E.F. Lightning Terminal

E.F. Key Words

• TERMINAL

Sealed and high voltage, ensuring an emission of 6 x 10^{12} electrons/second per microamp of current, regulated by the magnitude of lightning itself.

• EARLY STREAMER EMISSION

Feature of the Terminal in order to trigger an early initiation of the upward connecting streamer.

• CARRIER

Coaxial structured down-conductor designed for the purpose of hermetically conveying lightning discharges without electrificatiom of the structures.

• TRANSIENT ABSORPTION TECHNOLOGY (TAT)

Function incorporated into the Carrier that suppresses the primary lightning overvoltage.

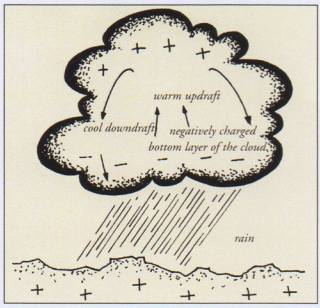
• LIGHTNING PROTECTION SYSTEM

Integrates hermetically its components which is made possible only through a new and unique design of a high voltage Terminal and Carrier.

CONTENTS

The Electrical Storm

When there is a large pressure and temperature variation in the atmosphere, cumulo-nimbus (the thundercloud) can be formed. These upward moving clouds can rise higher than 20,000 metres and travel at a speed exceeding 120 km/hr. The updraft motion of the cumulo-nimbus causes electric charge separation. The smaller positively charged particles are brought to the top of the cumulo-nimbus, while the larger negatively charged particles settle to the bottom. Arcing between the negatively charged layer of the cumulo-nimbus and the positively charged earth account for most of the cloud-to-ground lightning discharges (Figure 1).



A Typical Charge Distribution Within a Cumulo-Nimbus
Figure 1

As the cumulo-nimbus is separated into positively and negatively charged regions, neutralizing discharges can occur. In addition to the cloud-to-ground lightning discharges, there are also the cloud-to-cloud discharges.

Due to the negatively charged bottom layer of the cloud, the electric field strength of the earth rises rapidly. Buildings and other protrusions undergo the Corona Effect when the electric field strength reaches 10k V/m (Figure 2).

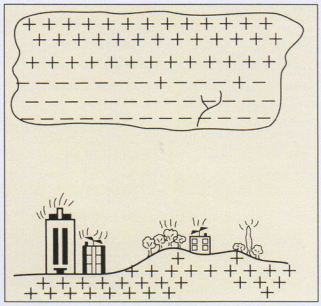


Figure 2

At this moment, the bottom layer of the cumulo-nimbus emits a faintly luminescent negatively charged downward leader, which moves in steps toward the ground (Figure 3).

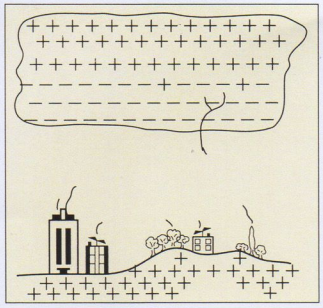


Figure 3

As the downward leader advances towards the earth, the collective action of the high electric field at the ground and the corona effect generate a positive upward moving streamer, which is emitted from certain structures or objects, such as lightning conductors (Figure 4).

The electric field strength associated with an upward streamer must be sufficient to strip 10^{7} electrons/s.

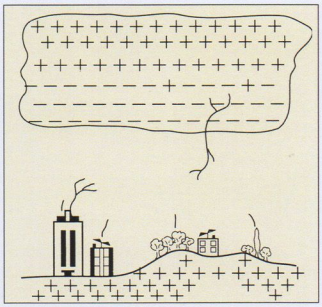


Figure 4

When the upward moving streamer connects with the downward leader, the ionized path between the cloud and the earth is completed and the main discharge current, called the return stroke, flows into the ground (Figure 5). The final length of the upward streamer is called the striking distance.

