

SLAGTERIERNES FORSKNINGSSINSTITUT  
4. juni 1964

BEDØVNING - ELEKTRISK  
Manuskript nr. 274 E

The effect of electrical stunning on the blood pressure in pigs in  
comparison to the appearance of haemorrhages in lungs and musculature.

(Contribution to the 10<sup>th</sup> European Meeting of Meat Research Workers, Roskilde Aug. 1964)

By Mogens Mandrup, Danish Meat Research Institute, Denmark

### Introduction

As well known "blood splashing" can often be seen in lungs and musculature of electrical stunned pigs. In the lungs the haemorrhages are typical pettichial - in the worst cases with tendency to confluence especially in the dorsal part of the lungs. In the musculature the haemorrhages are following the direction of the fibres by which they often get a striated and lengthy appearance. The haemorrhages can be seen all over in the carcass but most often they are seen in ham, belly, back and shoulder. They are a considerable problem for the bacon factories both as regards economy and quality and many investigations have, therefore, been carried out in order to find some way to prevent them.

"Blood splashing" is not only seen after electrical stunning but also after stunning with captive bolt pistol and CO<sub>2</sub>. In an investigation of 1049 CO<sub>2</sub>-stunned slaughtered pigs 28 % had haemorrhages in the lungs of exactly the same character as those in electrical stunned pigs (M. Mandrup, 1963). In another investigation on CO<sub>2</sub> stunned pigs haemorrhages were found in the pectoral-musculature with a frequency of 20-40 % varying between the bacon factories (T. Wichmann Jørgensen, 1962). The etiology of these haemorrhages is supposed to be the same as those in electrical stunned pigs.

It has been shown that in electrical stunned dogs, cats, and sheep, and in sheep stunned with captive bolt pistol the arterial blood pressure suddenly rise to about twice the initial value (Clark, 1932. Tweed, Clark, and Edington, 1931. Ross and Koopmans, 1933 and 1934. Kokand van Harreveld, 1934). Therefore, it is usually assumed that the haemorrhages in electrical stunned slaughtered pigs are caused by capillar burstings produced by a strong rise in the blood pressure. (Hess, 1960).

This work has been done to study the changes in blood pressure during electrical stunning of pigs in order to investigate the possibility of eliminating the rise in the blood pressure with the intention of preventing capillar burstings.

### Experimental

The experiments were carried out on pigs at a weight of abt. 20 kg. To follow the changes in blood pressure produced by the electrical stunning a cannula was inserted into the femoral artery and connected with a mercury manometer, the movements of which could be recorded on a smoked drum by a writing lever. During this operation the pigs were slightly narcotized with Trilen inhalation and anaesthetized local with lidocaini chloridum 5%. The electric current was applied when the pigs were completely recovered after the Trilen narcosis. The voltage and current strength

were measured during the experiments, and in some cases the current was recorded on the drum. Alternating current (50 cycles) was used. In some of the experiments the pigs were stuck and bled during the blood pressure recording by cutting both the bijugular and the bicarotid trunk.

The finding of haemorrhages is reported according to the following scheme:

- Lungs: + = only few pettichial haemorrhages with a mutual distance of 1 cm or more.
- ++ = several more dark-red haemorrhages with tendency to confluence in dorsum of the lungs.
- +++ = the lungs covered with pettichial haemorrhages which confluent in the dorsum of the lungs to dark blue areas.

M. pectoralis profundus, pars humeralis:

left side	,	right side	
+	,	+	haemorrhage with a size of abt. 1 cm
++	,	++	- - - - - 2 cm
+++	,	+++	- - more than 2 cm

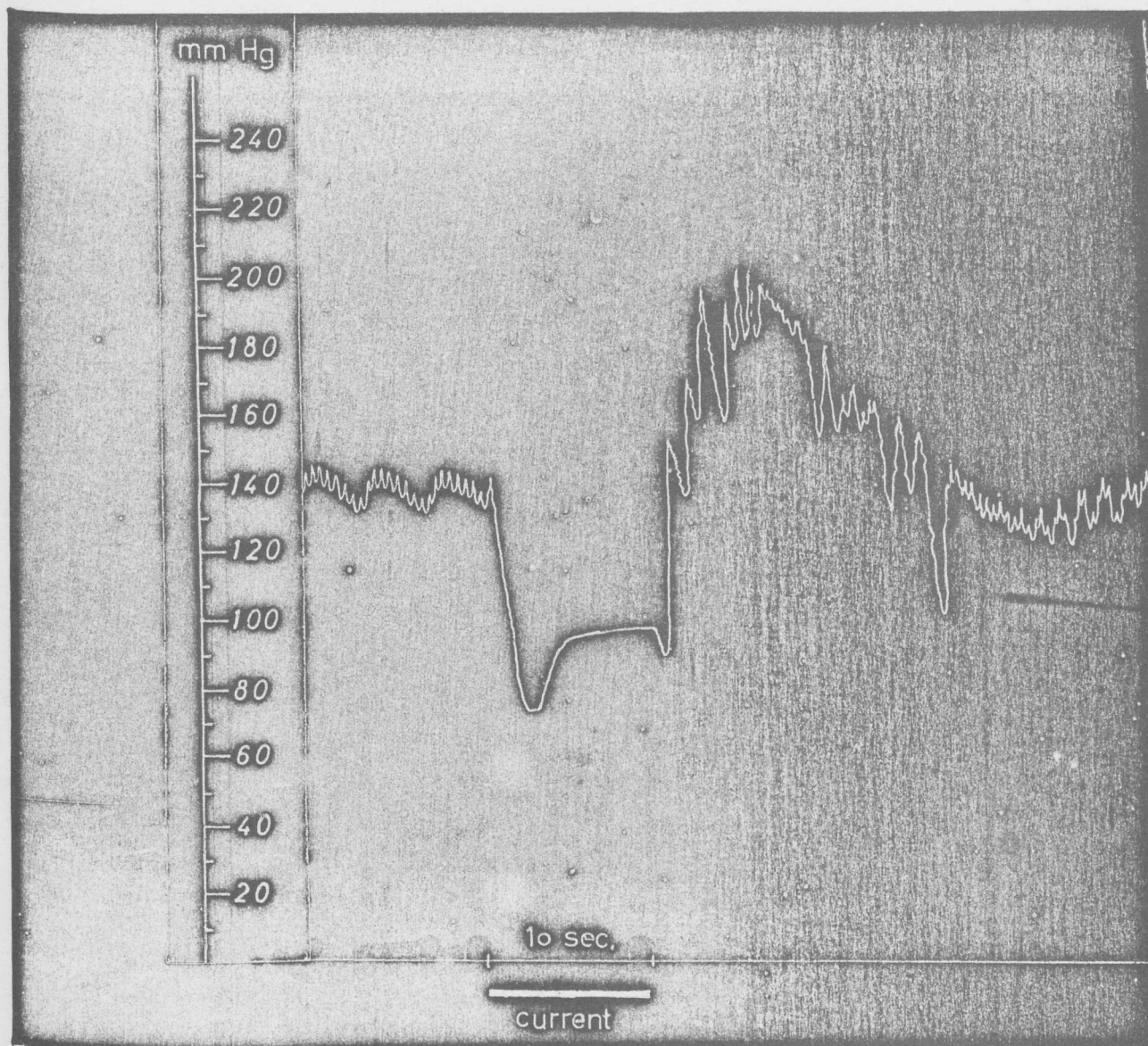
The connective tissue under the shoulder: (below the figures called "connective tissue")

left side	,	right side	
+	,	+	only few pettichial haemorrhages
+++	,	+++	numerous " "

Results and discussion:

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Electrodes:

