Electronic system for loss of contact control in Race Walking

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INTRODUCTION

Race walking is an athletic activity mainly based on the action of walking.

The regulations thereof in competitions are governed by Rule 230 of "*IAAF Competition Rules"*, which reads as follows:

"Race Walking is a progression of steps so taken that the walker makes contact with the ground, so that no visible (to the human eye) loss of contact occurs. The advancing leg must be straightened (i.e. not bent at the knee) from the moment of first contact with the ground until the vertical upright position."

As it can be noted, there are only two basic rules: the one stating that the knee cannot be bent from the moment that the foot's walker makes contact with the ground until the vertical upright position of the body, and on the other hand, the one stating that the walker cannot lose contact with the ground, in other words, he must always have at least one foot on the ground, and this is the feature that differentiates race walking from running.

In order to control the compliance of said two rules, in the competitions there are judges who observe and judge whether the walker always fulfils the regulations or not, in case of being close to non-compliance the athlete shall be warned, and a yellow paddle shall be shown to him with a symbol corresponding to the offence that he is about to make.

In case that the judge observes an obvious non-compliance of any of these two points of the regulations, he shall proceed to issue a disqualification order against the infringing athlete that shall be delivered to the referee of the event. When the referee receives three of such disqualification orders, by three different judges, he shall proceed to notify the disqualification to the athlete, by showing him a paddle similar to the previous yellow one, but in this case in red, and the athlete shall abandon the competition immediately, given that he will be disqualified.

In principle, the rules are clear and the way of ensuring their compliance by means of visual observation seems to be suitable and effective, however, in practice, things are not that easy.

On the one hand, it goes without saying that the judges responsible for judging the race walking in high level competitions are particularly qualified and selected for performing their duty with the highest degree of effectiveness and accuracy.

However, on the other hand, the current competition speeds have largely increased, making possible race walking speeds of more than 4 steps per second, throughout the competition.

Taking into account this significant piece of information, we can deduce that the visual control of the rule related to not bending the knee can be precise enough, given that the duration in time of this "failure" ranges between at least 1-2 tenths, time enough to be visually observed.

However, problems arise with the rule related to loss of contact.

The phase of loss of contact of a high level walker does not last more than some hundredths, adding to this time factor the fact that the human eye must be paying close attention at the

same time to two portions of the athlete's body which are relatively away from each other, such as the toes of the retreating leg and the heel of the advancing leg.

Actually, and in high level walkers, it is completely impossible for the human eye to detect the loss of contact if the athlete does not exceed a certain "flight" height and also maintains a fluid race walking technique without visible jumps or vibrations at the shoulders and at the upper body.

By way of illustration, in the following picture, there is a frequent example of loss of contact in high level competitions.

It is a picture of one participant in men's 20km race walk of the European Athletics Championship Barcelona 2010. As it can be observed, the athlete was walking in the air, but he was not disqualified.

It must be pointed out that this loss of contact is not a specific moment of the competition, but rather it occurs during the whole competition, and by almost all the participants in high level competitions.

As observed, he complied with the regulations, given that his loss of contact could not be seen by human eye.

(Note: this athlete has been used by way of real example, but, please note that the comments expressed here are not to be considered as a criticism towards him or his technique).

Taking the above into account, there are two questions to be considered:

- The constant inconsistency suffered by race walking given that the winner is an athlete who appears in the air in the pictures of the same competition which he has just won.
- The accuracy of the correct judging of race walking depends on the subjectivity of the judges taking part in the competition, and thereby, on their own visual acuity, which may vary among them.

The conclusion to be drawn is that it is necessary to include a technological medium in race walking rulings, in order to provide the necessary accuracy and objectivity for fulfilling the regulations and keeping the spirit of this athletic activity which is based on walking and not on running.

METHOD

In the past, to be more specific two decades ago, there was already an attempt to introduce an electronic system to control loss of contact in race walking.

