ESTABLISHMENT OF THE INDIVIDUAL CHARACTERISTICS OF MAGNETIC RECORDING SYSTEMS FOR IDENTIFICATION PURPOSES

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ABSTRACT: Traditionally, in the process of authentication and establishment of the originality of recordings on magnetic tapes, the marks generated by the heads of recorders (STOP, START and PAUSE) have been used as the elements that make possible to determine what recorder was the source of a given recording. However, there have always been some questions that were never answered fully or clearly enough. Specifically, the literature consulted did not answer questions like the following:

- Does an individual recorder produce a mark different from the others (distinctive marks)?
- Are the marks of recorders of the same brand and model significantly different from one another?
- Are these marks stable for long periods of time or do they change with use?
- Do these marks remain after copying or modifying the recordings?

In this report, the author studied fifty (50) different types and brands of recorders and tried to answer these questions.

KEY WORDS: Authentication of recordings; Marks of recorders.

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INTRODUCTION

The Criminal Investigation Centre (CIC) is often requested by the Judicial Authorities to carry out authentication and originality research of recordings on magnetic tapes.

There are several different techniques applied to these analyses in order to obtain a correct final conclusion. Many of these techniques rely heavily on the study of the known marks generated by the recorders' reading and erasing heads when the recording is stopped (STOP, PAUSE) as well as when they are activated (START). These marks are imprinted in the time domain using a computer and the appropriate software and they are visually compared with those obtained as samples of the recorder provided along with the questioned recording. It is usually assumed that the marks whose waveforms are identical were made by the same device.

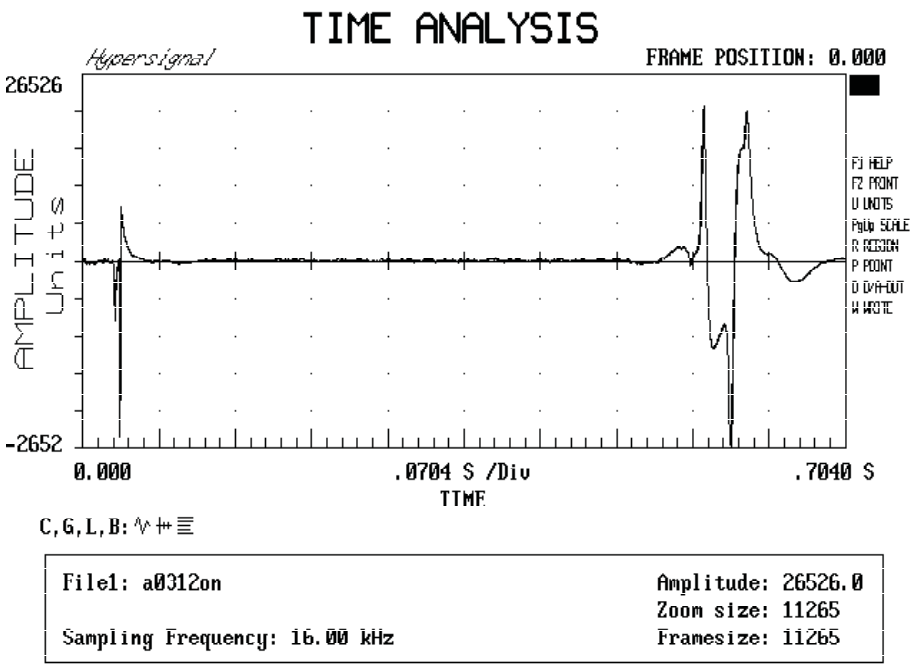


Fig. 1. A typical example of one of these marks. It shows a STOP mark and describes its components.

However, not all researchers seem to agree with this approach. While Bruce E. Koenig [2] states that these signals are exclusive of each recorder and different from the others (even in the case of devices of the same model and brand), H. Hollien [1] expresses serious doubts about this. Hollien and his team have announced that they are about to conclude an extensive study about this issue, but the author of the present report is unaware of its conclusions and whether they have been published.

For this reason, the author decided to personally check the actual scope of this problem and therefore he started an investigation process that lasted a whole year, fully funded by the General Direction of the Civil Guard and titled "Establishment of the Individual Characteristics of Magnetic Recording Systems for Identification Purposes".

Without doubt, one of the main aspects of the project was a proper selection of the recorders taking part in the study. The choice criteria were the following:

– All formats have to be represented (open reel tape, cassette and microcassette);

