Chapter 6
Scalar Waves

There is wide confusion about what "scalar waves" are both in serious and less serious literature on electrical engineering. This chapter explains that this type of wave is a longitudinal wave of potentials. It has been shown that a longitudinal wave is a combination of a vector potential with a scalar potential. There is a full analogue to acoustic waves. Transmitters and receivers for longitudinal electromagnetic waves are discussed. Scalar waves were found and used at first by Nikola Tesla in his wireless energy transmission experiments. The SW is the extension of the Maxwell's equation part that we call the More Complete Electromagnetic equation, as described herein.

6.1 Introduction

It is the purpose of this chapter to discuss a new unified field theory based on the work of Tesla. This *unified field* and particle theory describes quantum and classical physics, mass, gravitation, the constant speed of light, neutrinos, waves, and particles—all of which can be explained by vortices [1]. In addition, we discuss unique and various recent inventions and their possible modes of operation in order to convince those studying this of their value for hopefully directing a future program geared toward the rigorous clarification and certification of the specific role the electroscalar domain, and how it might play a role in shaping a future consistent with classical electrodynamics. Also, by extension, to perhaps shed light on inconsistencies that do exist within current conceptual and mathematical theories in the present interpretation of relativistic quantum mechanics. In this regard, we anticipate that by incorporating this more expansive electrodynamic model, the source of the extant problems with gauge invariance in quantum electrodynamics and the subsequent unavoidable divergences in energy/charge might be identified and ameliorated.

Not only does the electroscalar domain have the potential to address such lofty theoretical questions surrounding fundamental physics, but another aim in this chapter

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is to show that the protocol necessary for generating these field effects may not be present only in exotic conditions involving large field strengths and specific frequencies involving expensive infrastructures such as the *large hadron collider* (LHC). As recent discoveries suggest, however, SWs may be present in the physical manipulation of everyday objects. We also will explain that nature has been and may be engaged in the process of using *scalar longitudinal waves* (SLWs) in many ways yet unsuspected and undetected by humanity. Some of the modalities of SW generation we will investigate include chemical bond-breaking, particularly as a precursor to seismic events (i.e., illuminating the study and development of earthquake early warning systems); solar events (i.e., related to eclipses); and sunspot activity and how it affects the Earth's magnetosphere. Moreover, this overview of the unique aspects of the electroscalar domain suggests that many of the currently unexplained anomalies—for example, overunity power observed in various energy devices and exotic energy effects associated with *low-energy nuclear reactions* (LENRs)—may find some basis in fact.

In regard to the latter, cold fusion or LENR fusion-type scenarios, the *electroscalar wave* might be the actual agent needed to reduce the nuclear Coulomb barrier, thereby providing the long sought for viable theoretical explanation of this phenomenon [2]. Longitudinal electrodynamic forces (e.g., in exploding wires) actually may be because of the operation of electroscalar waves at subatomic levels of nature. For instance, the extraordinary energies produced by Ken Shoulder's charge clusters (i.e. Particles of like charge repel each other - that is one of the laws describing the interaction between single sub-atomic particles) perhaps may be because of electroscalar mechanisms.

Moreover, these observations, spanning as they do many cross-disciplines of science, beg the question as to the possible universality of the SLW—that is, the concept of the longitudinal electroscalar wave, not present in current electrodynamics, may represent a general key, overarching principle, leading to new paradigms in other sciences besides physics. This idea also will be explored in the chapter, showing the possible connection of scalar–longitudinal (i.e., electroscalar) wave dynamics to biophysical systems. Admittedly, we are proposing quite an ambitious agenda in reaching for these goals, but we think you will see that recent innovations may have proved equal to the task of supporting this quest.

