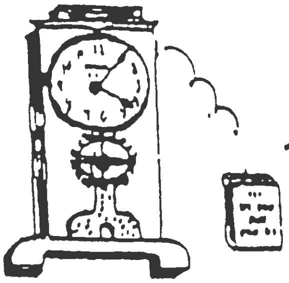
1



The
JOURNAL
OF THE
ELECTRICAL HOROLOGY SOCIETY
Chapter No 78
NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

VOLUME XVIII, #1, MARCH 1993

Fellow Horologists:

The first issue of 1993 brings you the newly updated index of previous Journal issues, as prepared by our member, Bill Ellison, FNAWCC. This index covers Journal articles which appeared in issues from March 1972 through December 1992.

We suggest that the reader review the preliminary information in order to gain a better insight into the manner in which the material is indexed along with some corrections needed to identify 2 issues. A debt of gratitude is due Bill for his efforts on behalf of the chapter... Thanks for this outstanding job!

A frequent question asked of the editorial team covers the subject of meetings... When and where does the Electrical Horology Society meet? The answer requires some explanation... Due to the non-geographical nature of the group, any attempt at meeting would involve only a handful of our membership. As a result, we encouraged the establishment of "branch chapters" who could provide a meeting locale wherever practical. This resulted in the formation of Chapter 125, the MIDWEST HOROLOGY GROUP, meeting in the Chicago area, and Chapter 133, WESTERN ELECTRICS, meeting in the Los Angeles area. Chapter 78, the parent group, holds an informal meeting in the New York area approximately once a year, in one of the member's homes. The best is yet to come, however... Plans were made a few years ago, to provide the facility to meet on a more frequent basis which resulted in an annual meeting at the Ft. Mitchell Regional, as well as the Great Lakes Regional in Dearborn, Michigan. We have additionally requested of the Program Committee of the NAWCC National Convention, a meeting room and advertising in the program to advise interested members, and hope to make this an annual event. In summation, we are trying to provide more frequent and diversified meetings for the future, as conditions permit. Let us hear from you on this subject...

The MART in this issue includes those ads that were newly submitted, with the old ones eliminated as discussed in our last editorial. If you would like an ad in the MART, please advise Harvey Schmidt, our secretary-treasurer, and it's a done deed!

We've also included in this issue, a reprint of a few pages that appeared in the KEYSTONE JEWELER'S INDEX of 1931 that will almost certainly bring on a feeling of nostalgia. Some of the oldies have a charm all of their own that cannot be ignored.

In closing, let us remind the membership that **DUES ARE DUE** again, and if you haven't paid yet, please send it in **NOW**. It's a real nuisance to delete a member's name from the roster for non-payment only to have to put it back again a month or two later!

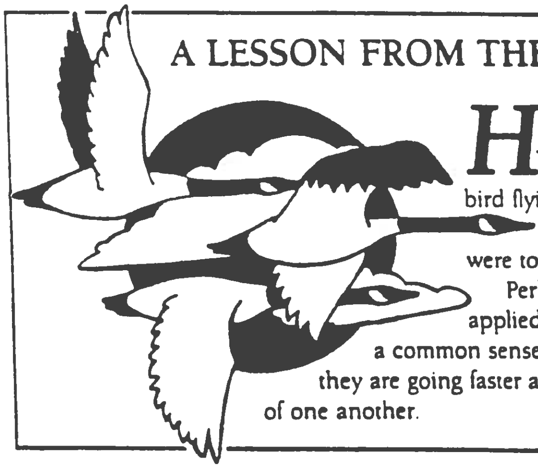
Enjoy this issue... Good reading ahead.

Martin Swetsky, FNAWCC, President
Harvey Schmidt }
Dr. George Feinstein } Co-Editors

FOOD FOR THOUGHT.....

A bit of trivia and assorted useful and useless information...

A LESSON FROM THE GEESE



Have you ever stopped to think about why geese fly in formation? When flying in a "V", the flap of each goose's wings creates an "uplift" for the bird flying behind. The flock thus achieves about 70 percent more flying range than if each goose were to fly alone.

Perhaps this is a lesson from nature that can be applied to all of us. When workers, for example, share a common sense of purpose and direction, they can get where they are going faster and easier by moving ahead on the "thrust" of one another.

Doesn't this hold true for our organization as well? Why not pull together and make our chapter even better... Submit that article for publication, offer some helpful hints, tell us about the shortcut that you discovered, but **participate!**

THE 60Hz FROM THE POWER COMPANY

To many people, the 60 Hz delivered from the power company is just that: 60 Hz. To anyone who has ever monitored the frequency, however, you realize that the frequency is only nominally 60 Hz.

In real life, the power grid is a dynamic system. Every single load that you add to a power system lowers the frequency from the huge industrial loads that measurably reduce the frequency to the smallest loads (night lights, 'PLUG INS,' wall transformers) that are for all practical purposes unmeasurable. The cumulative effects of all these loads going on and off at unpredictable times is what causes the power company to have to 'chase' the frequency continuously

At the central control point of a power company there is some equipment designed to receive one of the several time and frequency standards maintained by NBS, the National Bureau of Standards. NBS transmits the time on several frequencies and using a variety of methods. WWVB transmits data on a 60 KHz carrier wave. WWVB transmits voice and sub-audible data on 5, 10, and 15 Mhz. There are two satellite systems that can be used for precise frequency and time data, the GOES satellites and the GPS (Global Positioning System) satellites.

No matter which method is used at the power company, however, they keep track of two parameters: the instantaneous frequency, and the cumulative time error. The Control Center tries to keep the frequency on 60 Hz within several guidelines. The first guide is that the frequency at no time will go below 58.000 Hz. At this frequency, automatic equipment at the substations will open breakers in an attempt to relieve the system of load.

The second guideline is that at no time will the cumulative time error be behind by more than 10 seconds. This rule has one interesting offshoot:

> If you have a clock that gets its timing from the 60Hz power line, whether the clock is digital or consists of a synchronous motor, that clock is likely to be the most accurate clock you can have!

The reason for this is that even though you may have a digital watch that is accurate to 1/2 second per month, since it has essentially no feedback to any other standard, it can drift by a 1/2 second every month. The clock attached to the power line is going to speed up and slow down on a fairly unpredictable basis, but at no time will it ever be more than 10 seconds behind or 3 seconds ahead! This applies to the time for a one year period, a two year period, or whatever period you select. Always an error of not less than 10 and not more than 3! Of course, to obtain this precision, requires that the power to the clock be uninterrupted power — something that is becoming harder and harder to come by.

The JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY
Chapter No 78
NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

INDEX OF THE JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY

Introduction

The following pages contain the Index of the Journal of the Electrical Horology Society. This Index was developed primarily for use by the collector of electro-mechanical clocks and the intended purpose of the Index is to locate information concerning a particular clock. As a consequence, if a clock is commonly referred to using different names (ie. "Gents Pul-Syn-etic" and "Pul-Syn-etic") articles will be indexed under both names. In instances where companies operated under different names such as is the case with I.T.R., IBM, and Simplex; the information contained in this Index is listed under the name which was in use when the information was produced.

In searching for information concerning a particular clock, users are encouraged to examine the information with the latest date and to then work backwards in time. This is not a criticism of earlier authors, it is just that, over the years, a great deal has been learned about electro-mechanical clocks. Also, many of the later articles used earlier articles as a source of information.

During the period of time from May 1976 until June 1981, Dr. George Feinstein edited a Question and Answer column entitled "The Electric Time Machine." Subjects covered in the ELectric Time Machine are noted in the Index. Information contained in the Electric Time Machine is usually relatively succinct.

Different numbering systems were applied to the Journal over the years. As a consequence, it was decided to use the month and year of the Journal as the means of identifying each Journal. Some issues of the Journal are identified as covering several months. Only the first month is listed in the Index. For example, the masthead for the issue originally identified as Volume XI, Issues #5-6 is dated October-December 1985. In this index, this issue is identified as the October 1985 issue.

For those who have back issues of the Journal available, two issues need to

K

be dated in order to bring them into agreement with this Index. The first is the issue which was mailed out during the first part of 1987 and has no date nor volume identification. The first page of this issue begins as follows:

"Fellow Horologists:

In this, our second issue of the EHS Journal...".

This issue of the Journal should be identified as "April 1987."

The second issue which needs to have a date added follows immediately and is identified as Volume XIV, #1. A date of "January 1988" should be added to this issue.

This Index is based on earlier indexes of "The Journal of the ELectrical Horology Society" prepared by Marty Feldman, the original editor of the Journal for 15 years. Particular thanks are extended to Marty for all his efforts on behalf of electrical horology. Special thanks are due to the editorial committee of Messrs. Martin Swetsky and Harvey Schmidt, and Dr. George Feinstein who have kept the technical and interest level of issues of the Journal constantly high. This was particularly evident as I updated the Index of the Journal and reviewed the articles of the past three years.

Bill Ellison January 1993

INDEX OF THE JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY

MARCH 1972 - DECEMBER 1992

American Electric Clock Makers; Listing of	June 1982
Aron, Herman [Electric Time Machine]	June 1981
Astronomical Regulators, Catalog of; Synchronome	December 1992
ATO (Junghans Transistorized Clock)	December 1988
ATO (Junghans) Technical Description and Servicing Instructions for Single Clocks - Part 1	October 1980
ATO (Junghans) Technical Description and Servicing Instructions for Single Clocks - Part 2	December 1982
ATO 1000-Day Clock; Technical Analysis of	December 1982
ATO Battery Electric Clock; Description and Catalog	August 1980
ATO Cathedral Mantel Clock; Photograph of	June 1983
ATO Regenerative Pendulum System	December 1988
ATO Set-Up Instructions (In French)	December 1977
ATO [Electric Time Machine]	August 1976
Automatic Electric Clock Co. (Same as American Clock Co.)	February 1980
Automotive Electric Clocks	October 1985
Barr Clock Escape Wheel Drawings	December 1982
Basic Electricity as Applied to Horology	June 1980
Battery Building Supplies (ca 1920)	October 1990
Battery Eliminator Schematic	November 1974
Battery Instructions for the Operation of Exide Cells	February 1989
Battery Testing; Techniques and Equipment	December 1978
Battery, How to Rebuild Dry Type (1895)	October 1990
Battery, Metallic Galvanic made by "Eagles"	October 1990
Battery; Copy of Cardboard Outside Cover	December 1980
Beat Amplifier and Inductive Pick-Up for Repair - Helpful Hint	October 1990
Beat Amplifier Construction	October 1976

Hamilton Sangamo Electric Clock Service Manual	December 1979
Hansen Signal System (Clock) Catalog	December 1989
Hayden Century Clock, Description of (July 1896 Article)	April 1983
Herschede Electrically Wound Clock Instruction Book	May 1991
Hipp Contact System; Master Clocks Using - Part 1	December 1977
Hipp Contact System; Master CLocks Using - Part 2	August 1978
Hoggson Patent Clock; Description of	September 1974
Holtzer-Cabot Electric Company Master Clock Inst.-Part 1	June 1981
Holtzer-Cabot Electric Company Master Clock Inst.-Part 2	August 1981
Hope-Jones, F.; Lecture on Free Pendulum Clocks	December 1992
Howard Clock Repairs & Maintenance; Listing of Charges	May 1991
Howard Electric Master CLock Catalog (ca 1918)	March 1990
Howard Model 89 Self-Winding Master Clock	October 1978
IBM (ITR) Type 25 Master Clock Parts Manual - Part 1	December 1980
IBM (ITR) Type 25 Master Clock Parts Manual - Part 2	April 1981
Imperial Clock Corporation Advertising	April 1986
Imperial Electric Clock Co. Advertisement	December 1990
Improvements to Astronomical CLocks; Aked, Charles K.	May 1991
Index of "Model Engineer" Articles (Complete)	April 1973
Index of "Model Engineer" Articles (Partial) - Part 1	December 1972
Index of "Model Engineer" Articles (Partial) - Part 2	February 1973
Index of Electric Clock Patents - Part 1	January 1987
Index of Electric Clock Patents - Part 2	April 1987
Index of Electric Clock Patents - Part 3	July 1987
Index of Electric Clock Patents - Part 4	January 1988
Index of Electrical Horology Articles in the "American Horologist and Jeweler" 1941-1975	October 1979

