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Description

This invention relates to a thermal head for a thermal printer, and in particular to such a head which operates at higher temperature and at a high power rating, for providing clearer and more rapid printing.

With the advent of computer technology and advances in the arts of data processing, data communication and/or facsimile communication, requirements for increased speed of information handling have become more stringent. One known type of rapid printing is a high speed thermal printer, which has a thermal head and a thermal printing paper, and operates on the principle that a thermal head, heated to a high temperature according to the pattern of a desired character to be printed, selectively changes the colour of the thermal paper. A thermal printer has the advantage that it can print not only a predetermined pattern of characters, but also any desired pattern including pictures, Chinese characters, and/or Arabian characters.

A thermal printer is a kind of dot printer which composes the pattern to be printed as a plurality of dots, and a thermal head has a plurality of heat cells arranged, for example, in a straight line for printing these dots. As the thermal paper moves in a direction perpendicular to the straight line of heat cells, the heat cells are selectively heated, so that the colour of the thermal paper is selectively changed. Thus the desired pattern is printed on the thermal paper.

We have proposed some thermal heads, such as that shown in United States Patent No. 4,136,274 (British Specification No. 1,524,347).

Fig. 1 of the accompanying drawings shows the cross-section of a prior thermal head disclosed in the above-mentioned US patent and possessing the features in accordance with the preamble of claim 1. In Fig. 1, a glazed alumina substrate 10 has a glazed layer 15 of 40—80 μm thickness. A heater layer 30 has a thickness of 1000 Å to 2000 Å and is made of, for example, tantalum nitride (Ta_2N). A conductive layer 40 is attached to the heater layer 30 for providing electrical coupling of the heater line to an external circuit. An SiO_2 layer 50, which has a thickness of 1—3 μm, prevents oxidation of the heater line. A protection layer 60 reduces wear on the heaters due to friction with the thermal paper. The layer 60 is made of, for example, Ta_2O_5 with a thickness of 3—10 μm.

The structure of Fig 1 has the advantages that fluctuation in the resistance of a heater layer is small, and the life-time of the head is long, provided the power applied to the head is small. However, it has the disadvantage that the power capacity of the head is low. That is to say, the prior thermal head cannot have a high power capacity, and cannot, therefore, provide a high temperature. Operation at a high temperature is essential for high speed printing. For instance, the highest power consumption of a prior thermal head is up to 1.2 watts when the width of the heater layer is 100 μm, the length of the heater layer is 215 μm, the sheet resistance of the heater layer is 17 ohms/square. The heater layer is heated for 30 minutes with a pulse signal having a pulse width of 1 msec and a period of 50 msec. If that prior thermal head is heated with a power higher than 1.2 watts, the heater is damaged.

Fig. 2 is an explanatory drawing of a sheet resistance, in which a rectangular heater 30 has a side length L, and conductors 100 and 102 have a width L. In that configuration, the resistance between conductors 100 and 102 is independent of the length L, but depends solely upon the thickness of the heater 30 and the material of which the heater 30 is made. Therefore, the sheet resistance of the heater 30 is defined by the resistance between the conductors 100 and 102, and is expressed as R ohms/square, if the resistance appearing between the conductors 100 and 102 is R ohms.

It is an object of the present invention to provide a new and improved thermal head which can operate at high temperature for high speed printing, and has long life.

According to the invention a thermal head comprising a dielectric plane substrate; a plurality of heater layers, each having an elongated finger, insulated from one another; conductive layers attached to both extreme ends of the fingers of the heater layers the width of each finger of the heater layers at the region between the conductive layers being less than 30 μm; and an insulation layer on the heater layers; is characterised by an insulation layer made of SiO_2 (silicon dioxide) between the substrate and the heater layers.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings wherein:

Fig. 1 is a cross-sectional view of a prior thermal head as described above,

Fig. 2 is an explanatory drawing of sheet resistance,

Fig. 3 is a cross section of one form of thermal head according to the present invention,

Fig. 4 is a plan view of a prior thermal head,

Fig. 5 is a plan view of the thermal head according to the present invention,

Fig. 6 is a plan view of another thermal head according to the present invention,

Fig. 7 is a plan view of a further thermal head according to the present invention,

Fig. 8 is an experimental curve which shows the effect of the structure of the present invention, and

Fig. 9 shows other experimental curves.