6.2 Descriptions of Transverse and Longitudinal Waves

As you know from a classical physics point of view, typically the following are three kinds of waves—the *soliton wave* is an exceptional case and should be addressed separately—and wave equations that we can talk about:

1. Mechanical waves (i.e., waves on string)
2. Electromagnetic (EM) waves (i.e., $\vec{E}$ and $\vec{B}$ fields from Maxwell's equations to deduce the wave equations, where these waves carry energy from one place to another)
3. Quantum mechanical waves (i.e., using Schrödinger equations to study particles' movements)

The second one is our subject of interest in terms of te two types of waves involved in EM waves: (1) transverse waves and (2) *longitudinal pressure waves* (lpws), also known as *scalar longitudinal waves* (slws).

From the preceding two waves, the SLW is of interest in directed energy weapons (DEWs) [3] and here is why. First, we briefly describe SLWs and their advantages for DEW purposes as well as communication within non-homogeneous media such as seawater with different *electrical primitivity* ε and *magnetic permeability* μ at various ocean depths (see Chap. 4 of this book).

A wave is defined as a disturbance that travels through a certain medium. The medium is material through which a wave moves from one to another location. If we take as an example a slinky coil that can be stretched from one end to the other, a static condition then develops . This static condition is called the wave's *neutral condition* or equilibrium state.

In the slinky coil the particles are moved up and down then come into their equilibrium state. This generates disturbance in the coil that is moved from end one to the other. This is the movement of a *slinky pulse*, which is a *single disturbance in medium* from one to another location. If it is done *continuously* and in a *periodical manner*, then it is called a *wave,* also known as an *energy transport medium*. They are found in diverse shapes, show a variety of behaviors, and have characteristic properties. On this basis, they are classified mainly as longitudinal, transverse, and surface waves. Here we discuss the properties of LWs and provide examples. The movement of waves is parallel to the medium of the particles in them.

1. **Transverse Waves**

For TWs the medium is displaced perpendicular to the wave's direction of propagation. A ripple on a pond and a wave on a string are visualized easily as TWs (Fig. 6.1).

TWs cannot propagate in a gas or a liquid because there is no mechanism for driving motion perpendicular to the propagation of the wave. In summary, a transverse wave (TW) is a wave in which the oscillation is perpendicular to the direction of wave propagation. Electromagnetic waves (and secondary waves, S-waves or shear waves, sometimes called elastic S-waves) in general are TWs.

2. **Longitudinal Waves**

In a LW the displacement of the medium is parallel to the propagation of the wave. A wave in a slinky is a good visualization. Sound waves in air are LWs (Fig. 6.2).