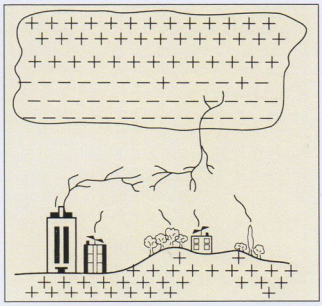


Figure 5

During an electrical storm, the electric field between the thundercloud and the earth intensifies. Geometric configurations, such as corners, edges, and sharp projections, and objects situated at higher elevations will experience greater degrees of electric field intensification (Figure 6).

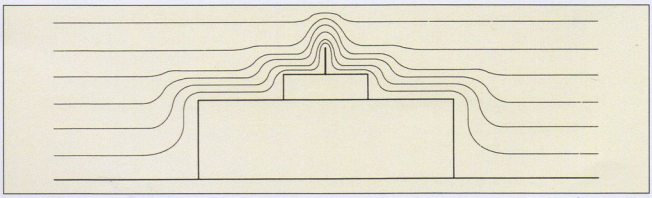


Figure 6
Diagram of Electric Field Strength

A sharp object that has enhanced free electron generation capacity and is placed at a high elevation can launch an upward streamer to intercept a downward leader, before any vulnerable parts of the structure can do the same.

This is the basis for the EARLY STREAMER EMISSION technology in lightning protection.

This technology was first invented and worldwide patented by *E.F.* INTERNATIONAL S.A.

E.F. Basic Components

An effective lightning protection system is composited of a lightning air terminal at the top, a lightning counter and earthing at the bottom, and a electrically sealed downconductor linking both ends.

E.F. LIGHTNING TERMINAL

The worldwide patented *E.F.* Lightning Terminal is the top part of the *E.F.* Carrier System of Lightning Protection. The *E.F.* Lightning Terminal is made of materials resistant to high voltage and is the place where upward streamers are emitted. During a lightning event, the strong ambient electric field causes the stripping of electrons from the lightning terminal to occur, and arcing follows. The electric field strength increases as the cumulo-nimbus gets closer to the lightning terminal.

The emission of the *E.F.* Lightning Terminal increases to $6x10^{12}$ electrons/sec per microamp of current during the approach of a downward leader.

This unique feature gives the *E.F.* Lightning Terminal a time advantage in the competition of the upward streamer generation.

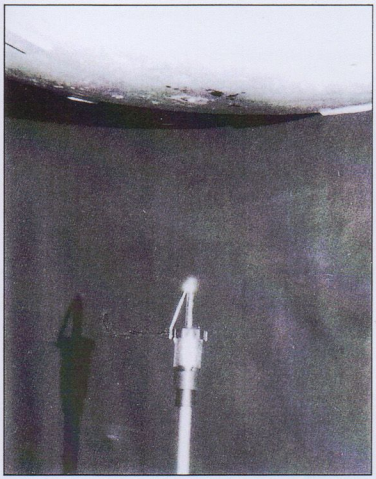
An *E.F.* Lighning Terminal installed on top of a building, can intercept lightning via Early Streamer Emission. The protection radius of the *E.F.* Lightning Terminal increases during this event. Area within the protection radius is safe from lightning strikes. The *E.F.* Lightning Terminal is also designed to offset interferences due to ground protrusions.

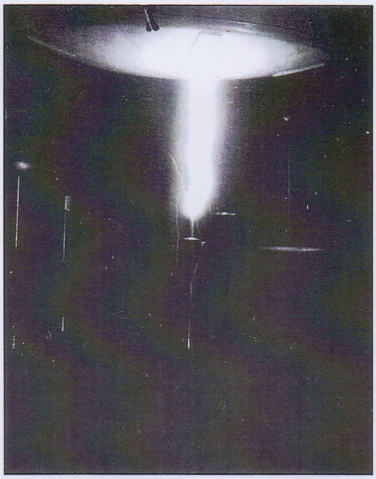
The protective radii of the *E.F.* Carrier System of Lightning Protection for various building heights are listed in the chapter "Lightning Protection for Buildings and Structures".