Fig. 3 shows the cross section of one form of the present thermal head, in which a glazed alumina substrate 10 has a glazed layer 15 of 40—80 μm thickness. An SiO_2 layer 20 has a thickness of 1—6 μm and is provided for improving the thermal characteristics of the head. A heater layer 30 has a thickness of 1000 Å to 2000 Å, and is made of, for instance, tantalum nitride (Ta_2N). A conductive layer 40 is connected to the heater layer 30 for providing electrical coupling of the heater line to an external circuit. An SiO_2 layer 50 with a thickness of 1—3 μm prevents oxidation of the heater line. A protection layer 60 reduces wear of the heaters due to friction with a thermal paper. The protection layer 60 is made of, for instance, Ta_2O_5 with a thickness of 3—10 μm.

The feature of the structure of Fig. 3 as compared with that of Fig. 1 is the presence of the thin SiO_2 layer 20 between the glazed layer 15 and the heater layer 30, so that the heater layer 30 is enclosed between a pair of SiO_2 layers 20 and 50.

With the presence of the lower SiO_2 layer 20, the heater layer 30 can take more power and can, therefore, provide a high temperature. The effect of the presence of the lower SiO_2 layer 20 depends upon the width of the heater layer, as described later.

Table 1 below shows experimental results for three samples of thermal heads with the cross section of Fig. 3.

Table 1

	Width of heater layer	Highest power capacity
Example 1	20 μm	2.4 watts
Example 2	30 μm	1.7 watts
Example 3	110 μm	1.2 watts

The above experiments are accomplished by applying, for 30 minutes, a pulse signal with a pulse width of 1 msec and a period of 50 msec, and the power consumption shows the power of that pulse signal for which a heater layer is damaged within the 30 minute period. In the above three examples, the density of the heater layer is 8 dots/mm, the sheet resistance of the heater layer is 17 ohms/square, and the thickness of the SiO_2 layers 20 and 50 is 2 μm.

Fig. 5 is a plan view of a thermal head of the Examples 1 and 2 above, in which heater layers 31a—31d are in zigzag fashion or in a meandering or tortuous configuration as shown in Fig. 5, with a width $d_1 = 20$ μm, a spacing between adjacent fingers of the meandering pattern $d_3 = 20$ μm, and a spacing between adjacent heater layers $d_2 = 20$ μm. Example 2 of the above table is accomplished for a similar heater layer to that of Fig. 5, but the width d_1 is 30 μm, and the spacings d_2 and d_3 are 10 μm.

It should be appreciated in the above experimentation that the power capacity is considerably increased when the width of the heater layer is less than 30 μm and, therefore, high temperature and/or high speed printing operation is accomplished. In Example 1, when a power of 2.4 watts is applied to the heater layer, the heater layer is red-heated, and that red-heated layer is visible through the protection layer 60. Also, in Example 2, a red-heated heater layer is visible. Therefore, it should be noted in Examples 1 and 2 that the power capacity is large. In case of Example 3 in which the width of the heater layer is large, the power consumption is not increased.

Fig. 4 is a plan view of a thermal head of Example 3, in which heater layers 30a—30d are straight, as shown in the figure, and the width d of each heater is 110 μm. The spacing between adjacent heaters is 10 μm, and the length A of each heater is 215 μm. It should be noted that the power consumption in the experiment 3 is only 1.2 watts, which is considerably lower than that of the other Examples. Therefore, the conclusion is reached that it is preferable for the width of the heater line to be less than 30 μm.

Fig. 6 is a plan view of another embodiment of the present thermal head, in which a heater layer is in a meandering or tortuous configuration with a slit S in the layer. When the dot density of a thermal head is not so dense, the width of the heater layer is rather wide, and it cannot be less than 30 μm. In that case, the slit S is provided in the tortuous pattern. In Fig. 6, when the width d_{10} of a finger of the heater layer is 50 μm, a slit S with a width $d_{13} = 10$ μm is provided in the finger, so that the rest of the finger is in two parts $d_{11} = d_{12} = 20$ μm. Therefore, the effective width of the finger may be less than 30 μm, and the high power capacity is obtained as shown in the Table 1.

