACSIMILE DEVICE

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10 Claims. (Cl. 178—5)

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The present invention relates to improvements in telegraph recording arrangements for the facsimile reproduction of messages.

A well known facsimile transmission system consists of a transmitter and receiver, the latter having, as an essential feature, a rotating worm or screw with at least two complete turns of coarse pitch, and an electro-magnetically operated lever carrying a narrow anvil lying parallel with the axis of the worm. A strip of paper passes in a narrow gap between the anvil and the worm, approximately at right angles to the anvil, so that when the lever moves to its operated position in response to current in the electromagnet, the paper is compressed between the anvil and the tip of the thread in two or more places.

Ink on the tip of the thread, or more usually, the presence of a type-writer ribbon between the paper and worm, causes visible marks to be produced on the paper at the points of compression, and since the worm is rotating rapidly and the paper is fed slowly forward, lines would be drawn nearly perpendicular to the length of the paper, if the lever were held in the operated position.

The two or more points of compression between the anvil and the thread draw lines which if extended, by keeping the magnet operated, lie side by side and cover the whole surface of the paper, but which reproduce characters in duplicate when the magnet is operated intermittently in accordance with the appropriate code of signals.

In practice this known instrument suffers from several disadvantages, the chief of which is the difficulty of maintaining good adjustment owing to the speed with which the electromagnet is called upon to respond and the very small range of movement to which the anvil is in consequence restricted. The life of the type-writer ribbons is also short.

The indication is either black or white with practically no intermediate half tone, and when the signal-to-noise ratio is poor, a moderate variation in signal strength will suffice to leave the tape record almost all white or make it largely black. The absence of half tones is a very convenient and desirable property when the signal-to-noise ratio is good, for the signal strength may be set high, so that signal fading does not affect the blacks, and the absence of half tones means that a clean white background is still obtained.

When the signal fading is accompanied by a poor signal-to-noise ratio, a wide range of half tone values would however be very desirable, for it would enable the eye to discriminate between signal and noise by comparing the intensity of

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the half tones, even if, at times when signal and noise are strong, the half tone due to noise should be darker than the half tone produced by signal at a time when both signal and noise were relatively weak. With half tones the appearance of the printed message would be relatively poor under average conditions, but it would be still readable in worse conditions, and thus the half tones would be justified when conditions are bad.

Obviously it would be desirable to have the ability to secure at will either clearly defined black and white or to reproduce variations in the total of signal and noise in a wide range of proportionate half tones.

It is the principal object of the present invention to provide a telegraph recorder which is generally of the type initially referred to, but which includes means whereby the characters are marked electrically on electric recording paper instead of being marked mechanically with ink.

This object is achieved according to the invention by providing a device for recording telegraph signals comprising a recording head carrying two or more writing electrodes insulated from one another, one or more backing electrodes, means for compressing a recording tape between the said writing and backing electrodes, means for rotating the recording head and for simultaneously causing the tape to travel in a direction approximately at right angles to the axis of rotation, and means controlled by one or more sources of telegraph signals for supplying writing currents to each of the said writing electrodes in such manner as to mark the tape in two or more separate places in accordance with the said signals.

More specifically the invention provides a device for recording telegraph signals comprising a multiple-start writing worm carrying a plurality of separate co-axial metal writing helices insulated from one another, a straight metal backing anvil electrode arranged approximately parallel to the axis of the helices and adapted to press a recording tape against the helices, means for rotating the worm and for simultaneously causing the tape to travel in a direction approximately at right angles to the said axis, and means controlled by a single source of telegraph signals for supplying writing currents to each of the said helices in such manner as to mark the tape in two or more separate places in accordance with the said signals.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 shows diagrammatically a recorder according to the invention, together with the circuit

arrangements for supplying the writing currents to the metal helices; and

Figs. 2 and 3 show alternative circuit arrangements.

