CENTRAL SCIENTIFIC COMPANY

OPERATING INSTRUCTIONS

Electronic Doppler Effect Apparatus
No. 32492

1. Introduction

The Electronic Doppler Effect Apparatus demonstrates the Doppler Effect, which is the apparent change in the frequency of sound waves when the sound source and the listener are in motion relative to each other. The listener hears this apparent change in frequency as an increase in the pitch of the sound as the sound source approaches, and a decrease in the pitch as the source moves away. You experience this phenomenon every time a car or a truck honks its horn as it passes by. Your ears actually receive additional sound waves per unit of time as the vehicle approaches you and fewer as it travels away from you.

This apparatus consists of a 2kHz fixed-frequency electronic sound generator attached to the end of an aluminum arm, which you whirl in a horizontal path above your head at a safe distance from your students. You can demonstrate the Doppler effect in three different modes by flipping the desired switch before whirling the arm. The familiar continuous mode produces a clear continuous tone as the arm revolves. As the electronic sound generator moves toward the students, they hear an increase in the pitch and then a decrease in the pitch as it moves away from them. The alternating mode produces two distinct tones (like an ambulance siren) during each revolution of the arm, one as the sound source moves toward the students and a second as it moves away.

We have also provided an intermittent mode, which produces one tone per revolution, either as the sound source moves toward or moves away from the listeners. Your students can compare the pitch produced by the intermittent mode to the pitch produced by the sound generator when it is stationary. For all three modes, you can measure the frequency of the sound produced by the Electronic Doppler Effect Apparatus using your oscilloscope and a microphone. Your students can calculate the apparent frequency of the sound by plugging the actual frequency, the velocity of the source, and the velocity of sound into your equations.

2. Description

The Electronic Doppler Effect Apparatus consists of an electronic sound generator attached to one end of a 100cm-long aluminum arm (see Fig. 1). A battery chamber at the opposite end of the arm holds a 9VDC dry battery, which supplies power to the sound generator. When the power switch next to the battery is on, the green pilot light glows; and the sound generator can produce sound at a 2kHz (2000Hz) fixed frequency. A large bearing holds the arm on a metal rod, above which the arm revolves in a circular path with a diameter of 150cm. A supplied handle must be screwed tightly onto the rod before operating the apparatus.

aluminum arm
bearing
red pilot light
continuous switch
electronic sound generator

Fig. 1 Components of Doppler Effect Apparatus

This apparatus has three controlling switches for selecting the desired sound mode. When you flip the continuous-mode switch, adjacent to the power switch, the sound generator emits a continuous tone of a 2kHz fixed-frequency. Gripping the supplied handle firmly, you can whirl the arm in a horizontal path above your head at a distance of several meters from your students. They will hear a change in pitch with each revolution of the arm. When you flip the alternating-mode switch, located in the right side of the housing affixed to the metal rod, and then whirl the arm, the sound generator emits two distinct tones per revolution. Your students hear a high-pitched tone as the sound source approaches them and then a low-pitched tone as the source recedes.

When you hold down the orange intermittent mode switch, located in the left side of the housing on the metal rod, and whirl the arm, the generator emits one tone per revolution. This tone can occur either when the source moves toward or away from the students, and should be

compared to the tone produced by the generator when it is stationary. When one of the three mode switches is on, a red pilot light next to the sound generator glows. We have also included a hollow sponge that fits over the sound generator to prevent it from being damaged when you whirl the arm above your head. You can use your own microphone and an oscilloscope to quantitatively measure the frequency of the sounds produced.

3. Setup and Operation

Screw the supplied handle onto the metal rod tightly. Then put the 9VDC battery in the battery chamber at the end of the aluminum arm. Fit the hollow protective sponge over the electronic sound generator at the opposite end of the arm so the generator is completely covered. Flip the power switch so that the green pilot light is on, and then select the desired sound mode, as described below.

Caution! Be sure that the handle is secured to the rod and that there is a distance of at least 5 meters between your students and the Electronic Doppler Effect Apparatus before proceeding with the demonstration.