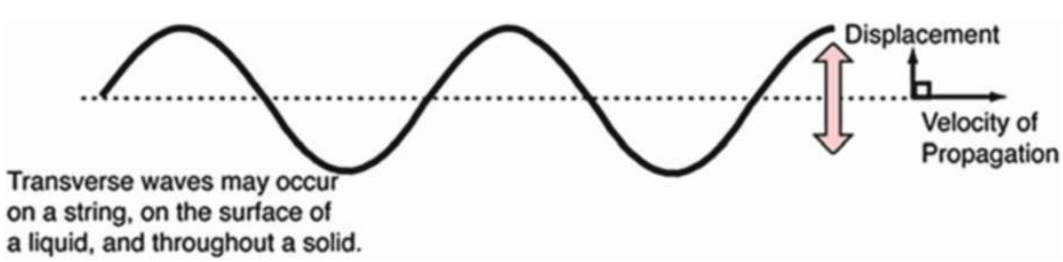

Fig. 6.1 Depiction of a transverse wave

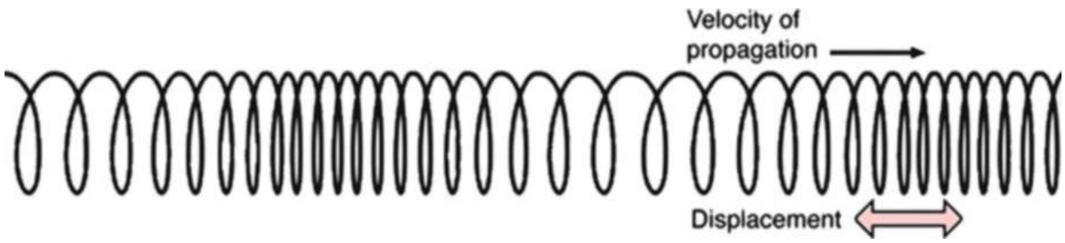

Fig. 6.2 Depiction of a longitudinal wave

In summary, an LW is a wave in which the oscillation is in an opposite direction to the direction of wave propagation. Sound waves—that is, primary waves, or P-waves, in general—are LWs. On the other hand, a wave with a motion that occurs through the particles of the medium oscillating about their mean positions in the direction of propagation is called an LW.

We use our knowledge to expand the subject of the *longitudinal wave* before we go deeper into the subject of the *scalar longitudinal wave*; for an LW the particles of the medium vibrate in the direction of wave propagation. An LW proceeds in the form of compression and rarefaction, which is stretch and compression in the same direction as the wave moves. For an LW at places of compression the pressure and density tend to be maximal, whereas at places where rarefaction takes place, the pressure and density are minimal. In gases only an LW can propagate; LWs are known as *compression waves*.

An LW travels through a medium in the form of compressions or condensations, C, and rarefaction, R. A compression is a region of the medium in which particles are compressed (i.e., particles come closer); in other words, the distance between the particles becomes less than the normal distance between them. Thus, volume temporarily decreases and, therefore the density of the medium increases in the region of compression. A *rarefaction* is a region of the medium in which particles are rarefied (i.e., particles get farther apart than what they normally are). Thus, volume temporary increases and, consequently, the density of the medium decreases in the region of rarefaction.

The distance between the centers of two consecutive rarefactions and two consecutive compressions is called *wavelength*. Examples of LWs are sound waves, tsunami waves, earthquake P-waves, ultra-sounds, vibrations in gas, and oscillations in springs internal water waves, waves in slink, and so on.

(a) *Longitudinal waves*

Examples of the various types of waves are:

1. Sound wave
2. Earthquake *P*-wave
3. Tsunami wave
4. Waves in a slinky
5. Glass vibrations

6. Internal water waves
7. Ultra-sound
8. Spring oscillations

(b) *Sound waves*

Now the question is: *Are sound waves longitudinal?* The answer is *Yes*. A sound wave travels as an LW in nature. It behaves as a TW in solids. Through gases, plasma, and liquids the sound travels as an LW. Through solids the wave can be transmitted as a TW or an LW.

A material medium is mandatory for the propagation of the sound waves. They mostly are longitudinal in common nature. The speed of sound in air is 332 m/s at normal temperature and pressure. Vibrations of an air column above the surface of water in the tube of a resonance apparatus are longitudinal. Vibrations of an air column in organ pipes are longitudinal. Sound is audible only between 20 Hz and 20 KHz. Sound waves cannot be polarized.

(i) *Propagation of sound waves in air*: Sound waves are classified as LWs. Let us now see how sound waves propagate. Take a tuning fork, vibrate it, and concentrate on the motion of one of its prongs, say prong A. The normal position of the tuning fork and the initial condition of air particles is shown in Fig. 6.3a. As prong A moves toward the right, it compresses air particles near it, forming a compression as shown in Fig. 6.3b. Because of vibrating air layers, this compression moves forward as a disturbance.

As prong A moves back to its original position, the pressure on its right decreases, thereby forming a rarefaction. This rarefaction moves forward like compression as a disturbance. As the tuning fork goes on vibrating, waves consisting of alternate compressions and rarefactions spread in the air as shown in Fig. 6.3c,d. The direction of motion of the sound waves is the same as that of air particles, thus they are classified as LWs. The LWs travel in the form of compressions and rarefactions.