The *E.F.* Lightning Terminal design is based on the high voltage Early Streamer Emission technology. Where it is erected at the highest point of a building structure, it emits an upward streamer faster than all other pointed objects on or around the building structure. Not only is the chance of the occurence of lateral lightning strikes reduced, this method of lightning protection is also much cheaper to install than the traditional Faraday Cage method. Because the *E.F.* Carrier System of Lightning Protection is completely self-enclosed, the downconductor can be connected to the ground using the most direct route. This unique design is highly cost effective in installation and maintenance.

The *E.F.* Lightning Terminal is made of Non-radioactive material and does not require a battery source to function. It is completely powered by the stong atmospheric electric field present during a lightning storm.

HIGH VOLTAGE LABORATORY TESTING OF THE *E.F.* LIGHTNING TERMINAL





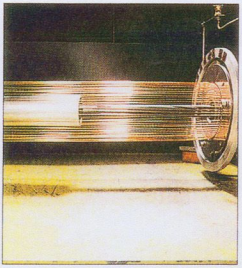
The *E.F.* Lightning Terminal was tested in a high voltage laboratory. When the electric potential of the overhead dome was raised to 80kV, arcing took place between the discharge arms of the lightning terminal and the central earthed finial at the rate of 300 times per second. This arcing phenomena gives the *E.F.* Lightning Terminal a time advantage over other pointed objects in emitting an upward streamer to intercept a downward leader (diagram left). When the overhead electric potential reaches 1500kV, lightning discharge occurs. This test demonstrates that the *E.F.* Lightning Terminal is able to withstand strikes from a large lightning storm (diagram right).

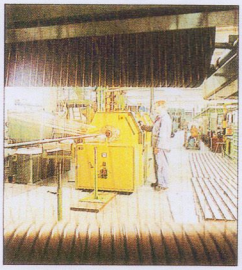
E.F. LIGHTNING CARRIER

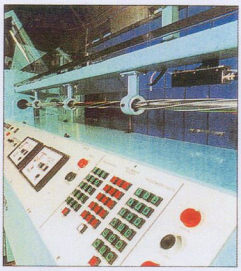
The worldwide patented *E.F.* Lightning Carrier is the central portion of the self-enclosed *E.F.* Carrier System of Lightning Protection.

The function of the *E.F.* Lightning Carrier is to safely conduct the high voltage lightning energy from the lightning terminal down to the ground. No side flashing occurs. The impedance of a traditional downconductor mechanism raises the voltage to over 1 MV when lightning current is flowing through. As a result, side flashing often occurs and leads to damage to building integrity, life and property.

The *E.F.* Lightning Carrier is composed of two identical conductors that one is coaxially placed about the other. The conductors are separated by a layer of insulator, which does not have the potential to cause side flashing. The dual channels of electrical conductance in the *E.F.* Lightning Carrier causes it to form a high capacitance between the two conducting layers. This design drastically reduces the impedance of the inner conductor and alleviates voltage rise in the lightning carrier due to transience. The possibility for the occurence of side flashing is hence very low. The *E.F.* Lightning Carrier can safely be fitted around building corners and even inside the building.