Electric recording papers which operate by chemical action, or those in which marks are made by perforation or burning by high voltages (such for example as the paper which is sold under the registered trade-mark "Teledeltos") all display in varying degrees the property that the voltage which must be applied between the front electrode or stylus and the back electrode to initiate a mark is higher than that necessary to sustain it. In each case this property results from the rise in temperature at the writing point when current passes, and has the effect of rendering it impracticable satisfactorily to operate two pairs of writing electrodes in parallel from the same source because one pair would inevitably commence marking first, and would cause the voltage to fall and starve the other. If the supply source is made of low impedance to render the voltage independent of current, thus avoiding the effect already mentioned, it will be found that an excessive current passes once a mark has commenced, and therefore, either the writing points must be supplied from separate sources of moderate or high impedance, or else the pairs must be connected in series.

Certain types of recording papers have a conducting backing which prevents the use of more than two pairs of writing electrodes in series, but with paper perforated by high voltage and even with electrochemical paper, more than two pairs can often be operated in series from the same source if sufficiently widely separated.

It is an essential feature of a facsimile recorder of the type referred to that marks should be simultaneously made at two or more points on the recording paper, or alternatively, that marks should be made cyclically at two or more points in turn at a frequency of several hundred cycles per second. It is principally for this reason, therefore, that the recorder according to the invention includes two or more insulated writing electrodes and one or more backing electrodes which may be either connected to separate signal sources (or to one or more common sources through separate impedances), or connected in pairs in series to one or more separate signal sources.

The recording device shown in Fig. 1 comprises a single wedge-shaped writing anvil or electrode **1** mounted on a light curved spring **2** by which it is resiliently attached to the main metal case **3** of the recorder. This anvil presses a recording tape **4** against a triple-start writing worm **5** which comprises a cylinder of insulating material mounted on a shaft **6** and carrying three independently equally spaced sharp-crested metal helices **7**, **8** and **9** which stand up above the surface of the cylinder. The metal of which these helices are made should preferably be hard and incorrodible, such as stainless steel, or iridium, and may conveniently be moulded into the insulating cylinder. Alternatively, brass helices could be used, if the crests are edged with platinum-iridium alloy, or are thickly plated with rhodium. The pitch of each of the helices should be one-and-a-half times the length of the cylinder measured parallel to the axis, which length should preferably be slightly less than the width of the tape **4**.

Mounted on the shaft **6** are three slip-rings **10**, **11**, **12** connected respectively to the helices

7, **8**, **9** by insulated wires **13**, **14**, **15** which pass through the shaft **6**. Brushes **16**, **17**, **18** make contact with the slip rings **10**, **11**, **12** respectively.

The tape **4** is caused to travel in a direction at right angles to the axis of the worm **5** by means of rollers **19**, **20** in a conventional manner. These rollers and the worm **5** are driven by a main shaft **21** from a motor (not shown) and the gearing and mechanical arrangements may be the same as for the ordinary facsimile recorder, except that the worm **5** should be run at one-third the speed of a normal single-start recorder worm, that is, one-third of a revolution should occupy the time taken to transmit a capital letter I, including the spaces above and below, but disregarding the space which follows. This will produce one complete record of the signals and one record divided between the upper and lower edges of the tape. If the length of the worm **5** were increased to equal the pitch of the helices then two complete records and one divided record would be obtained.

The incoming signal voltages are rectified and are applied to terminals **22** and **23**, the former of which is connected to the three control grids of three thermionic amplifying valves **24**, **25**, **26**, and the latter is connected to the three cathodes and to ground.

The three anodes are connected respectively to the three brushes **16**, **17** and **18**, and also respectively through three anode load resistances **27**, **28**, **29** to a high voltage source **30**. The case **3** of the device to which the anvil **1** is connected, is grounded at **31**.

The signal voltages should be applied in negative sense to the terminal **22**. In the absence of any signal voltage, the valves are all conducting and the anode voltages, which will act from front to back of the tape **4** between the corresponding helices **7**, **8** or **9** and the anvil **1**, will in this condition be too low to make any mark on the tape. The negative signal voltage should be of such magnitude that the anode currents of the valves are reduced sufficiently to allow the anode voltage to rise to the marking value for the type of tape employed. Preferably the signal voltage should be sufficient to cut the valves off altogether. It will be evident that each of the helices will make its own mark on the tape independently of the others and three simultaneous records will be obtained, only the centre one of which is complete.

