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THE MONITORING SYSTEM FOR WATER QUALITY IS BASED ON THE INTERNET OF THINGS (IOT) AND USES A TDS SENSOR

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ABSTRACT

This research focuses on designing an Internet of Things (IoT)-based water quality monitoring system for aquaculture ponds, utilizing Total Dissolved Solids (TDS) sensors and the ESP32 microcontroller. The system is developed to monitor water quality in real-time by measuring the concentration of dissolved solids in the pond water. Data from the TDS sensor is collected by the ESP32 microcontroller, which is connected to a WiFi network and subsequently transmitted to the cloud, where it is displayed on a website. The study shows that the system can categorize water quality into three statuses: safe, alert, and poor. These categories are based on predefined TDS threshold values. Daily collected data is processed to provide accurate information on water quality status. This system enables continuous monitoring, facilitating pond management. Users can easily access data through a web page that presents information in an easily understandable format. The research demonstrates the effectiveness of using the ESP32 microcontroller and TDS sensors in an IoT-based monitoring application, as well as the system's capability to provide clear and timely indications of water quality status.

Keywords**—** *ESP32 Microcontroller; Total Dissolved Solids (TDS); Water Quality Sensor*

I. INTRODUCTION

Indonesia, as a maritime nation, relies heavily on the fisheries sector, which plays a crucial role in its economy. Despite global economic challenges, this sector remains stable and continues to grow. Indonesia's research and development in fisheries is diverse, encompassing various observation methods and cultivation forms. The country has three types of water environments: saltwater, freshwater, and brackish water. Among these, brackish water ponds (fish pond) are particularly promising due to their controllable production processes and ease of maintenance. Despite Greek fish having a larger market presence, the production of Lamongan pisces surpasses that of Greek varieties(Sundari et al., 2019).

In fish farming, water quality is crucial since the entire life cycle of aquatic species depends on it. Key parameters include clear water, temperature (25-32°C), water exchange, depth, and turbidity. These factors reflect the physical, chemical, and biological conditions of the water, which must be well-managed to support fish growth. Rainfall, leftover feed, and fish waste can alter water conditions, potentially leading to acidic environments that promote fungal and bacterial growth (Aprillya &Chasanah, 2022).

Currently, pond water quality monitoring is often done conventionally and periodically, which poses challenges such as high costs and significant time investment. Remote monitoring methods can enhance efficiency and reduce costs by using specialized tools. In Indonesia, various IoT-based monitoring systems have been developed. IoT, or the Internet of Things, refers to the concept where objects can transmit data over a network without requiring direct human-to-human or human-to-computer interaction.

Fish farming is a popular activity among fish farmers in Pengangsalan Village, Kalitengah District, Lamongan Regency, due to its high profit potential. However, bandeng (milkfish) farmers in Pengangsalan often face harvest failures due to environmental factors like water temperature and turbidity caused by dirty ponds. Bandeng require clean environments and clear water to thrive; polluted or dirty water can stress the fish and lead to serious health issues.

II. METHOD

Modern technology has made it necessary to prioritize many functions and ease of use in carrying out daily tasks. As a result, many people have developed various types of automated technology that are intended to facilitate work tasks and reduce the need for extensive time commitment (Eko Handoyo et al., 2014).

The development of information technology in the Industry 4.0 era is quite rapid. The majority of monitoring work has been aided by technology to make maintenance tasks easier. The first one is the use of the Internet of Things (IoT). This IoT system can be used by farmers to maintain the state of their fields so that their productivity can increase (Dharmawan &Gata, 2019).

The parameters that are used to maintain the pH and temperature conditions in the fish pond. This kind of maintenance is carried out in real time so that data and condition from the tank may be accessed. If at any point in time it is discovered that there is an anomaly, the fish farmer can quickly develop a plan to address the problem. The quality of air has a significant impact on daily life and the growth of fish in religious rituals (Norhikmah et al., 2015).

Monitoring systems involve a continuous process that is integral to management, encompassing systematic assessment of work progress. The main stages include data collection, data analysis, and presentation of monitoring results. Conventional monitoring methods have drawbacks, such as lower data accuracy, lengthy monitoring times, and the need for intensive data collection activities (Ardiansyah &Bianto, 2022).