It was a system invented and patented by Mr. Dennis Furlong (patents: EP0360930A1 and US 4956628), based on the use of specific sneakers provided with pressure sensors inserted in the sole giving electrical signals to two electronic devices included in the sneakers.

These devices, in turn, provided an alarm when there was a failure or loss of contact by the walker.

The system was then examined and assessed by the IAAF to consider the use thereof in competitions, but it was discarded as it had several problems due to its excessive weight and volume, and also due to the insufficient accuracy of its operation.

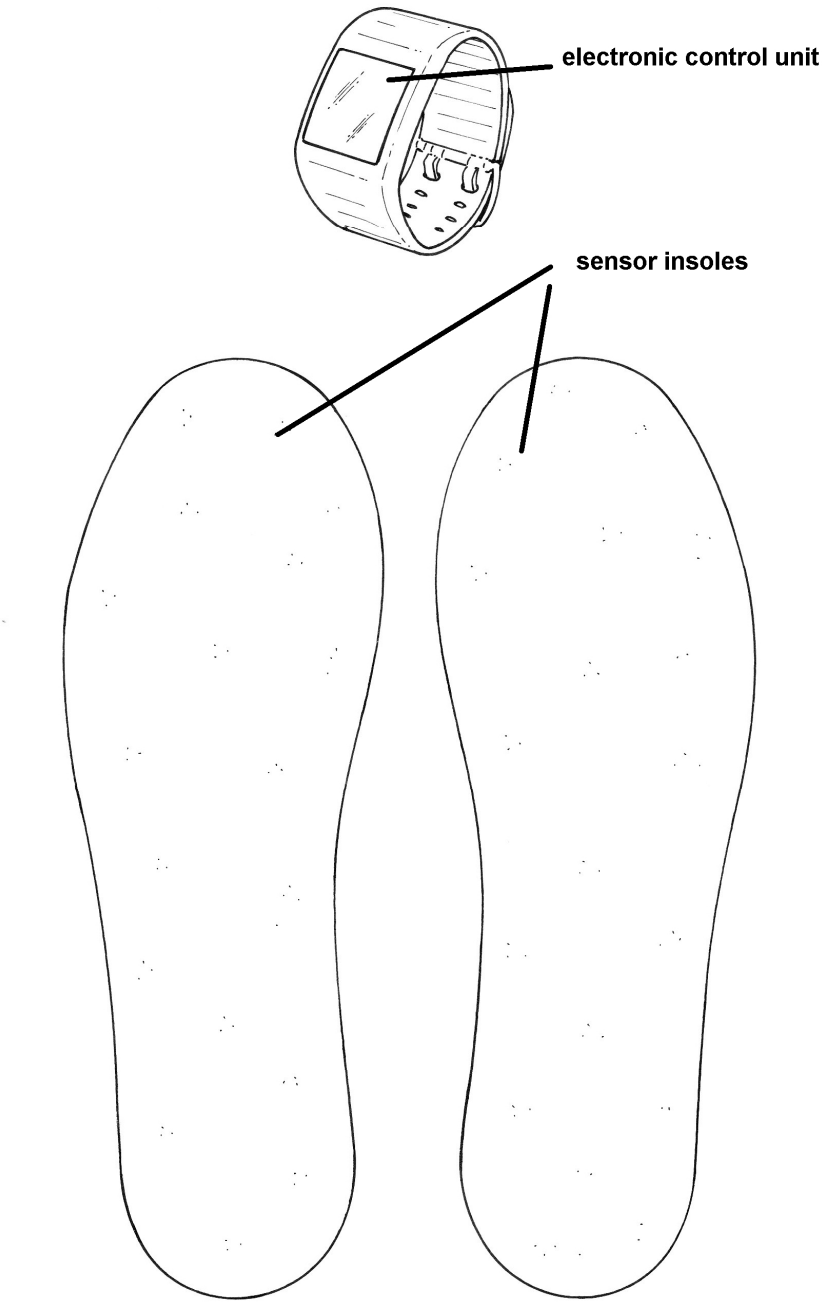
Technology has highly progressed and nowadays we can use new technological resources to develop a new device to control loss of contact of walkers.