Fig. 7 is another plan view of a thermal head, or a conductive layer of the thermal head, according to the present invention. In Fig. 7, the conductive layer 30a extends as two fingers 30a-1 and 30a-4, between which a pair of fingers 30a-2 and 30a-3 are positioned. The layer 30a is coupled to a confronting layer 30b through the fingers 30a-1, 30a-2 and 30a-3, and through the finger 30a-4, and fingers 30b-2 and 30b-1. Thus, the width of each layer 30a or 30b is divided into four spaced-apart fingers. When the width of each finger is the same as the spacing between the fingers, the width of each finger is only one-seventh of the width of the layer 30a or 30b. Therefore, even when the layer 30a or 30b is wide, the width of a divided finger can be less than 30 μm for providing high temperature operation.

As described above, the important features of the present thermal head are that a thin SiO_2 layer is provided between a heater layer and the substrate, and that the width of a finger of the heater layer is less than 30 μm. Figs. 8 and 9 show experimental curves which prove the above features.

Fig. 8 shows the curves of a step stress test on a thermal head, in which a pulse signal with a period of 20 msec and a pulse width of 0.5 msec is applied to each finger of a heater layer through a pair of conductive layers, and the structure of the heater layer is such that the width of each finger is 22 μm, the spacing between adjacent fingers is 19.5 μm, and the length of the tortuous portion of the heater is 230 μm, as shown in the figure. The horizontal axis of Fig. 8 shows the power of the pulse signal applied to each heater, and the vertical axis of Fig. 8 shows the ratio $\Delta R/R$ in which R is the initial resistance of a heater, and ΔR

is the change in resistance from the initial value. The test is carried out for 30 minutes for each input power, and each dot in the curve shows the result after a corresponding test of 30 minutes duration. The curve in Fig. 8 shows the test results for a thermal head which has an SiO_2 layer between the heater layer and the substrate, the thickness of the SiO_2 layer being 2 μm. It should be appreciated from the curve of Fig. 8 that the sample being tested is not destroyed by the heat until the input power reaches 3.5 watts.

Similar tests were carried out by changing the pulse width of the input pulse from 0.5 msec to 2.5 msec, and similar results were obtained. The change in the resistance R(or $\Delta R/R$) in Fig. 8 is of no importance in the present test as far as the temperature of the heater, the power consumption of the heater, and/or the life of the heater is concerned. It is the fact that the input power can be high and the life of the sample (2) of the curve is long which is important.

It should be appreciated from the curve of Fig. 8 that a sample which has an SiO_2 layer can accept a high input power, and has long life-time.

Fig. 9 shows another test result, in which the pulse period is 20 msec, the pulse width is 2.5 msec and the width of the heater layer is 110 μm. The horizontal axis shows the input power and the vertical axis shows the ratio $\Delta R/R$. The test is carried out for 30 minutes for each input power. The curve (2) in Fig. 9 shows the test result where an SiO_2 layer is provided between the heater layer and the substrate, and the curve (1) in Fig. 9 shows the test result where no such SiO_2 layer is provided, i.e. the heater layer is located directly on the substrate.

It should be noted from Fig. 9 that the heater layer is broken when an input power of just less than 1 watt is reached.

According to the experimental results of Figs. 8 and 9, the conclusion can be reached that two conditions (1) an SiO_2 layer is provided between the heater layer and the substrate, and (2) the heater is narrow, are necessary for applying high power to the heater.

We have also carried out an experiment to replace the SiO_2 layer between the heater layer and the substrate by an Si_3N_4 layer, which has the property of preventing diffusion of a molecule and/or an atom. However, it has been found that the life-time of a thermal head provided with such Si_3N_4 layer is worse by 10% than the prior head without the SiO_2 layer.