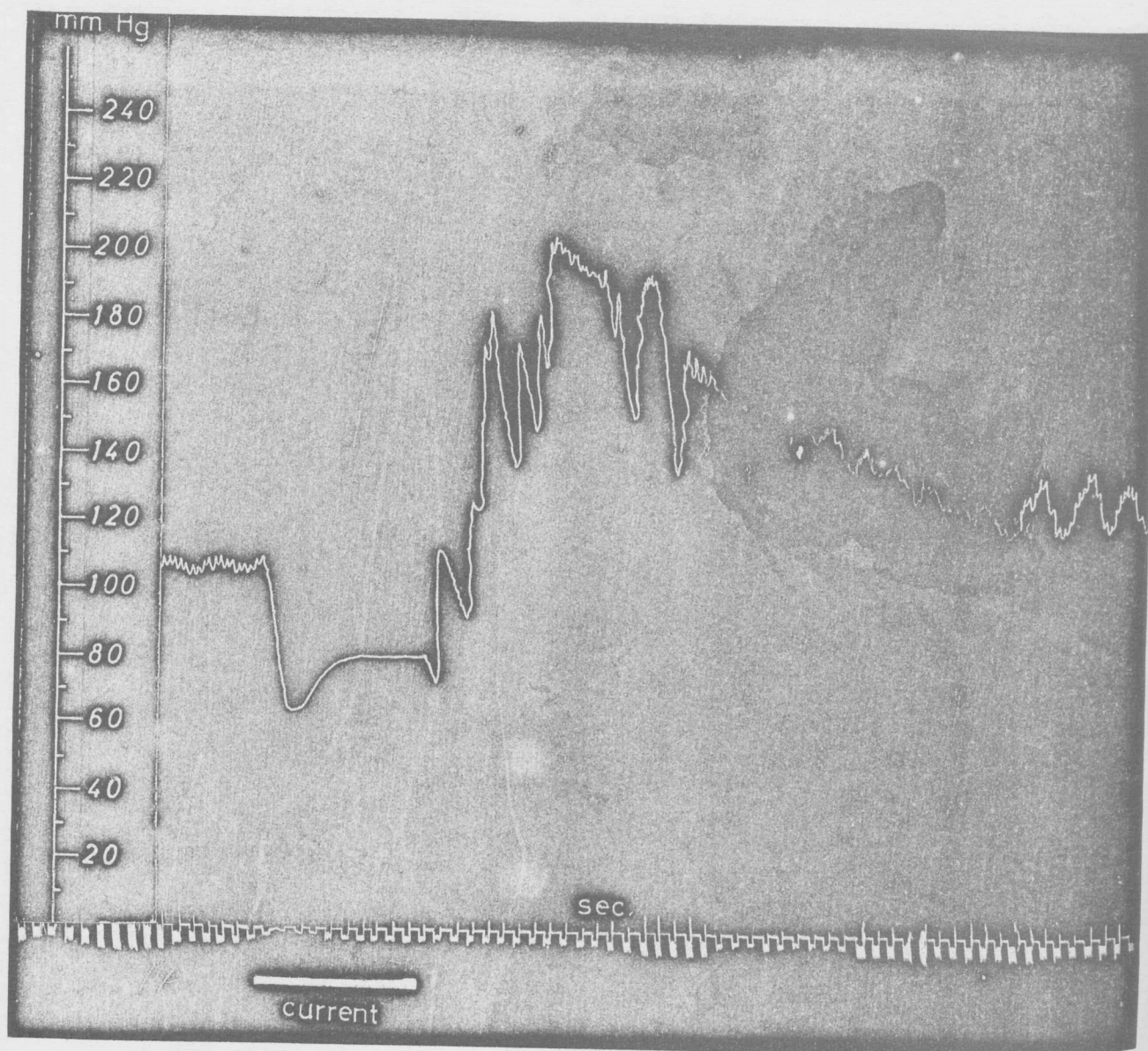
Eye/Eye



80 Volt  
0.72 Amp.  
10 Seconds

Fig. 1. shows the characteristic changes in the blood pressure during and after electrical stunning. The electrodes have been placed on the eyes of the pig and the current has been on for 10 seconds. As soon as the current is switched on total heart block occurs because of a strong stimulation of n. vagus and the blood pressure consequently falls to abt. half the initial value. After this a small increase gradually occurs, probably because of an increased pressure in thorax and abdomen owing to the strong tonus in the muscles which surrounds these cavities. When the current is switched off and these muscles relax again a consequent fall in blood pressure will also be seen at the curve.

Now the heart is no longer influenced by the stimulation and it begins again to pump and though the frequency is reduced during the first seconds the blood pressure rise considerably above the initial value. The notable big increase for each heart action is probably produced for two reasons: on account of the decreased frequency the



Electrodes:

Neck/Eye



80 Volt  
0.55 Amp.  
10 Seconds

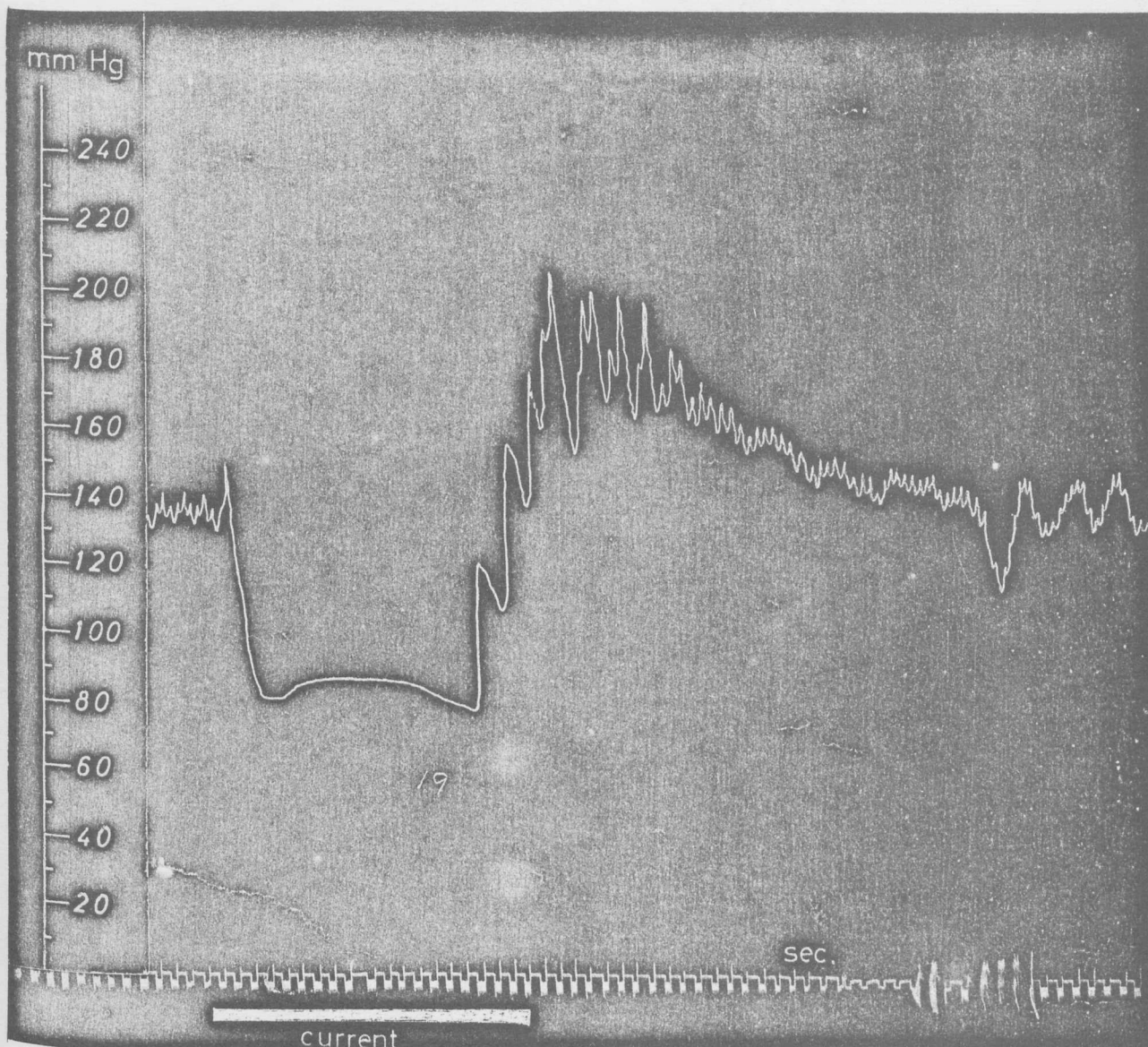
diastolic period is prolonged which cause an increase in the beat volume. At the same time the small arteries probably are contracted because of the vigorous stimulation of the vaso-constrictor center in medulla oblongata. The rise in the blood pressure culminates quickly and after 10 - 20 sec. the pressure and the heart-frequency are normal again. 3 - 5 sec. after the electro-shock the pigs developed hyperaemia in the skin on the head, neck, and belly. This phenomenon was seen in all pigs during recovering from the electrical stunning.