Listing of Clock Literature at the Franklin Institute	August 1976
Magneta Clock Manual - Part 1	December 1982
Magneta Clock Manual - Part 2	February 1983
Magneta Clock Manual - Part 3	April 1983
Magneta Clock Manual - Part 4	June 1983
Magneta Electric Clock System	November 1974
Magneta Master Clock; Description of	November 1974
Magnetic Clock Escapement; Technical Description of	February 1980
Measurement of Time; by Konstantinov (Describes Fedchenko Astronomical Clock) - Part 1	May 1977
Measurement of Time; by Konstantinov (Describes Fedchenko Astronomical Clock) - Part 2	October 1977
Mercury Switch for Pendulum Control; Article Describing	February 1984
Milliammeter for Repair; Helpful Hint	October 1990
National Self-Winding Clock Company Advertising	July 1986
National Self-Winding Clock Company Movement Photograph	March 1977
National Self-Winding Clock Company; Description of Clock	September 1974
National Self-Winding Clock Company; Description of Mvt.	November 1974
National Self-Winding Clock Company; Listing of Patents	February 1974
NAWCC 1992 National Conv. Exhibit & Souvenier Book	September 1992
New York Standard Watch Company; Advertisement	December 1990
New York Standard Watch Company; Advertising and Prices	June 1980
New York Standard Watch Company; Movement Photograph	March 1977
New York Standard Watch Company; Reprinted from the NAWCC Bulletin - February 1961, Volume IX, Number 8	April 1975
Niagara Clock Company [Electric Time Machine]	August 1976
Patent: #256,256 (Absurd Alarm Device)	August 1978
Patent: Crane, A.S.; #301,569 (Electro-magnetic Clock)	April 1987

Patent: Davis, W.M.; #120,185 (Electro-magnetic Clock)	August 1978
Patent: Dickinson, S.C; #346,094 (Electric Clock Mvt.)	December 1988
Patent: Drawbaugh, D.; #367,898 (Magnetic Clock)	January 1988
Patent: Ethridge & Eastman; #536,962 (Mercury Switch Applied to Electric Winding Mechanism)	April 1982
Patent: Farmer, M.G.; #9,279 (First U.S. Patent for an Electro-mechanical Clock)	January 1987
Patent: Fenner, R.E.; #345,292 (Electric Clock)	April 1977
Patent: Fisher, S.; #555,313 (New York Standard Watch Co.)	April 1978
Patent: Gerry, J.H.; #405,089 (Electric Clock)	October 1991
Patent: Grregory, Fred I.; #535,370 (Striking Clock)	October 1990
Patent: Hall, A.; #11,723 (Early Electric Clock)	April 1978
Patent: Kennedy, S.A.; #71,624 (Electric Clock)	July 1977
Patent: Kennedy, S.A.; #71,624 (Electric Clock)	April 1986
Patent: Kennedy, S.A.; #99,321 (Electric Clock)	July 1977
Patent: Kennedy, S.A.; #99,321 (Electric Clock)	January 1986
Patent: Menns & Dudley; #457,030 (Mercury Switch)	June 1982
Patent: Pond, C.A.; #308,521 (Self-Winding Clock Co, 2 Pole Winding Motor)	March 1977
Patent: Rempe, H.; #737,019 (Rempe Electric Clock)	May 1976
Patent: Sheehy, R.J.; #179,873 (Printing Chronograph)	August 1984
Patent: Thompson, W.H.; #1,060,380 (Seth Thomas Electric)	February 1981
Patent: Tiffany, G.S.; #754,397 (Tiffany Never-Wind)	April 1976
Patent: Tiffany, G.S.; #754,398 (Tiffany Never-Wind)	August 1975
Patent: Vande Plancke and Vande Plancke; #446,801 (Electrically Impulsed Clock)	February 1989
Patent: Vande Plancke and Vande Plancke; #446,801 (Electrically Impulsed Clock)	May 1990
Patent: Warren, H.E.; #1,160,346 (Warren Type C Clock)	February 1977

Self-Winding Clock Company; Photograph of a Desk Model	June 1983
Self-Winding Clock Company; Photograph of "F" Movement	June 1983
Self-Winding Clock Company; Photo of Early Single Pole Motor	June 1983
Self-Winding Clock Company; Photograph of Round Case Clock	June 1983
Self-Winding Clock Company; Photograph of the 2 Pole Motor	March 1977
Self-Winding Clock Company; Photograph of Type A Movement	April 1982
Self-Winding Clock Company; Removing and Installing Movements	June 1975
Self-Winding Clock Company; Styles for Hands	December 1984
Self-Winding Clock Company; Wiring for Metal Cased Clocks	December 1981
Self-Winding Clock Company; Wiring for the Type "C" Motor	December 1981
Sempire Clock Company (Electrometers); Advertising and Prices	December 1981
Sempire Clock Company (Electrometers); Operation of the Switch	December 1988
Seth Thomas Electric Clock Movements; Catalog of	February 1981
Shortt, W.H.; Shortt-Synchronome Clocks	December 1992
Shortt-Synchronome Clocks, Locations of	December 1992
Simplex Time Recorder Company; Installation, Setting, and Programming Units	December 1984
Simplex Time Recorders (IBM) Production Dates vs. Serial No.	December 1980
Slave Clock Timing Signal Distribution Panel	August 1975
Standard Electric Time Company (Modern Catalog)	May 1991
Standard Electric Time Company; Industrial Plant Catalog-Part 1	April 1986
Standard Electric Time Company; Industrial Plant Catalog-Part 2	July 1986
Standard Electric Time Company; Cleaning and Oiling Movements	December 1989
Standard Electric Time Company; Instal. Instructions - Part 1	February 1979
Standard Electric Time Company; Instal. Instructions - Part 2	April 1979
Standard Electric Time Company; Master and Slave Clocks	April 1980
Standard Electric Time Company; Parts List for 60 Beat Master	October 1976

Standard Electric Time Company; Wiring Diagram June 1984

Standard Electric Time Company; Wiring Schematic November 1974

Standard Electric Time Faraday; Catalog May 1991

Stromberg Division, General Time Corp.; Synchronous Master Clock - Model 50 Parts Catalog - Part 1 August 1982

Stromberg Division, General Time Corp.; Synchronous Master Clock - Model 50 Parts Catalog - Part 2 October 1982

Stromberg Electric Clock Company; 60 Beat Autoset Movement August 1983

Stromberg Electric Clock Company; 60 or 120 Beat Master Mvt. August 1976

Stromberg Electric Clock Company; Drum Program Parts List - Model #6C October 1982

Stromberg Time Corporation; Autoset Installation and Operating Instructions - Part 1 August 1981

Stromberg Time Corporation; Autoset Installation and Operating Instructions - Part 2 October 1981

Stromberg Time Corporation; Unispeed Recorder Model 9 Installation and Directions for Using October 1981

Synchronome Astronomical Regulator Clock; Leaflet 1912 March 1991

Synchronome Clock Catalog July 1992

Synchronome Clock Catalog December 1992

Synchronome Clock Installation and Operating Instructions July 1992

Synchronome Clock; General Principles of December 1992

Synchronome Master Clock; Installation and Servicing of (Repeat of July 1973 Article) April 1980

Synchronome Master Clock; Installation and Servicing of July 1973

Telechron Clocks, Development of; Warren, H.E. April 1992

Telechron Master Clock Type A; Installation Instructions April 1992

Telefonbau & Normalzeit of Berlin (Electric Time Machine) June 1981

Telsa Electric Clock; How to Make One (ca 1920) December 1990

Tiffany Electric Manufacturing Company Advertisement December 1990

18

Western Union Telegraph Company; History of Time Service	December 1981
Western Union Time and Messenger Service	February 1981
Zenith "Calora" Clock Manual - Part 1	February 1982
Zenith "Calora" Clock Manual - Part 2	October 1982

--- MART ---

All MART Ads are FREE, Send copy to the attention of the Editor: Harvey Schmidt, 75-80 179th St., Flushing, NY 11366. Limit 3 lines.

WANTED: HOROLOGICAL LITERATURE, Repair info, Catalogs, etc. for the Journal
PORTESCAP Secticon Clock or Movement. (718) 969-0847
Harvey Schmidt, Editor, 75-80 179th St., Flushing, NY 11366

Junker EARLY BATTERY CLOCKS, Movements, Parts, etc, send details.
Martin C. Feldman, 6 Stewart Pl., Spring Valley, NY 10977

Motor for a "CALCULAGRAPH" clock. (This clock was made by the CALCULAGRAPH CO., New York. It was used for timing telephone calls). Paul Hopkins, 2717 Millwood Rd., Birmingham, AL 35243

Pendulum support casting, suspension spring, pendulum rod, and bob for a 1 second GENTS
Richard B. Pridham, 10402 Bellman Ave., Downey, CA 90241

Plans, drawings to build a SETH THOMAS No. 2 Case
K. C. Denney, 3819 E. 55th Street, Tulsa, OK 74135

F.L. GREGORY (SEMPIRE) Movement, & like to know if you have a clock with "F.L. Gregory Clock Company, Electric Gravity, Chicago, Illinois" on dial. Early Bipolar Motors, & Early Electric Fans. A complete DARCHE Medical Clock as shown on pg. 19 of "150 Years of Electric Horology" (817) 267-9851
Steve Cunningham, 3200 Ashland Dr., Bedford, TX 76021

N.Y. STANDARD WATCH CO. movement, short pendulum type (approx. 120 beat), any repairable condition. Would also like dial, hands, and pendulum if available. (713) 554-7387
Kenn L. Koerber, 105 Royal Dr., League City TX 77573

ELECTRO-MECHANICAL CLOCKS, preferably fancy cased and exposed pendulum clocks. Elliot Siegel, 103 East Neck Road, Huntington, NY 11743, Day or Night (516) 541-2400 or (516) 351-5869

MART (continued)

REPAIR: ALL EARLY BATTERY CLOCKS Specializing in BULLE using orig. parts. Martin C. Feldman, FNAWCC, 6 Stewart Pl., Spring Valley, NY 10977

FOR SALE: TIFFANY NEVER WINDS, Double Contact, Wood & Dome Cases; Single Contact, Dome Case.
Harvey Schmidt, 75-80 179th St., Flushing, NY 11366 (718) 969-0847

Repair Parts for TIFFANY NEVER-WIND Clock Co., CLOISTER Mfg. Co., & NATIONAL MAGNETIC Clock Co.
David Lee, P.O. Box 171, Knox, NY 12107

REVERE Electric (Herschede) Grandfather Clock, 7 ft. Mahogany Case w/glass 3 sides. 9 tubes, 3 chimes. Circa 1928. $900.00
(201) 652-1025 Mon, Wed, Fri. 9am to 9pm, other 9am to 5pm.
Roger Sanford, 12 Godwin Plaza, Midland Park, NJ 07432

Hi-Grade Electromechanicals such as: MONARCH with Mercury Pendulum, MERCER Chronometer in a Carved Mahogany Case, Early Wall Regulator in Carved Mahogany Case (6 ft.) maker unknown, etc. (617) 599-4171 or 598-3881, Evenings and Weekends.
Steve Lefkowitz, 13 Puritan Park, Swampscott, MA 01907

RADIOCHRON, scallop top cathedral style tube radio with built in manual start clock on matching table. Radio and clock work, $200
Terry Willett, 10306 Ky 815, Utica KY 42376, (502) 785-4808

SYNCHRONOME (Hope-Jones) Master Clock, as on p. 72 of "150 Years of Electric Horology" w/ separate slave & multiple relay for control of large system of slaves. Synchronome Master Clock w/ Hipp toggle to maintain pendulum, provides impulses at 1, 5, & 30 sec. w/ one usual Hope-Jones slave. ITR (predecessor of IBM) elect. rewound master clock w/ mercury pendulum. (206) 842-5835
Alan Seymour, 10847 Bill Pt. Bluff, N.E., Bainbridge Is. WA 98110

20

ELECTRIC CLOCKS EXPLAINED

Synchronous, Sub-Synchronous, Motor Wound and Battery Operated Types Described

By JOHN J. BOWMAN, Technical Editor THE KEYSTONE

Electric clocks for household and general use have progressed to a point where it is foolish to question either their practical value or their commercial importance. The time is past for jewelers to debate whether to sell these new timepieces or to ignore them. The way to profit now lies in studying how to take advantage of the favor with which the public has come to look upon the clock that never needs winding.

