MYP Personal Project: creating a recharger for my phone using the power of my walk

Planning

Learning Goal: Understand how can I charge my phone by walking using the new technology of piezoelectrics

It took me some time to find what I was going to do as my Personal Project. I have various hobbies like drawing, sports, physics and I really like doing Arduino's projects and learning about robotics, but I wanted to create something sustainable and something that I could reuse and find useful also in the future not only in terms of the actual product, but also as the knowledge I would acquire. With these guidelines in mind, I started looking around and brainstorming, searching for an issue in my everyday life that I could solve with my Personal Project. There I found that the battery of my phone was always dead, and this would become a problem when I was in a place where I couldn't recharge it, as at school. I immediately thought about a sustainable way to generate electricity and charge my phone, and after some research I found a shoe that used the power of the walk to charge a phone. That would also connect both my wish to do something green, and the fact that, following these principles, I rarely take the bus or the car, and go everywhere on foot hence I walk a lot. To construct the charger I obviously would have had to learn about circuits and to use specific electronic tools, maybe using Arduino, my passion. I immediately knew that was going to be my Personal Project. The learning goal would be to understand how to charge my phone using the power of my walk. The global context would be scientific and technical innovation because I think it's the one that best suits my idea, because of the importance of technology in the project.

ME	
My interests and hobbies	**My skills**
• Volleyball • Sports in general • Drawing • Robotics	• I can play volleyball • I can run pretty fast • I already know how to do a simple arduino circuit
My project ideas	**My academic preferences**
• Do a sustainable charger for my phone (solar panels) • Do a robotic hand • Understand the physic behind the jump float serve	• Maths • Art • Design • Science (especially physic)
My academic shortcomings	**What I don't want**
• English vocabulary • Speaking skills in german and english • Organisation skills	• Learn a new language • Learn a new sport
Taking these findings into account, what learning goals (what I want to learn) could I develop?	
• Understand how I can charge my phone by solar panels • How volleyball players use physics in the jump float serve • Understand the science and the work behind a robotic hand	

(table about my interests and initial ideas for my personal project)

The product

I will design and build a circuit inside a shoe, using the technology of piezoelectrics. That will charge a power bank, therefore if I don't need to charge my phone that day, I could still store it for emergencies.

Success Criteria

To decide my success criteria for my product I thought about the must-have features of the project. I really thought about the important details that would allow me to make this Personal Project a useful tool for the future. For the evaluation of the achievement I tried to be the most objective possible by using experimental measurements and by being specific. In order to do that, I did a little bit of research, looking at how other people made similar projects and comparing them to what my project would be. Because I wanted to acquire scientific knowledge from this project, I set up a criterion made especially for this aspect, looking at the science Criterion A, of the MYP4-5 program, and personalising it to fit my product.

Knowledge:	I will be able to explain scientific knowledge (draw and understand scientific language), apply scientific knowledge (create a circuit with piezo+diode+capacitor+voltmeter) and understanding to solve problems set in familiar and unfamiliar situations (creating the final product) and analyse and evaluate information to make scientifically supported judgments(analyse oscilloscope data and adjust the circuit). (Criterion A physics). I will self-evaluate my achievement of this criterion, by being able to draw a suitable circuit, to understand the scientific language used in the tools' tutorial/articles used in the research, to create a working circuit with piezo+diode+capacitors+oscilloscope, to create the final product, to analyse the oscilloscope data and to adjust the circuit accordingly.
Function:	The product will charge my phone 10% after a walk from home to school and back (around 6km).
Cost:	It will cost me maximum 30/40€
Design:	The charging circuit and the power bank will all be inside the shoe.
Resistance:	I am able to walk, jump and run properly without the circuit to break

Plan

For creating my product I made a plan with all the deadlines. My planning was pretty general, especially in the “make the circuit” part being a very important milestone of the project where I would make adjustments to the product while doing it, so I couldn’t have known the deadlines in advance. To organise myself during this period of time (when working on the electronics of the project), I decided on a day, Saturday, of the week where I had to work on the project for at least one hour and a half and then add work hours if needed. Apart from this, everything was planned monthly-weekly in order to keep myself on track.