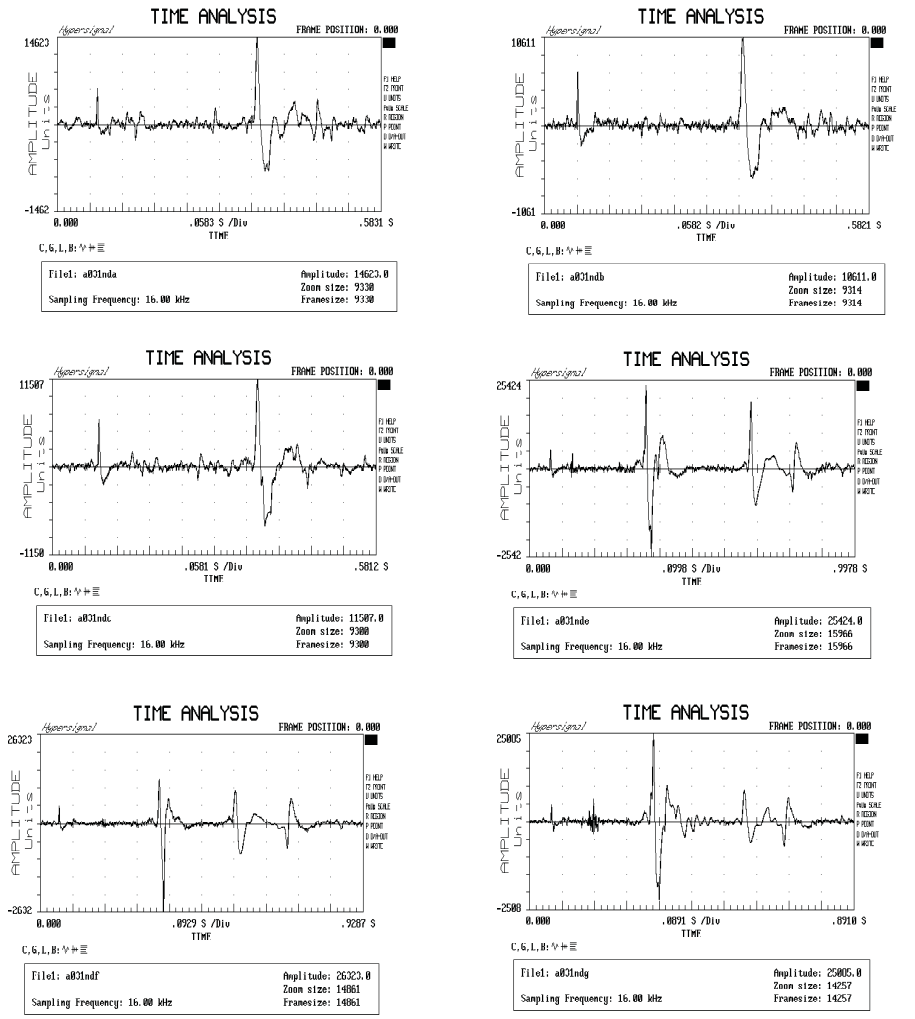


Fig. 2. START signals obtainet with the same recorder.

– All functions of every recorder should have been used on a regular basis;
– Some recorders of the same trademark and model should be included, and even recorders with consecutive serial numbers.

38 cassette type, 8 micro cassette type and 4 open reel type recorders were finally obtained.

The devices of the same model and trademark were:

– 6 Sony, mod. TCM 818, three of them with consecutive serial numbers,
– 3 Olympus, mod. L-200,

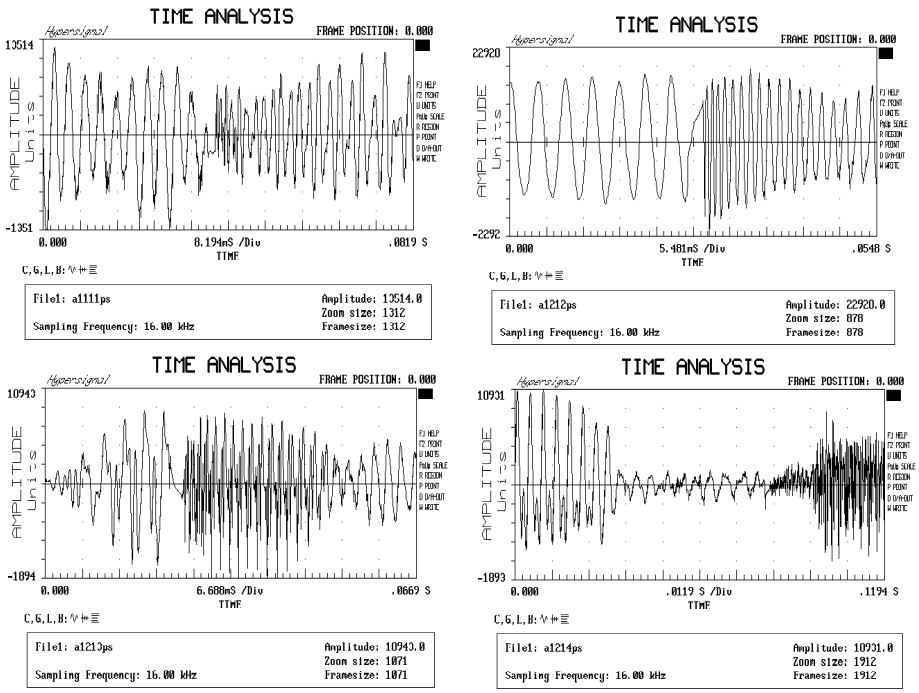


Fig. 3. Four PAUSE signals obtainet with different records.

– 3 Tascam, mod. 122 MK II,
– 4 Uher, mod. CR 1600,
– 2 Marantz, mod. PDM 201,
– 2 Pioneer, mod. DC 293,
– 2 Uher, mod. 6000,
– 2 Uher, mod. 4000.

Another important aspect was to carry out the analysis of the marks obtained in conditions of no audio input and with high-level audio input. This would reveal if audio presence could mask or somehow distort the mark.

WORKING METHODOLOGY

The study was carried out following several steps:

1. Obtaining the STOP, START and PAUSE marks of each individual recorder, both with and without audio input.
2. Digitalisation of recorded signals and storage on the computer hard disk.