The NodeMCU ESP32, often referred to as NodeMCU32, is a microcontroller developed by Espressif Systems and is the successor to the ESP8266. It features an integrated WiFi module, making it ideal for Internet of Things (IoT) applications. Compared to other microcontrollers, the ESP32 offers more pins, additional analog inputs, larger memory, and includes Bluetooth 4.0 Low Energy, alongside WiFi capabilities. These features make the ESP32 well-suited for IoT implementations (Imran & Rasul, 2020). Total Dissolved Solid (TDS) sensor is a tool used to measure the amount of water vapor in the air

(Nuvreilla, 2020). This item can be illustrated in Figure 1.

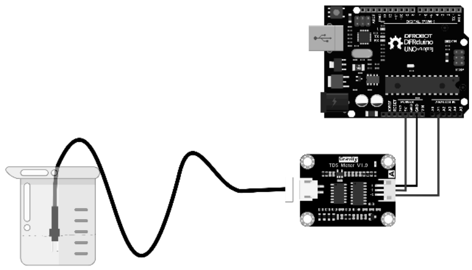

Figure 1. Benefits of TDS Sensor and TDS Skema

TDS (Total Dissolved Solids) sensor measures the total concentration of dissolved solids in a liquid, such as water. These solids can include inorganic salts, organic matter, and other substances that dissolve in water. The sensor typically consists of two electrodes placed in the water; the amount of electrical current that passes between the electrodes is used to estimate the TDS level, usually expressed in parts per million (ppm) or milligrams per liter (mg/L). High TDS levels can indicate poor water quality, which is important for monitoring in various applications, including drinking water treatment, aquaculture, and environmental monitoring.

	Actor	specifies the set of roles that users play when interacting with a use case.
·······>	*Include*	specifies that the source use case is explicitly
——	*Associantion*	what connects one object to another object
	System	specifies a package that displays the system in a limited way
	Use Case	A description of the sequence of actions performed by the system that produces a measurable outcome for an actor.

Figure 2. Use Case for A Symbol Diagram

A TDS (Total Dissolved Solids) sensor measures the concentration of dissolved solids in a liquid, such as water, by assessing its electrical conductivity. It uses two electrodes to determine the amount of electrical current passing between them, which correlates to the TDS level in parts per million (ppm) or milligrams per liter (mg/L). High TDS levels can signal poor water quality, making this sensor crucial for applications like drinking water treatment, aquaculture, and environmental monitoring (Karman, 2017).

The rule-based method uses rules as knowledge representation in system design. It is effective in simple domains because these rules are easy to verify and validate. However, in more complex domains, rule-based systems can struggle if they cannot recognize applicable rules, potentially resulting in no outcomes. Rules consist of conditions (IF) and actions (THEN). The system checks all rules to determine the conflict set and, if conditions are met, performs the corresponding actions. This process continues until a condition is satisfied or no applicable rules are found, at which point the system terminates the loop. While rule-based systems are simple and adaptable to many problems, they become complex to maintain with a large number of rules and are prone to failures. Additionally, rule-based systems cannot create or modify rules autonomously, as they are not designed for learning (Shodiq &Saputra, 2022).

Implementation refers to the process or technique used to set up or carry out a system, process, or idea. This is an action that has been properly planned and carried out with the intended goal in mind. Implementing specific steps that are taken to start a project or make a resolution becomes a statement. In the context of system or project development, implementation ensures that every component or feature that has been identified is used and functions in accordance with expectations.

The research materials that are used use air that has been placed under an ikan. As the primary material for this study. The method used in the implementation of the TDS meter air quality based on the Internet of Things (IoT) to identify:

1. Laptop with specifications including an Intel® CoreTM i5-8250U CPU running at 1.60GHz (8 CPUs), about 1.8GHz, 8 GB DDR4 RAM, and Windows 11 Home 64-bit OS.

2. TDS Sensor Meter
3. Microcontrollers: Microcontrollers such as Arduino or ESP-32 can be used as a system controller.
4. IoT Module: Wi-Fi modules such as ESP-32 can be utilized to connect a platform's system to an IoT platform.

The software used is:

1. HTML and PHP for programming languages.
2. The Arduino IDE as a code editor.
3. The web browser that Google Chrome uses.
4. Xampp as an online server.
5. Visual Studio Code as a place to edit code for the research process.