Furthermore, we have carried out an experiment to replace the SiO_2 layer between the heater layer and the substrate by a tantalum oxide layer, which has the property that the melting point is high (the melting point of SiO_2 is 1710°C, and the melting point of tantalum oxide is 1870°C). However, it has been found that the life-time of a thermal head with tantalum oxide is worse than that with SiO_2 layer.

We have also experimented to change the heater layer from tantalum nitride to nickel. However, a thermal head with a nickel heater cannot be heated to red heat even though an SiO_2 layer is provided. Therefore, the tantalum nitride is superior to nickel as the material for the heater layer.

As described above, it has been proved by experiment that the temperature and the life time of a thermal head are improved by providing an SiO_2 layer between the heater layer and the substrate, and designing the width of a finger of the heater to be less than 30 μm. The material of the heater layer is preferably tantalum nitride with a view to improving the operational temperature of the thermal head.

Claims

1. A thermal head comprising a dielectric plane substrate (10, 15); a plurality of heater layers (30), each having an elongated finger (31a—31d), insulated from one another; conductive layers (40) attached to both extreme ends of the fingers of the heater layers the width of each finger of the heater layers at the region between the conductive layers being less than 30 μm; and an insulation layer (50) on the heater layers; characterised by an insulation layer (20) made of SiO_2 (silicon dioxide) between the substrate and the heater layers.

2. A thermal head according to Claim 1, characterised in that the heater layer (30) is made of tantalum nitride.

3. A thermal head according to Claim 1 or Claim 2, characterised in that each finger (31a—31d) of the heater layers has a tortuous configuration.

4. A thermal head according to any preceding claim, characterised in that the width of each finger of the heater layers is wider than 30 μm, and the finger has a longitudinal slit (S) along its centre for separating the finger into two paths (32a, 33a—32d, 33d), the width of each separated path being less than 30 μm (Fig. 6).

Revendications

1. Tête thermique qui comprend un substrat diélectrique plan (10, 15); un certain nombre de couches chauffantes (30), ayant chacune un doigt allongé (31a, 31d), les doigts étant isolés l'un de l'autre; des couches conductrices (40) reliées aux deux extrémités des doigts des couches chauffantes, la largeur de chaque doigt des couches chauffantes dans la région comprise entre les couches conductrices étant inférieure à 30 μm; et, une couche isolante (50) sur les couches chauffantes; caractérisée par une couche isolante (20) faite de SiO_2 (bioxyde de silicium) entre le substrat et les couches chauffantes.

2. Tête thermique selon la revendication 1, caractérisée en ce que la couche chauffante (30) est faite de nitrure de tantale.

3. Tête thermique selon la revendication 1 ou 2, caractérisée en ce que chaque doigt (31a—31d) des couches chauffantes a une configuration tortueuse.

4. Tête thermique selon l'une quelconque des

revendications précédentes, caractérisée en ce que la largeur de chaque doigt des couches chauffantes est supérieure à 30 µm et en ce que le doigt a une fente longitudinale (S) le long de son centre qui le sépare en deux parties (32a, 33a—32d, 33d), la largeur de chaque partie séparée étant inférieure à 30 µm (figure 6).

Patentansprüche

1. Thermischer Druckkopf mit einer dielektrischen ebenen Unterlage (10, 15); mehreren Heizelementschichten (30), die jeweils einen langgstreckten Finger (31a—31d) aufweisen, die gegen- einander isoliert sind; leitenden Schichten (40), die an den beiden äußeren Enden der Finger der Heizelementschichten angebracht sind, wobei die Breite jedes Fingers der Heizelementschichten in dem Bereich zwischen den leitenden Schichten kleiner als 30 µm ist; und einer silierenden Schicht (50) auf den Heizelementschichten, gekennzeichnet durch eine isolierende Schicht (20) aus SiO_2 (Siliciumdioxid) zwischen der Unterlage und den Heizelementschichten.

2. Thermischer Druckkopf nach Anspruch 1, dadurch gekennzeichnet, daß die Heizelementschicht (30) aus Tantalnitrid hergestellt ist.