Overdone conservatism can be the cause of loss, as when the English watchmaking industry lost its world-supremacy by refusing to move with the times and adopt machinery. Lessons such as this should be remembered in our attitude toward electric clocks. It is the part of wisdom for the retail jeweler in America now to learn all about electric clocks; to become able to advise buyers helpfully about the various types, makes, and grades, and thus to remain in the clock business, and not stand by and see the most commercially important part of it go into the hands of dealers in other lines.

An earlier idea was that electric clocks might do away with the need for the jeweler's clockmaker. But the stability of demand for striking and chiming, in electric clocks; and the latest trend in designing the mechanism even of non-striking electric clocks, emphasizes that the clock repair service of the jeweler's shop should be continued. This gives the jeweler an advantage over others who offer electric clocks for sale. The long established habit of going to the jeweler for clocks—both service and sales— can in worth-while measure be maintained, if the jeweler will make it his business to know electric clocks, as he has long known the older kinds.

The purpose of this article is to present an outline of information about the electric clocks that are in the market today; to clarify what may seem a somewhat vague and confused mass of terms; and to furnish a reliable starting point from which the jeweler can keep track of and understand the new inventions and products that are coming into the market continually. This purpose suggests a brief historical introduction of the subject.

Whatever part electricity plays in timekeeping, it always works through the agency of its inseparable companion, magnetism. And it may surprise many to learn that the first use of magnetism in connection with timekeeping, was made as long ago as during the lifetime of Nicolas Grollier, who was born at Lyons, France, in 1593. This ingenious man made clocks that were probably, by some of neighbors, thought to be works of the devil. In one of these he fastened a horseshoe magnet to the center arbor of a clock concealed inside a cabinet. Above the cabinet, a frame held suspended a basin of water, with the hours marked around its rim. A small figure of a turtle, when placed to float on any part of the water, would mysteriously swim and align itself pointing its nose at the correct time! Within the turtle's body, of course, was the bar of the clock's magnet. The nature of this work may forbid taking it so seriously as to say that it was a true ancestor of the electric clocks of today. For this, we must come down two centuries from Grollier's time, to the year 1843. Then Alexander Bain, a Scottish philosopher, made and patented a pendulum which used electrically induced magnetism as motive power. No practical use was made of Bain's invention; and for nearly the next forty years little importance was attached to electric clocks. But the end of that period was the beginning of the present era, during which electrical timekeeping inventions have been coming into practical use at a pace that is almost bewildering.

Alternating Current Clocks

Synchronous, Self-Starting

Telechron — Revere, Strike
General Electric — Chelsea

Synchronous, Manual-Starting

Elm City (New Haven) — Lux
Gilbert — Herman Miller

Sub-Synchronous, Self-Starting

New Haven-Westinghouse — Waterbury

Sub-Synchronous, Manual-Starting

Hamilton-Sangamo, "Synchronous," Time
Seth Thomas, "Electric," Time
Sessions — Hammond
Manning-Bowman — Radiochron

Electrically Wound

Hamilton-Sangamo, Strike, also Non-Strike
Seth Thomas, Strike, also Non-Strike
New Haven-Westinghouse, Strike and Alarm, with Sub.-Synch. Time
Herschede, Strike — Waterbury, Time
Herman Miller — Franklin

Battery Clocks

Poole — Herman Miller

NOTES: Words in "—" are on dials of clocks to indicate type. The term "strike" includes chime

See text for explanation of above table

Fig. 1

Periods of development in any art cannot usually be defined by dates; and so in this; it is enough to say that the present era of electric clocks began about fifty years ago. But during the first forty years of this time, most of the inventions introduced were local systems of master and secondary clocks in which the latter were simple electromagnetic "minute-jumpers"; program clock systems to ring electric bells at stated times in various rooms of a building; local systems of clocks wound by motors and set at intervals by an electromagnetic cam; and various other devices for special and scientific uses. It is characteristic of this forty years that the electric clocks which proved successful then, were practically all for either scientific or institutional uses. The attempts then made to introduce electric clocks for use in homes, which is commercially the most important part of the clock business, were generally failures. Whatever technical defects the clocks may have had; and whatever business shortcomings in some of these enterprises may have contributed to the general record of failure, it is perhaps also true that the time had not yet arrived when the public was psychologically ready to buy electric clocks for general use.

The real beginning of the present popularity of the electric household clock came about ten years ago with the introduction of the Telechron clock. The outcome of this seems to have been, in the language of the snappy salesman, making the American people "electric clock-minded."

So the electric clock is here to stay; and in the belief that its sale and upkeep offers a profitable opportunity for jewelers, THE KEYSTONE is presenting this article on the subject. Our aim is to outline the essentials. That is thought to be more needed now than a detailed treatise. Each manufacturer can furnish details of his own clocks; while our purpose is to show all of the principal types analyzed and compared with each other.

You are asked first to examine the list at Fig. 1. In this are grouped as five types, all of the clocks that are run by plugging their connections into the alternating current now delivered by most of the power companies. In the list will be found the clocks of the principal makes now marketed. It does not include assembled clocks marketed by merchants who are not manufacturers, nor brands of makers now out of business. Nor does it include a few makes which have merit but small production, not outside of merely local territory in each case. The list is limited to clocks which have nation-wide distribution.

The first thing to observe is that there are listed two kinds of clock motors: synchronous and sub-synchronous; and that each of these kinds is made in two subdivisions: self-starting and manual-starting.

The right beginning for an explanation of how these types of motors differ from each other, will be to explain the working of one of them; and this will be the Telechron, as it was the first to enter the field as a clock synchronously driven by alternating service current.

Synchronous Motor Clocks

The word "synchronous" means a condition in which two or more things move in the same time with each other—all moving, in one sense, at the same speed. A synchronous motor moves in time with the generator that furnishes the current which keeps the motor going. Large synchronous motors have long been used for various purposes. The idea of designing a small synchronous motor for the special purpose of moving clock hands is of comparatively recent development. Its usefulness is based upon the fact that alternating current delivered for electric lighting and other purposes can be controlled in its speed or

ELECTRIC CLOCKS EXPLAINED (*Continued*)

rate of flow, so as to provide accurate timekeeping by simply "plugging in" synchronous motor clocks to the service current. How the clock works will be explained by referring to the illustration at Fig 2.

At I and I' are shown the wires connecting the clock motor with the service current. The current flows through the coil B and magnetizes the steel field bars A. These are cut through and a circular opening made in them at J. Into this opening is thrust the neck of a bottle-shaped case K made of thin sheet brass. This case contains the moving parts of the motor, and is closed and sealed with solder. The shaft H passes through a packing-box to the outside of the case, to turn the clock dial-train and hands.

Pivoted inside of the neck of the case, is the "rotor" G which is an arbor carrying

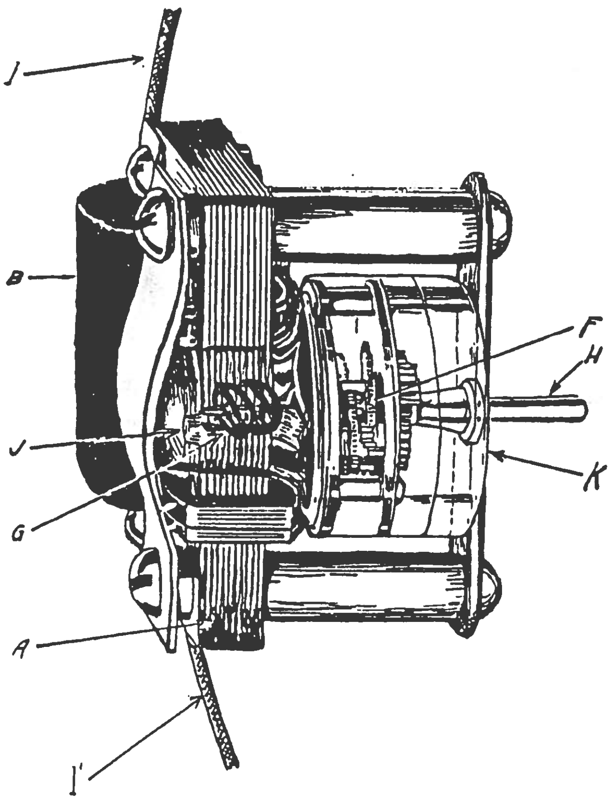


Fig. 2. Detail of Telechron synchronous motor clock

a combination of magnetized steel bars and rings. These are acted on by magnetism induced in the field bars A by the current flowing through the coil B. The magnetism passes through the brass of the case neck and "takes hold of" the rotor G. The magnetism—the "magnetic field"—rotates and carries the rotor around with it at synchronous speed. The speed of rotation of the magnetic field that turns the rotor, corresponds to the rate at which the generator makes current at the power plant. In a "fully synchronous" clock motor, on a 60 cycle current the rotor would have to make 60 turns in a second of time. To grasp this, just reflect that it is equal to 12 turns while a watch balance makes a single beat. This speed must be reduced, first, to the speed of the second-hand of the clock, dial, or one turn per minute, as that is the most rapid motion that is of any use in everyday timekeeping. This reduction is accomplished by a train of wheels and pinions F, the action of which terminates at the motor terminal shaft H, which makes one turn per minute, and to which the second hand is attached. From the terminal shaft, further reductions of speed are made by gearing, to move the minute-hand one turn per hour, and the hour-hand one turn in twelve hours.

A basic difference should be noted between the trains in synchronous motor clocks and the trains in spring-driven or weight-driven clocks. In the latter, the speed of the gearing is least, and the power greatest, at the end of the train where the power is applied. In the synchronous motor clock these conditions are reversed.

Since the principal moving parts of the Telechron motor are inside a sealed metal case, lubrication is effected by a supply of oil that is injected into the case before it is soldered shut.

How Current-Time Is Controlled at Power Plant

Now shall be explained what seems to most watchmakers and jewelers to be the great mystery of synchronous motor time transmission. That is the means used at the power plant to make the current carry accurate time. This is really quite simple in principle and in practice.

Any number of synchronous motors in an alternating current circuit will move at the same time-rate as the current generator moves. Owing to the type of machine which generates alternating current, this current is made in throbs or pulsations that move alternately in opposite directions through its circuit. The pulsations are so close together that when seen, as in the glow of an incandescent lamp, they cannot be distinguished from one another. Yet each starts as nothing, rises, decreases to nothing, then in the opposite direction does the same. Each two pulsations, each pair in opposite directions, are called a "cycle" —a word meaning a complete rotation of events of any kind. So when an electrical current is described as "alternating 60 cycles," that means a current that alternates its direction at a speed of 60 times during each second of time. This speed depends upon how fast the machine that generates the current is made to run. If the generator is driven by a steam engine, then when more steam is turned on the engine will run the generator faster, and the current will be made at a faster rate—more cycles per second. In a hydro-electric plant, if more water is turned into the turbine it will run the generator faster, and the generator will make current at a rate of more cycles per second. It is easy enough for the men at power plants to alter the speed of their machines from time to time so as to keep them running at desired speed.

Now see how service current is controlled in speed of cycles so as to serve to run clocks driven by synchronous motors at the exact speed to indicate correct time. What is needed is some means of continually comparing the speed of the current generators with the timekeeping of an accurate clock. For this purpose the Telechron master clock, shown in Fig. 3, is largely used.

This master clock is a very finely made clock with Graham dead-beat escapement and seconds pendulum, keeping very accurate time. On this clock is a dial which has two hands turning from the same center. One hand carries the accurate time of the master clock; the other hand is run by a synchronous motor clock moved by the current that is made by the generator right there in the power plant—the generator making the current sent out to consumers who have their electric clocks connected in this same circuit. As long as the generator is moving at the correct speed of 60 cycles per second, the master-clock hand and the synchronous motor clock hand will travel together. Should the generator slow down, the fact will be known by the power plant operator when he sees the motor clock hand fall behind the master clock hand; then he will turn on more steam or water, to increase the speed of the generator, until the two hands again travel together—or vice versa. In this way the current is kept at controlled speed, and all the clocks on the circuit—be it thousands of them, and many miles away, are kept on time.