Figure 3. Php

In Figure 3 is Php software symbol. PHP (Hypertext Preprocessor) is a server-side scripting language used to process and manage data in web contexts. It handles data sent from clients, processes it, and stores it in a database. When users revisit a web page, PHP retrieves and displays the data from the database. Running PHP code involves uploading files to the server, which allows developers to update or add functionality to web applications, enhancing dynamic interaction between users and servers (Mubarak, 2019).

Figure 4. My SQL

Figure 4. is MySQL software symbol. SQL (Structured Query Language) is a fundamental scripting language for database management, used by major database software like MySQL, PostgreSQL, and SQL Server. While implementations may vary slightly, the core principles of SQL remain consistent. For instance, MySQL uses SQL to manage database access and offers both an open-source version (licensed under FOSS License Exception) and a commercial version. MySQL is a widely used open-source database, compatible with various platforms such as Windows and Linux. Tools like phpMyAdmin and MySQL Workbench provide intuitive graphical interfaces for managing MySQL. Overall, SQL is essential for efficient data organization, storage, and retrieval across different database environments (Mukhaiyar &Ramadhan, 2020).

Figure 5. XAMPP

Figure 5 is XAMPP software symbol. XAMPP is an application that easily turns a computer into a local server, allowing users to create and manage websites offline. It's useful for web development and testing without needing an internet connection or complex server infrastructure. XAMPP provides a complete web development environment in a single package, including Apache for web serving, PHP for scripting, and MySQL for databases. All components are pre-configured to work together, simplifying the development process. XAMPP is easy to install and use across various platforms, making it a popular choice for web developers to start and test local web projects before deploying them to a public server (Josi, 2017).

Figure 6. HTML

Figure 6 is HTML software symbol. The language used to display web pages is called HTML. Generally, it has extensions ending in.htm,.html, or.shml. HTML is a tag-based language that is used to describe the contents of an HTML document. This is displayed by the browser. HTML tags are not case-sensitive. Thus, you can use or both produce identical results (Rokhmawati &Sardjito, 2020).

A use case or use case diagram models the behaviour of an information system by describing interactions between one or more actors and the system. It provides a high-level view of the system's functions and identifies who is authorized to use those functions. The naming of use cases should be as simple and understandable as possible. The two main components of a use case are defining what constitutes an actor and what constitutes a use case (Karman, 2017).

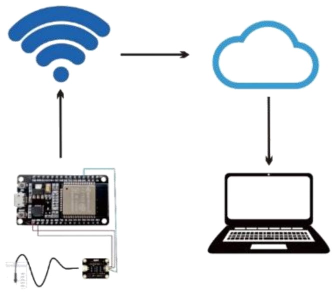

Figure 7. TDS Sensor Circuit

Figure 7 is the TDS Sensor System. To further explain, here is a complete description of the system:

1. TDS Sensor: Measures dissolved solids in water and provides data in ppm or mg/L.
2. Microcontroller (ESP32): Connects to the TDS sensor and processes the data. It also has built-in WiFi for network connectivity.
3. WiFi Connectivity: The ESP32 transmits the TDS data to the cloud via a wireless network.
4. Cloud Storage: Stores the data securely and allows for remote access and analysis.
5. Web Interface: Displays the TDS data on a web dashboard, enabling users to view real-time and historical information.

This setup allows for efficient and remote monitoring of water quality.

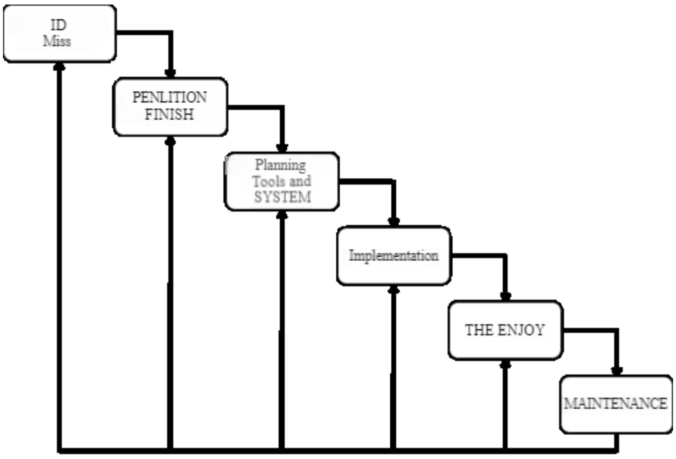

Figure 8. Method of Research

From Figure 8, the research method can be described as follows:

1. Problem Identification:
   Define the specific issue or challenge to address.
2. Literature Review:
   Research existing solutions and technologies relevant to the problem.
3. Design:
   Create detailed plans and prototypes for the tool or system.
4. Implementation:
   Build and deploy the designed system.
5. Testing:
   Evaluate the system's performance and functionality.
6. Maintenance:
   Provide ongoing support and updates to ensure continued effectiveness.

The results of observation and literature research are very important in the maintenance of equipment and the air quality monitoring system that uses an ESP32 module and a TDS sensor. The following are some examples of includes services:

1. Circuit Schematic
   Create a diagram that illustrates how the TDS sensor is connected to the ESP32 module and other components.
2. The Blok Diagram
   Create a block diagram that shows the key components of the device and system, as well as the connections between the components.
3. Flowchart System

Create a flowchart that explains the various data entry and processing steps carried out by the system, starting from reading the air pressure and temperature and ending with data entry.

This system's testing is done with the intention that perangkat and the air quality monitoring system will use TDS sensors, which are based on the internet of things and can function reliably based on their behavior. In addition to that, this pengujian is also intended to detect and identify potential kelemahan or malfunction in the system and device that have been tampered with.

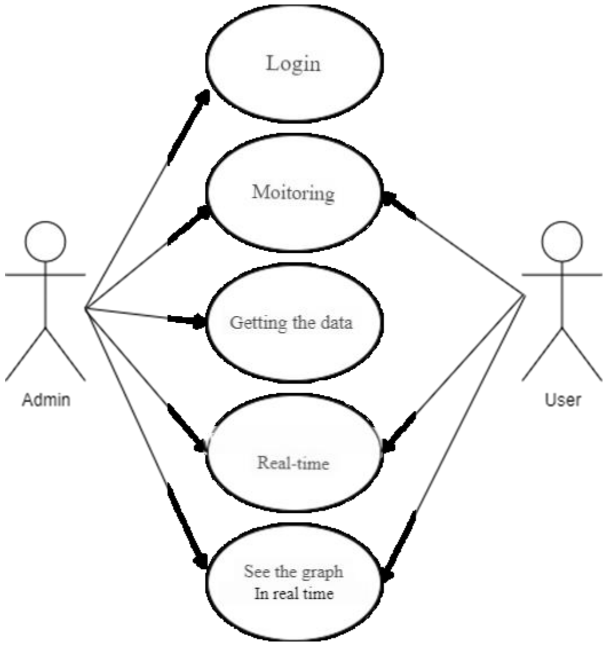

Figure 9. Use Case Admin

The conventional scientific method of observation was used to acquire data for this study. At a milkfish pond in Pengangsalan Village, Kalitengah District, Lamongan Regency, the author conducted fieldwork. According to data gathered, the Pengangsalan milkfish pond is close to residential areas and produces a significant amount of milkfish when compared to neighboring villages. It is challenging for the local milkfish farmers to keep an eye on the amount of dissolved solids in their pond water, though, because of their tight budgets. The purpose of the observation was to examine the circumstances and state of the milkfish pond. The findings showed that the TDS sensor-based water monitoring system is operating effectively, allowing the ESP32 microcontroller to handle data efficiently.

Based on Figure 9, the administrator can access the website with secure features such login, monitoring, data gambil, real-time data viewing, and real-time graph viewing. On the other hand, the user can access monitoring, view data in real time, and view graphs in real time based on data input that is received from a TDS sensor that is received via a website.