Fig. 2.

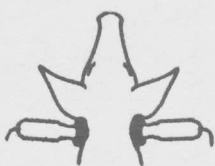
In fig. 2. the current has been applied neck/eye, but the picture is just the same as described above.

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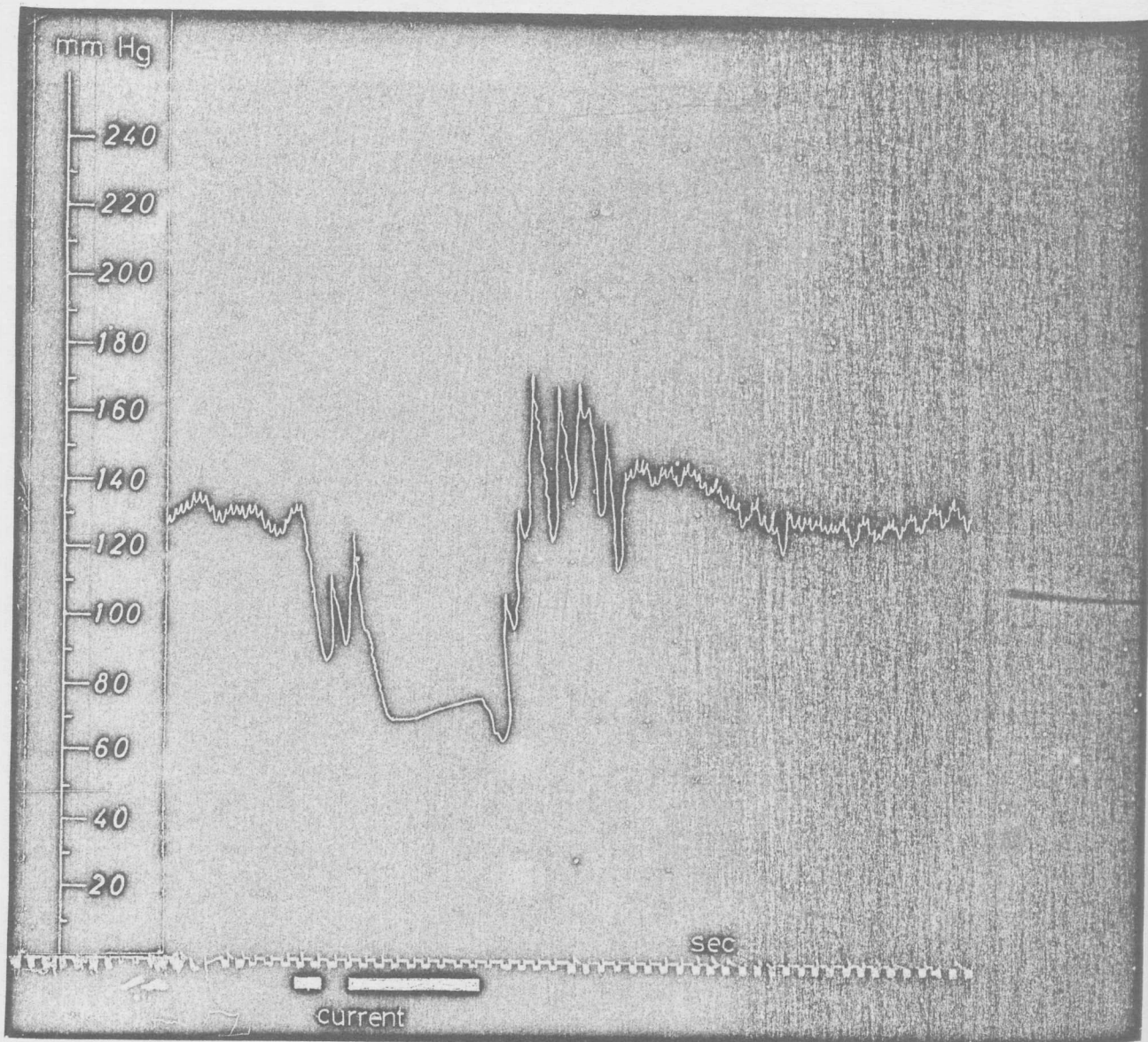
Electrodes: Neck/Neck



80 Volt  
abt. 0,6 Amp.  
20 Seconds

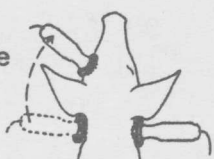
Fig. 3.

The electrodes have been placed neck/neck and the current has been on for 20 sec. After 17 sec. the heart has started to beat again but with decreased frequency as if it is no longer influenced by the stimulation through n. vagus.



Electrodes:

Neck/(Neck)Eye



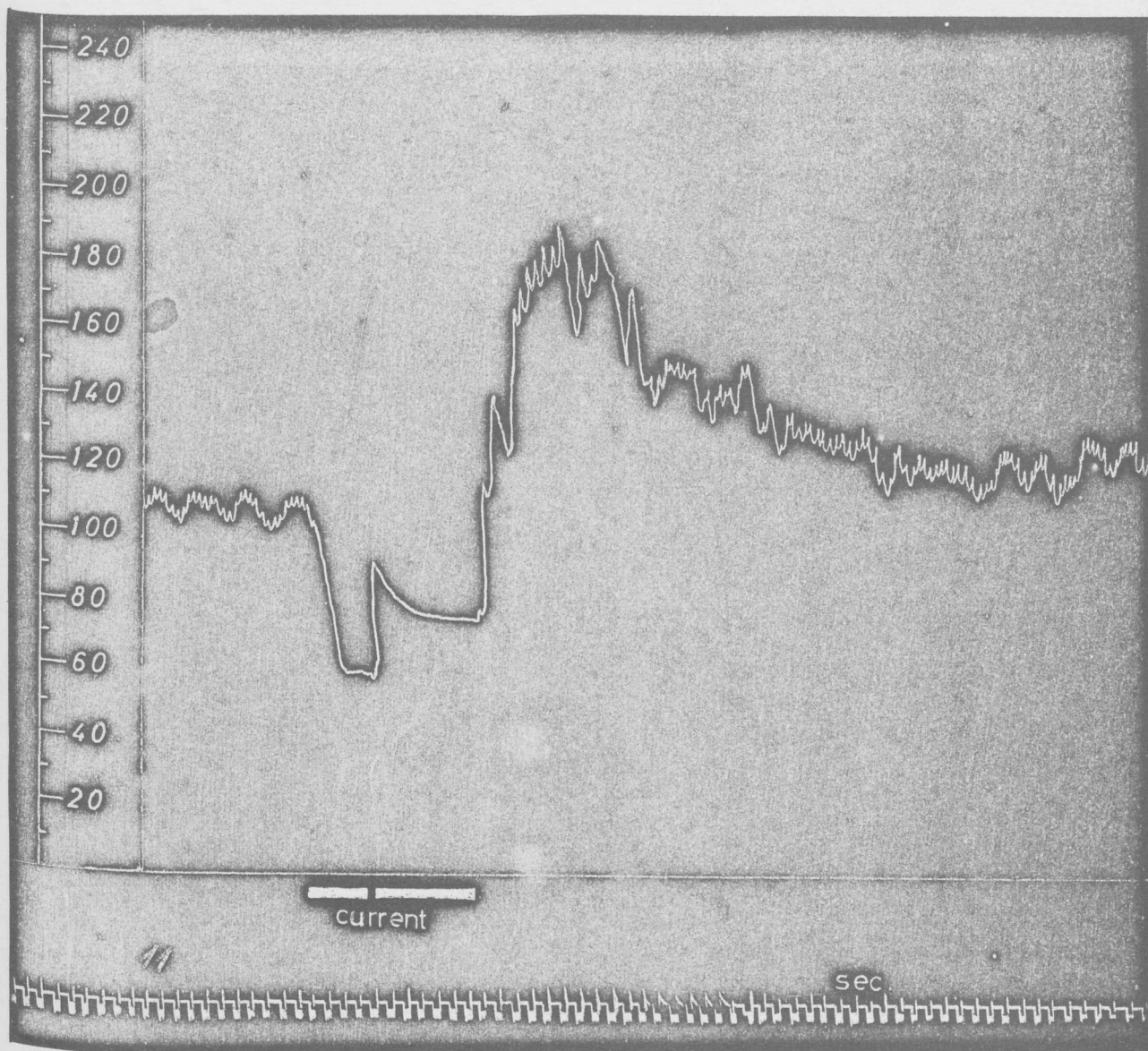
80 Volt  
0.3 Amp.  
11 Seconds

Fig. 4.