The three helices **7**, **8**, **9** and the anvil **1** are preferably made of triangular section as indicated in Fig. 1, and though they be made of the best known hard and uncorrodible metal, their life will not be indefinite, and in time the insulation of the work cylinder would be impaired by the smoke or fumes from the writing. These parts should therefore, preferably be made easily replaceable, for example, by making the worm removable from the shaft by means of a three-conductor plug-and-socket arrangement (not shown) of any suitable type, through which the conductors **13**, **14**, **15** for the helices **7**, **8**, **9** are taken. Either the plug or socket portion could be on the worm, as may be convenient.

Figs. 2 and 3 show two simpler circuit arrangements which may be used for a double-start worm, which will be arranged along the same lines as Fig. 1 except that there are only two helices angularly spaced apart by 180°, the length of the worm being equal to the pitch of each helix. The corresponding one of the three slip-rings and brushes will also be omitted. In

Figs. 2 and 3 the two helices **32** and **33** and the anvil **1** are diagrammatically shown. In both figures the two pairs of writing electrodes are arranged in series.

Referring to Fig. 2, the helix **32** is connected to the cathode of a valve **34** the anode of which is connected through a high voltage source **35** to the other helix **33**. The control grid of the valve **34** is connected through a high resistance **36** and a biassing source **37** to the cathode, and the rectified signal voltages are applied to terminals **38** and **39** which are connected to the ends of the resistance **36**, terminal **38** being also connected to the control grid of the valve **34**. The source **37** should preferably bias the control grid negatively to the cathode so that the valve is cut off. It will be seen that the writing electrode pairs **32—1**, and **1—33** are connected in series to the source **35** through the valve **34** which is substantially equivalent to an open switch. The signal voltages should be applied positively to the control grid so as to unblock the valve, thus substantially closing the switch through a resistance (constituted by the anode-cathode impedance of the valve when conducting) so that marks are made by both the helices, and the valve limits the writing current to a safe value. If necessary, additional resistance (not shown) may be connected in series with the anode of the valve.

In Fig. 3, the valve **34** is connected in parallel with the helices **32** and **33** instead of in series. The helix **32** is connected to the cathode as before but the helix **33** is connected directly to the anode. The source **35** is connected in series with a resistance **40** between the anode and cathode. The source **37** should bias the control grid so that in the absence of any signal voltages, the valve conducts and reduces the difference of potential between the helices **32** and **33** so that neither pair of writing electrodes can make any mark. In some cases the source **37** could be omitted altogether. The signal voltage should in this case be applied negatively to the control grid so as to reduce the anode current sufficiently to permit the voltage across each pair of writing electrodes to rise to the marking value. Preferably the signal voltages should be sufficient to cut off the valve.

In Figs. 2 and 3, no connection need be made to the anvil electrode **1**, but in order to prevent the anvil and case of the device from being at a high potential, it is preferable to ground the anvil as shown. However, this will, of course, prevent any other ground connection being made to the valve circuit or to the source of the signal voltages.

In Fig. 1, the slip rings are shown placed on the opposite side of the instrument from the writing worm **5** and are connected through the hollow shaft **6** in order to reduce to a minimum the amount of exposed metal connected to the high potential source of writing current, thus reducing the risk of electric shock. Covers (not shown) should preferably be provided to protect all the live parts as far as possible. Also for safety, the back electrode and the frame of the instrument would usually be earthed, particularly in the cases of Figs. 2 and 3.

In radio telegraph systems, when noise is small, but fading is troublesome, it is very desirable to obtain the sharpest possible distinction between black and white in the record. In other conditions, as already mentioned, when noise is bad,

for example, it is desirable to obtain a range of half tones.

The ordinary radio telegraph receivers are adapted to secure the sharpest possible distinction between the output current corresponding to the amplitude adjudged to represent noise only and the output current corresponding to the amplitude adjudged to represent noise plus signal, and if the signals from such radio receivers are applied to control a recorder according to the invention, and if the control valve or other device is in series with the high voltage source, as shown in Fig. 2, and is capable of complete cut off, the desired clean black and white effect is obtained. Moreover, if the cut off is not complete, a moderate resistance (not shown) connected between each helix and the anvil **7** (or the corresponding anvil if there are more than one) will suffice to prevent the potential due to writing current when incompletely cut off, from rising to such value that a visible mark is produced.