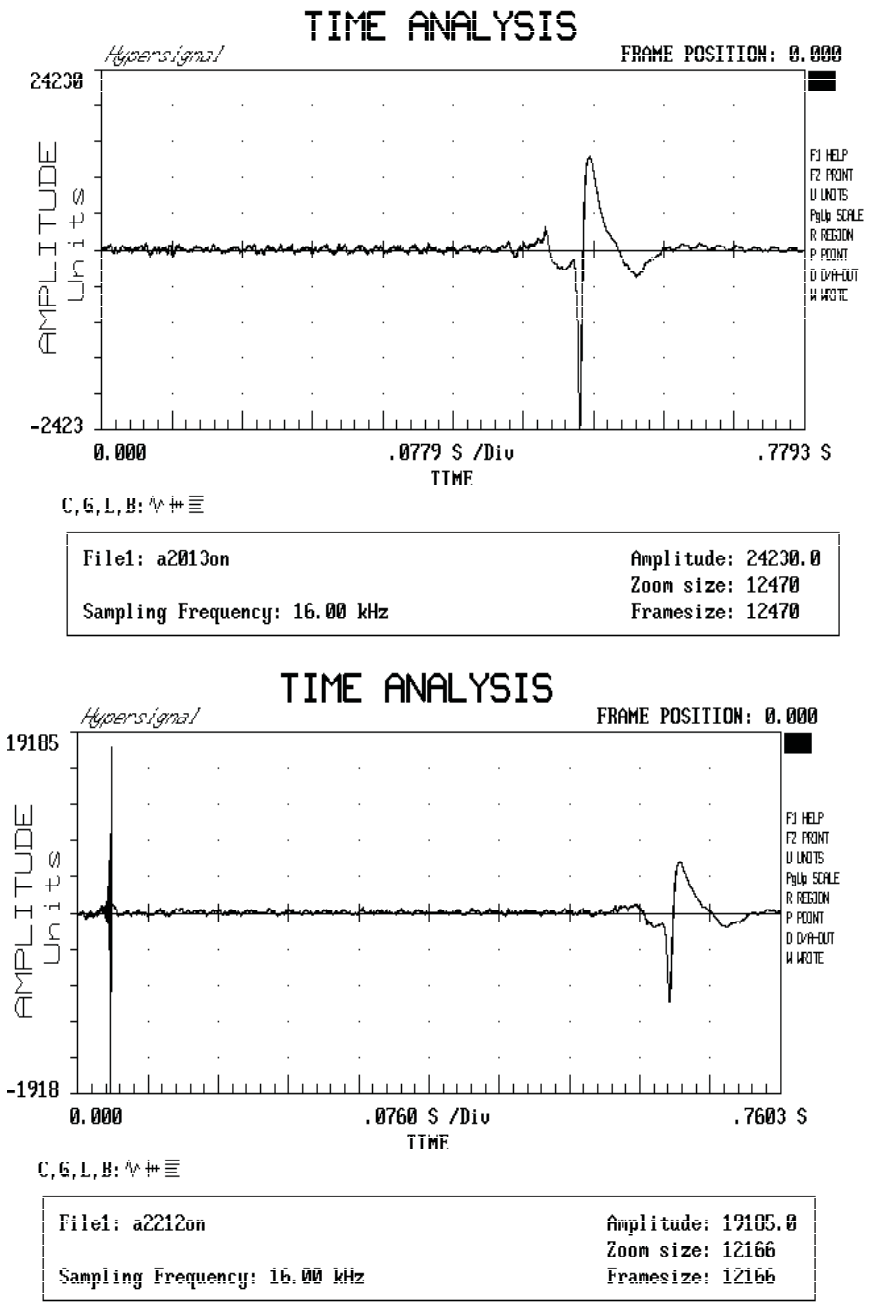


Fig. 4. Different brand recorders do not always imprint very different marks. The first figure corresponds to an AIWA recorder and the second one was generated by a Worldstar. Both devices are cassette-type and have a passive erasing head. They are very similar with exception of the transitory of the recording head.

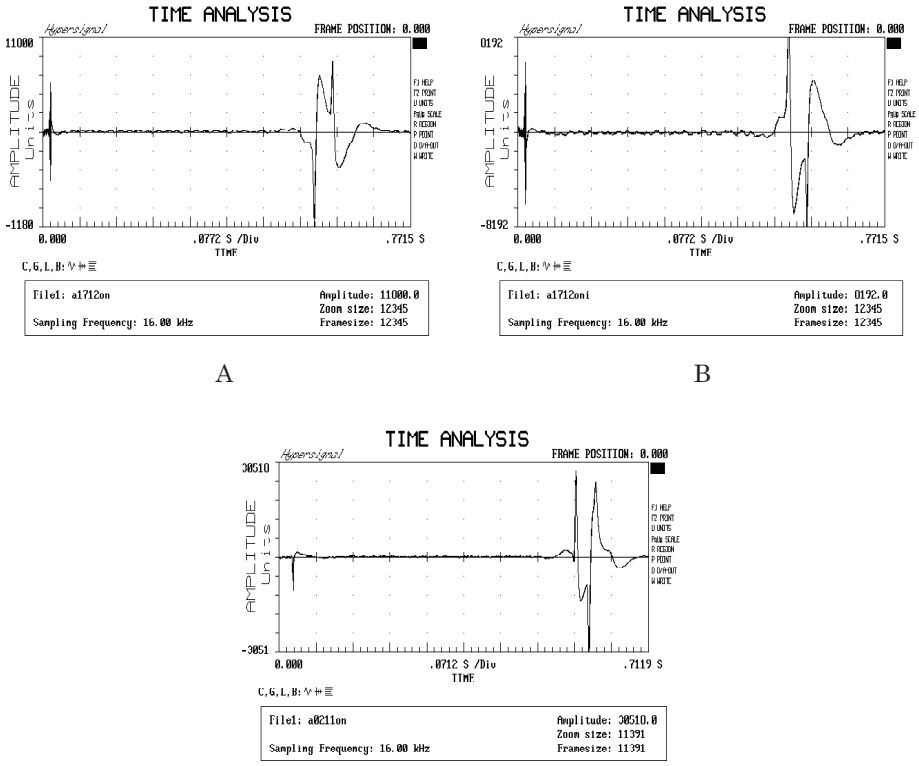


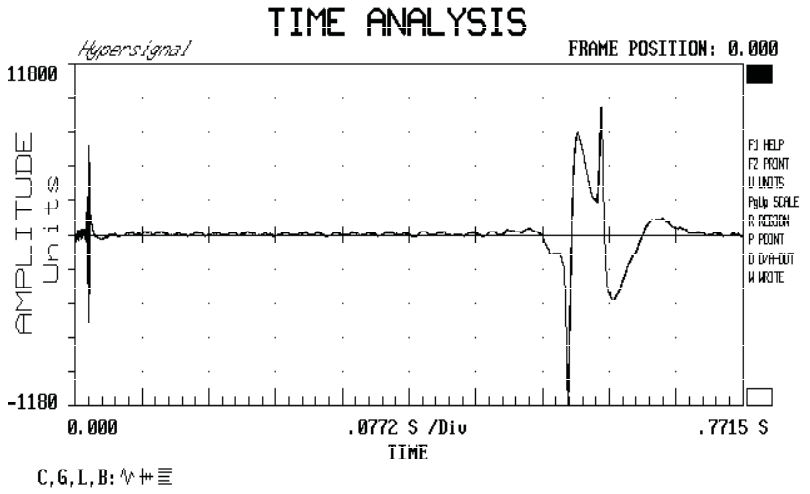
Fig. 5. In this case, both signals were generated by different recorders – Sony and Sanyo respectively – and they are nearly equal if one of them is inverted. See Figure A that corresponds to the Figure B inversion; this can be compared with Figure C.

3. Checking the stability and representativeness of the marks.
4. Assessing the identification capability of the STOP mark.
5. Obtaining new STOP marks seven months later and studying their long-term stability.
6. Copying marks on analog and digital systems.