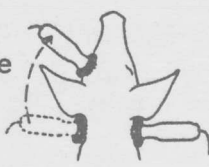
When stunning pigs electrically it is generally used first to place both electrodes on the neck and after a few seconds to move one of them to the eye to utilize the good conduction through n. opticus. The blood pressure changes during this method is showed in fig. 4 and 5. During the removal of the electrodes the heart begins to beat and consequently the blood pressure rise a little. But as soon as there is contact again total heart block appears and the following course is the same as described below fig. 1.

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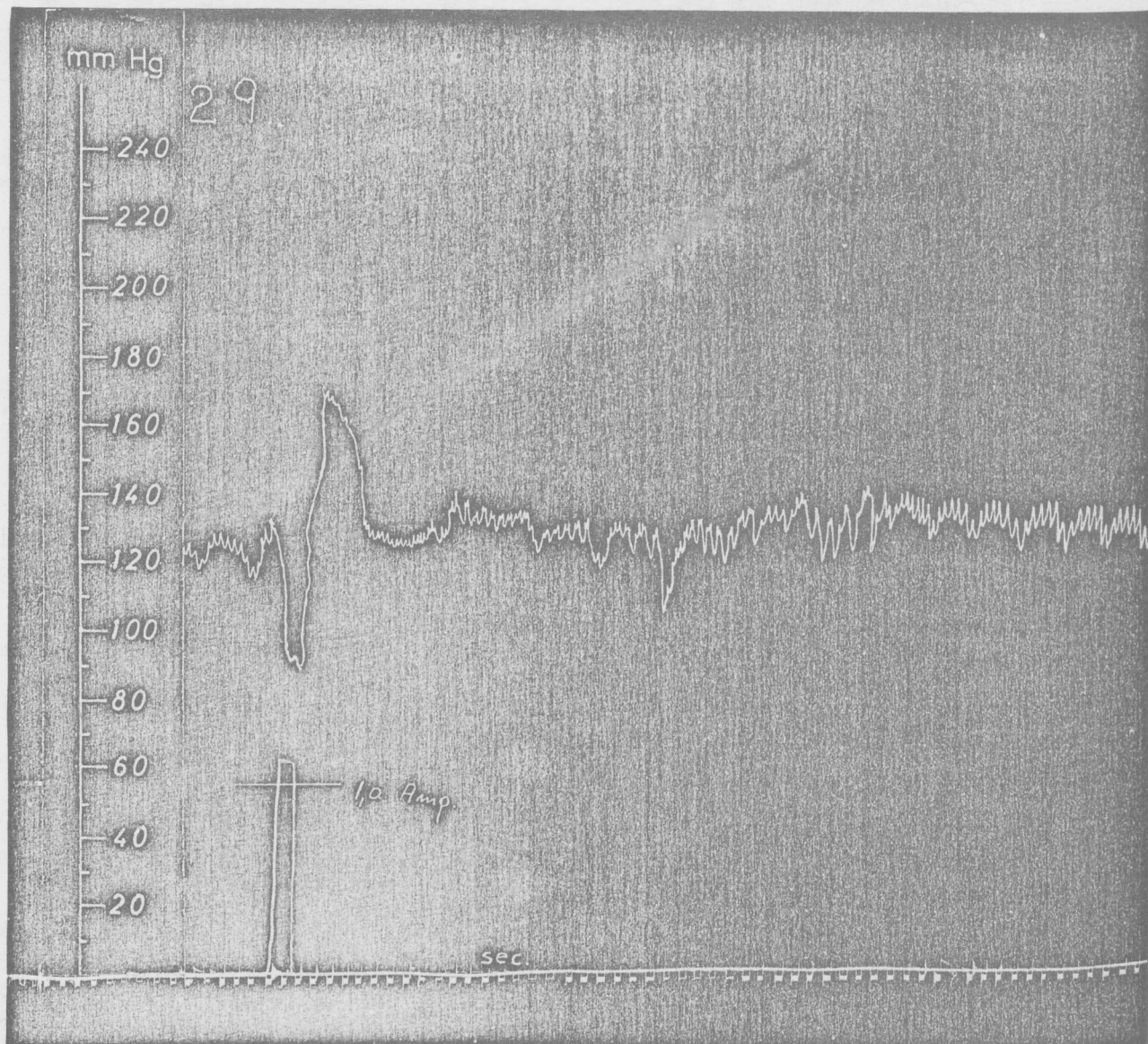


Electrodes: Neck/(Neck)Eye



90 Volt  
0.8 Amp.  
11 Seconds

Fig. 5.




<u>Electrodes:</u>	Forehead		350 Volt 1,5 Amp. 1.5 Seconds
<u>Haemorrhages:</u>	Lungs		+++
	M. pect. prof.		+++ , +++
	Connective tissue		++ , ++

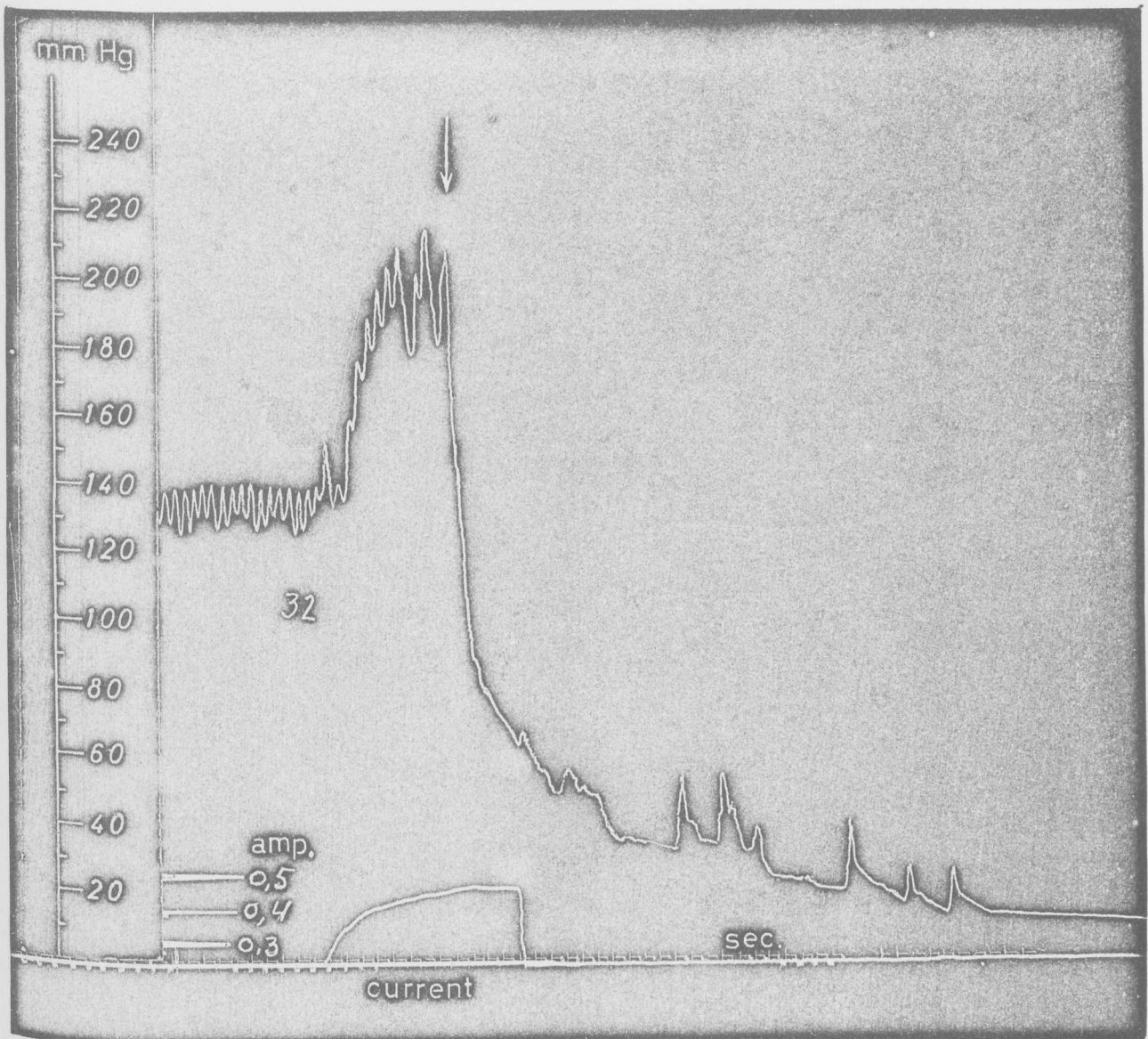
Fig. 6.