Master Clock the Source of Accuracy

When synchronous electric time distribution was introduced, the mistake was prevalent among jewelers of thinking that some mysterious magic had been discovered whereby electricity has the innate property of keeping accurate time. But reading the explanation just given should make it clear that the timekeeping is done by the master clock; and that the generator, and the current it makes, are no more capable of keeping time than is a train of gearing, or a pair of clock hands, alone. The only thing in the entire system between the engine or turbine and the clock hands in the owner's home, that is worthy of being called a timekeeper, is the **pendulum** of the master clock. Everything else is under its rule; it has many servants in the other parts of the system, but the pendulum is the master. In the strictest sense, it is incorrect to say that synchronous motor clocks are clocks at all! They are secondaries to the master clock at the power plant. Think of what depends upon the master clock! It may control thousands of synchronous clocks; should it err, its fault would be multiplied by thousands. Then for its accuracy it should receive manifold appreciation. In contemplating the marvels of synchronous electrical time distribution, one is inspired with deep respect for the genius of George Graham, whose escapement and pendulum, which he invented two hundred years ago, is still the best means known for use in controlling and making reliable time-tellers of the far-flung myriads of motor clocks of this modern addition to horology.

"Self-Starting" and "Manual-Starting"

What remains to be explained under the head of Synchronous Clocks is the difference between these as to "self-starting" and "manual-starting."

It hardly needs saying that a synchronous motor clock will stop every time there

ELECTRIC CLOCKS EXPLAINED (*Continued*)

is a cessation of the electric current that keeps the clock going. When this happens, the clock will remain stopped as long as the current remains interrupted. When current comes on again, all of the clocks listed in Fig. 1 as "Synchronous, Self-Starting," will start running again, and will continue running, but will be slow an amount equal to the duration of the current interruption, until reset to correct time. A signal spot on the dial turns red whenever there is a current interruption; this remains red after the clock starts, to show that the clock needs setting to correct time; after the clock is set, the signal changes to the color of the dial. This warning-device comprises a pivoted rod with a turn-button on one end, protruding from the clock case; on the other end, back of the dial, is a metal plate half of which is painted red, the other half painted the color of the dial. On the rod, above the motor field-magnet, is an iron blade which is held against the magnet only while the latter is magnetized by the current which runs the motor. If the current stops, the blade is let go, and then the weight of the two-colored plate allows its red half to drop into position to be seen through the hole in the dial. After the clock is reset after stoppage, the signal is to be turned by hand until the red disappears; this at the same time brings the blade into contact with the field magnet, which holds the signal at dial-color until the next current interruption.

In the clocks listed in Fig. 1 under the heading "Synchronous, Manual-Starting," an interruption of the current is shown by the stoppage of the clock; this is quickly noticed when the very conspicuous second-hand stands still. To start the clock again, a lever is pushed, or a button is turned, which provides the impulse to start the motor, which will then continue running until there is another current interruption.

After the customer is told the difference between all kinds of electric clocks, he will be able to decide which comes nearest to his needs. This may be an electrically wound clock, a synchronous clock, a battery clock, or even a clock which needs to be wound by hand. The jeweler's opportunity in this is to remain the man who knows the clock business in all of its branches—knows it so well that he can give good advice, and so is the man the public will prefer to buy of. This is the argument for studying electric clocks as one part of the whole clock subject.

Sub-Synchronous Motor Clocks

In Fig. 4 is shown the Hamilton-Sangamo sub-synchronous motor clock, in which the rotor is indicated at B. This, as in the synchronous motor, is the magnetic part on an arbor which rotates between the magnetic poles of the field magnets. From the rotor shaft is delivered the power which keeps the clock hands moving. The term "sub-synchronous" indicates a motor in which the rotor moves less than 60 turns per second.

Now the question may arise "how can synchronous and sub-synchronous motors, in which the rotors turn at different speeds, both be used on the same current to keep time alike?"

In order to understand how this is possible, it must be borne in mind that what makes synchronism between the master clock, the generator, and the clocks in the circuit, is the fact that alternating current is throbbing in the circuit at a definite time-rate—say, at 60 cycles per second. Synchronism depends on that, and not on generator and motor rotors running at the same number of turns per second.

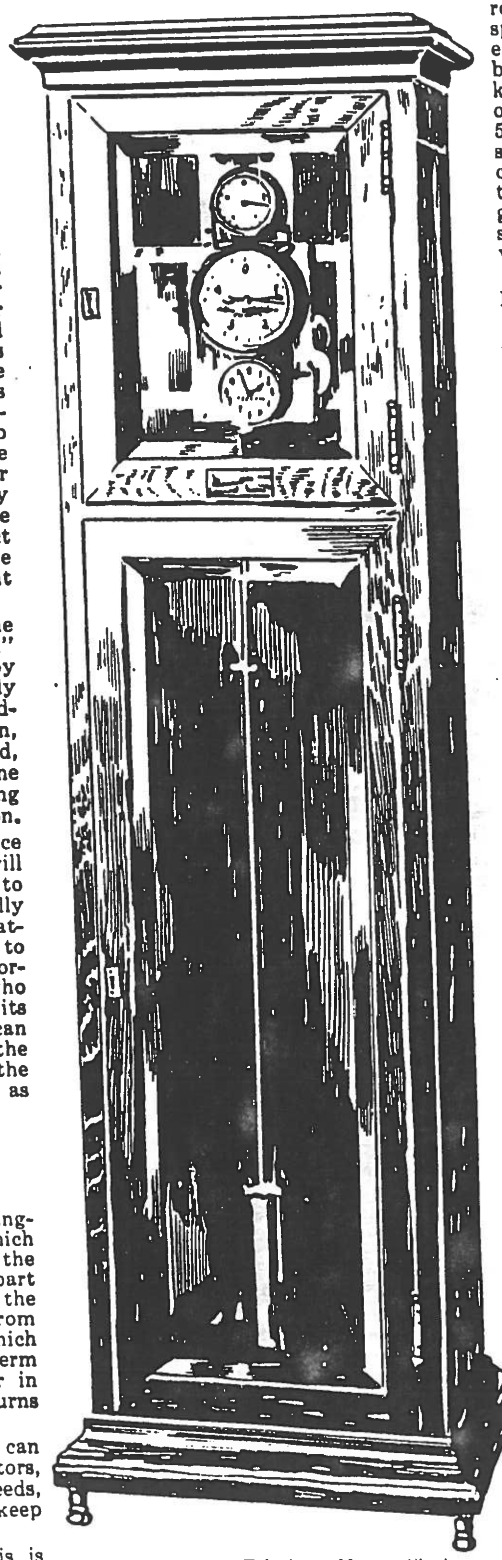


Fig. 3. The Telechron Master Clock with Graham escapement and pendulum

Fast and Slow Rotors

Imagine an electrical circuit with a number of clock motors connected together in it. In some of the motors the rotors are turning fast, and in some, slow. But the slow rotors have less gearing, and the fast rotors have more gearing, to reduce the speed, between the rotor and the hands in each of the clocks. Now the current throbbing at the rate of 60 cycles a second is keeping all of these clocks running alike, on time; but if the current rate drops to 59 cycles a second, all the clocks will run slow; or if the current rate rises to 61 cycles, all the clocks will run fast. It is in this way that synchronism exists between generator and motors; not in similarity of speed or number of turns per second in the various rotors in the circuit.

Number of Poles Govern Rotor Speed

In designing motors, increasing the number of magnetic poles which exert the force that turns the rotor, will result in a slower running rotor. For illustration, let us say that the rotor must turn so that a point on it will pass a pole every time a cycle of current is completed; imagine there is only one pole to be passed; then the rotor must make an entire turn each cycle, and must turn very fast to travel so far in such a short time. But if more poles are distributed around the circle of travel, then the point on the rotor need not go so far, therefore will not go so fast, in order to pass one pole during each cycle of time. So the difference between synchronous and sub-synchronous motors is that the latter have more magnetic poles acting to pull on and turn the rotor, which consequently runs at a slower speed.

The reason for desiring slower speed in the rotor is so that the bearing between it and the clock hands may be lessened and simplified, and to secure the additional mechanical advantage of avoiding high speed in the moving parts.

Synchronous and Sub-Synchronous Clocks Alike in Principle

So it is seen how an alternating current can be used so that its pulsations will drive a number of differently designed mechanisms, each of them in its own way translating the current into clock time alike at all of the dials. Now there is no difficulty in understanding that the clocks known in the trade as synchronous, and sub-synchronous, are both synchronous in the fullest sense of the word; and the difference in terms is really used to distinguish two different members of the same family.

Referring again to the list at Fig. 1, it will be seen that, the same difference as to self-starting and manual-starting exists in sub-synchronous as in synchronous clocks. The explanation of this was made in describing synchronous clocks, and need not be repeated here. But in it the New Haven - Westinghouse sub - synchronous clock, the starting arrangement is a combination of self-starting and manual-starting which calls for explanation. There is a pointer on the dial with a scale of one, two, and three minutes. If the pointer is set at three minutes, then the clock will be self-starting until all stoppage totals three minutes; then the clock will stop; this will be notice to start it going, by hand, as in purely manual-starting clocks. The object is to eliminate stoppage on brief interruptions, and so that the owner will know that his clock, if running, cannot be more in

ELECTRIC CLOCKS EXPLAINED (*Continued*)

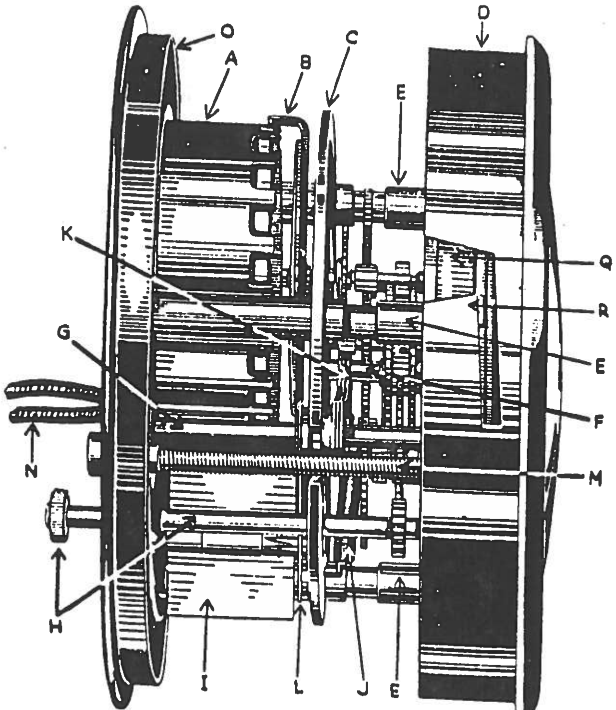


Fig. 4. Detail of Hamilton-Sangamo sub-synchronous motor clock

error than he has set it for. He may set it for two minutes, or one minute if he prefers, in which it will be closer to correct time, but would more frequently need resetting, than if set for three minutes total stoppage.

Controlled Current Widely Obtainable

Before quitting the subject of synchronous motor clocks, it should be explained that if one's service current is sent out by the power company at other than 60 cycles rate of pulsation, or "frequency" as the electrician says it, clocks are furnished by all of the manufacturers to run on such currents; the principle is the same; the difference is in the proportioning of the electrical parts in designing the motor.

A large proportion of the alternating current made in the United States is under controlled frequency for time transmission purposes. Power plants wherein there are no master clocks vary in their attention to the matter of uniformity of frequency; some deliver current which is fairly close to 60 cycles rate, and on which synchronous clocks will run closely enough to standard time to satisfy most persons. You can learn the facts applying to your locality by inquiring at the office of the local public utility company.

Electrically Wound Clocks

Clocks in which the motive power is either mainsprings or weights will, of course, continue in use, because there always will be situations in which controlled alternating current for running synchronous electric clocks cannot be obtained. Then there will always be some persons who for various reasons will prefer mechanical to electrical clocks of any kind. But a greater number there are and perhaps will continue to be, who desire the convenience of not having to wind the clock, but object to the chance of its stopping on account of current interruptions; and for these there are clocks driven by mainsprings or weights, but wound by automatic electric motors. The current to run these clocks need have no frequency control whatever, which is another feature fitting them for use in places where synchronous motor clocks would not serve.

In Fig. 5 is shown the Seth Thomas electrically wound strike clock. The descriptive notes on the drawing make it unnecessary to describe the mechanism in the text, and are even more convenient for the reader.