Expected date	Task	New date if needed	Project tracking comments
30/06/2021 (criterion 1, knowledge)	Do the research about the product: -Do a list about the basic materials I will need -Understand if the work done until that moment was right		I didn’t find any difficulties while doing this step. I found that there were different options to do my circuit so I did further research and decided the one that suited my project best.
30/07/2021 (criterion 1, knowledge)	Do the research about the circuit -Understand how to integrate the piezos in a circuit - Understand how to do a circuit		I didn’t find any major inconvenience while doing this process. I already knew the basics of a circuit but only with Arduino so this prior knowledge really helped me with new electronic devices such as the piezoelectric and their usage.
15/08/2021 (criteria 1-3, knowledge and cost)	Make a simple circuit with the piezoelectrics I bought		I did a very simple circuit connected to the voltmeter to understand the voltage of one piezo versus two of them. I ordered the piezos on amazon and they arrived on time.

10/09/2021 (criterion 1, knowledge)	Understand how to use the oscilloscope	30/09/2021	Trying to use the oscilloscope is actually quite difficult and I had various problems at first because it can't be used everywhere (if there are background sounds it doesn't work as expected) and I didn't know this. Therefore I had to postpone my deadline and give myself twenty more days.
15/11/2021 (criteria 1-2, knowledge and function)	Make the circuit and put it inside the shoe 1.redo the simple circuit with only piezo 2. piezo+diode 3.piezo+capacitor 4.battery+capacitor+diode 5. Piezo+capacitor+diode recharging a battery 6. Piezo+capacitor+diode recharging a power bank 7. Put number 5 on a sample shoe	15/12/2021	I had problems with the capacitor and I had to do various trials. When I adjusted this part I had a problem with the wire going to the power bank. This postponed my deadline and give myself one additional month
30/11/2021 (criteria 4-5, resistance and design)	Do the sketch of the shoe		Because I still didn't know if I would recharge a power bank or a battery, I did the sketches for both of the possibilities. I didn't find any big problem with this step
15/12/2021 (criteria 4-5, resistance and design)	Making the actual product	20/12/2021	Because in the end I charged only the battery, my final product was pretty easy to do, this because a battery is significantly smaller than a powerbank and allows me to put it in a normal shoe, something I couldn't

			with the powerbank. I used a sample shoe. The new deadline, didn't affect the all timeline as the school asked me to submit the final product on the 30/12/2021

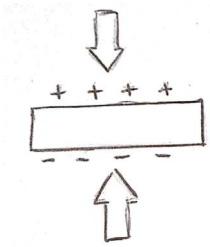
Applying skills

ATL skills for the learning goal: Research

To achieve the learning goal of understanding how to create the circuit that would feed my phone using the power of my walk I had to acquire new knowledge. I took information from different sources. I searched for online sites, I used my physics book, and I interviewed the physics lab teacher of my school, being an expert in the field of circuits:

Summary of the knowledge acquired after the research:
This is a small description about the information I gathered and the things I understood after doing the research.

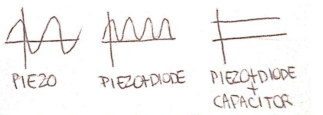
Here is a brief summary of what I understood during my research process. I am also adding the capacitor, even though at the end I didn't use it because it was part of my research.



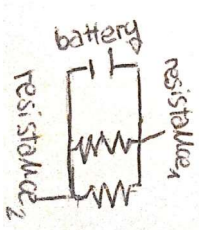
(representation of what happens when a force acts on a piezo)

A piezo is a crystal normally on a disc of metal. When you apply pressure or stress on this disc the electric charges get out of balance. This creates an excess of positive or negative charges on the sides of the disc.The excess of charges on the sides of the piezo creates a potential difference. This current is alternated, while to charge the power bank I need a direct current. So the next passages are created to transform the alternating current in a direct one.

After the piezo the electrons go through the diode bridge. This is used to make all the current and voltage positive or negative. Finally there is the capacitor which is used to pave the current and voltage. Infact at this time of the process, before the capacitor, the graphic representation of the voltage-current are peaks that indicate every time you press the piezo, they are all positive thanks to the diodes but it's still an alternate current. All the elements in the circuit will be connected in series but the piezo that are connected with each other in parallel. In a circuit connected in series the current that flows through each of the components is the same, while to get the voltage you need to sum all the individual voltages in the circuit. In a parallel circuit the voltage is the same everywhere. I tried both ways and found that the parallel one was more beneficial because the voltage was higher and if one of the piezo brakes, the circuit will continue to work.