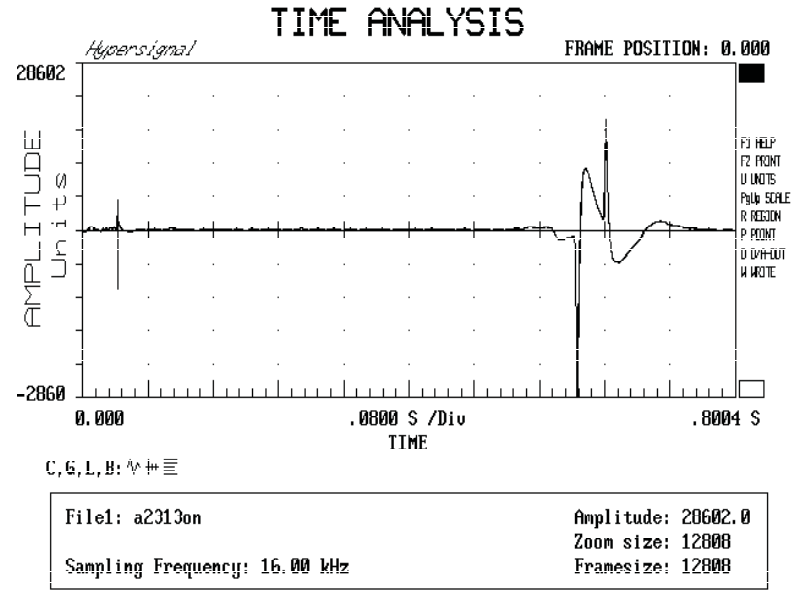
The study led to the results shown at the conclusion of each paragraph.

Obtaining the marks

In order to obtain a series of marks, each recorder was assigned a correlative number from 01 to 50 by means of a spoken message at the beginning of each series. The recorder was activated (START), stopped in PAUSE mode for five seconds and then restarted with a final STOP five seconds later. These series were repeated four times thus obtaining four STOP marks, four PAUSE marks and four STOP marks.



A



B

Fig. 6. Recorders of the same brand but different model may generate signals so similar that they can be confused. Figure A shows the STOP signal of a M-1012A model Sanyo recorder, and Figure B corresponds to a M-1118 model of the same brand. Both are portable cassettes "palm-fit" design.

This sequence was performed both with and without audio input.

The tapes used were chrome (Cr) type for the cassettes (Sony, UX 60); iron (Fe) type for the micro cassettes (Sony, MC 60); and iron for the open reel type (BASF Z-826).

Recorded signals digitalisation

Once the tape recordings were obtained, they were entered in a Tascam 122 MK II reader that sent the signal to a 16-bits A/D converter operating at a 16 kHz sampling frequency. This converter was the Ariel "Proport 656" run by the Hypersignal Macro software of Signalogic, Inc.

Using the software ZOOM function, each mark was isolated and after assigning them an identification code, they were stored on the hard disk for later analysis.

The total number of stored marks was 1 200.

Checking the stability and representativeness of the marks

The process to carry out this analysis is fully visual and although it is to a extent subjective, another observer experienced in visual comparative analysis of signals could duplicate the results with only minimal differences.

START and STOP marks study

Five different stability levels were established:

1. Mark absence (there is no mark);
2. No marks are representative (four marks are different) (0%);
3. Only two marks are representative (only two marks are equal) (50%);
4. Only three marks are representative (only three marks are equal) (75%);
5. All the four marks are representative (the four marks are equal) (100%).

Table I shows the results of the analysis.

What is specially remarkable is the high representative capacity of the STOP mark versus the START mark. The 78–80% of the questioned recorders show a stable STOP mark versus the 34–46% of the START mark.

The cause of this lies in the fact that the operator has an important influence on the activation of a START and, depending on the pressure applied when pushing the touch buttons, the approximation of the heads to the tape will vary in quickness, generating different transitories. This was experimentally verified as shown in Figure 2, depicting six START signals obtained with the same recorder but pressing the REC touch button (recording start) with different pressure levels. However, in the case of the STOP mark, there is no influence by the operator as the heads separation is automatic and always occurs in the same way.

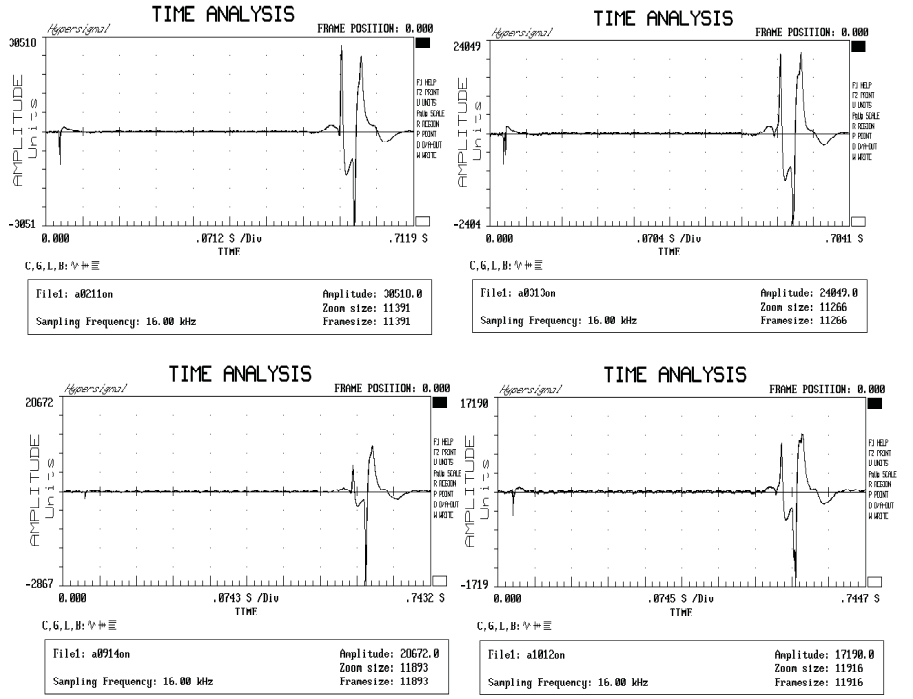


Fig. 8. Same brand and model recorders can generate nearly equal signals. The signals depicted were generated by recorders of the same brand and model (Sony TCM-818).