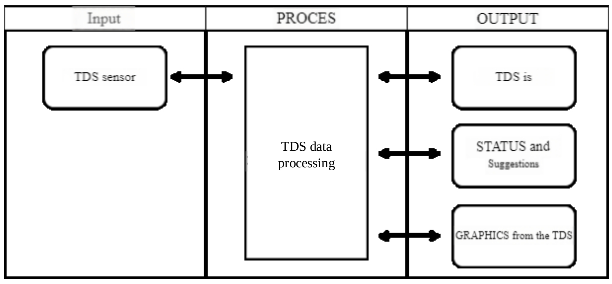

Figure 10. Blok Diagram

Figure 10 explains the process involving a TDS (Total Dissolved Solids) sensor that measures the concentration of dissolved solids in pool water. The sensor collects and sends data to the ESP32 microcontroller. The ESP32 converts the analog data to digital format and processes it. The processed TDS values are then sent to a web interface, where they are displayed as real-time information on water quality (safe, poor, or alert) based on predefined thresholds. The TDS values are visualized in real-time graphs, allowing users to monitor trends and fluctuations in water quality daily or weekly.

The Flowchart Rule Base Sensor in figure 11 illustrates the sensor's method for reading pages and generating output on a website. This procedure provides an example of how a sensor works to detect objects in the air and transform data into relevant, real-time outputs.

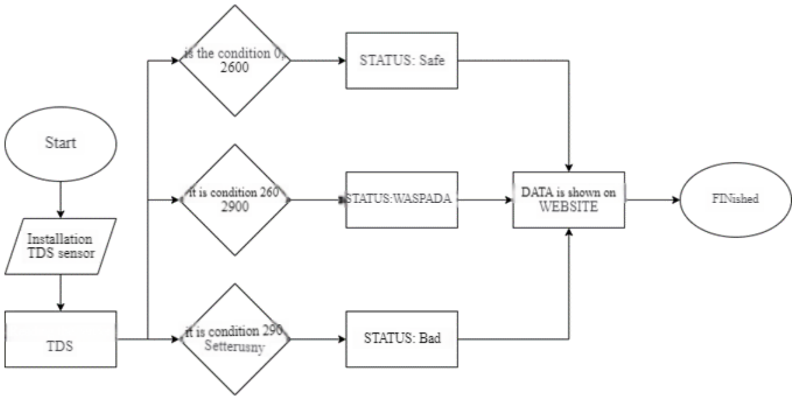

Figure 11. Flowchart Rule Base Sensor

The design process of the research tool involves several key steps. First, the TDS sensor is strategically placed to ensure accurate detection of water quality.

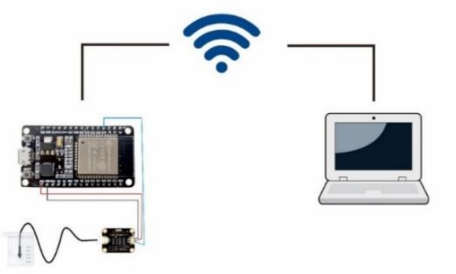

Figure 72. Tool Design

As seen in Figure 12, this sensor is connected to the ESP32 microcontroller, which collects data and manages communication via WiFi to a designated server. The straightforward web interface helps users quickly assess the intensity and changes in water quality, supporting informed decision-making for effective pond management.

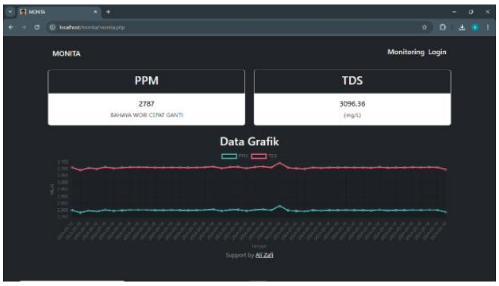

Figure 13. Tool Implementation

Figure 13 shows, the interface implementation, combining elements arranged in the Arduino IDE software, produces a simple website displaying real-time data from the TDS sensor. The website features tables showing the TDS values in ppm and the condition of the pond water. Additionally, the interface includes real-time updated graphs that visualize the TDS data, providing a clear view of the water quality. This graphical representation effectively illustrates the performance of the interface in presenting data visually and accurately reflecting the current water quality.

Figure 14. Tool Application

The maintenance process starts with reading all the data that is captured by the TDS sensor and sent to the ESP32 microcontroller, which is connected to the internet. This microcontroller is able to display the TDS value in real time as well as the time and air quality status. The data collected by the TDS sensor is processed by the ESP32 and sent to a specially designed web page for maintenance.

This information-gathering website is designed to enable easy and instant access to air quality data. Users can view graphs and real-time data regarding TDS concentration in the tank, as well as receive notifications if there are any significant changes in the air quality parameter.