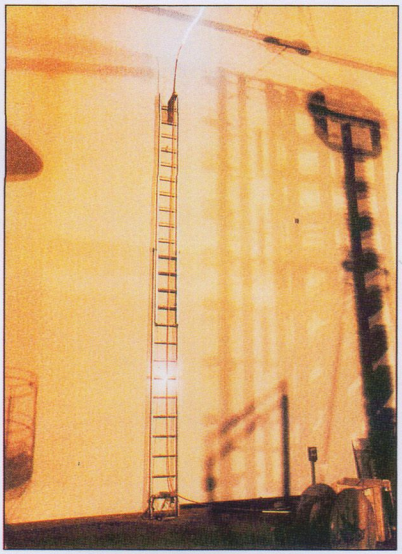


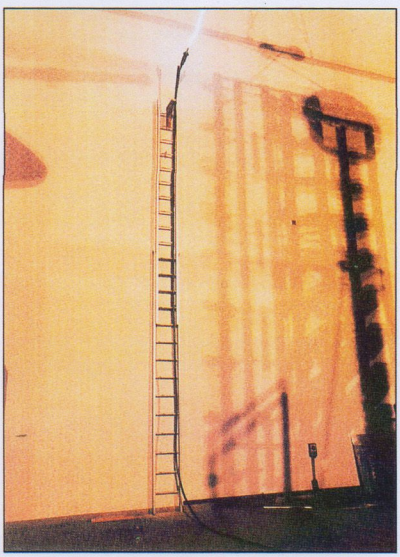


**E.F.* Lightning Carrier Production Line*

**E.F.* Lightning Carrier*
Scale 1:1

Very High Voltage Laboratory Comparative Testing of the Traditional Copper Downconductor and the *E.F.* Lightning Carrier





A very high voltage laboratory test was conducted at the Istituto di Elettrotecnica e di Elettronica in Italy. Under identical testing conditions, the traditional copper downconductor generated arcing between itself and the metal ladder (diagram left). The *E.F.* Lightning Carrier safely conducted the lightning energy without causing side flashing to the metal ladder (diagram right).

Transient Absorption Technology (TAT)

The growing use of sophisticated computer technology, even in small and medium-sized firms, requires that more lightning protection be given to prevent lightning overvoltage from entering power lines and damaging data lines or destroying the equipment.

Because this need has arisen, *E.F.* International S.A. has incorporated the Transient Absorption Technology (TAT) into its lightning carrier. TAT suppresses the destructive lightning overvoltage effect by assimilating the bulk of this discharge as it travels. Electro magnetic pulse influence to the structure will be minimal by use of E.F. carrier downconductor.

E.F. LIGHTNING COUNTER

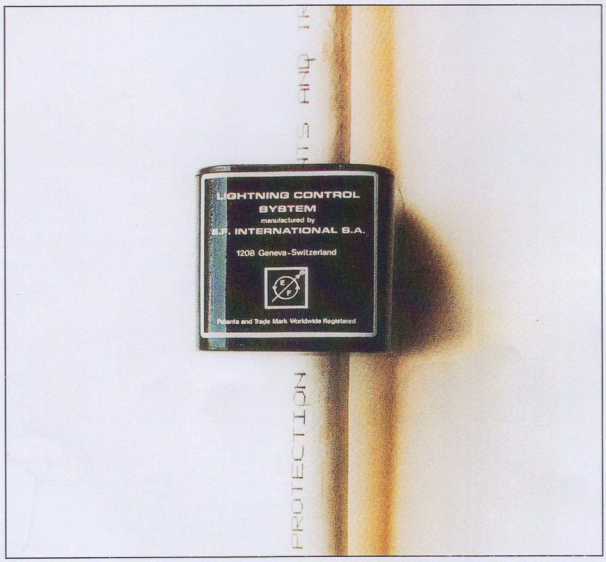
The *E.F.* Lightning Counter keeps track of the number of lightning strikes that the *E.F.* Carrier System of Lightning Protection intercepts. The *E.F.* Lightning Counter is small, light weight and waterproof. It can operate normally in extreme climatic conditions. It does not need a battery source to operate nor does it need to be regularly maintained.

Each time a lightning pulse travels down the *E.F.* Lightning Carrier, the local electromagnetic field rises sharply and causes the *E.F.* Lightning Counter to advance by one count.

The *E.F.* Lightning Counter can record up to 999,999 lightning strikes. The counter is triggered whenever it encounters a 1.5 KA impulse current in 1.5 microseconds duration. The counter cannot be reset.