A. Continuous Mode: To select the continuous mode, flip the switch adjacent to the power switch so the red pilot light next to the electronic sound generator is on. The generator now produces a clear continuous tone. Grip the handle firmly with one hand, and grip the aluminum arm with the other hand. Raise the apparatus high above your head, and then whirl the arm in a horizontal path at the desired speed (see Fig 2). We recommend speeds from 1-3 revolutions per second for the best results. As you whirl the arm, ask your students to note an increase in the pitch of the continuous tone as the sound source moves toward them and a decrease in the pitch as the source moves away from them.

Fig. 2
Path of Sound Source

B. Alternating Mode: To select the alternating mode, flip the switch located in the right side of the housing on the metal rod. Be sure that the red pilot light next to the electronic sound generator is on before proceeding. Grip the handle firmly in one hand, and grip the aluminum arm with the other hand. Raise the apparatus high above your head, and then whirl the arm in a horizontal path at the desired speed. We recommend speeds from 1-3 revolutions per second for the best results. As you whirl the arm, ask your students to note the high-pitched tone produced when the sound source approaches them and the low-pitched tone produced when the source moves away from them.

C. Intermittent Mode: To select the intermittent mode, grip the handle firmly with one hand, and using your thumb, hold down the small orange switch located in the left side of the housing on the metal rod. Be sure that the red pilot light next to the electronic sound generator is on before proceeding. Grip the aluminum arm with your other hand, and raise the apparatus high above your head. Still holding down the switch, whirl the arm in a horizontal path at the desired speed. We recommend speeds from 1-3 revolutions per second for the best results.

As you whirl the arm, have your students determine whether the intermittent tone occurs as the sound source moves toward them or away from them. Repeat the experiment so they can hear the tone both ways and identify the difference in the pitch. In both cases, have them compare the pitch of the intermittent tone produced when the sound source is moving to the pitch of the tone produced when the source is stationary.

For all three demonstrations, you can measure the frequency of the sound by sending it through a microphone to an oscilloscope, which displays the signal. Your students can then compare the actual frequency of the electronic sound generator (2kHz) to the frequency measured by the oscilloscope (apparent frequency). They can also calculate the apparent frequency using your equations.

4. Theory

The Doppler effect is a familiar phenomenon which occurs for all types of harmonic waves when the wave source and the observer are in motion relative to each other. For sound waves, we can easily demonstrate the Doppler effect by rotating a sound generator of a fixed frequency on a rod at a known velocity. To a stationary observer several meters from the rotating sound source, the frequency of the sound apparently increases as the sound source approaches and apparently decreases as the source recedes.

The apparent increase in frequency is heard as an increase in the pitch of the sound resulting when the source “catches up” with its own sound waves. In this case, the observer’s ears receive additional sound waves per unit of time. On the other hand, the apparent decrease in frequency is heard as a decrease in the pitch of the sound resulting when the source “falls behind” its own sound waves. In this case, the observer’s ears receive fewer sound waves per unit of time.

Because we know that the velocity of sound V is 343m/s, we can calculate the apparent frequency f'

of the source when it moves toward us with the following equation, where ***f*** is the actual frequency in Hertz and V_s is the velocity of the source in m/s:

$$f' = f\,(F(V, V - V_s))$$

When the source is moving away from us, we can calculate the apparent frequency ***f '*** with a similar equation:

$$f' = f\,(F(V, V + V_s))$$

Note that ***f '*** is always greater than ***f*** when the sound source moves toward the observer, and that ***f '*** is always less than ***f*** when the source moves away. In the first case, the wavelengths are "shortened" by the motion of the source so we hear a higher-pitched sound. In the second case, the wavelengths are "stretched" by the motion of the source so we hear a lower-pitched sound.

5. Maintenance

The Electronic Doppler Effect Apparatus is made of lightweight materials and should be handled with care. To avoid damaging the electrical components, turn off the power switch after a demonstration. You should also replace the 9VDC battery on a regular basis and remove it before storing the apparatus. If this apparatus malfunctions, or you need more information about operating it, contact Central Scientific Company. Please do not return any equipment until we have sent you authorization.

6. Accessories

Description	Catalog No.
Compact Dual-Trace 20MHz Oscilloscope	32046
Universal Microphone with Preamplifier	58626

Written 4/90