(what you see on the oscilloscope during the construction of the circuit)



(a circuit in parallel)

(a circuit in series)

For the project I will analyse the data using an oscilloscope. This tool gives you the graphic representation of the voltage-current produced by the circuit. This really helps me because I can see the maximum voltage obtained and understand by what the oscilloscope detects, where the possible problem is, whether it's the piezos, the diodes or the capacitor.
I made all the drawings in this section.

CARDS Sources Analysis:
To analyse the sources and see if they were reliable I used the technique CARDS, an acronym which consists of: credibility, accuracy, reliability, date and source. Much of this information could be found at the top or bottom of a document or under the description if it was a video.

	Source: Mehrotra, Utkarsh. "Walking Charger Using Piezo-Electric Material." *International Journal For Technological Research In Engineering*, Sept. 2016, https://www.researchgate.net/profile/Utkarsh-Mehrotra/publication/308719637_WALKING_CHARGER_USING_PIEZO-ELECTRIC_MATERIAL/links/57ecb23e08ae92a5dbd079c9/WALKING-CHARGER-USING-PIEZO-ELECTRIC-MATERIAL.pdf.
Credibility	The author, Mehrotra Utkarsh is Pursuing his Ph.D. at the Packaging Research in Electronic Energy Systems (PREES). He published 10+ conference publications, 4 IEEE journal publications, multiple non-referenced publications, and 2 US patents; also contributed and provided presentations and tutorials at several conferences including APEC, WiPDA, IMAPs conferences.
Accuracy	This was obviously part of my research and I didn't find any inaccuracy between this journal and the other sources I used. There weren't any grammatical mistakes and it used the terminology I have seen used before in other journals and that I learned during my Personal Project
Reliability	At the end of the document there is the bibliography with all the sites cited. The site where it is uploaded is a famous scientific paper. It publishes about Technological Research in Engineering (the site is called IJTRE) and it invites research students to upload their paper.
Date	This article was published in September in 2016, which is not so recent. This research, however, is not based on a "specific year data", and can be performed whenever needed and the results will be the same. The only thing affected by the date are possible improvements to this technology, still piezo is quite a recent technology and there hasn't been any new improvements. Furthermore, I searched for more recent papers and they all confirmed what is written in this paper.
Source	All the sources he used were cited at the end of the article and all the data reported were really taken by them and not taken by another source as the final conclusion.

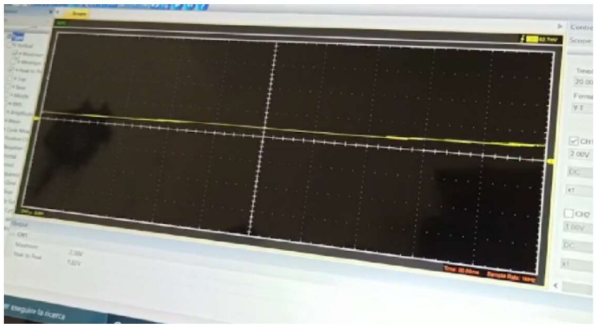
Interview:
Before the interview, in order to not forget anything or get panicked, I prepared a set of questions and check-points I had to ask my teacher.

Define the purpose of the meeting
Understand the problems in my circuit and understand how to build/build a better one
Prepare questions and things to check
1. Show him the circuit I did this summer to check if it was correct 2. Do I need to insert a resistor in the circuit to improve the coupling with the capacitor? 3. Redo the experiment to show him as values read on the oscilloscope do not match with what expected - Try firstly only with piezo - Then with piezo and diode - Finally piezo, diodes and capacitor to understand why the circuit didn't work 4. Why does the oscilloscope show a signal even when I don't do any pression (show him videos taken previously)? 5. Is it better to put piezo in parallel or in series (and why)?
Answers
1. checked 2. The resistance in the circuit is made by wires and the capacitor so it's not really needed 3. After trying the three steps, he confirmed the circuit was ok and then the problem was on the reading of the voltage. 4. With him we put my circuit in two different classes, one with a background noise and one more silent. We saw that the one in the silent classroom worked better. That's probably because piezos detect noises, I will try to use it away from all machines (for example the washing machine) and on a stable surface. 5. Parallel (and in the summer I did in series) because like this, the voltage is higher with the same amount of piezo, and to recharge a power bank I need to arrive at around 5V, which with piezo is a lot.