The main parts of the sound wave follow, along with descriptions:

1. *Amplitude*: The maximum displacement of a vibrating particle of the medium from the mean position. A shows amplitude in $y = A \sin(\omega t)$. The maximum height of the wave is called its amplitude. If the sound is more, then the amplitude is more.
2. *Frequency*: The number of vibrations made per second by the particles and is denoted by f, which is given as $f = 1/T$ and its unit is Hz. We also can get the expression for angular frequency.
3. *Pitch*: It is characteristic of sound with the help of which we can distinguish between a *shrill* note and a note that is *grave*. When a sound is shriller, it is said to be of higher pitch and is found to be of greater frequency, as $\omega = 2\pi f$. On the other hand, a grave sound is said to be of low pitch and is of low frequency. Therefore the pitch of a sound depends on its frequency. It should be made clear that pitch is not the frequency but changes with frequency.

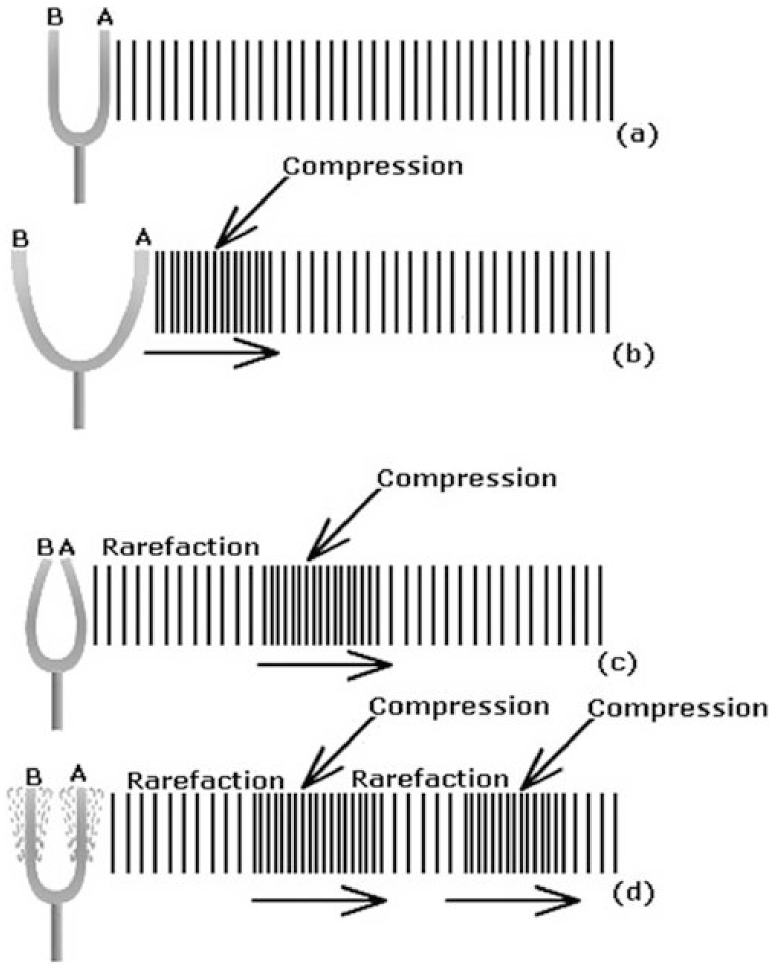

Fig. 6.3 Tuning fork

4. *Wavelength*: The distance between two consecutive particles in the same phase or the distance traveled by the wave in one periodic time and denoted by lambda, Λ.
5. *Sound wave*: This is a LW with regions of compression and rarefaction. The increase of pressure above its normal value may be written as:

$$\sum p = \sum p_0 \sin \omega\left(t - \frac{c}{v}\right) \tag{6.1}$$

where

$\sum p =$ increase in pressure at x position at time t
$\sum p_0 =$ maximum increase in pressure
$\omega = 2\pi f$ where f is frequency

If $\sum p$ and $\sum p_0$ are replaced by P and P_0, then Eq. 6.1 has the following form:

$$P = P_0 \sin \omega\left(t - \frac{c}{v}\right) \tag{6.2}$$

(ii) *Sound intensity*: Loudness of sound is related to the intensity of it. The sound's intensity at any point may be defined as the amount of sound energy passing per unit time per unit area around that point in a perpendicular direction. It is a physical quantity and is measured in W/m^2 in S.I. units.