On the other hand for reception under conditions when half tone effects are desirable, the radio receiver should be provided with automatic gain control, as for telephonic reception, and the signal recording device should preferably be arranged as shown in Fig. 3, and should, if anything, give in its output a narrower range of amplitudes than it receives in the input. The control circuits for the writing current should also be arranged so that, when no signal is received, a current passes which is just insufficient, or only just sufficient, to produce a visible mark up on the paper. The circuit should also be arranged to give a current which increases less than in proportion to an increase in the signal to be recorded, in spite of the falling resistance of the paper with increase of current, for example, a tenfold increase of signal might appropriately yield a three-fold increase of writing currents.

A convenient method of achieving such a relationship between signal currents and writing currents is to connect across the transmission path at some convenient point a non-linear voltage-dependent resistance of well known type, in which the relationship between the voltage V and the current I is expressed by the formula

$$I=k.V^n$$

in which k is a constant, and n is a quantity greater than unity. Such a non-linear resistance could be connected between terminals **22** and **23** of Fig. 1, as shown dotted at **41**, or in place of the resistance **36** in Fig. 2 or 3.

Although reference has been made to the use of a series control when sharp black and white values are desired, and to shunt control when half tones are preferable, it will be understood that these properties can be secured by either method of connection by one skilled in the art by appropriate design of the control circuit constants. By whatever method the variable property of the control circuit is secured, it is desirable to provide switching means so that the circuit constants can readily be varied or the circuit rearranged and elements added or removed to permit a quick change from clear black and white recording to half tone recording.

What is claimed is:

1. In a device for recording facsimile telegraph messages, in combination, a recording head mounted for rotation around an axis and carrying a plurality of interleaved conductive helices insulated from one another, drive means for rotating said head, a straight backing electrode

extending substantially parallel to said axis, feed means for advancing a current responsive recording medium between said backing electrode and said head in a direction transverse to said axis, pressure means for compressing said recording medium between said helices and said backing electrode, single signal receiving means including amplifier means, said amplifier means having a common output connection to said backing electrode and a plurality of output electrodes each connected independently to respective of said helices whereby separate marking current adapted to mark said recording medium will pass between each of said helices and said backing electrode.

2. The combination according to claim 1 wherein said amplifier means comprise a plurality of vacuum tubes connected in parallel across said signal receiving means, each of said helices being connected to an electrode of a respective one of said tubes.

3. The combination according to claim 1 wherein said amplifier means comprises a single vacuum tube having a plurality of output electrodes.

4. The combination according to claim 3 wherein said backing electrode is grounded.

5. In a device for recording facsimile telegraph messages, in combination, a double-start worm having two mutually insulated conductive helical threads, drive means for rotating said worm about its axis, a straight backing electrode extending substantially parallel to said axis so as to register with both of said threads in all angular positions of the worm, feed means for advancing a recording tape between said backing electrode and said worm in a direction transverse to said axis, pressure means for compressing said tape between said threads and said backing electrode, single signal receiving means including an electric discharge tube, said tube having an anode and a cathode, and circuit means

for independently connecting said anode and said cathode to different of said threads, respectively, whereby a load circuit for said tube including both of said threads, said backing electrode and two spaced portions of said tape will be formed for passing separate marking currents adapted to mark the tape in said spaced portions.

6. The combination according to claim 5 wherein said backing electrode is grounded.

7. The combination according to claim 5 wherein said threads are connected in series with a source of plate current for said tube.

8. The combination according to claim 5 wherein said threads are connected in parallel with a source of plate current for said tube.

9. The combination according to claim 5 wherein said tube is arranged to produce a current which varies over a proportionally smaller range than does the signal applied to said signal receiving means.

10. The combination as claimed in claim 1, further comprising a rotatable hollow shaft and a plurality of conductors, said recording head mounted on said shaft and said conductors disposed within said shaft, each respectively interconnecting one of said output electrodes with a corresponding of said helices, said conductors adapted to rotate with said head.

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