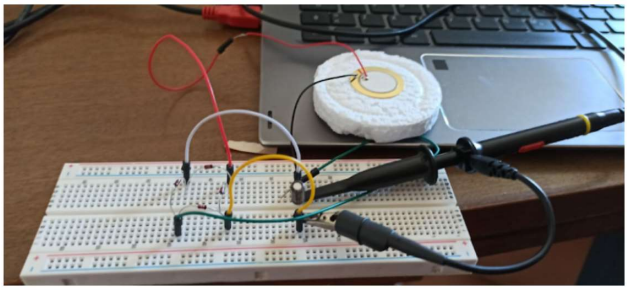
My research was very useful as it helped me understand how my circuit was going to be and it helped me understand the physics behind this project. I used mainly videos so I could see the movements that the person did to construct the circuit, and visually what the circuit would look like. I used the physics textbook to refresh the knowledge about circuits and to understand better why I needed certain tools. Some of the sources I gathered weren't reliable, but because maybe I needed that information, I tried to search for other sites that stated the same thing but were trustworthy. To understand if the sources were reliable I used the method CARDS as in the example above. This method really helped me because I didn't know most of the sites I gathered information from, hence I didn't know whether they were reliable or not. Doing the research on the internet assisted me achieve my learning goal because it made me acquire new knowledge in the field related to the learning goal.
I used the interview later during the process, while I was doing tests, improving the circuit. This interview really helped me because it cleared some knowledge doubts that were brought up during the practical part. For example I couldn't understand why the oscilloscope

wasn't working as expected and, even though I did some research to solve this problem, I couldn't find a solution. This interview helped me achieve my learning goal because it solved some conceptual problems both on the tools I was using and on the circuit.
All in all I think without the research part I wouldn't have achieved my learning goal as to actually learn about circuits and the physics behind the one I was going to do. The table I prepared before the interview was essential, as it helped me not to forget any question. Moreover, before the actual meeting, I sent the expert the questions in order to give him time to answer them properly and to dedicate the necessary timeslot to the meeting with me.
I think that I will use this ATL technique also in the future meetings.

ATL skills for the product goal: Self management
When reflecting about which ATL skill would best represent the process of making my product, I immediately thought of Self management Skills, especially the strand of perseverance. This is because the construction of my product has been the most difficult part of the project as I encountered many obstacles. A big problem was that the oscilloscope is a very difficult tool to use, quite often it would give us absurd results that contributed to the confusion. To solve this problem I decided to use a voltmeter to understand which of the results the oscilloscope was right and which weren't and retry and retake the data every time they would result wrong. This really helped me get on with the project and clarify my ideas. Even Though this big problem was solved, the project wasn't complete. I persisted to try and charge my power bank, and not only my battery, because I was determined to finish the product. This determination helped me create and finish the circuit for at least the battery, and made me continue trying till the end of the project. The problem with the power bank is that to charge it you need 5 Volts. Piezos are very little and they don't produce a lot of Volts, also because the maximum number of piezos that could fit my shoe was 6. I tried different combinations with the elements in the circuit, but in the end I decided to take away the capacitor, because to "spread" the voltage-current it took a lot of voltage away. I was finally able to feed the power bank but the problem was that the electricity arrived only when the piezos were pressed, and for a very short period of time. I continued trying for all the time I had available, but unfortunately I couldn't get the results I wanted. My alternative creative solution was replacing the power bank with the battery also in the final product. The pictures show my circuit and the oscilloscope and the steps I took to finish it.