Upon this subject of electrically wound clocks there is less need for lengthy descriptions than in the part explaining synchronous motor clocks, because so much of the mechanism in electrically wound clocks is of a type already familiar to the workmen in our trade. But a few notes on the classification of electrically wound clocks in the table at Fig. 1 are necessary. Among the clocks on this list, as will be seen in the illustration, Fig. 5, the Seth Thomas strike clock employs a pendulum as its timekeeper. The Hamilton-Sangamo clocks, strike and non-strike, employ a lever escapement and a balance of watch type, adjusted to temperatures. The Herschede Company is making a change in the mechanism of some

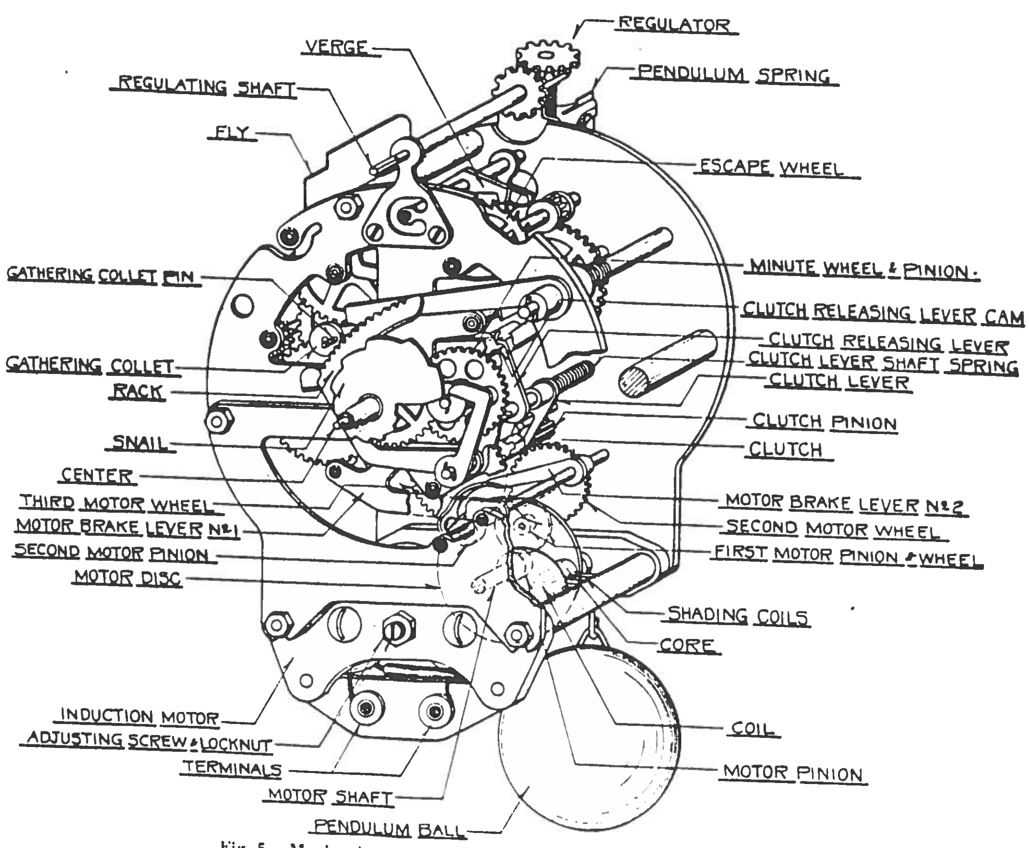


Fig. 5. Mechanism of Seth Thomas electrically wound strike clock

ELECTRIC CLOCKS EXPLAINED (*Continued*)

of their line, and their listing applies to clocks now in the market only.

The reader is reminded that this article is confined to clocks for general use, such as are sold by jewelers, so there do not appear on the list in Fig. 1 some electrically wound clocks which are sold and serviced by their makers only, for special purposes, and which therefore do not concern the jewelry trade.

Clocks Run on Battery Current

There has always been a demand for a clock that runs by electricity so as to avoid the need for winding, but which yet can be used in places where no service current is available. This, of course, calls for a clock in which a battery supplies the current. There are battery clocks on the market not very widely nor actively sold, and therefore outside the sphere of this article; but an exception to this is the Poole clock, which has for that reason been chosen for description here. The essential mechanism of this clock is shown at Fig. 6. This clock reverses the usual arrangement in which the train, through the escapement, drives the pendulum, because in the Poole clock, the pendulum drives the train through the escapement. The pendulum is kept going by impulses at intervals of about half a minute, by the weight arm 19, Fig. 6. This is raised by an electromagnet (not shown) and kept up by a trigger 22. Whenever the pendulum needs power, the trigger is automatically pulled and the weight-arm drops and its roller 28 presses against the pin 29, which gives an impulse to the pendulum through the crutch 14. The swinging of the pendulum operates pawls, one of which is shown at 16, which moves the wheel 17, which propels the train and through it the hands of the clock. After receiving an impulse, the pendulum, of course, gradually lessens its swing, and after the swing has decreased to a certain point, the pendulum trips a latch which pulls the trigger that releases the weight-arm 19, which gives the pendulum its next impulse.

Repairing Electric Clocks

Engineers may design a thing, and laboratories test it and pronounce opinions on it; but no test is completely reliable except that of actual use. This is as truly applicable to synchronous electric clocks as it is to any other piece of mechanism. These clocks have been used now sufficiently long to know their value for their purpose; but it is yet a little too early in their era, to know from experience all that should be known, in order to write fully upon the subject of repairing them.

An earlier idea, now seen to be erroneous, was that there would be little or nothing to employ the clockmaker in repairing synchronous electric clocks. That

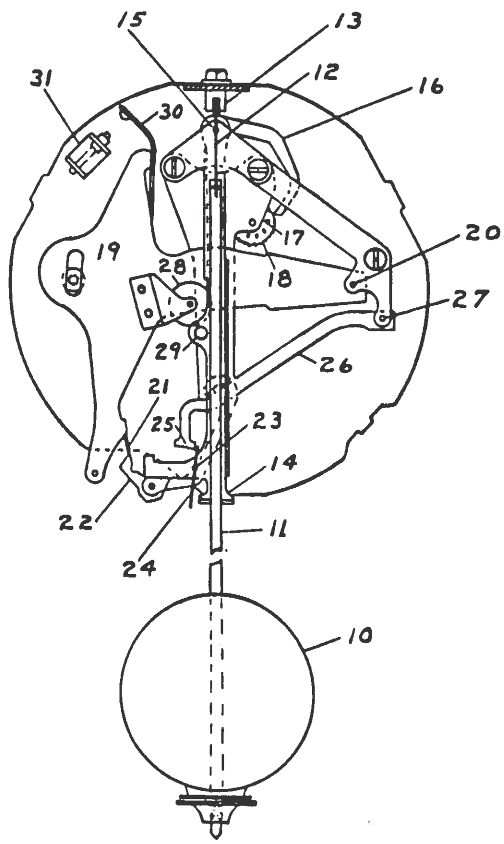


Fig. 6. Mechanism of Poole battery clock

was before the latest types of these instruments came into the field. The earlier clocks are, it is true, little more than small electric motors; their wheelwork, enclosed in a sealed casing in an oil bath, was perhaps expected to run until worn out and then be thrown away; the mechanism was hardly considered subject to repair. But recent developments using slow rotors with unenclosed gearing, are more like the traditional type of clockwork, and may be expected to duplicate it in respect to repairs. Clocks of this kind will not be discarded when parts show wear, but there will be holes to bush, pivots to polish, and other repairs as in the familiar spring and weight clocks which keep us busy now. As to the electrical parts, these are not frictional, and repairs likely to be needed are such things as keeping up connections and minor matters which are not difficult to learn, and which the clockmaker already has more than ample skill to execute.

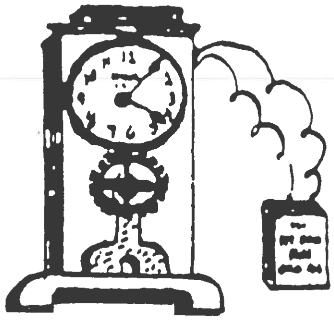
The time will soon be here when sufficient practical experience has accumulated upon the effects of use, to write fully about repairing synchronous electric clocks; and THE KEYSTONE promises its readers to gather this information and present it at the earliest time when it can be made of practical value.

Electrically wound, and battery clocks, have mechanism so much like that in the older type clocks that a competent clockmaker should be able to diagnose and repair their faults without special instruction. The precaution of looking the mechanism over carefully, to make sure of understanding its action, before taking it apart, goes without saying.

Now this sketch-map of our survey of the electric clock field is completed, and will be helpful as a guide to whoever may wish to explore the territory in detail. To do this, he would do well to study the elements of electricity, for which there are good textbooks everywhere. The principles of trains of gearing are already familiar to clockmakers and watchmakers, and these are the same in electric clocks as in all other horological instruments. With the background of this knowledge, there should be made a further study of its practical application, by taking apart and becoming familiar with electric clocks of the various types. Thus can be acquired the knowledge that wins for its possessor recognition as a person of **authority**. Such reputation has the greatest power in sales-building. With it, the jeweler may take advantage of the coming of the electric clock as an exceptionally profitable opportunity.

EDITORIAL NOTE: Due to the rapid changes in the electric clock business the many new concerns entering the field and the variety of products being offered the author of the foregoing article has made no attempt to list all of the manufacturers or importers in this line. Merely for purposes of explaining mechanical details of predominating types a number of clocks have been selected. Consequently the fact that a line of clocks is not listed or referred to by Mr. Bowman should in no wise be construed as a reflection on either the quality of the product or the standing of its manufacturer.

ELECTRICAL HOROLOGY SOCIETY



Chapter No 78

RENEWAL MEMBERSHIP or APPLICATION FORM

The ELECTRICAL HOROLOGY SOCIETY, Chapter 78 was formed in 1972 to provide a means whereby members of the NAWCC who have a primary interest in Electrical and Electro-mechanical clocks would have a means to meet and communicate with other members with similar interests. Due to the non-geographic nature of the group, the cohesiveness of the chapter depends upon two factors. One is the JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY, published quarterly with an annual content of approximately 100 pages of material. This includes a FREE MART which lists items for sale, parts needed, and other services of interest to members. Additionally, technical articles, original items and articles, and reprints of important material, and questions and answers are included. The information is intended to provide a mixture of historical as well as technical information, thereby offering something for everyone. Secondly, the encouragement of branch chapters to provide local facilities for meetings provides a forum for the exchange of information as well as an opportunity to socialize with kindred souls. Meetings are also scheduled at various Regional meetings and the NAWCC National Convention, whenever the programs provide an opportunity for Chapter 78 members to get together... these may include programs on subjects of interest along with informal questions and answers.

Any NAWCC member in good standing is eligible for Chapter 78 membership. The fiscal year begins in January, and a member joining at any time after January 1st will receive all of the Journals for that year, with membership expiring at the end of December. There are no provisions for less than full year memberships, and membership in Chapter 78 is separate from branch chapter dues and memberships.

DETACH ALONG THIS LINE

ATTENTION MEMBERSHIP: **DUES... ARE DUE**

RENEWAL MEMBERSHIP or APPLICATION FORM

Please print all information:

NAME ______________________ **NAWCC#** ______________

ADDRESS ______________________________________

➡ I wish to become a member of the Electrical Horology Society--#78 and enclose my $10.00 dues for the year 1993.

__________ check here

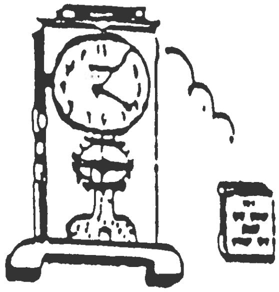
➡ I wish to renew my current membership in the Electrical Horology Society--#78 and enclose my $10.00 dues for the year 1993

__________ check here

SIGNED: ______________________ **DATE:** ______________

Send check to Harvey Schmidt, 75-80 179th Street, Flushing, NY 11366, and make payable to EHS #78, % Harvey Schmidt, Secretary-Treasurer.

NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.



The JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY Chapter No 78

VOLUME XVIII, #2, JUNE 1993

FELLOW HOROLOGISTS:

We thought that we fully covered the SHORTT and SYNCHRONOME clocks in our July & December journals, and to the chagrin of your editorial team, additional material was brought to light that appears herein. Hopefully, this will finally cover ALL of the available information on this fascinating phase of precision electrical horology.

Annual dues of $10, ($15 for foreign members) are due again, and we still have a few members who have not paid for 1993. IF you have a notice attached to the cover page of this journal, you are delinquent and this will be your final issue unless payment is received.