The *E.F.* Lightning Counter provides data, which can be used to analyze the performance of the entire lightning protection system.

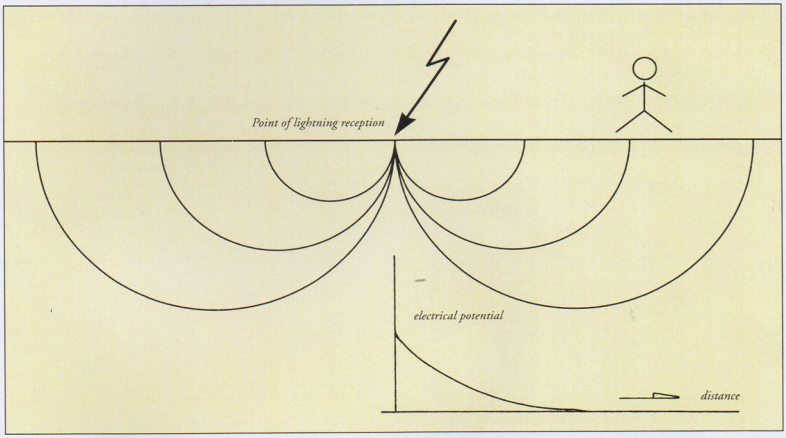
For high-rise residential and commercial buildings, transmission and microwave towers, and other civil structures, the *E.F.* Lightning Counter should be installed at the bottom of the lightning protection system. The *E.F.* Lightning Carrier fits through the internal aperture of the *E.F.* Lightning Counter. The *E.F.* Lightning Counter should be placed such that the lightning counter is clearly visible.



Earthing

A well-prepared earthing system is vital to the function of the lightning protection system.

The earth has a certain level of resistance. The voltage of the earth rises sharply when it receives a 500A to 150,000A transients from the downconductor. The electric potential falls exponentially away from the point of lightning reception. This phenomena is called the step potential, which can cause injury to pedestrian and properties. Normally, the lightning protection earthing system should be situated away from pedestrian sidewalks.



Step Potential

The measured resistance of the earthing at the point of lightning reception should be below 5 ohms. Under no circumstances should the earth resistance exceed 10 ohms.

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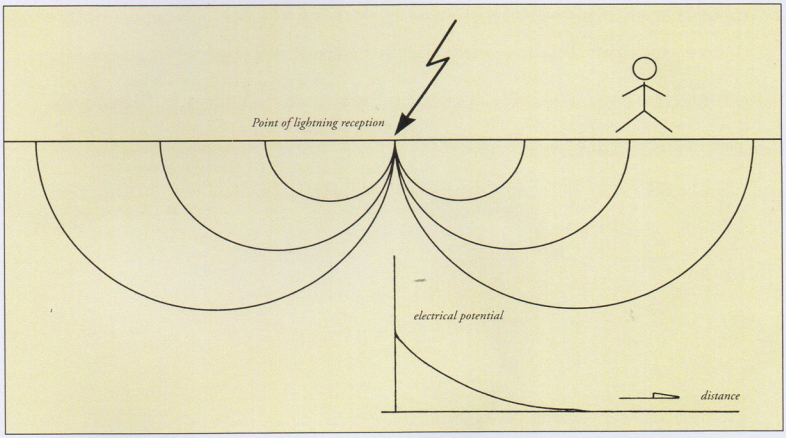


Step Potential

The measured resistance of the earthing at the point of lightning reception should be below 5 ohms. Under no circumstances should the earth resistance exceed 10 ohms.

Lightning Protection for Buildings and Structures

1. Select an appropriate level of lightning protection.
   (a) Standard level of protection - suitable for most commercial buildings and other structures
   (b) High level of protection - suitable for structures containing vital communications and computers, or for hospitals, key airport facilities, and military installations.
2. On a plan view of the structure to be protected, select the location for erecting the lightning terminal supporting mast.
3. Using an appropriate radius, draw a circle centred on the lightning terminal location.
4. If the circle completely encloses the plan view of the structure, the structure is protected to the nominated risk level. Any part of the structure lying outside the circle is unprotected. The remedy is to reposition the lightning terminal location or to use two or more lightning terminals.
5. Under all circumstances, the lightning terminal ought to be at least 10 metres higher than the ground level.