To begin with, it has been necessary to establish some basic requirements to be met by the device without any exception, and which are the following:

- Allowing the use of any kind of shoe or sneaker available in the market, thereby giving the walker the chance of freely choosing the more suitable one.
- Adding the minimum possible weight to the sneaker, given that the lightness thereof is an important value which may affect the performance of the athlete in the competition.
- Providing maximum accuracy and precision in its operation.
- Being totally waterproof, either to splashes or immersion, as well as sweat proof.
- Providing the athlete with a clear and simple indication of the number of offences or losses of contact made.

- The use thereof must go as unnoticed as possible to the athlete, causing him the least possible problem or load.

Considering the requirements above-mentioned, it has been developed a control system made up of only a total of 3 elements: a pair of “insoles” provided with sensors and a watch-like control unit.



SENSOR INSOLES

The requirement of being possible to be used in any kind of shoe made it impossible to include any sensors in the sole thereof, as this should be done in the same shoe factory.

By analyzing the problem, it can be noted that the sneaker's sole receives a pressure force against the ground every time the walker treads, but in turn, the inner insole also receives a similar force in this action, going from a very reduced value due to the effect of the compression of the foot inside the shoe to a very high value depending on the body weight of the athlete. Therefore, this already gave us the first key to the design of the device.

An insole can be placed in any kind of shoe as long as it is not too thick. This was the second issue to be solved.

The insole had to be very thin, completely waterproof and sweat proof, and therefore, the fact of including an electronic circuit with its corresponding supply by means of a battery therein seemed to be almost impossible to achieve.

Thus, the insole should serve the purpose of transmitting a pressure or contact signal with the ground in a passive fashion.

The solution is to use a radio-frequency identification system, commonly known as RFID, for performing this task.

These systems are made up of a reading unit (electronic device) and information carrying elements, so-called tags, which can be of different kinds. Although here we are interested in the passive type, as they do not need any supply.

Upon entering a RFID tag in the field generated by the reading unit, it is activated and it is established a communication, in which the information contained therein is transferred to the reading unit.

In the following picture, there is an example of a passive RFID tag:

Therefore, by introducing the reading unit in the control device placed in the walker's wrist, we manage to obtain a data transmission system between the insoles and said device. And that is achieved without the need of any supply in the insoles.

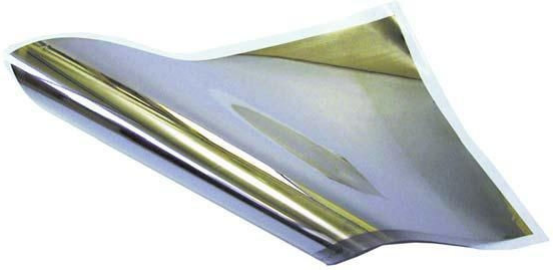
Furthermore, given that each insole carries a different RFID tag, this allows us to identify them as belonging to our athlete, as well as to distinguish them between right and left, in order to be able to analyze later on the transmitted signals thereof, corresponding to the footprint of each foot.

The next step is to provide these insoles having RFID tags with a system detecting pressure or non-pressure of the athlete's foot during his walk.

To this purpose, piezo film sensors have been introduced both in the heel and in the toe of the insoles (key points of the footprint that will enable us to determine the contact of the walker with the ground).

Piezo film sensors can be extremely thin, having a thickness of hundredths of millimeters, and they have at the same time certain flexibility, which make them suitable to be used in this device.

In the following picture, there is a sample of this type of element:



The piezo film sensors are connected to the RFID tags of the insole by embedding a passive circuit of static switch type associated to the same RFID tag. In this way, we are able to activate-deactivate the tag in synchronicity with the signals from the sensors. The static switch circuits do not need any electric supply, since the piezo sensors signals are enough for their operation.

Such static switch design using a passive circuit associated to a piezo sensor is already known and used at an industrial level, although with a very different design.