A local meeting is planned for New York and Long Island area members through the good graces of Dr. Bruce Levy and his charming wife Maxine. The date has been set for Sunday, August 1st, at 11:00 AM, and an RSVP is necessary for the reservation and address, by calling (516) 433-6836.

Additional meetings have been planned at the following Regionals; Syracuse: August 20th & 21st, Dearborn: September 9th, 10th and 11th, and at the National Convention in Dallas on June 30th thru July 4th. We hope to continue with this schedule for 1994, which will include Ft. Mitchell, KY, and Orlando, FL. We'll keep you posted as the dates become firmed up.

Material for future journals is needed again, and we request any information that might be of interest, be it historical, technical, or of general usefulness. Tips on repairs, availability of hard-to-find parts, shortcuts and troubleshooting assistance are all welcome. Get with it and be a PARTICIPANT, and not just a sideline member.

On a positive note, we're pleased to report that we presently have approximately 130 members (assuming everyone pays their dues) with about 10 members from foreign lands including Canada, Netherlands, and Great Britain. Our total keeps growing on a small but regular basis each year, which is an indication of greater interest in Electrical Horology, or a greater awareness of chapter 78's existance, but no matter the reason, we're pleased with the result.

Enjoy this issue and have pleasant summer. Good reading ahead...

Martin Swetsky, FNAWCC, President
Harvey Schmidt
Dr. George Feinstein } Co-Editors

2

ASTRONOMICAL REGULATORS

AND

OBSERVATORY TIME INSTALLATIONS

●

TOGETHER WITH A BRIEF ESSAY ON THE

FREE PENDULUM

AND THE GENERAL PRINCIPLES OF THE

SYNCHRONOME SYSTEM

ON WHICH IT IS BASED

●

THE SYNCHRONOME COMPANY LTD.

MOUNT PLEASANT . ALPERTON . MIDDLESEX

TEL. WEMbley 3643/4/5

Printed in England for the Synchronome Co. Ltd.

THE SYNCHRONOME

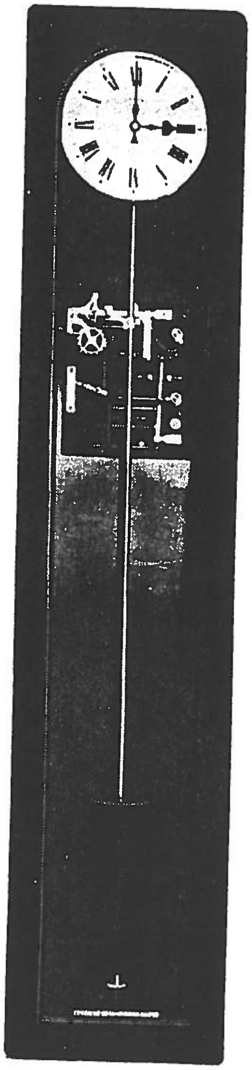


Fig. 1

STANDARD

ELECTRICAL

CONTROLLING PENDULUM

OR

MASTER CLOCK

AN ELECTRICAL

TIME TRANSMITTER

USED TO OPERATE

CIRCUITS OF

ELECTRICAL IMPULSE DIALS

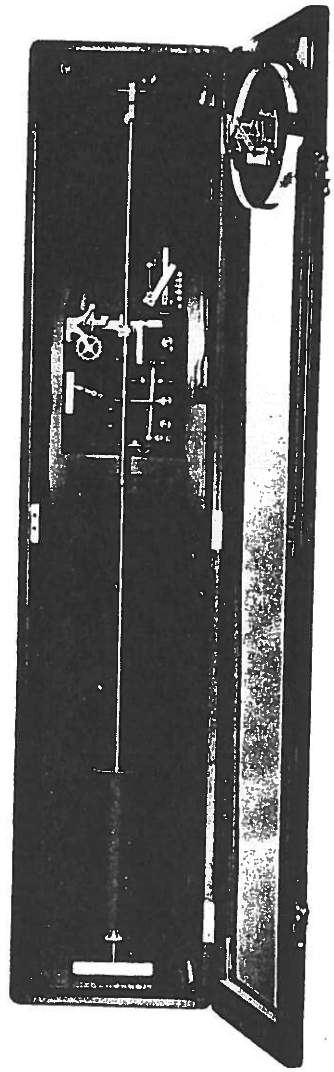


Fig. 1a

4

OBSERVATORY TIME INSTALLATIONS

THE SYNCHRONOME SYSTEM

In order that the method of operation of the Synchronome "Shortt" Free Pendulum Astronomical Regulators described in the second half of this pamphlet may be properly understood, it is necessary first to describe briefly the general principles of the SYNCHRONOME SYSTEM, whose standard time transmitter with seconds pendulum is shown in Figs. I and Ia, and is used as a "Slave".

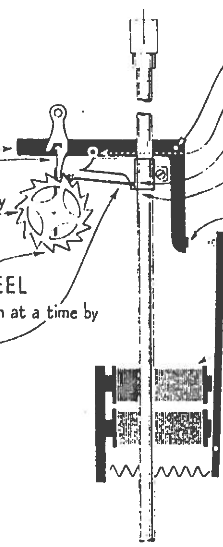


Fig. 2

THE FUNDAMENTAL UNITS

The unit of time measurement is the pendulum. It is combined with a switch, the unit of remote control, and the method of their reciprocal automatic operation is known as the Synchronome "Remontoire". The switch consists of two moving parts: the right-angled lever, and the vertical armature A, both shown in black in Fig. 2, which is self-explanatory.

IMPULSE OF THE PENDULUM

At the moment of release the sloped face of the bracket or pallet has just *not* passed under the roller (from left to right) and the pendulum has just *not* reached its mid position. Thus the impulse is given while the pendulum is passing through its zero or central position, and the pendulum is quite free at the ends of its swing. The escapement is therefore not only detached but operates at zero and thus fulfils the horologist's ideal. The shape of the pallet has been determined mathematically, so that the impulse commences very gradually, increases to its maximum at zero and then decreases in an identical manner.

THE CONTACT

The electrical contact, occuring at each half-minute precisely, is perfectly clean in the make and break. The gravity lever moves into contact at the speed of the moving pendulum and the opening is performed by momentum. It is the only contact in the system and owing to the fact that the whole of the energy required to keep the pendulum swinging is transmitted through the contact surfaces, there is no question about its reliability.

A Main wheel
B Electro-magnet
C Armature
D Armature lever
E Driving click
F Driving spring
G Backstop lever
H Momentum stop
I Stroke limit stop

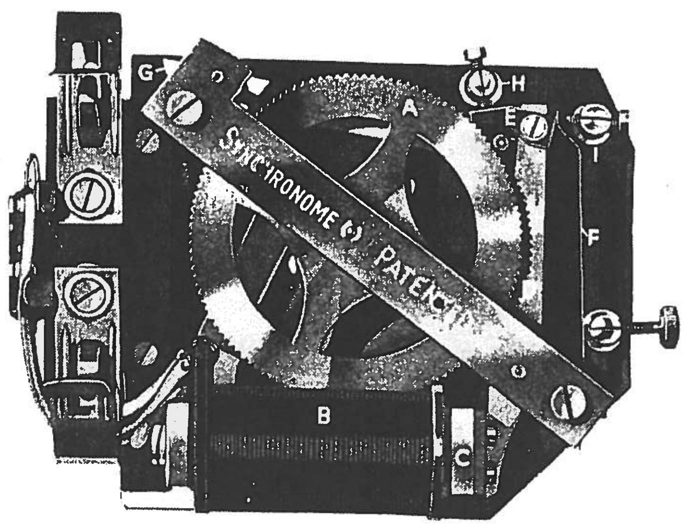


Fig. 3

COMPENSATORY ACTION

Under normal circumstances the switch operates and the circuit is broken before the current has reached its maximum value so that a drop in the battery voltage merely results in a reduction in the rate of growth of the current and the reduced voltage is compensated by an *increase in the duration* of the contact. In consequence a very considerable voltage drop can take place before the magnet refuses to throw up the lever. When that happens the circuit

6

remains closed until the pendulum on its return swing comes to the assistance of the magnet. The duration of the contact is therefore increased thus giving a visible and audible warning of the impending failure of the batteries. The pendulum will usually continue to operate under battery warning conditions for some days and only ceases to do so when the current has fallen so low that the magnet plays practically no part in the lifting of the lever, and ultimately if it is allowed to stop, the contact is held open, consequently the battery is prevented from committing suicide.

BATTERY WARNING

The unit above described serves as a never-failing automatic transmitter for the operation of electrical impulse dials. Thanks to its perfection, dial movements of ideal simplicity as illustrated in Fig. 3 can be used with confidence that they will keep in step.

DIAL MOVEMENTS

From the movement as illustrated, it will be understood that the electro-magnet B receives an impulse every half-minute which attracts the armature C and by means of the lever D enables the click E to drop one tooth down the wheel A. The spring F then propels the wheel A and the minute-hand attached to it one half-minute. The stops H and I are so arranged that the wheel is locked at every point in the cycle of operations, yet is capable of being freed at any moment by merely lifting the backstop lever by depressing its tail G.

SUFFICIENT CURRENT ASSURED

The Synchronome Switch is so designed that its minimum operating current is greater than the minimum operating current of any dial or other instrument in the circuit, and, as all the operating magnets are in series, the circuit has considerable self-induction and the current takes some hundredths of a second to attain its full value. Consequently it is impossible for the switch to operate without supplying sufficient energy to the dials or other instruments to propel them.

THE HISTORY OF THE SYSTEM

In conclusion it should be stated that the history of the Synchronome System on which the Free Pendulum is based is the story of a consistent endeavour to obtain reliable electric contacts from clock mechanisms or their pendulums without taking energy from either.

The first of a long series of patents was taken out in 1895 and the Synchronome Company was then established by Mr. F. Hope-Jones, who read a Paper in description of the new system before the British Horological Institute in that year. Numerous lectures followed and the scientific world has bestowed many honours upon the system including Medals of the Royal Society of Arts, the British Horological Institute and the Franklin Institute of Philadelphia.

Electric time service has been established as a recognized branch of the Electrical Engineering Profession ; and British practice, as based upon its principles is generally admitted to be superior to the electric clock systems of any other country.

THE FREE PENDULUM

It will have been noticed in the foregoing description that the pendulum of the standard instrument is charged with the duty of rotating the count wheel one tooth every two seconds and with the release of the impulse

ENERGY REQUIRED TO COUNT AND RELEASE

lever once every half-minute, and although these operations are performed while the pendulum is swinging through its central position they rob it of energy. Whilst this energy is inconsiderable in quantity, it is nevertheless more than equal to that required to overcome the air friction of the bob. If only these two duties could be done for it, then we could truthfully call it a free pendulum, subject to no interference whatever excepting only that which is inevitable and inherent in the act of impelling it.

For nearly two centuries it was taken for granted that nothing but the pendulum itself could unlock its maintaining force by releasing an escapement, because it alone knew the precise time and phase at which the impulse should be given. It seemed so impossible to do without it that no one even asked for a substitute. After all we can hardly blame clockmakers for not inventing an escapement which does not escape.

The problem was solved by the employment of two pendulums, one for time-keeping only which we will call the Master or FREE PENDULUM, and the

THE WORK GIVEN TO THE SLAVE

other in a clock which we will call the SLAVE, since it releases the maintaining force for it. To enable the Slave to perform this escapement function for the Free Pendulum, the two must keep perfectly together—they must be synchronized. As a result of the invention of Mr. W. H. Shortt, M.Inst.C.E., two of the clocks such as we have described can be electrically linked together. His "Hit-or-Miss" synchronizer for the Free Pendulum enables the Free Pendulum to impose its timekeeping upon the Slave. The ability of the Free Pendulum to transmit a synchronizing signal without expending any energy—actually without being conscious that it has done anything at all—is due to a peculiar virtue of the system above described, the signal being derived from the fall of the gravity lever *after* it has given its impulse to the pendulum.

The arrangement and interconnection of the two clocks is seen in Fig. 4. It shows on the left the master pendulum which, because it has nothing to do but to measure time, is called the FREE PENDULUM. It shows on the right the SLAVE clock, so called because it does all the work of time-counting as distinct from measuring and releasing.

The Free Pendulum P carries a small wheel J. At every fifteenth swing to

SCHEME OF OPERATION

the left (at thirty-second intervals), the jewel R on the gravity lever G_1, released by the magnet E in the circuit of the Slave, falls on the wheel giving it an impulse. As the jewel falls off the wheel the end of the lever G_1 releases the Synchronome Remontoire G_2 which resets the lever G_1 by the pin S and plane T and operates the synchronizing electro-magnet H.