The Protective Radii of the *E.F.* Lightning Terminal for Buildings and Structures

(a) Level of Protection with average lightning discharges of 25kA

Building Height (m)	*Protective Radii (m) (for 5m tall lightning terminal supporting mast mounted above the highest point of the building)*
10	*100*
20	*110*
30	*120*
40	*130*
50	*140*
60	*150*
70	*160*
80	*170*
90	*180*
100	*190*
110	*200*
120	*200*
130	*200*
140	*200*
150	*200*
above 150	*Enquire Local *E.F.* Authorised Licensee*

(b) High Level of Protection (for peak current of 10kA or higher, 93% probability of exceedance)

Building Height (m)	*Protective Radii (m) (for 5m tall lightning terminal supporting mast mounted above the highest point of the building)*
10	*43*
20	*53*
30	*65*
40	*70*
50	*75*
60	*77*
70	*79*
80	*80*
90	*82*
100	*81*
110	*81*
120	*80*
130	*79*
140	*78*
150	*77*
above 150	*Enquire Local *E.F.* Authorised Licensee*

The protective radii increase with the magnitude of lightning discharge because the effectiveness of the *E.F.* Lightning Terminal is dependent on local electric field strength, which is a function of leader charge and lightning intensity.

Notes:

1. The lightning terminal should be 2 meters higher than the highest point of the building, which includes antenna, rail fence, communication equipments, machine room, water tower, air conditioners and other objects that protrude from the roof of the building. The protective radius of the lightning terminal increases with the height of the supporting rod.
2. The *E.F.* Lightning Terminal shall be installed on top of the accompanying lightning terminal supporting fibreglass mast.
3. The table of protective radii is statistically calculated based on empirical data. The field situation is also affected by the proximity of other-pointed objects.

Specifications of the *E.F.* Carrier System of Lightning Protection

Concept: A well-placed lightning protection system can protect buildings and structures from damages related to lightning activities. During a lightning storm, the high voltage design *E.F.* Carrier System of Lightning Protection intercepts all lightnings that fall within its vicinity. Subsequently, the lightning discharge is conveyed through the electrically sealed *E.F.* Lightning Carrier system into the ground without side-flashing. The *E.F.* Carrier System of Lightning Protection shall be manufactured in Switzerland.

The *E.F.* Carrier System of Lightning Protection shall include an *E.F.* Lightning Terminal, Lightning Terminal Supporting Mast, *E.F.* Lightning Carrier, *E.F.* Lightning Counter, and Earthing System. The specifications for each component is as follows.

***E.F.* Lightning Terminal:**

1) When the electric field in the atmosphere is large enought to initiate a lightning event, enhanced emission shall be produced through arcing in the air gap between the finial and the discharge arms of the *E.F.* Lightning Terminal.
2) Arcing shall not be continuous, and shall occur only during an electrical storm.
3) The *E.F.* Lightning Terminal shall not be made of radioactive material.
4) The protective radius provided by the *E.F.* Lightning Terminal shall comply with Collection Volume Design and shall be calculated depending on the level of protection required.
5) The *E.F.* Lightning Terminal shall not have any moving parts and shall be completely isolated from the structure to be protected. It shall be made of a material resistant to high voltage.
6) The *E.F.* Lightning Terminal shall be made of material that will not be corroded in normal atmosphere.
7) The *E.F.* Lightning Terminal shall not have to rely on batteries to be effective.
8) The *E.F.* Lightning Terminal shall be made in accordance with ESE codes.