In the following picture, there is an example of this component for a "Pinball" gambling machine:

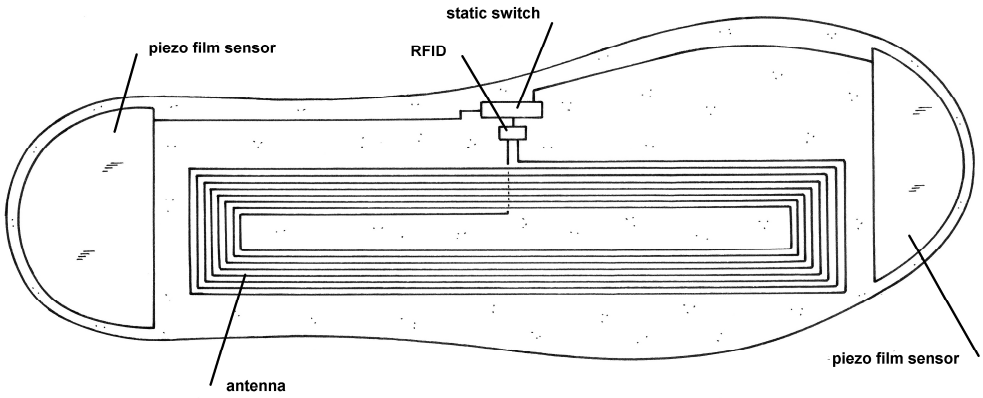
With this design, we obtain an activated or deactivated RFID tag through pulses generated by the piezo sensors upon receiving or not pressure from the athlete's foot.

- Pressure in the sensors = activated tag and signal received and identified as contact by the reading device placed in the wrist.
- No pressure in the sensors = deactivated tag and thus, no signal in the reader and counted as foot in the air.

And all that without the need of any kind of electric supply, as the whole circuit is passive.

In the following drawing, there is a plan view of the insole with all its inner components, which are as follows: two piezo film sensors, a RFID tag provided with a highly dimensioned antenna

(in order to allow a good range to the reading unit), the static switch, as well as the whole general connecting arrangement by means of conductor tracks.



As can be noted, all the components are extremely thin and this makes possible that after the external sealed encapsulation of the insole, of silicone material or the like, the insole would be very thin, with a maximum thickness of 2-3mm.

Therefore, we obtain a component of the system, which is waterproof, sweat proof and passive (no need of supply, and thus the operation thereof can be unlimited), it can be placed in any sneaker (by inserting it underneath the insole belonging to the sneaker), provided with electronic identification, and low cost, given that all its parts are cheap and easy to make. This enables the fast replacement by other new ones in case of damage, and even the availability of a small stock by sizes in the different clubs, federations, etc. intended to be used in competitions and training.

CONTROL UNIT

We are focusing now on the control unit.

It was very important not to introduce any other device in the walker's shoe, due to weight and vulnerability to impacts, splashes, etc, for this reason we have designed the control unit as a watch.

This design offers a number of unquestionable advantages. On the one hand, any athlete usually wears a stopwatch for controlling his time, speed, etc. during the race, and thus, there will be no problem for him to wear this "watch" in his other wrist, as he is familiar to its use.

The little weight that may add does not affect either the performance during the race (as could indeed do it a device in the sneaker).

On the other hand, it gives also the possibility of providing it with a digital display where the athlete could see the information on his offences or losses of contact during the race. This is a critical advantage for the athlete, because it allows him to be aware of when he is infringing the regulations, and thus, he has the chance to correct his walking technique.

Since a walker may be subject to different circumstances in which he may involuntarily lose contact (stumble, etc.), he must have a margin of mistakes or losses of contact during the race.