3. Thermischer Druckkopf nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß jeder Finger (31a—31d) der Heizelementschichten eine gewundene Form hat.

4. Thermischer Druckkopf nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Breite jedes Fingers der Heizelementschichten breiter als 30 µm ist und der Finger einen Längsschlitz (S) in seiner Mitte zum Trennen des Fingers in zwei Bahnen (32a, 33a—32d, 33d) aufweist, wobei die Breite jeder getrennten Bahn kleiner als 30 µm ist (Fig. 6).

Fig. 1

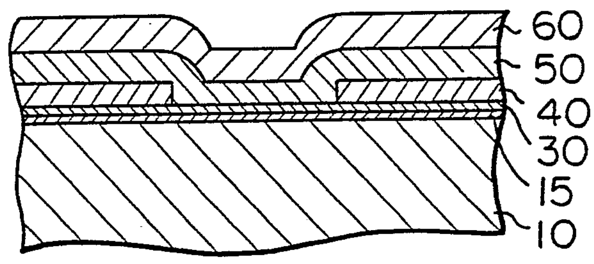

Fig. 2

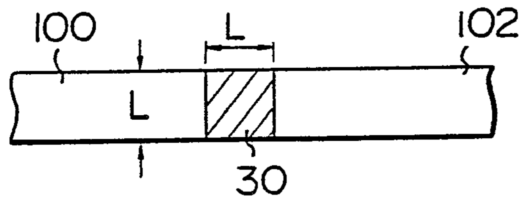

Fig. 3

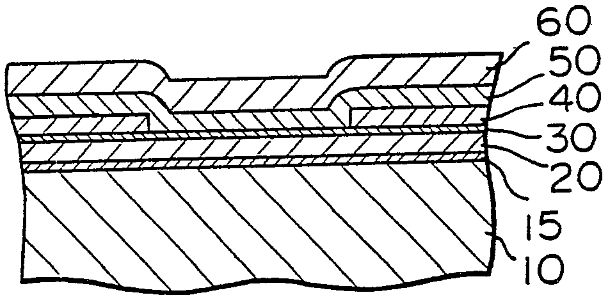

Fig. 4

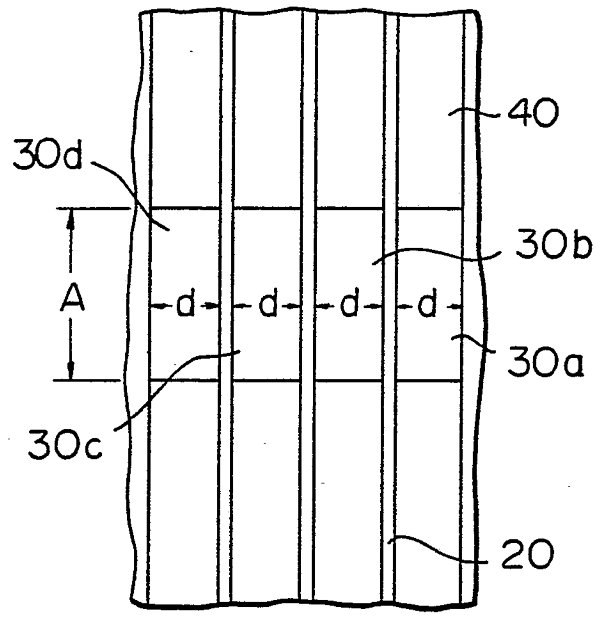
40
30d
30b
A
d
d
d
d
30a
30c
20

Fig. 5

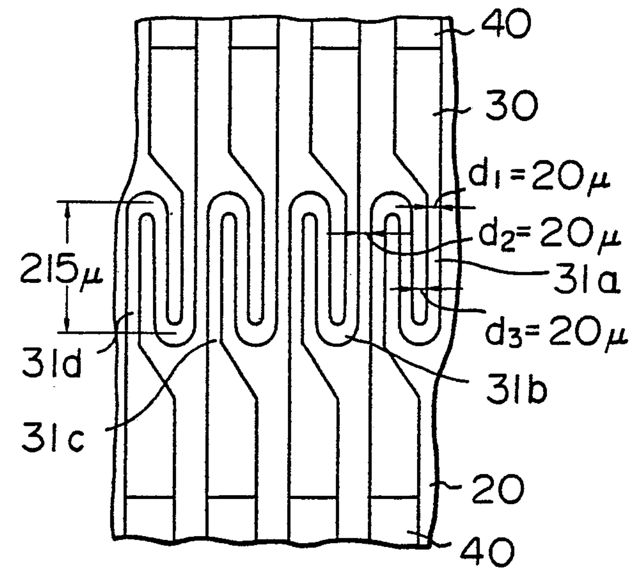
40
30
d1=20μ
d2=20μ
215μ
31a
d3=20μ
31d
31b
31c
20
40

Fig. 6

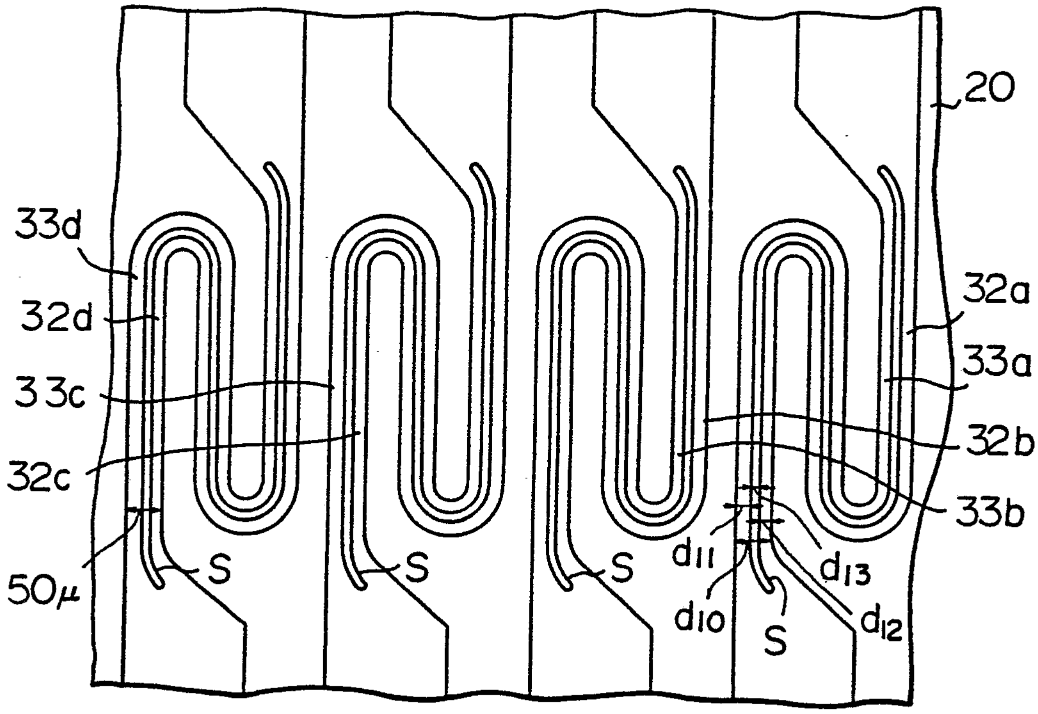
20
33d
32d
33c
32c
50μ
S
S
S
32a
33a
32b
33b
d11
d13
d10
S
d12

Fig. 7

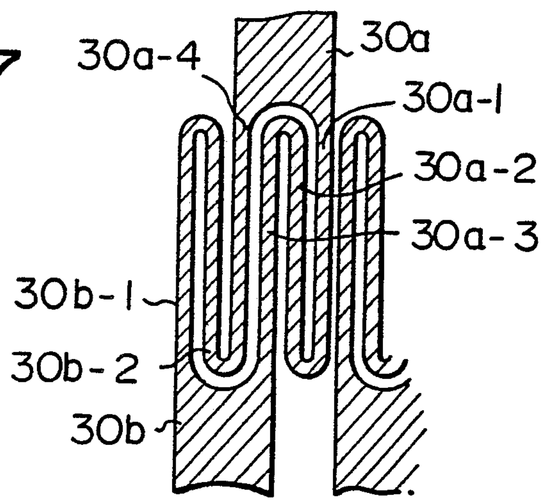
30a-4
30a
30a-1
30a-2
30a-3
30b-1
30b-2
30b