This instability prevents the START signal from being a fully reliable identifying component, therefore this mark has to be carefully considered.

Erratic behaviour of the START mark has also been observed depending on the audio input presence or absence.

The high level audio tends to modify or mask the START mark. This condition was already outlined by Koenig [2].

Nevertheless, the STOP mark presents a high stability both with and without audio input. This allowed us to focus our study in depth on this mark.

If we rename the above defined levels as “very stable” for the case of four representative marks; “relatively stable” for the case of only three representative marks and so on “hardly stable”, “unstable” and finally “mark absence” and if we enter as a new variable the type of recorder’s erasing head (active if it performs high frequency current erasing and passive if the head features a permanent magnet), and taking into consideration that 21 of the 50 recorders under study present an active erasing head and 29 a passive one, then we are able to reorganise the data contained in Table I as shown in Table II.

TABLE I. REPRESENTATIVENESS OF THE START AND STOP MARKS

	N1 of recorders	Percentage of the total
RN (START without audio input)		
Mark absence	3	6%
Any mark is representative (0%)	5	10%
Only two marks are representative (50%)	12	24%
Only three marks are representative (75%)	13	26%
All the four marks are representative (100%)	17	34%
RS (START with audio input)		
Mark absence	7	14%
Any mark is representative (0%)	7	14%
Only two marks are representative (50%)	3	6%
Only three marks are representative (75%)	10	20%
All the four marks are representative (100%)	23	46%
ON (STOP without audio input)		
Mark absence	0	0%
Any mark is representative (0%)	1	2%
Only two marks are representative (50%)	3	6%
Only three marks are representative (75%)	7	14%
All the four marks are representative (100%)	39	78%
OS (STOP with audio input)		
Mark absence	1	2%
Any mark is representative (0%)	2	4%
Only two marks are representative (50%)	0	0%
Only three marks are representative (75%)	7	14%
All the four marks are representative (100%)	40	80%

TABLE II. STABILITY OF THE START AND THE STOP MARKS

	Very stable	Relatively stable	Hardly stable	Unstable	Mark absence
START RN	34%	26%	24%	10%	6%
START RS	46%	20%	6%	14%	14%
STOP ON	78%	14%	6%	2%	0%
STOP OS	80%	14%	0%	4%	2%
STOP OS (active head)	52.38%	33.33%	0%	9.52%	4.76%
STOP OS (passive head)	100%	0%	0%	0%	0%
STOP ON (active head)	47.61%	33.33%	14.28%	4.76%	0%
STOP ON (passive head)	100%	0%	0%	0%	0%
START RN (active head)	38%	28.57%	14.28%	9.52%	9.52%
START RN (passive head)	31%	24.13%	31%	10.34%	6.89%
START RS (active head)	23.8%	28.57%	0%	28.57%	19.04%
START RS (passive head)	62%	13.79%	13.79%	0%	10.34%

This table is extremely illustrative. If we observe the marks made by the passive erasing heads, it is found that there is a 100% stability both with and without audio input. This does not occur with the active erasing heads, in which case the stability percentage is approximately 50%.

Conclusions:

– The only mark that presents stability in every case is the STOP mark, specially when it is generated by a passive erasing head.
– The instability affecting the START mark makes the use of this mark inadvisable. In any case, its results should always be carefully considered.

PAUSE mark study

When studying the PAUSE mark the results vary considerably.

The first survey carried out was to check for the presence of the mark without audio input. This would allow us to recognise the mark and, if it exists, compare it with others.

The marks observed are usually very simple (only one peak in many cases), very low level and in most cases they are accompanied (or masked) by different transitories generated by operator handling when activating the relevant key or switch in those cases in which the microphone is an integral part of the recorder.

There is a large number of recorders that do not imprint any mark. A relatively high percentage of them show stable and clearly visible marks. Sometimes, a recorder imprints a mark while another one of the same brand and model does not.

All these facts suggest that it would be extremely difficult to detect this kind of marks with high-level audio input, as it will be later shown.

Following the same working methodology, all the PAUSE marks are analysed individually. Table III shows the results.

TABLE III. STABILITY OF THE PAUSE MARKS

Very stable	Relatively stable	Hardly stable	Unstable	Absence of mark	No available
16	7	7	1	17	2
(33.3%)	(14.58%)	(14.58%)	(2.08%)	(35.41%)	(4.16%)

As we can observe, the largest single group of recorders (35.4%) do not imprint any mark. There are also 16 that imprint stable marks. Two recorders lacked the PAUSE function.

The percentage of recorders that showed either “very stable” and “relatively stable” levels exceeds 47%, which means that nearly half the analysed

recorders could be identified by means of the PAUSE mark as long as this function is activated in absence of audio input and this mark differs significantly among different recorders.

The next survey intends to ascertain if this mark has discriminating capacity.

We selected the 23 recorders included in the groups "very stable" and "relatively stable" and set up a table in which every single mark is compared with the others. This is performed in the same visual way already used for the STOP and START marks.

Three different levels were established to assess the results of the visual comparison:

OK: Clearly different marks.

D: There is some assessing uncertainty.

C: The marks are easily confused due to its similarity.

Table IV shows the results of comparison. 253 comparisons were carried out, resulting in 4 confusing cases (1.58%), 8 unclear cases (3.16%) and 214 correctly classified cases (95.2%).

Once the PAUSE marks without audio input were analysed, the next step was to check what happened to these marks in presence of high-level audio input.

The outcome of this test corroborates our prior assumption. Al marks have disappeared. However, it is important to note that the PAUSE activation does not go unnoticed. The point where the PAUSE activated is easily detected by the human ear due to the sudden "compression" of the frequencies as variation of the hauling speed goes from 0 to v. A close listening will allow us to find the location where the handling was performed and a "zoom" on this area sometimes enables us to note the "gap" produced by the tape sliding before stopping and due to the inertia of the hauling mechanism and the frequency "compression" generated by the later activation.

Figure 3 serves to illustrate this.