(the data I recorded on the oscilloscope with a circuit with two piezo, diodes and condensator)



(a circuit with two piezos, diodes and capacitor)

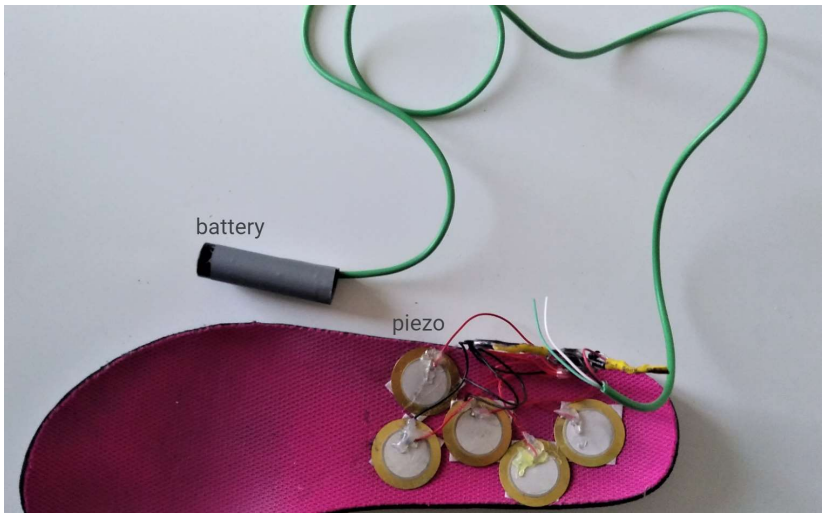
Reflecting

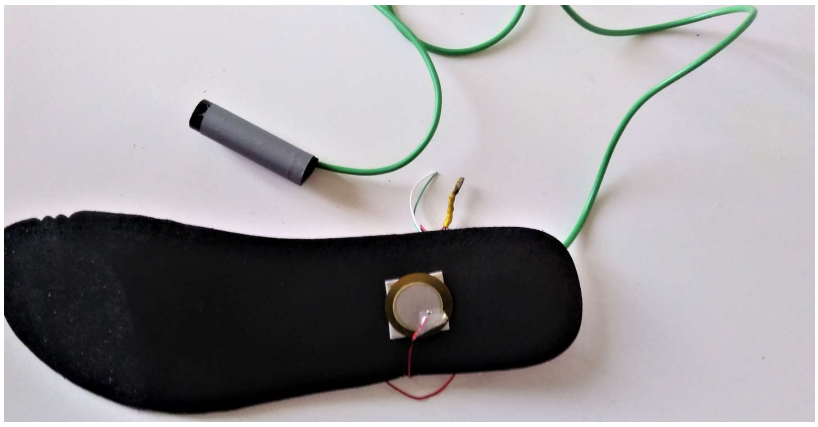
Impact on myself and on my learning

At the beginning of the project I thought that my biggest problem would be understanding the scientific knowledge, so the research behind this project, and I was afraid it would have been too difficult. However, as I went on, I realised that even though the theoretical part is very difficult and challenging, and most of the time I have to do additional research to understand certain terms or concepts, the biggest problem I encountered was during the process. There were hundreds of problems in the circuit, problems for which there wasn't a straight answer on the internet. With all the deadlines right there around the corner, I already knew I wasn't going to make it with the initial project, but I was determined to carry on and to try till there was no time left. Before this project I would have probably given up way earlier, probably when I started charging the battery, but thanks to the plan and to the fact that I really enjoyed solving the problems and constructing this circuit, and so using my thinking skills, I now know what perseverance means.

At the end of the project I think I reached the learning goal and the product: I wanted to "create something sustainable and something that I could reuse and find useful also in the future not only in terms of the actual product, but also as the knowledge I would acquire"(page 1). Evidently I reached the sustainability aim, and, although I couldn't accomplish my original idea and charging a battery is less useful than feeding a phone, I can for sure reuse the knowledge I acquired during my Personal Project. For example we are doing a unit in physics that talks about circuits. I feel like I am benefitted especially in the practical part, and these benefits will continue to show as I go on with learning about electronics. Learning how to use the oscilloscope, even though it took me a lot of time, helped me analyse the data in a more efficient way, and understand specific concepts that with a normal voltmeter would be not measurable. Overall, thanks to my Personal Project I now have, not only the practical and theoretical knowledge I acquired during the research and the construction of the circuit, but I also know that if next year in similar projects like extended essays, I find myself stuck, there probably is a way to solve the problems, like I did with my Personal Project.