In this experiment 350 volt for 1.5 sec. was applied. The changes in the blood pressure shows the same picture as when 80 volt is used, but with a tendency to lower rise in the blood pressure. The pig was stuck and bled 1 min. after the stunning.



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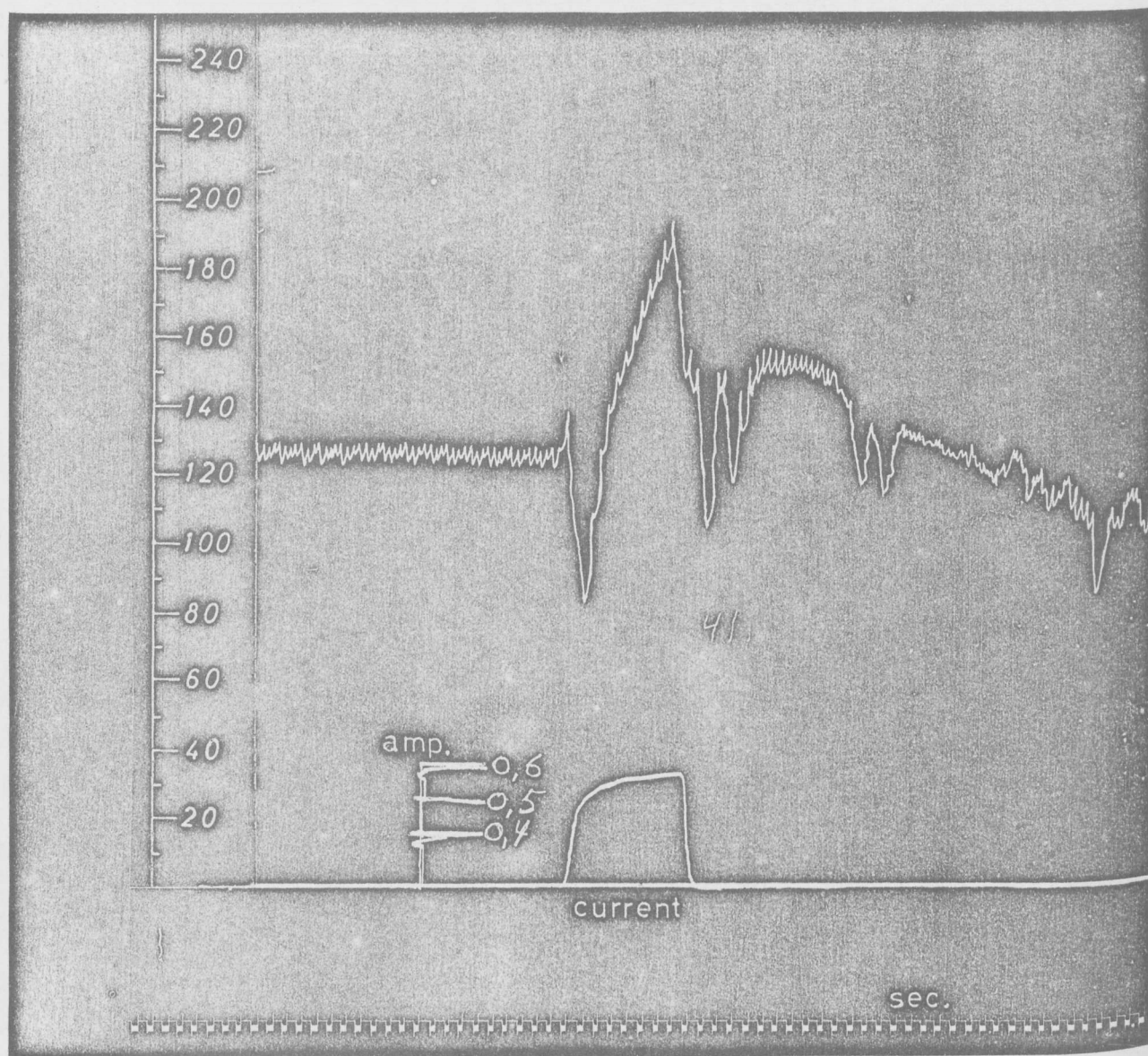
<u>Electrodes:</u>	Eye/Neck		80 Volt
			0.55 Amp.
			12 Seconds
<u>Haemorrhages:</u>	Lungs		+++
	M. pect. prof.		++, ++
	Connective tissue		++, ++

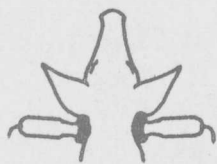
Fig. 7.

That heart block, which occurs as long as the current flows is produced by electrical stimulation of n. vagus. Fig. 7 shows the picture where the action of vagus has been blocked by placing Lidocaini chloridum around the nervelines on the neck before the experiment. The heart is not depressed during the electrical stimulation and the blood pressure rise immediately when the current is switched on because of increased resistance in the vessels of the tonic musculature. At the arrow mark the bijugular and the bicarotid trunk are cut and the blood pressure falls immediately.



Electrodes:

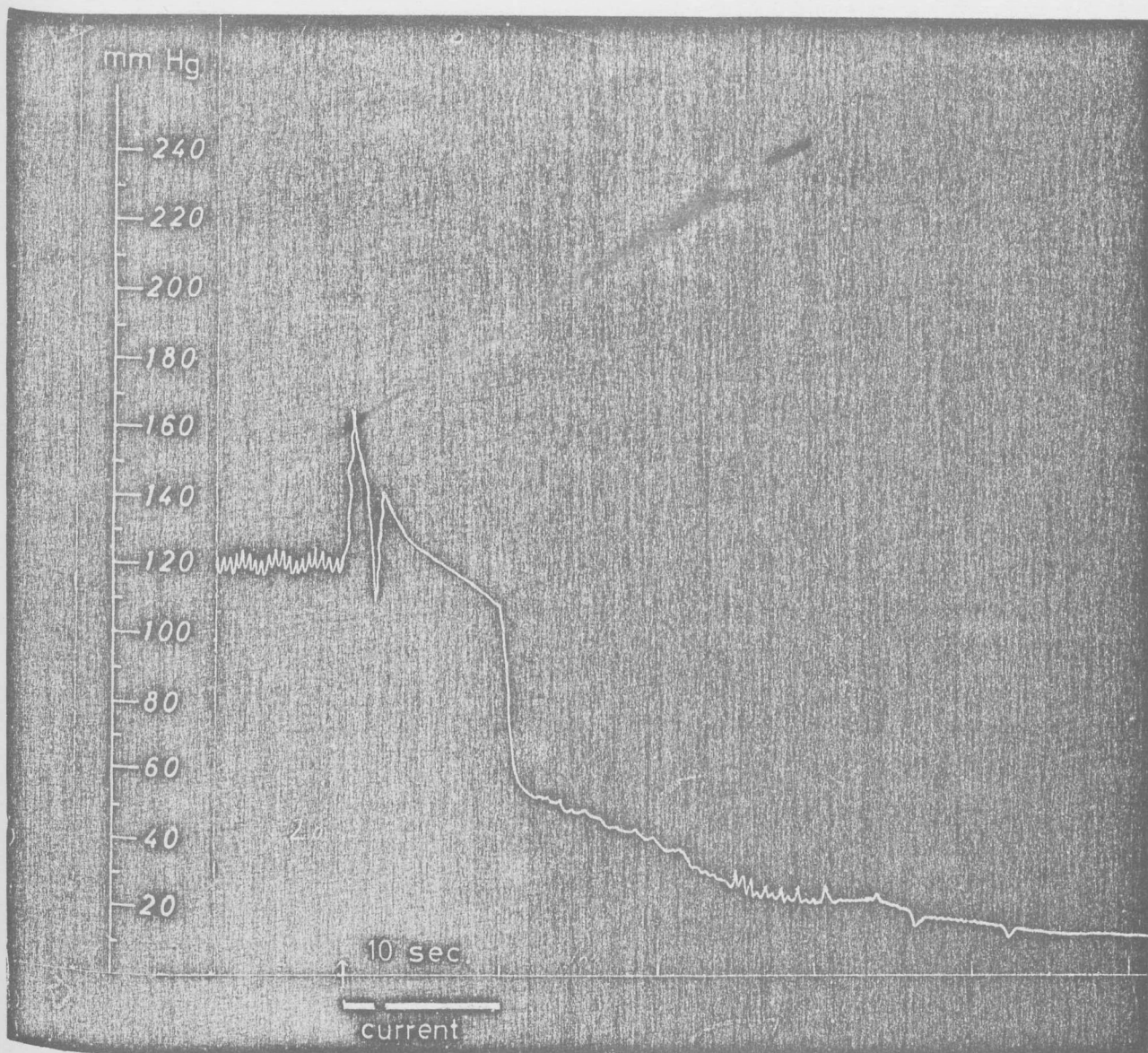
Neck/Neck



90 Volt  
0.6 Amp.  
8 Seconds

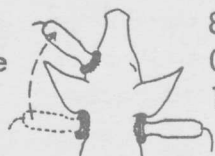
Fig. 8.

In this experiment a current of 30 m.amp. was led lengthly through the body of the pig besides of the ordinary stunning current through the central nervous system. As seen in fig. 8 the heart muscle is obviously stimulated directly by this current and is only depressed for a very short time in the beginning because of the action of n. vagus.



Electrodes:

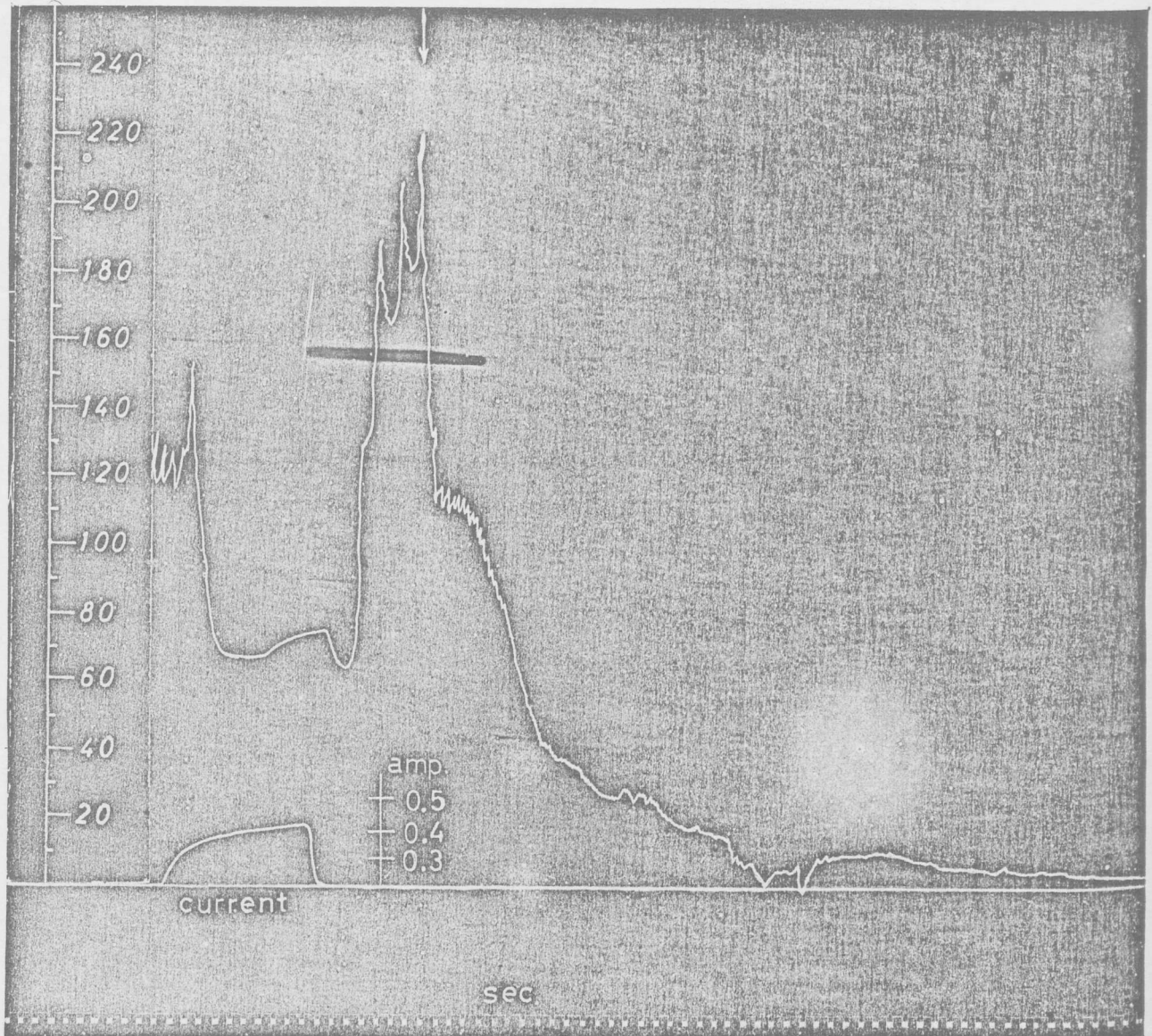
Neck/(Neck) Eye



80 Volt  
0.7 Amp.  
10 Seconds

Fig. 9.

If a strong current pass the heart the animal will be killed. In fig. 9 a current of 0.35 amp. has passed through the body of the pig during the electrical stunning. As seen in the figure the heart is permanently blocked and the pig died. This can actually happen when a pig is lying on a wet floor during electrical stunning.