Conclusions:

- The STOP mark can only be detected when there is no audio input.
- In presence of audio input, the usually low level mark is "absorbed" by the audio itself and thus it is not noticeable.
- A high percentage of the studied recorders (35.4%) do not generate this mark.
- When the mark exists, it is not always stable. Therefore, its stability must always be verified before carrying out any comparative study on it.
- If the mark is found to be stable, it can be a identification component.

TABLE IV. THE CONFIGURATION OF THE PAUSE MARKS FOR RECORDERS INCLUDED IN THE GROUPS "VERY STABLE" AND "RELATIVELY STBLE"

	2	3	4	6	7	8	9	14	24	25	27	28	30	32	33	34	36	37	39	41	42	47	50
2	X	C	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
3		X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
4			X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	D	OK
6				X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
7					X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
8						X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
9							X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
14								X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
24									X	D	C	D	OK	OK	D	OK	OK	OK	OK	OK	OK	OK	OK
25										X	D	C	OK	OK	D	OK	OK	OK	OK	OK	OK	OK	OK
27											X	D	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
28												X	OK	OK	D	OK	OK	OK	OK	OK	OK	OK	OK
30													X	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
32														X	OK	OK	OK	OK	OK	OK	OK	OK	OK
33															X	OK	OK	OK	OK	OK	OK	OK	OK
34																X	OK	OK	OK	OK	OK	OK	OK
36																	X	C	OK	OK	OK	OK	OK
37																		X	OK	OK	OK	OK	OK
39																			X	OK	OK	OK	OK
41																				X	OK	OK	OK
42																					X	OK	OK
47																						X	OK
50																							X

Key: OK – clearly different marks; D – there is some assessing uncertainty; C – The marks are confusing due to their similarity. Confusion: 1 case (1.58%). Uncertainty – 8 cases (3.16%). Correct – 241 cases (95.2%). Total comparisons: 253.

ASSESSING THE IDENTIFICATION CAPACITY OF THE STOP MARK

Once established that the STOP mark is the one that presents the highest degree of stability under any conditions, we shall now try to test its identification capacity. The questions to answer are the following:

A. Whether the marks generated by different brand recorders are different from one another.

B. Whether same brand but different model recorders generate different marks.

C. Whether same brand and model recorders generate different marks.

In order to answer question A, all different brand recorders are selected, obtaining 16 different devices.

The comparison process used is the one previously explained.

We set up a table (Table V) and implement the following identity levels:

OK: Clearly different marks.

D: There is some assessing uncertainty.

C: The marks are confusing due to its similarity.

120 comparisons were carried out, resulting in 4 uncertain cases (3.3%), and 2 cases in which the marks are confusing as they were practically identical (1.66%).

Therefore it can be stated with 95% confidence level that different brand recorders generate different marks. It is also true that different brand recorders can generate equal or very similar marks in 5% of the cases.

As the study was performed using 16 recorders, these percentages are to be considered illustrative.

In order to answer question B, we grouped the recorders depending on the brand. Seven different models of Sanyo brand, five of Sony and three of Uher were available. Table VI shows the results.

TABLE V. THE COMPARATION OF THE STOP MARKS GENERATED BY DIFFERENT BRAND RECORDS

	1	**2**	**4**	**7**	**8**	**17**	**18**	**19**	**20**	**22**	**25**	**26**	**30**	**31**	**38**	**40**
1	---	OK	OK	OK	OK	OK	OK	OK	**D**	**D**	OK	OK	OK	OK	OK	OK
2		---	OK	OK	OK	**C**	OK	OK	OK	OK	OK	**D**	OK	OK	OK	OK
4			---	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
7				---	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
8					---	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
17						---	OK	OK	OK	OK	OK	**D**	OK	OK	OK	OK
18							---	OK	OK	OK	OK	OK	OK	OK	OK	OK
19								---	OK	OK	OK	OK	OK	OK	OK	OK
20									---	**C**	OK	OK	OK	OK	OK	OK
22										---	OK	OK	OK	OK	OK	OK
25											---	OK	OK	OK	OK	OK
26												---	OK	OK	OK	OK
30													---	OK	OK	OK
31														---	OK	OK
38															---	OK
40																---

Key: OK – clearly different marks; D – there is some assessing uncertainty; C – the marks are confusing due to their similarity.

TABLE VI. THE RESULTS OF COMPARATION THE STOP MARKS GENERATED BY THE SAME BRAND BUT DIFFERENT MODEL RECORDERS

SANYO

	16	**17**	**21**	**23**	**33**	**43**	**45**
16	--	OK	OK	OK	OK	OK	OK
17		--	**C**	**C**	OK	OK	**D**
21			--	C	OK	OK	**D**
23				--	OK	OK	**D**
33					--	OK	OK
43						--	OK
45							--

SONY

	2	**5**	**24**	**32**	**50**
2	--	OK	OK	OK	OK
5		--	OK	OK	OK
24			--	OK	OK
32				--	OK
50					--

UHER

	8	**34**	**36**
8	--	OK	OK
34		--	OK
36			--

Key: OK – clearly different marks; D – there is some assessing uncertainty; C – the marks are confusing due to their similarity.

Three recorders (numbers 17, 21 and 23) generate marks so similar than they can be easily mixed up. Moreover, recorder number 45 imprints a mark extremely similar to the aforementioned ones. All of them are Sanyo brand.

This was not observed with the Sony and Uher devices.

The results corresponding to the Uher devices are not representative as only there are three recorders available.

In light of these conclusions, we are able to state that it is sometimes possible that same brand but different model recorders could generate signals so similar that the examiner could mix them up.

In order to answer question C, we selected the recorders of the same brand and model.

We have six Sony TCM 818 recorders, of which numbers 2, 3 and 10 have consecutive serial numbers; three Olympus L-200; three Tascam 122 MKII; four Uher CR 1600; two Marantz PDM 201; two Pioneer DC-293; two Uher 6000 and two Uher 4000. Table VII shows the obtained results.

As can be noticed in the case of the Sony TCM-818 recorder, all the signals are nearly equal and those with consecutive serial numbers provide practically identical signals.

The rest of the recorders show varying results.

Consequently, we can state that same trademark and model recorders may generate similar o equal STOP signals.