Lightning Terminal Supporting Mast:

1) The supporting rod shall be made of reinforced fibreglass material. The bottom of the *E.F.* Lightning Terminal shall fit neatly into the inner diameter of the fibreglass tube. The *E.F.* Lightning Carrier shall pass through the interior of the fibreglass tube.
2) The supporting mast that supports the *E.F* Lightning Terminal, which is at least 2 metres above the top of the building structure shall be able to withstand hurricane storms according to the local code.

***E.F.* Lightning Carrier:**

1) The *E.F.* Lightning Carrier shall consist of two conductors such that one is coaxially placed about the other, each insulated from one another and both insulated from the structure.
2) Each conductor shall be made of electrical grade copper with a cross sectional area of 35 mm^2
3) The insulation segregating the inner and the outer conductors shall be able to withstand a $^1/_{50}$ micro second waves at 250 KV transients to IEC 230 specification.
4) The bending radius of the *E.F.* Lightning Carrier shall not be smaller than 0.6 metres.
5) On one end of the *E.F.* Lightning Carrier, the inner conductor shall be connected to the base of the *E.F.* Lightning Terminal. On the other end of the *E.F.* Lightning Carrier, both the inner and outer conductors are connected and grounded.
6) The *E.F.* Lightning Carrier shall be manufactured with non-flammable materials.
7) The manufacturing of the *E.F.* Lightning Carrier shall comply with ISO 9001/EN29000.