III. RESULT AND DISCUSSION

Based on the study, we got the Table 1. It is the result of research.

Table 1. Research Results Table

No.	Date	Clock	PPM	TDS (Mg/L)	Status	Information
1	31/5/2024	10:05:27	2372	2490.6	BAD	Not safe for use in fish pond
2	31/5/2024	11:05:33	2538	2664.9	BAD	Not safe for use in fish pond
3	1/6/2024	7:43:48	487	511.35	SAFE	Suitable for use in fish pond
4	1/6/2024	7:47:29	1950	2047.5	BAD	Not safe for use in fish pond
5	1/6/2024	7:51:05	1607	1687.35	ALERT	Needs to be monitored because is is approaching an unsafe limit
6	31/5/2024	10:05:33	2538	2664.9	BAD	Not safe for use in fish pond
7	1/6/2024	7:43:48	487	511.35	SAFE	Suitable for use in fish pond
8	1/6/2024	7:47:29	1950	2047.5	BAD	Not safe for use in fish pond

The Table 1 presents data collected from the TDS sensor and includes the following columns:

1. Timestamp
   It shows the exact date and time when the TDS measurement was recorded. This helps in tracking changes over specific intervals.
2. TDS Value (ppm)
   It displays the concentration of Total Dissolved Solids in the water, measured in parts per million (ppm). This value indicates the level of dissolved substances in the water.
3. Status
   It categorizes the water quality based on the TDS value. Common statuses include:
   a. Safe
      Idicates that the water quality is within acceptable levels.
   b. Alert
      Signals that TDS levels are approaching thresholds that might require attention.
   c. Poor
      Shows that TDS levels are beyond acceptable limits, indicating potential water quality issues.

The TDS sensor can accurately and reliably detect air in the pampas that has been determined by analyzing the up boarder (Safe) Batas Ambang: When the Total Dissolved Solids (TDS) level reaches 500 ppm or more, air falls into a safe category to be used. This condition usually indicates that zat consciousness is found in the air, although it can also be felt in the batas for most major needs.

The 1000th level (ALERT): If TDS levels reach 1000 ppm or above, it must be checked since low air quality can lead to increased zat concentration, which may negatively impact health or perikanan quality. 2000 to above (BAD): When TDS levels above 2000 ppm, air becomes trapped due to zat concentrations that are too high. This can cause problems for living organisms and negatively impact production results.

The Table 1 shows the research data using a distance of 15 cm from the fish pond embankment.

IV. CONCLUSION

This study aims to design a pond water quality monitoring system with the integration of Total Dissolved Solids (TDS) sensors and NodeMCU ESP32, and apply a rule-based method for data processing. The following are the conclusions of the study:

1. System Design
   This monitoring system is designed to utilize a TDS sensor that measures the concentration of dissolved substances in pond water. NodeMCU ESP32 functions as the main controller that processes data from the sensor and applies a rule-based method for analysis and decision making.
2. TDS Sensor Function
   The TDS sensor plays an important role in detecting TDS levels in pond water. This sensor provides accurate and stable data on the concentration of dissolved

substances, which is essential for water quality assessment.

3. NodeMCU ESP32 Implementation
   NodeMCU ESP32 is used to process signals from the TDS sensor. With its capabilities in data processing and Wi-Fi connectivity, ESP32 sends data to the monitoring platform and executes the rules set in the rule-based method.
4. Rule-Based Method
   The rule-based method is applied to determine actions based on data obtained from the sensor. These rules are defined based on the range of TDS values that are considered safe or risky. For example, if the TDS value exceeds a certain threshold, the system can provide an alert or suggestion for corrective action.
5. Data Processing and Decisions
   The rule-based method allows the system to automatically process data and provide relevant decisions. This optimizes the system's response to changes in water quality, by providing alerts or recommendations based on predetermined rules.
6. User Interface
   The data obtained is monitored through a web-based interface or application, which allows users to view real-time information related to water quality status. This integration makes monitoring and management of the pond easier.
7. Development Suggestions
   To improve the system, it is recommended to expand the rule-based method by adding other water quality parameters such as pH and temperature. In addition, the development of more sophisticated automatic alarm features and reprogramming of rules based on historical data patterns can improve the accuracy and usability of the system.

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