Fig. 8

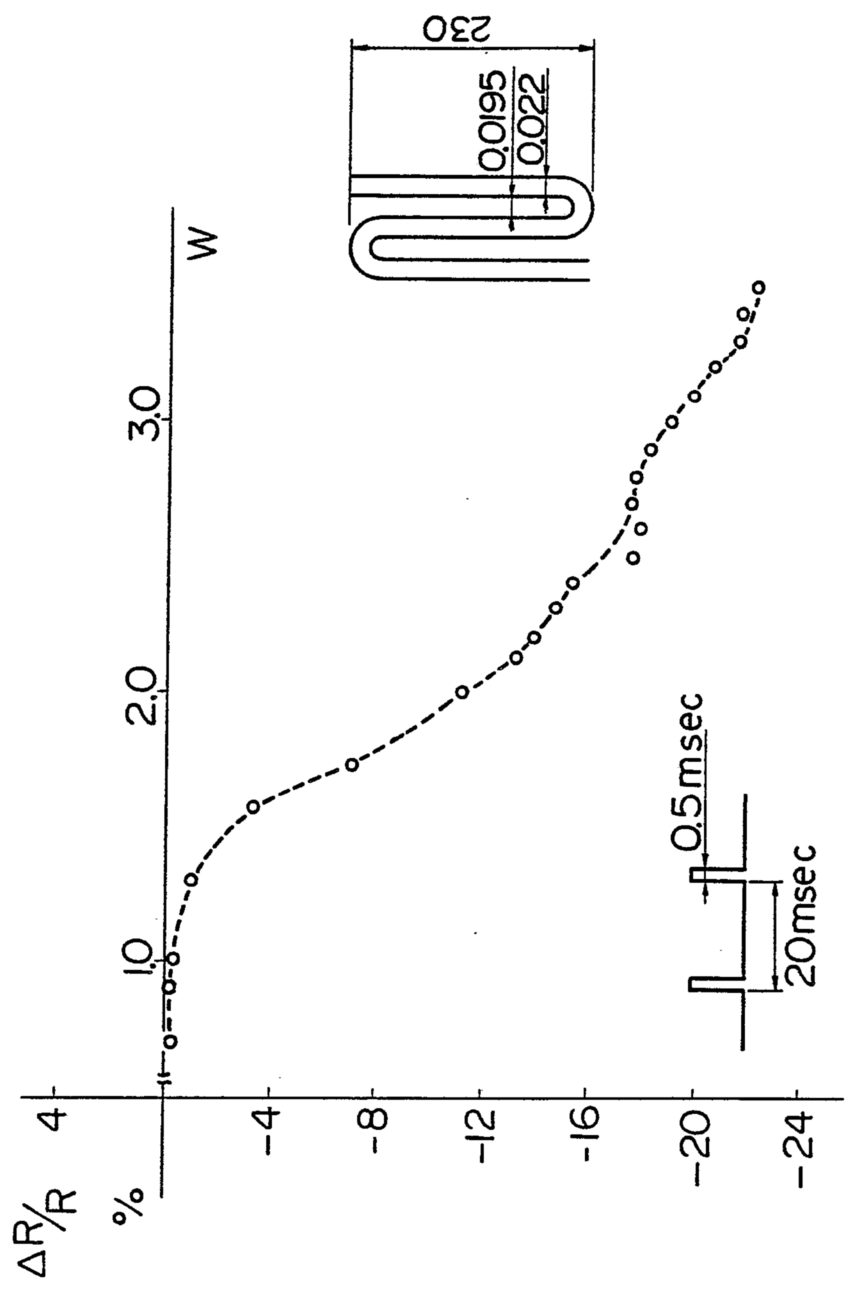

Fig. 9