Here there is an example of the information displayed by the device:

In the upper portion, there are the allowed offences in countdown (the athlete is still allowed to make 9 more offences) and in the lower portion there is the chronometer, which also stores in the memory the exact moment of each offence or loss of contact

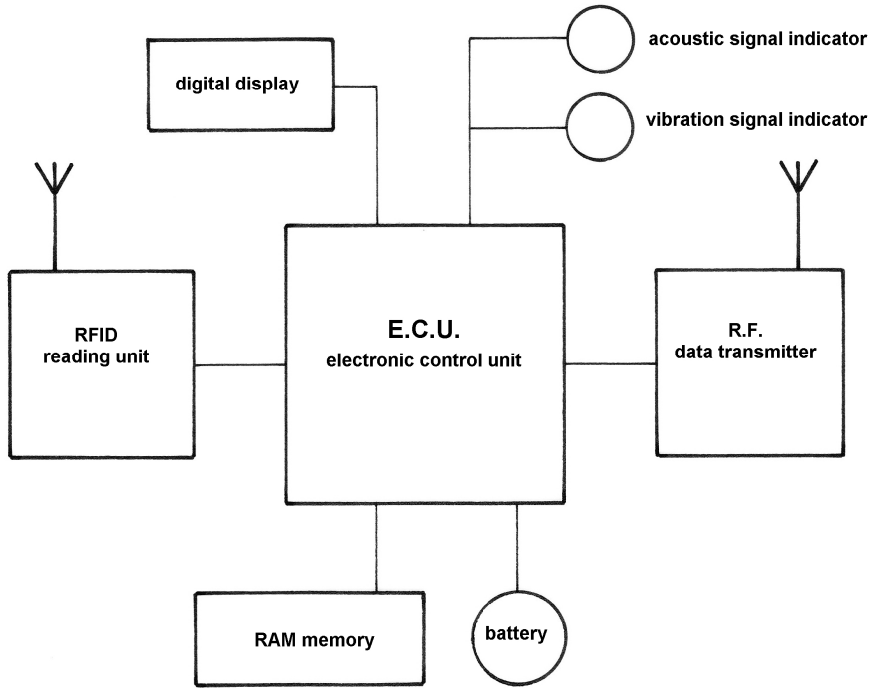
The control unit internally consists of a RFID system reading circuit with the corresponding antenna, plus an electronic circuit (E.C.U.) in charge of analyzing the received signals, identifying and associating them to a predetermined pattern corresponding to a correct walk or to loss of contact. The offences are stored in a RAM memory and they are notified to the walker by an acoustic and vibration signal, and of course, they are shown in the digital display in countdown.

Upon exceeding the 0 value, that is, when the athlete has used all the allowed offences and has made one more, the circuit stores the “disqualified” (DQ) value, informs the athlete about it immediately through an acoustic and vibration signal and shows it to him in the display. Then, the “disqualified” signal will be transmitted by the R.F. transmission unit included in the same device when contacting with the corresponding receiver placed in the finishing line, and the athlete will be officially disqualified and considered out of the race.

Image of the display showing the disqualification:

The device also has a codified function of resetting the accumulated offences, so that the starter can put it to zero before starting the race.

Basic block diagram of the control unit device:



The control unit is a generic one, that is, it is the same for each and all the walkers, as the identification is placed in the sneakers, and not in the control unit, which simply has a self-learning function when it is associated to a pair of insoles. This is extremely interesting for the manufacturing and purchasing cost, because the “expensive” element (control unit) is always reusable, whereas the element that may be replaced and damaged (insoles) is cost-effective.

RESULTS

The result of applying said system to race walking competitions is highly positive from several points of view.

From the point of view of judging the race walking technique, the progress is highly remarkable, as the subjectivity and limitations of the human eye in the follow-up of the compliance of the regulations are completely removed. There is either loss of contact or not.

Anyway, the judging of the not bent rule will still be done by the judges, as this control is not difficult to carry out. The role of the judge is not essentially changed; he is only released from judging the most complicated feature: loss of contact. Thus, competitions would not change their current organization and operation.

From the point of view of the walker, the result is that he has a device informing him on when he is walking well and when he is not, allowing him to adjust his technique as much as possible

in order to take the most advantage of it. His result will no longer depend on whether several judges consider it wrong or not, it will simply be exact and totally objective.