Product:





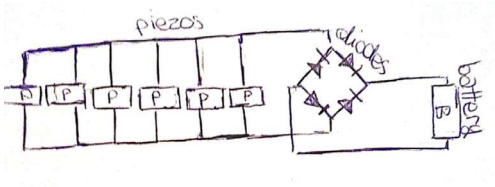
(The sixth piezo under the insole) first image n.1, the one under it image n.2

(How it looks when someone wears it)
On the left image n. 3 on top image n. 4

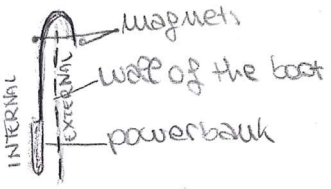
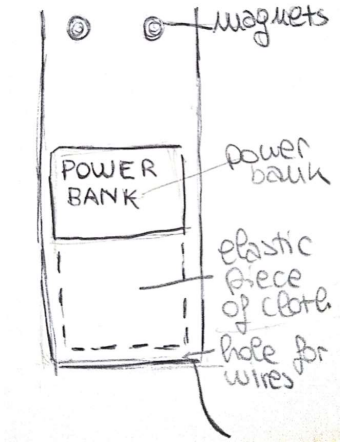
My final product was a normal shoe, with inside the circuit that uses the power of your walk to charge a battery. I put the battery inside a “pocket” made out of fabric that somehow every shoe has. I hot-glued the piezo with the wires so, even if your foot moves nothing breaks, and I used a super strong skotch to secure the AA rechargeable battery to the wire. While designing and researching for the shoe, I had the criteria by my side, so I wouldn’t forget anything and would get the best results from my project.

IB learner profile:
At the end of the project I think the IB learner profile adjectives that I used and developed the most are: inquirer, for all the questions I asked myself and tried to answer both during the research part and during the actual making of the project, and Knowledgeable for all the knowledge I collected and then used during the project, this adjective is also reflected in my first criteria. I think I could have used the adjective Communicator, ask more questions to my teacher and maybe write to the authors of the journals I took inspiration from and ask for clarification.

Product evaluation:

Knowledge: Explain scientific knowledge (draw and understand scientific language), apply scientific knowledge (create a circuit with piezo+diode+capacitor+voltmeter) and understanding to solve problems set in familiar and unfamiliar situations (creating the final product) and analyse and evaluate information to make scientifically supported judgments(analyse oscilloscope data and adjust the circuit). (criterion A physics)	7/8	I understood every knowledge and term required for my project, and applied when I was creating my circuit, in fact every time I was creating a circuit I would first draw it to understand what I was going to do. To create the final product I had to evaluate everything to understand where the problems were, looking at my drawings, looking at my research and searching a little more if needed.  (a drawing I made of my final circuit)
Function: The product will charge my phone 10% after a walk from home to school and back. (around 6km)	1/2	I had to change the product of my personal project because after trying for a very long time different combinations for my circuit, and trying to understand how the oscilloscope worked, I understood I couldn’t charge my power bank so I turned on a battery. After the walk I had already planned, I charged my battery up to 22.4%.
Cost:	7/8	The materials I had to buy at the beginning of the project were: 1. A pair of shoes

It will cost me maximum 70-80€		2. Around 20* piezo for trials and for the final product 3. An oscilloscope 4. Powerbank 5. Diodes 6. Capacitor 7. Arduino board But in the end: 1. **0€-**Because the battery could fit in a smaller space I used a normal pair of shoes that I had at home (I did a design of the shoe with the powerbank where I used normal boots, magnets and a piece of stretchy material which costed me around 15€) 2. **11.29€-** on amazon 3. **0€-** I asked the school to lend me an oscilloscope. 4. **0€-** I had one at home 5. **0€-** my cousin lend me some diodes she had at home 6. **0€-** the school lend me theirs 7. **8.99€-** this is the price of the arduino's motherboard I already had at home **Total: 20.28€**
Design: The charger and the power bank will all be inside the shoe.	7/8	Everything of my project can be put in my shoe as it can be seen in this photos: Images N. 3-4 This is the design of the shoe to fit a power bank:  (External side view)

		 (internal side view)  (internal frontal view)
I am able to walk, jump and run properly without the circuit to break	7/8	I did a few tests and the result is that I can run, jump and walk without the break of something in my circuit
General evaluation: I think that even though I couldn't do my initial idea I did a pretty good product respecting all of my criteria but one. I think I could have finished my product if I had done more specific research and not taken all the information possible. In Fact I think I collected too many ways to do this project, that differentiated one from the other, so when I started the project I took inspiration and information from everyone of them, this created an unrefined idea in my mind.I met my goal but not as I wanted.		

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