TABLE VII. THE COMPARATION OF RESULTS FOR SELECTED RECORDERS WITH SIMILARITY MARKS

SONY TCM-818						
	2	**3**	**6**	**9**	**10**	**13**
2	--	**C**	**D**	**D**	**C**	**C**
3		--	**D**	**D**	**C**	**C**
6			--	**C**	**D**	**D**
9				--	**C**	**C**
10					--	**C**
13						--

OLYMPUS L-200				
	25	**28**	**29**
25	--	OK	OK
28		--	**D**
29			--

UHER CR 1600					
	8	**11**	**12**	**15**
8	--	OK	OK	OK
11		--	**C**	**D**
12			--	**D**
15				--

TASCAM 122 MKII			
	4	**47**	**49**
4	--	OK	OK
47		--	OK
49			--

MARANTZ			
	7	**14**
7	--	OK
14		--

PIONEER			
	40	**41**
40	--	OK
41		--

UHER 6000			
	34	**41**
34	--	OK
41		--

UHER 4000			
	36	**37**
36	--	**D**
37		--

Key: OK – clearly different marks; D – there is some assessing uncertainty; C – the marks are confusing due to their similarity.

Conclusions:

– It can be stated that different brand recorders generate different STOP signals, although existing exceptions do not allow to establish this as a hard and fast rule.
– Same brand but different model recorders can generate STOP signals so similar that they can be confused.
– Same brand and model recorders can generate identical or extremely similar STOP signals.

Figures 4 to 9 show a sample of the undertaken study.

OBTAINING NEW STOP MARKS SEVEN MONTHS LATER AND STUDYING THEIR STABILITY

Another objective was to determine if the marks were stable for a period of time.

To this end, the recorders were sent back for regular use and six months later they were gathered again to undertake a new sample taking with the purpose of comparing these marks with the former.

Actually, not all the recorders were subjected to extensive operation. Only thirteen of them met this requirement, thus the study was carried out exclusively with them.

Note that recorder number 3 had been in use for ten months and number 13 was subjected to 3 000 START – STOP actions. The average operating time that recorders were in use before the second sample taking was about seven months.

The next step was to check if the marks generate by these thirteen recorders seven months before were identical to those in the second set of marks.

To simplify the study, only the STOP mark was considered due to the fact that this is the most complex and stable mark.

The marks comparing-procedure is the same as the one previously explained.

The "previous" marks are visually compared to the "later" ones. The results of this test are shown in Table VIII.

TABLE VIII. THE STABILITY OF STOP MARKS FOR A 6 MONTH PERIOD

Recorder	3	9	10	11	13	16	17	21	23	25	29	34
Resultado	OK	OK	OK	D	OK	D	OK	OK	OK	D	OK	OK
Tipo cabezas	PAS	PAS	PAS	ACT	PAS	ACT	PAS	PAS	PAS	PAS	PAS	ACT

Key: OK – clearly equal marks; D – there is some assessing uncertainty.

As can be noted, only three recorders offered inconclusive results. The ten remaining shown "previous" marks identical to the "later" ones.

In order to assess the degree of the identifying-capability of the marks, these were overlapped by means of transparencies and tiny differences in amplitude and phase can be observed, which indicates the existence of a certain variability between different sessions.

With reference to the three recorders that offered confusing results, numbers 11 and 16 had already be found to have an active erasing head whose mark was of very low level and not very stable. The results obtained are therefore consistent. In relation to number 25, it had also been found that it was not very stable and that the mark generated by it was low level.

Conclusions:

– The recorders with passive erasing head preserve practically the same marks, especially the high level ones.
– When marks do not present a good level, they tend to be unstable as time goes by. The level of the mark seems to be in direct relation with its long-term stability, and the passive heads always show a bigger stability that the active ones.

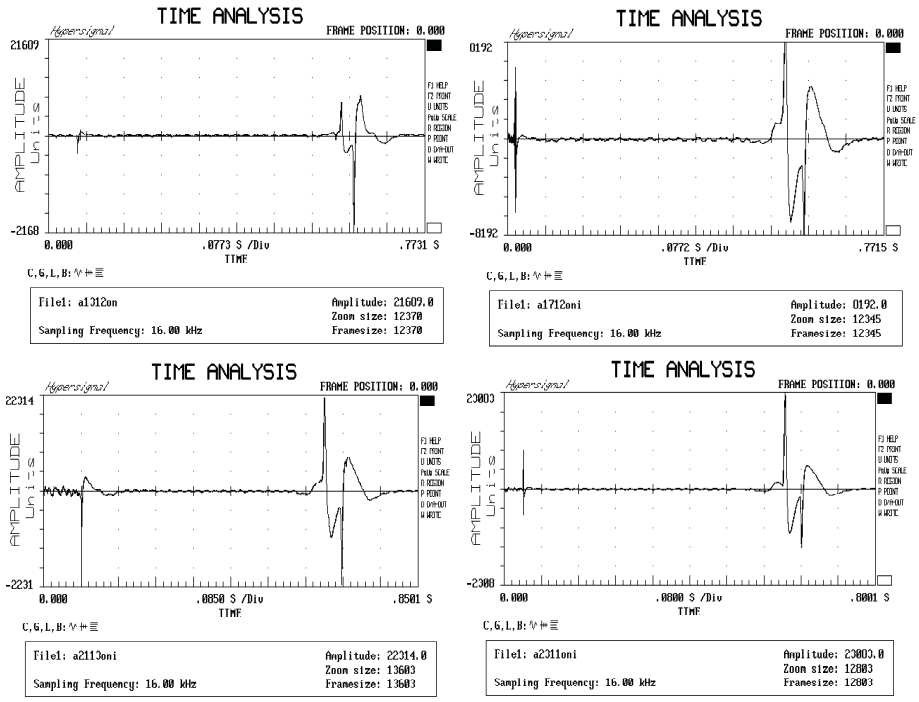


Fig. 9. All marks represented were generated by different recorders. However, their waveforms are very similar.

COPYING MARKS ON ANALOG AND DIGITAL SYSTEMS

Another objective was to determine what happened to marks when they are copied from an original tape to another.

In order to carry out this study, five recorders were selected.

The original tape was copied using another tape of same brand and model, i.e. identical characteristics, using the dual deck of a high quality Sony hi-fi system. This copy was in turn copied with the same device on an identical cassette, thus obtaining a second-generation recording.

The copied STOP marks were then compared with the original ones.