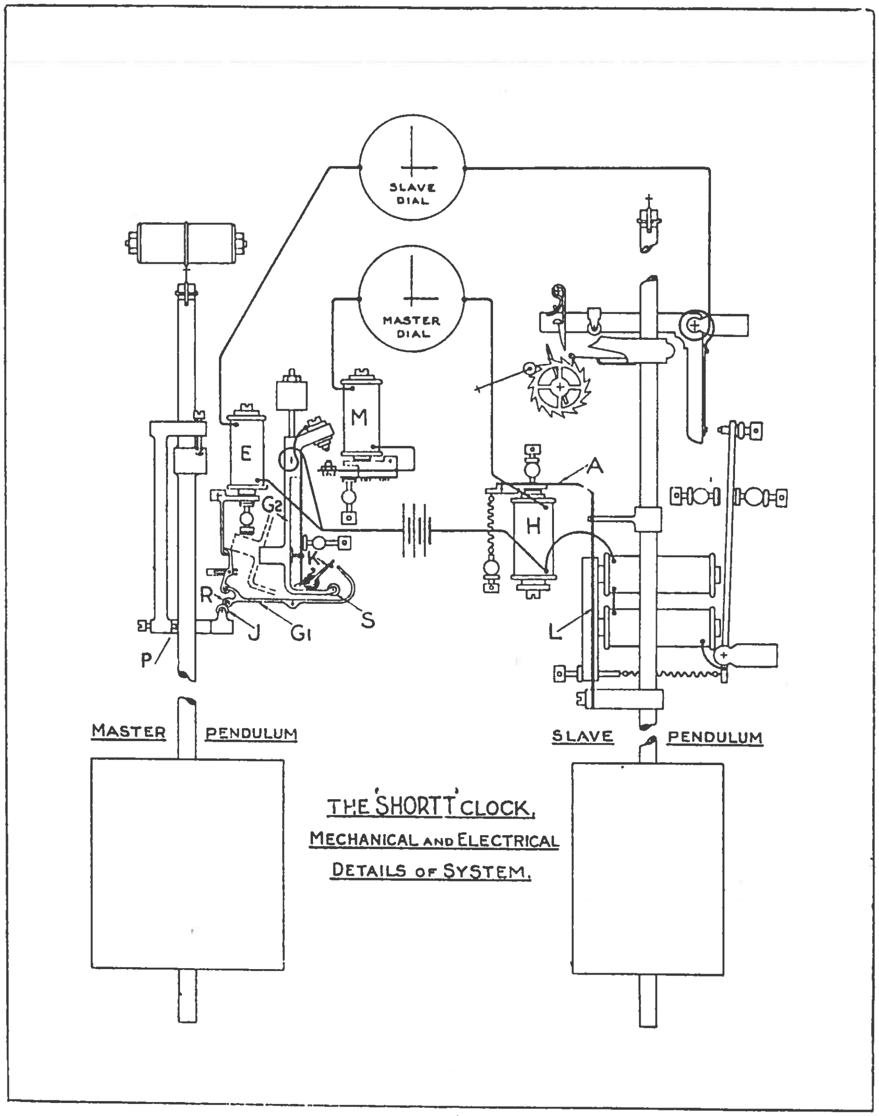


Fig. 4

The Slave Pendulum carries a vertical leaf spring on its left-hand side and the magnet H draws down a horizontal lever into its path, if it is slow, and on top of it, if it is correct or fast, which it never is, because the Slave Pendulum is rated to lose about six seconds a day or 1/480th second per half-minute. The action of the synchronizer advances its phase by approximately double this amount when the lever of the electro-magnet H engages. Consequently the synchronizing action to the Slave Pendulum usually occurs at alternate half-minutes, and that is why it is called "Hit-and-Miss". Perfect phase synchronization of the Slave Pendulum to the Free Pendulum is thus secured.

THE HIT-AND-MISS SYNCHRONIZER

The extraordinary accuracy of the Free Pendulum caused some embarrassment to Astronomers in ascertaining its error and stating it with confidence. As the standard against which a clock is checked is the rotation of the earth upon its axis, and the star transits by which this rotation is determined, a time chart becomes a comparison between the clock and the stars. Before the advent of the Free Pendulum, the differences were, in the main, debited to the clock; the transit observations were assumed to be correct, and would be represented by a straight horizontal base-line. The Astronomers' growing realization of the errors of individual observations and the instrumental errors of the telescope had already led them to take groups of transits and average them. Nevertheless, a perfect clock, before January 1925, could easily have been maligned.

A REVOLUTION IN TIME-KEEPING

This method was reversed at Greenwich, when their first Free Pendulum was installed in November 1924. In six weeks its rate was determined and forecast as a smooth line, so that when it took up its duty as the standard sidereal clock, on January 1st, 1925, the transits were plotted on either side of it.

SOME NOTABLE ACHIEVEMENTS

Thus the first notable achievement of the Free Pendulum caused a revolution in the method of time determination adopted at Greenwich Observatory on January 1st, 1925.

In 1927 at Greenwich, nutation was revealed though the maximum difference in daily rate was less than 0·002 of a second and the definition of Time itself had to be altered in the *Nautical Almanac* to include it. In 1929, three Free Pendulums were recorded against a quartz crystal clock, revealing a lunar period due to the diurnal change of gravity, though the maximum difference was only 0·0002 of a second.

The Free Pendulum at the Paris Observatory ran from August 1934 to July 1936, nearly two years without discoverable error (Montré une règulantè quasi—par faite). Free Pendulum No. 11 installed at Greenwich in February 1926, ran for nearly nine years without stopping, and No. 14, installed at Warsaw in 1927, ran until the Observatory was wrecked during the 1939-45 war.

On the following pages will be found detailed specifications of the Free Pendulum, Slave Pendulums, and the electrical impulse dials and accessories.

SPECIFICATION

AND

PRICES

11

DESCRIPTION OF THE FREE PENDULUM

THE CASE

The Free Pendulum is mounted in a cylindrical copper case, sealed at the top by a glass bell jar and at the bottom by a disc of heavy plate glass. The ends of the copper tube are flanged over substantial gun-metal rings and ground flat enabling the sealing joints to to be made direct between the copper and the glass with a thin layer of special sealing grease. The gun-metal rings are provided with fixing lugs by which the case is bolted to the wall. This should be a foundation wall in the basement or a concrete pillar let into the ground, free from the vibration of the building, and faced flat.

When sealed up, the case is exhausted to an internal pressure of 20 mm., suitable gauges being fitted in the case including a sensitive oil gauge which reveals the smallest leak. It is on record that one of these instruments ran for ten years without showing any signs of air leakage.

For suitable pumps see page 15.

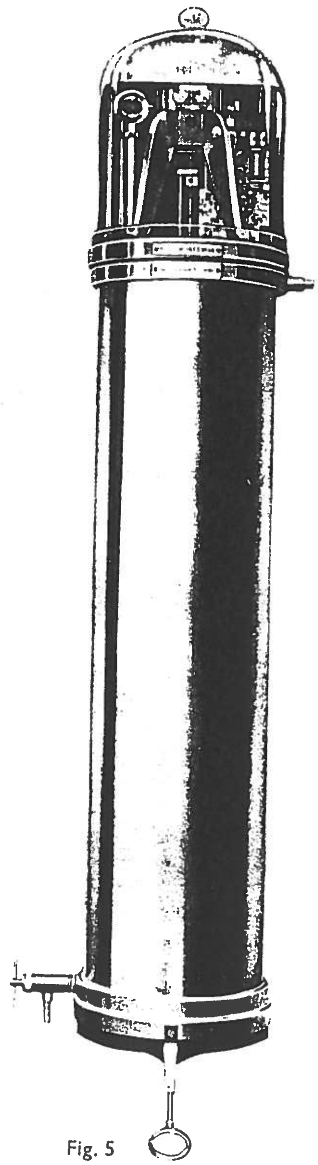


Fig. 5

Dimensions of copper cylinder :

Length	-	38½ ins. (130·8 cm.)
Diameter	-	9 ins. (22·85 cm.)

(Allow headroom for withdrawing pendulum)

12

THE PENDULUM

The pendulum rod is of fixed length rated to beat seconds, Mean Solar Time or Sidereal, in the latitude in which it is to be used. It is made of Stabilized Invar. The bob is also of Invar and weighs 14 lbs., supported on its centre, the support being pinned to the rod.

The Pendulum is fully compensated, the co-efficient of every rod and all its component parts being tested by the National Physical Laboratory at Teddington. Nevertheless, it is desirable that the temperature of the clock chamber should be kept constant by means of thermostatically controlled heaters with a fan to operate when they are cut off, to prevent stratification of the air.

A beat plate is provided at the bottom of the rod for reading the arc. Our standard method is to read it through a reflecting mirror on a fine line zero which enables one to read within one minute of arc. An alternative method is to use a reflecting microscope by which the arc can be checked to within four seconds direct on a micrometer scale and finer by interpolation. The extra price for reflecting microscope with its micrometer traverse and diamond engraved beat plate will be quoted on application.

THE MOVEMENT

The movement is of the finest workmanship. Its moving parts are fitted with sapphire jewel holes and end-stones.

Imparting an impulse to a pendulum is, technically, an interference, but it is reduced to a minimum in this instrument. The impulse is given once every half-minute and consists of gravity pressure upon a finely-pivoted wheel on the pendulum, resulting from the fall of a lever weighing 0·35 grams for a distance of 2·5 millimetres. This interference is confined to 0·001 part of the time measured.

SLAVE CLOCKS

TYPE A

A Free Pendulum requires a Slave clock to work in conjunction with it in order to release its gravity arm every half-minute. It may be erected in any convenient room on the ground floor. It consists of a standard Synchronome controlling pendulum of the highest quality as shown on page 2 fitted with "Hit-and-Miss" synchronizer as illustrated (*Fig.* 6) in the margin and an extra dial in circuit with the Free Pendulum's remontoire. The operation of the two dials at an interval of 0·8 sec. shows that the instruments are working correctly. A small silvered dial will be seen concentric with the 15-toothed wheel to indicate even-numbered seconds.

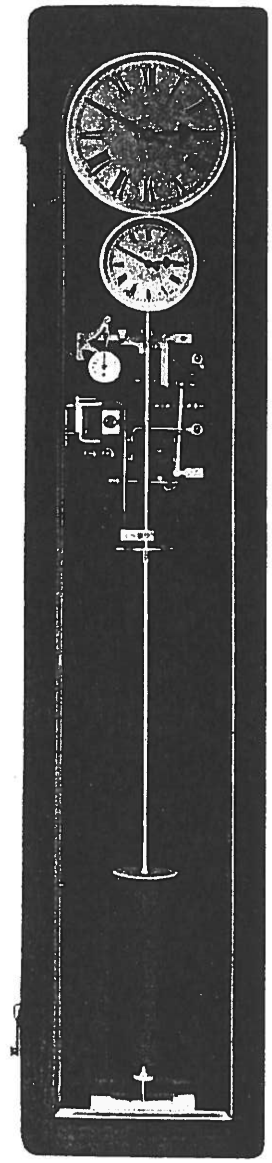


Fig. 6

14

SLAVE CLOCKS

TYPE AS

This clock is similar to Type A described on page 12, but is also provided with an "Inertia" type switch for transmitting electrical impulses every second with great precision. These impulses are useful for many purposes including chronograph comparisons, operating seconds impulse dials as illustrated (Fig. 10), etc., etc.

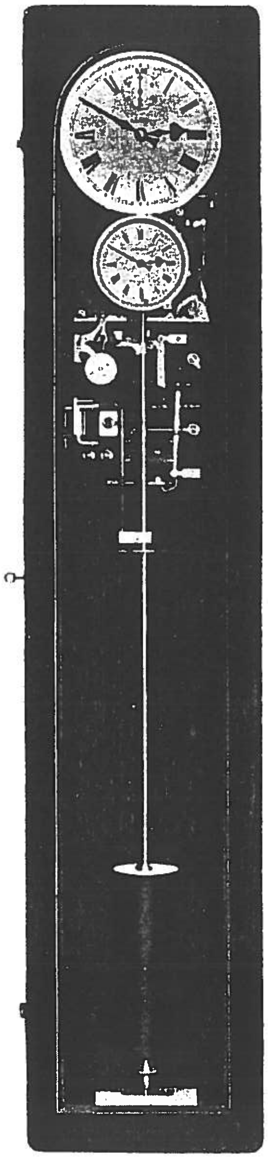


Fig. 7

The cases of Types A and AS are of polished hardwood and their overall dimensions are :

Length	-	51 ins. (129·5 cm.)
Width of trunk		10½ ins. (26·6 cm.)
Depth	-	6 ins. (15·25 cm.)