From the point of view of the audience and the followers of this sport, race walking will gain the consistency which is now lacking, given that many people cannot understand how is it possible that an athlete shown in TV loosing contact is not disqualified.

It will neither significantly change the course of current race walking competitions, because as already mentioned above, the figure of the judges will remain the same, and the athlete will neither be affected due to the little interference caused by the device.

Concerning the manufacturing and implementation in competitions, there should be no problem since all the technology thereof is based on products and techniques, which are already known and sufficiently developed.

Technically, the accuracy and reliability of the device can be very high, because its components at the sensor level are extremely tested and proven.

A static switch of piezo type is tested and guaranteed for at least 10 million opening-closing cycles. A walker in a 50-km race walking competition (the longest race) can make approximately 50,000 steps (steps of approx. 1m), that means, about 50,000 cycles for the sensor circuits, therefore, the wear caused thereto is insignificant as far as its estimated minimum life is concerned. Anyways, since it is a cost-effective component, it is possible to wear new insoles in each competition.

This is the part which is more likely to wear out (piezo sensors), since both the RFID tags and the electronic circuit of the control unit are parts with an almost unlimited useful life.

In summary, the design of the device bases its strength and reliability in its simplicity.

DISCUSSION

The use of this system would provide the highest precision in the compliance of race walking rules and would return it to its origin, which has always been walking (in an athletic or vigorous way).

We have already mentioned that, but we could start here a new line of discussion.

In my opinion, the not bent rule was established to make loss of contact more difficult to a certain extent and thereby to go from a walk to a sort of semi-bent down race and of course also to look like a walker and not like a runner.

But, if we now have a device detecting and totally preventing the run (loss of contact), maybe it would be the time to start thinking about removing said rule (not bent).

In this way, race walking would even be closer to natural walk, since nobody usually walks with a straightened leg, which is an artificial way of walking.

We could even compare the two “schools”, the one of classical walkers with a straightened leg and the new or “natural” one with a semi-bent leg. And all that knowing for sure that none of them would infringe the rules even if they run.

It would be very interesting, to be able to ascertain which is the most effective style, which is the most cost-effective one in terms of effort and resistance, and which one would be enforced in competitions.

There is no doubt that a new future in the current race walking would be opened.

It is a very interesting discussion that should be taken into account.

CONCLUSION

In the current state of affairs and with the speeds reached in competition by the best athletes, race walking is in a sort of dead end, trapped in its own origin, which is the simple human walk, the current very high speeds with a constant loss of contact and a regulation that in order to totally avoid possible suspicions is still relying on human eye as a way to control that race walking continues to be a walk and not a run, eventually becoming a kind of odd “almost circus” moving technique to make invisible which is, in fact, visible (with a simple camera).

The current walker is no longer concerned about losing contact with the ground or not, but rather about to what extent he can “fly” without being caught, without being visible to human eye.

The walk then loses its original essence and becomes a sort of strange race, which nobody knows what it really is.

RECOMMENDATIONS

I fear that race walking has reached the same point as fencing did in the past, in which it was either implemented an electronic control system of “touched” by the participants or the controversy and injustice in competitions was always present.

The speed of the action went simply beyond the human eye, and something had to be done, and it was done in the right way, as it is still there, giving accuracy and objectivity to each result of each completed competition.

In race walking, we have reached exactly the same point.

The electronic system for loss of contact control must eventually be used, since only that could offer current race walking a new life, a new future, free of the limits and inaccuracy of human eye.

In this project, I have tried to develop the best way, the best design that I could think of in order to solve the problem, based on my experience and self-taught knowledge in different fields of technology as a consequence of my wide experience as a patent illustrator and also based on my own experience as a walker after more than 30 years making kilometers and practicing this athletic activity which I especially love.

However, this is only one way of carrying it out; we should then keep on going.

Innovating and keeping the essence, the origin.

This is the way.