In all cases a remarkable difference was observed between the original mark and the two copies. However, both copies are similar.

Figure 10 shows an example of the STOP mark corresponding to recorder number 2: the original mark (A0212OS), its first copy (A0212OC1) and the second one (A0212OC2).

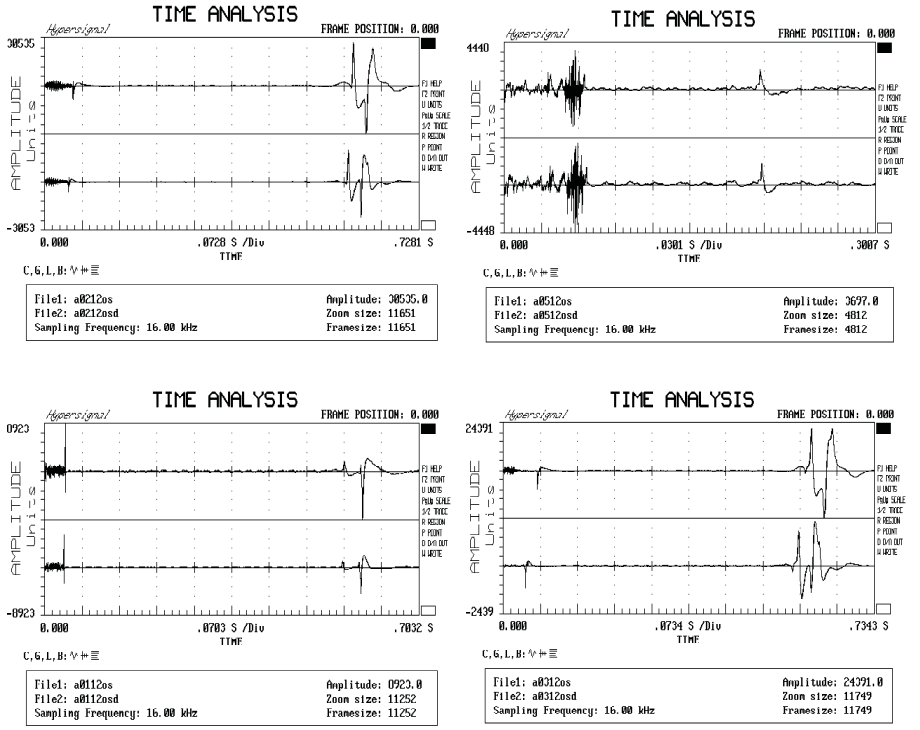


Fig. 10. A example of the STOP marks – the second copy (upper, left), the first copy (upper, right) and the signed mark (bottom).

For this reason and as all researchers consulted agree, the authentication process must never be undertaken using copies, especially when the device and procedure used to make the copy are unknown.

All this invariably brings us to the question; could digital copies be used?

In order to answer this, we used the same recorders chosen before. The reading is done using a TASCAM 122 MK II recorder, and the copy was made with a digital one, (DAT) Tascam DA 30 MK II.

The results allowed us to state that the marks digitally copied suffer less distortion than those copied with an analog system.

Sometimes there was no distortion at all, as happened with recorders numbers 2 and 5 (Figure 11). However, in some other cases differences that could lead to confusion were detected.

We think that the problem could lie with the analog reader instead of the digital recorder in all related to the reading-head parameters, as they must be strictly controlled before copies are made. Consequently, not even digital copies should be accepted for the authentication process.

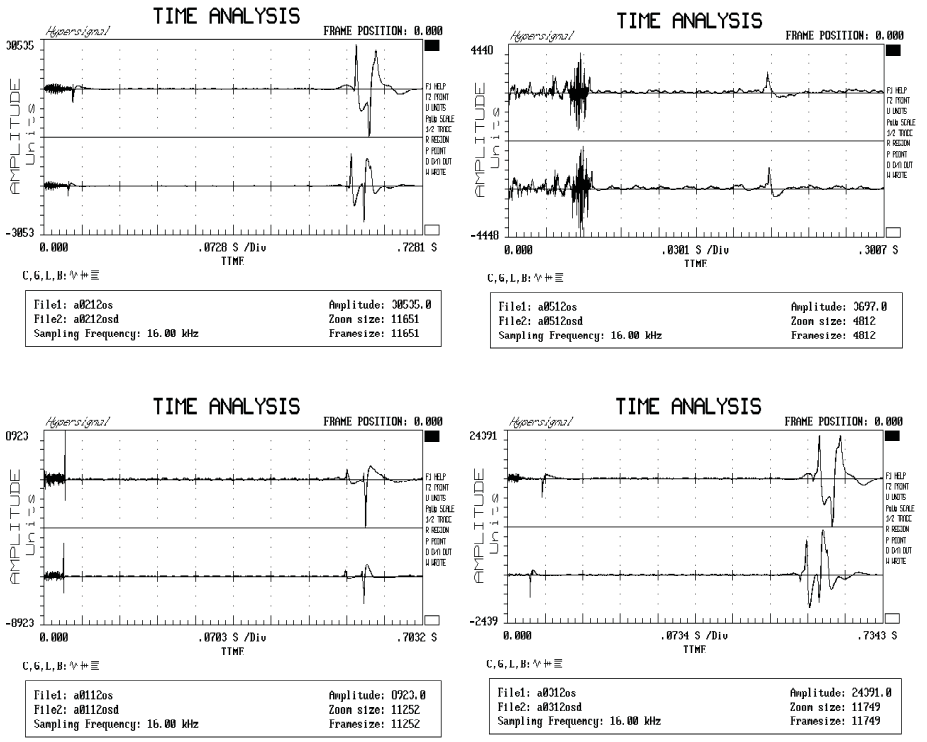


Fig. 11. Same brand and model recorders can generate nearly equal signals. The signals depicted were generated by recorders of the same brand and model (Sony TCM-818).

Conclusions:

– Copying the marks of a recording by means of an analog process is likely to introduce distortions on it. This definitively is the case if the copy process is not done under laboratory conditions.
– This same operation made using a digital recorder does not guarantee that the mark will not be distorted.
– In authentication studies non-original recordings should not be accepted.

References:

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3. Majewski W., Basztura C., Methods of Tape Recording Authentication, AES 102nd Convention, Munich 1997.