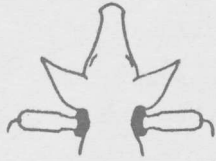
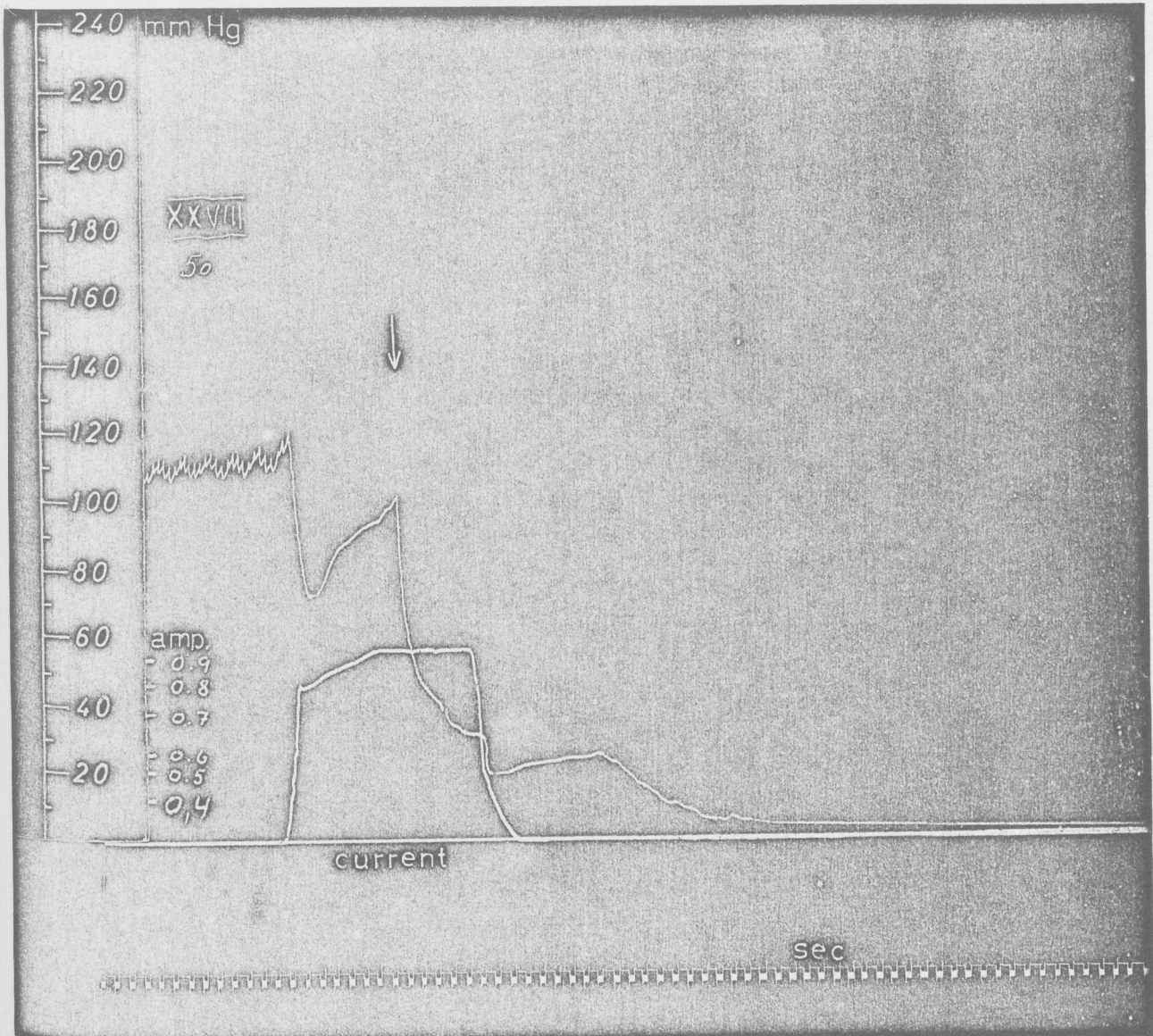
<u>Electrodes:</u>	Neck/Neck		68 Volt 0.45 Amp. 10 Seconds
<u>Haemorrhages:</u>	Lungs		-
	M. pect. prof.		+, +++
	Connective tissue		-, +

Fig. 10.

Fig. 10 shows the changes in blood pressure in a pig slaughtered according to the "short-interval-method". As to this method the pigs are to be stuck and bled not later than abt. 6 sec. after the electrical stunning i.e. before the clonic convulsions appear. This method has proved to decrease the occurrence of quality deteriorating haemorrhages in the carcasses. (Slagtemetodeudvalget 1957).

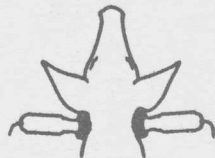
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Electrodes:

Neck/Neck



80 Volt  
0,9 Amp.  
12 Seconds

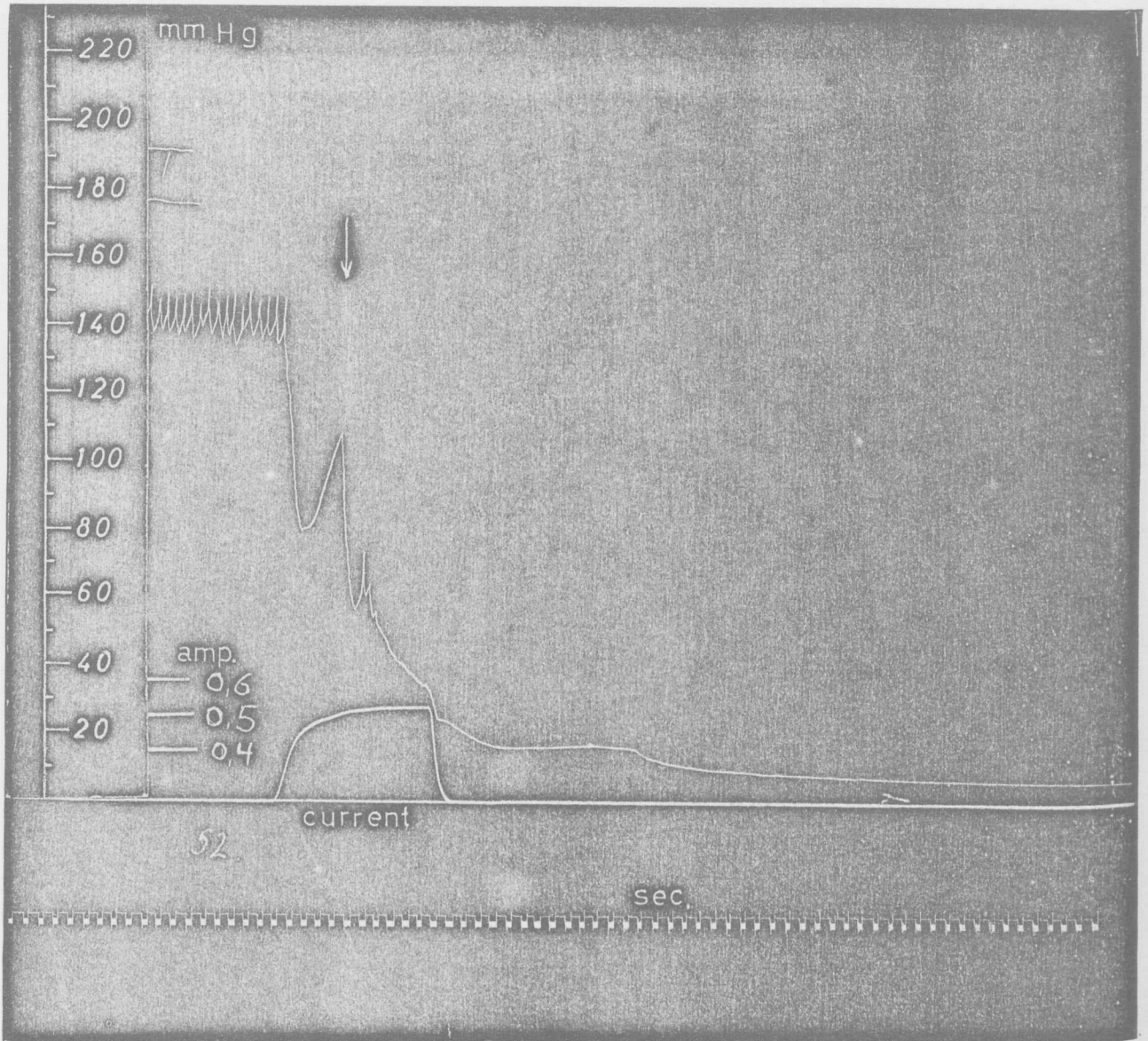
Haemorrhages:

Lungs  
M. pect. prof.  
Connective tissue

+++  
+++ , +++  
- , -

Fig. 11.

The rise in blood pressure, can be eliminated by sticking and bleeding the animals just before the current is switched off. In fig. 11-13 are shown 3 pigs slaughtered in this way. The time for cutting the bijugular and the bicarotid trunk is shown in the figures with an arrowmark. The blood pressure falls immediately and could not have caused capillar burstings but at the following autopsy haemorrhages were found in lungs and musculature in all three pigs, as described below the figures. These findings seem to indicate that the haemorrhages found in electrical stunned pigs are not caused by the strong rise in blood pressure as earlier assumed.