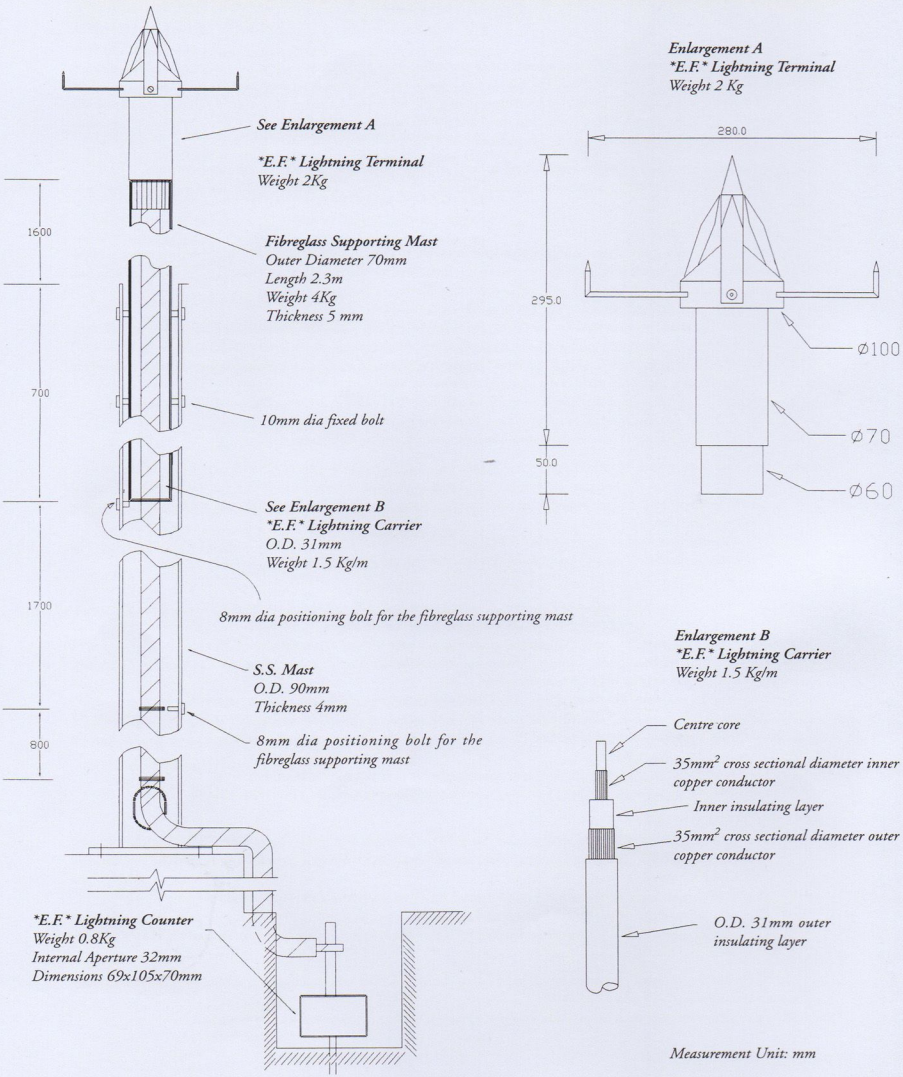
***E.F.* Lightning Counter:**

1) The *E.F.* Lightning Counter shall record the number of times lightning energy passes through the internal aperture of the *E.F.* Lightning Counter. The counter advances by 1 count for each lightning pulse that exceeds 1.5KA and 1.5 microseconds.
2) The *E.F.* Lightning Counter shall be designed to function 24 hours a day every day.
3) The internal aperture of the *E.F.* Lightning Counter shall be 32 mm.
4) The *E.F.* Lightning Counter shall be located such that the counter is clearly visible and accessable.

Earthing:

1) The ground resistance is recommended to be below 5 ohms. Under no circumstances should be ground resistance exceed 10 ohms.
2) The earth resistance shall be measured by the three-pin electrode resistance testing method.

Diagram of the *E.F.* Carrier System of Lightning Protection



Lightning storm is a natural phenomena. From the past to the present, lightning has occurred everywhere on earth, causing enormous damages. Due to scientific research in lightning, lightning protection technology has made significant advancements in the past decades. However, many questions remain to be answered.

It is impossible to provide a guaranteed lightning protection system. Around the world, all the codes of lightning protection reflect this reality. *E.F.* INTERNATIONAL S.A. has spent the past few decades in developing the components of the *E.F.* Carrier System of Lightning Protection providing a reliable and cost effective lightning protection for buildings and structures.

E.F. PATENTS

TERMINAL and CARRIER

AUSTRALIA: 564.606 + 591357
BRUNEI: 273/86 + 59/92
CANADA: 1.196.052 + 1.281.089
CHINA: 87107192.4
EUROPE: EP 009.66.55 + 0267870
HONG KONG: 273 of 1987 + 296 of 1993
INDONESIA: 004080 + 003446
JAPAN: 1651196
KOREA: 98963
MALAYSIA: 170 of 1987 + MY 109717-A
PHILIPPINES: 20584
SINGAPORE: 650/86 + 1169/92
TAIWAN: 29740
THAILAND: 005642
U.S.A.: 4.480.146 + 4.816.611

E.F. TRADE MARK

AUSTRALIA: 246197
CANADA: 199257
CHINA: 165990
HONG KONG: B2848
INDONESIA: 219716
INTERNATIONAL: 605802
KOREA: 146710
MALAYSIA: 70567
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SINGAPORE: B2509/86
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U.S.A.: 755902

The Trade Mark ® of *E.F.* INTERNATIONAL S.A. is registered worldwide.

E.F. Air Terminal is patented worldwide.

E.F. Lightning Carrier is patented worldwide.

E.F. INTERNATIONAL S.A. reserves the right to modify the specifications in this catalogue without prior notice.

If material and/or structural defect is found and proven in the components of the *E.F.* Carrier System of Lightning Protection within one year of the date of purchase, the manufacturer will replace the defective component without charge. The manufacturer or the supplier are not responsible for the cost of shipping, insurance, storage, handling or testing, or any related expenses.

After installation of the *E.F.* Carrier System of Lightning Protection or any portion thereof, the manufacturer or the supplier are not responsible for any damages, due to unusually large lightning events, to any portion of the *E.F.* Carrier System of Lightning Protection or the structures intended to be protected.