The sound wave falling on the ear drum of the observer produces the sensation of hearing. The sound's sensation, which enables us to differentiate between a loud and a faint sound, is called *loudness*, and we can designate it by symbol L. It depends on the intensity of the sound I and the sensitivity of the ear of the observer at that place. The lowest intensity of sound that can be perceived by the human ear is called the *threshold of hearing*, denoted by I_0. The mathematical relation between intensity and loudness is:

$$L = \log \frac{I}{I_0} \tag{6.3}$$

The intensity of sound depends on:

Amplitude of vibrations of the source
Surface area of the vibrating source
Distance of the source from the observer
Density of the medium in which sound travels from the source
Presence of other surrounding bodies
Motion of the medium

(iii) *Sound reflection*: When a sound wave gets reflected from a rigid boundary, the particles at the boundary are unable to vibrate. Thus, the generation of a reflected wave takes place, which interferes with the oncoming wave to produce zero displacement at the rigid boundary. At the points where there is zero displacement, the variation in pressure is at a maximum. This shows that the phase of the wave has been reversed, but the nature of the sound wave does not change (i.e., on reflection the compression is reflected as compression and rarefaction as rarefaction. Let the incident wave be represented by the given equation:

$$Y = a \sin(\omega t - kx) \tag{6.4}$$

Then the Eq. 6.4 of reflected wave takes the form

$$Y = a \sin(\omega t + kx + \pi) = -a \sin(\omega t + kx) \tag{6.5}$$

Here in both Eqs. 6.4 and 6.5 the symbol of a is basically the designation of the amplitude of the reflected wave.

A sound wave also is reflected if it encounters a rarer medium or free boundary or low-pressure region. A common example is the traveling of a sound wave in a narrow open tube. On reaching an open end, the wave gets reflected. So the force exerted on the particles there because of the outside air is quite small and, therefore, the particles vibrate with increasing amplitude. Because of this the pressure there tends to remain at the average value. This means that there is no alteration in the phase of the wave, but the ultimate nature of the wave has been altered (i.e., on the reflection of the wave the compression is reflected as rarefaction and vice versa).

The amplitude of the reflected wave would be a' this time and Eq. 6.4 becomes:

$$y = a' \sin\left(\omega t + kx\right) \tag{6.6}$$

(c) *Wave interface*: When listening to a single sine wave, amplitude is directly related to loudness and frequency and directly related to pitch. When there are two or more simultaneously sounding sine waves, wave interference takes place. There are basically two types of wave interference: (1) constructive and (2) destructive.

(d) *Decibel*: A smaller and practical unit of loudness is a decibel (dB) and is defined as follows:

$$1\ \text{Decibel} = \frac{1}{10}\ \text{bel} \tag{6.7}$$

In dB the loudness of a sound of intensity I is given by

$$L = 10 \log\left(\frac{I}{I_0}\right) \tag{6.8}$$

(e) *Timber*: Timber can be called the property that distinguishes two sounds and makes them different from each other, even when they have the same frequency. For example, when we play violin and guitar on the same note and same loudness, the sound is still different. It also is denoted as *tone color*.

(f) *S-waves*: An *S*-wave is a wave in an elastic medium in which the restoring force is provided by shear. *S*-waves are divergence-less,

$$\nabla \cdot \vec{u} = 0 \tag{6.9}$$

where $\vec{u}$ is the displacement of the wave and comes in two polarizations: (1) SV (vertical) and (2) SH (horizontal).

The speed of an *S*-wave is given by:

$$\upsilon_s = \sqrt{\frac{\mu}{\rho}} \tag{6.10}$$

where μ is the shear modulus and ρ is the density.

(g) *P-waves:* Primary waves also are called P-waves. These are compressional waves and are longitudinal in nature. They are a type of pressure wave. The speed of P-waves is greater than other waves. These are called the primary waves