Electrodes: Eye/Eye



65 Volt  
0.55 Amp.  
10 Seconds

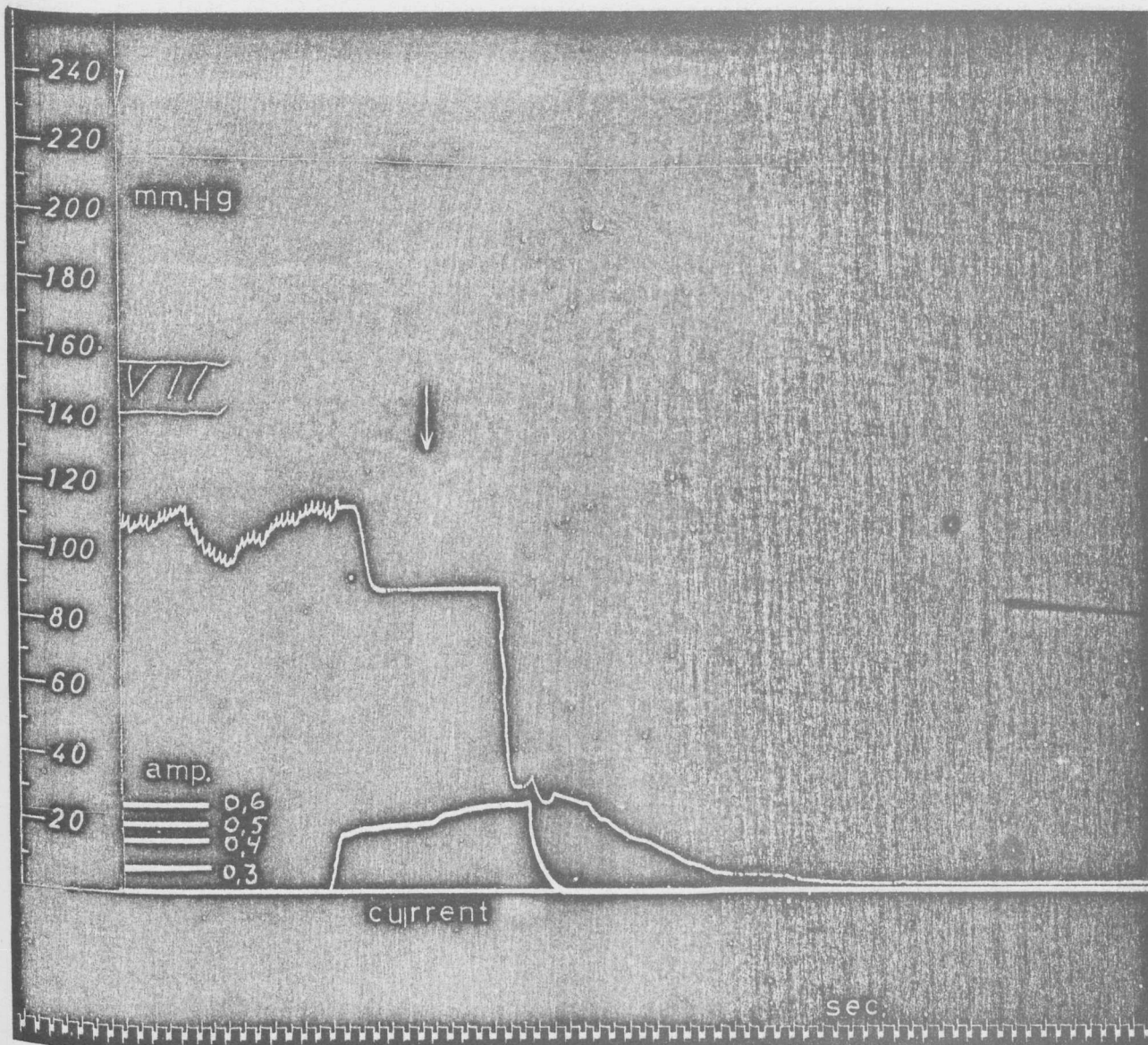
Haemorrhages:

Lungs	++
M. pect. prof.	+, ++
Connective tissue	++, ++

Fig. 12.

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Electrodes:

Neck/Neck



80 Volt  
0.55 Amp.  
15 Seconds

Haemorrhages:

Lungs  
M. pect. prof.  
Connective tissue

++  
++++, ++++  
++, ++

Fig. 13.

### Conclusion

In electrical stunned pigs the arterial blood pressure rise to about twice its initial value. This rise takes place when the current is switched off and can consequently be eliminated by sticking the animals just before this moment.

The "blood splashing" in electrical stunned pigs are usually regarded as capillar burstings produced by a suddenly strong rise in the blood pressure. The experiments reported here could not confirm this since haemorrhages were present in pigs slaughtered in a way which eliminated such a rise in the blood pressure. This finding seems to indicate that haemorrhages are not caused by capillar burstings and that they should be regarded as diapedesis of an still unknown etiology.

It is, however, obvious that if capillar leakages had occurred, a high blood pressure after the stunning for each second elapsing before sticking will increase the gravity of the haemorrhages and it should, therefore, still be important to bleed the animals as quick as possible.

### Conclusion

L'emploi d'anesthésie électrique pour des porcs cause une montée de la tension artérielle à peu près le double de la valeur initiale. Cette montée se produit, quand le courant d'anesthésie sera coupé, et elle peut par conséquent être éliminé, si on saigne les bêtes juste avant ce moment là.

Des hémorragies pulmonaires et musculaires chez des porcs anesthésiés par électricité sont généralement considérées comme des déchirures capillaires causées par une augmentation subite et forte de la tension artérielle. Les expériences décrites ne pouvaient pas justifier cette théorie, puisque ces hémorragies se produisaient également chez des porcs abattus d'une telle façon, qu'on éliminait cette augmentation de tension artérielle. Ces découvertes indiquent donc, que les hémorragies ne sont pas dû aux déchirures capillaires; il faut les plutôt considérer comme des hémorragies de diapedesis d'une étiologie inconnue jusqu'à présent. Cependant d'est évident, qu'une tension artérielle augmentée après l'anesthésie, s'il y a des déchirures dans le système capillaire, ajoute à la gravité des hémorragies pour chaque seconde écoulée avant qu'on saigne les bêtes. C'est alors toujours utile d'avancer la saignée des bêtes le plus possible.



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### Konklusion

Bei der elektrischen Betäubung von Schweinen erhöht sich deren arteriellen Blutdruck bis etwa das doppelte des Initialwertes. Diese Erhöhung tritt ein, wenn der Betäubungsstrom abgeschaltet wird und kann deshalb dadurch eliminiert werden, dass die Tiere grade vor der Abschaltung des Stromes gestochen werden. Lungen- und Muskelblutungen bei elektrisch betäubten Schweinen werden gewöhnlich als Kapillärberstungen, die durch die Blutdruckerhöhung verursacht sind, betrachtet. Unsere Experimente konnten dies nicht bestätigen, da Blutungen auch in Schweinen auftraten, die in einer solchen Weise geschlachtet wurden, dass die Blutdruckerhöhung eliminiert war. Es ist hierdurch angedeutet, dass die Blutungen nicht von Kapillärberstungen verursacht sind, eher aber als Diapedeseblutungen einer nicht bekannten Ätiologie betrachtet werden sollen.

Es ist jedoch zweifellos, dass falls Undichtigkeiten in dem Kapillärsystem vorhanden sind, wird ein hoher Blutdruck nach der Betäubung jede Sekunde die Blutungen erschweren, und es ist deswegen immer noch zweckmässig die Tiere so schnell wie möglich abbluten zu lassen.

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The effect of electrical stunning on the blood pressure in pigs in comparison to the appearance of haemorrhages in lungs and musculature

(Contributed to the 10th European Meeting of Meat Research Workers, Roskilde)

By Mogens Mandrup, Danish Meat Research Institute, Denmark.

Summary

Experiments were carried out on pigs (20 kg weight) to study the changes in blood pressure during electrical stunning. The current was applied to the head or the neck of the pigs and the blood pressure was recorded through a cannula inserted into the femoral artery. Alternating current (50 cycles) with a voltage of 65, 68, 80, 90 or 350 volt was used. Primarily the electrical stimulation of the central nervous system causes a fall in blood pressure owing to heart block which usual continues as long as the current flows. When the current is switched off the heart begins again to pump and though the frequency is reduced during the first seconds the blood pressure rise to about twice the initial value. This rise in blood pressure could be eliminated by sticking and bleeding the animal before the current was switched off but in three pigs treated in this way pettechial haemorrhages could still be found. This seems to indicate that haemorrhages in electrical stunned pigs are not - as earlier assumed - caused by capillar burstings produced by a high blood pressure, but that they should be regarded as diapedesis of a still unknown etiology.