SLAVE CLOCKS

TYPE B

This clock is mounted in a carved polished mahogany case with a 10-inches diameter "Regulator" type dial showing seconds and hours in inset circles with the minute hand sweeping the full diameter of the dial. Below are two dials set in an oblong panel showing the time indicated by the Free Pendulum and Slave half-minute switches.

This clock is of the seconds impulse type, operated by a subsidiary Synchronome switch with jewelled movement and is therefore a transmitter of seconds as well as half-minute impulses. The seconds contacts in no way affect the Free Pendulum, even indirectly.

The Free Pendulum and its B type Slave are used as standard clocks in many Observatories, both for Sidereal and Mean Solar Time.

Additional apparatus is supplied for the automatic transmission of time signals of the six-dot seconds, Onogo and Rhythmic types.

The overall dimensions of the polished mahogany case with plate-glass front are :

Length	-	$55\frac{1}{2}$ ins. (134·7 cm.)
Width	-	$13\frac{1}{4}$ ins. (33·6 cm.)
Depth	-	$7\frac{1}{4}$ ins. (18·4 cm.)

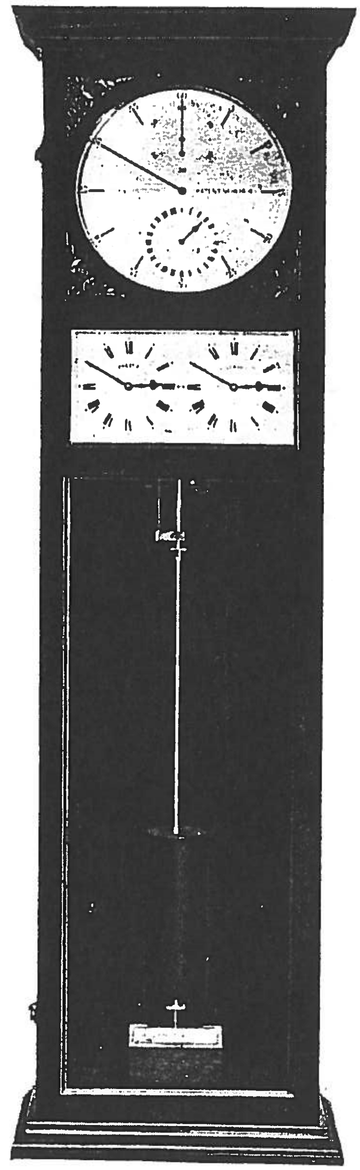


Fig. 8

ACCESSORIES

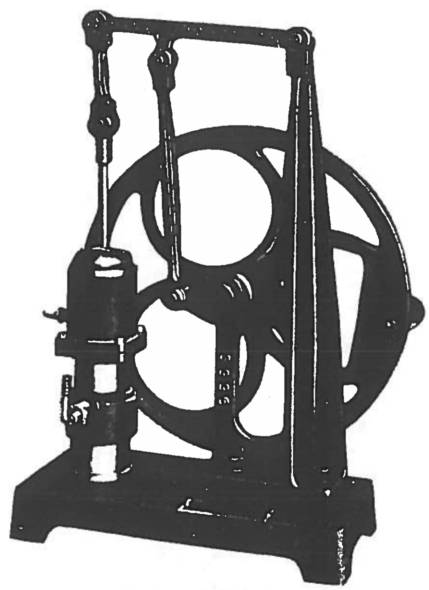


Fig. 9

THE ROTARY "GERYK" TYPE PUMP

Hand-operated reducing the pressure in the Free Pendulum case down to the required amount —20 millimetres in 8 minutes. A can of special oil is supplied with the pump.

Accessories supplied with the pump are as follows:—

- 4 ft. of rubber pressure tubing;
- 1 glass drying tube;
- 1 2-oz. bottle of Phosphorous Pentoxide.

SETS OF WEIGHTS ranging from 10 mg. to 10 grams, in wood block with forceps.

ELECTRICAL IMPULSE DIALS

Separate electrical impulse dials of half-minute periodicity, in polished mahogany cases, can be supplied in 8, 10, 12 and 18 ins. diameter. A full range of sizes and types will be found listed in Catalogue E.I. 48.

Electrical impulse dials of seconds periodicity, 10-ins. diameter regulator type, can also be supplied with inset seconds and hours silvered engraved dials in oak, mahogany or teak frame as Fig. 10.

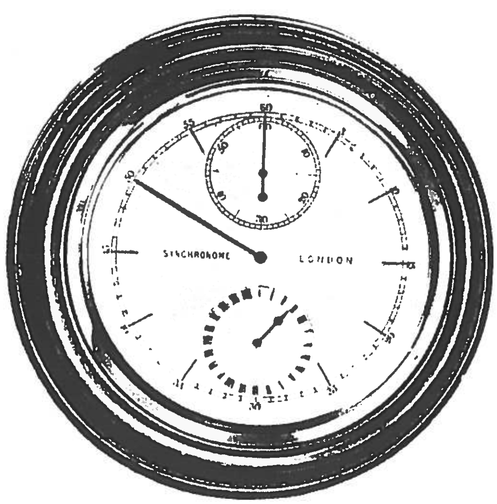


Fig. 10

THE MAGNETIC CORRECTOR

When a Mean Solar Time Free Pendulum and Slave Clock is used for transmitting time signals by Radio, or is used on Civil Time service, it is necessary in the former use of the clocks to ensure that the transmitter switch is correct for time just before transmission commences. It is also necessary to ensure that the clocks are periodically corrected in the latter case, that is to say—although the Free Pendulum is capable of keeping a very constant rate, within a few thousandths of a second per day—it may not have a zero rate, and it becomes necessary to put it to correct time before transmission.

The Magnetic Corrector provides the means of applying this correction to both Free Pendulum and Slave, and in either direction, fast or slow, by the exact amount required.

The lower end of each pendulum is fitted with a permanent ring magnet. Under the ring magnet, and fitted to the case, are a pair of solenoid coils. To apply correction, current is passed through the coils to produce like poles to the magnet for slowing, and unlike poles for quickening, the swing of the pendulum.

The winding of the coils, the gap between the magnet and coils, and the amount of current passed through the coils, all combine to alter the rate of the pendulum by a known amount.

A Control Panel is also supplied which may be fitted at any convenient position, not necessarily near the clocks to which the corrections are to be made. Incorporated in the Control Panel is a dead beat moving coil Ammeter and the necessary switches and resistances, the whole being carefully calibrated and set at our works for the following correction values :—

To advance or retard 0·01 seconds per minute.
" " " " 0·02 " " "
" " " " 0·03 " " "

The operator switches on two switches—one for direction, i.e., advance or retard, the other for the amount of correction he wishes to use, 0·01, 0·02, or 0·03.

The ammeter is a centre zero type, one half of the scale being marked slowing and the other quickening. In operation the pointer will read :—

0·1 amp. on the slowing side for 0·01 seconds per minute retard,
0·2 amp. slowing for 0·02 seconds, and
0·3 amp. slowing for 0·03 seconds.

It will show 0·1 amp. quickening when switched to 0·01 second per minute advance, 0·2 amp. quickening for 0·02 seconds and 0·3 amp. for 0·03 seconds.

With these combinations it is quite easy to correct the clocks by the amount required. Magnetic correctors may be fitted to any pendulum clock under the control of the Free Pendulum.

When it is desired to magnetically correct a transmitting clock which is not under the control of the Free Pendulum and will, therefore, have a comparatively large change of rate, correction values are increased to 0·1 and 0·2 seconds per minute.

ELECTRICAL CONTACTS

Electrical contacts of any duration or periodicity, in multiples of a half-minute or of a second respectively, arranged according to any programme, can be operated from the clock system for chronograph recording or other purposes without the Free Pendulum being affected, even indirectly.

(*Reprinted from* NATURE, *June* 2, 1928.)

THE ACCURACY OF SHORTT FREE PENDULUM CLOCKS

By Dr. J. JACKSON and W. BOWYER.

THE period of vibration of a simple pendulum, swinging in a vacuum through the small semi-arc α is given by $2\pi\sqrt{\frac{l}{g}}\left(1+\frac{1}{16}\alpha^2\right)$.

Variations in the rate of a pendulum clock are produced by variation in (1) the length of the pendulum; (2) the arc of vibration; and variation in several factors which produce a departure from the above formula; namely: (3) air resistance; (4) elasticity of the spring; (5) interference with the free motion of the pendulum by the escapement and impulsing mechanism.

We will consider these in turn.

(1) The principal cause of variation in the length of the pendulum is change of temperature. This can be overcome by keeping the pendulum at constant temperature. Attempts have also been made with more or less success to compensate the effect by the use of metals of different coefficients of expansion so as to make the effective length of the pendulum practically independent of the temperature. But the parts of such compound pendulums may not take up changes of temperature at the same rate, and those of the grid-iron type are apt to roll. The discovery of invar has greatly simplified the temperature question. But invar is a rather unstable substance and its growth produces slow secular change in the clock rate.

(2) If the bob moves in a cycloid instead of a circle the period is independent of the amplitude. Clocks have been constructed with 'cycloidal cheeks' to guide the pendulum, but these have not proved of value. When the semi-arc of vibration is 1° a change of 1′ in the amplitude affects the daily rate of a simple pendulum by only 0·05*s*.

The change of arc in precision clocks is not great, and, moreover, as a result of the action of the suspension spring, the effect of change of arc in such clocks may easily be less than the theoretical amount given, so that this source of irregularity is not very serious.

(3) A change of 1 per cent. in the air pressure under ordinary conditions changes the daily rate of a standard type of pendulum by about 0·1*s*. This can be fairly accurately compensated in various ways, but for the most accurate clocks it is best to keep the pressure constant. For Riefler clocks this is usually about 600 mm. of mercury, but for the Shortt clocks it is of the order of 30 mm.

(4) The effect of the suspension spring does not appear to be very great, although various methods of supporting the pendulum have been invented. Change of elasticity with temperature and fatigue of the material from continuous bending, may produce variations of arc and so affect the rate of the clock.

(5) The most difficult problem in clock making has been in the escapement. In the usual type of clock the escapement serves a double purpose. It enables the number of vibrations to be counted, and through it the impulse is given which maintains the vibrations of the pendulum. The pendulum is in more or less continuous contact with the escape wheel, and although this is generally situated fairly near the point of suspension, it is clear that frictional forces and continuous interference by the escape wheel may easily produce considerable irregularity in the clock rate.

At the end of 1924 the clock Shortt 3, made by the Synchronome Co., Ltd., was installed at the Royal Observatory, Greenwich, and it proved so reliable that it was introduced as standard on Jan. 1, 1925. It consists of a 'free pendulum' and a 'slave clock.' The free pendulum is made of invar swinging in an air-tight case at a pressure of about 1 inch of mercury. The free pendulum has no escapement. On a bar about one-fifth of the way from the top it carries a very light wheel about 6 mm. in diameter. At every fifteenth swing to

20

the left (30 seconds) a gravity lever carrying a weight of ⅓ gm. and released by the slave clock, falls on the wheel, giving it an impulse. As this lever gets clear of the wheel a tail-piece releases mechanism which resets the impulse lever and also causes an electric contact to be made which synchronises the slave clock. An action of the synchroniser on the slave clock advances its phase by approximately 0·004*s*. The slave clock is rated to lose about 5*s*. a day, or 0·002*s*. per 30*s*. Under these conditions the synchronising action on the slave pendulum occurs at alternate half minutes with considerable regularity. The slave clock does all the work of counting the vibrations and releasing the impulse lever. Consequently, the only interference with the free pendulum is the impulsing during a fraction of a second every thirty seconds. The great advantage which the Shortt clock has shown over all other types of clock is undoubtedly due to the relative freedom of the pendulum from mechanical interference.

This clock was started at a practically zero rate at the beginning of 1925, but it acquired a losing rate at about 0·04*s*. per day per month. By the autumn of that year the rate of change of rate had fallen to about 0·012*s*. per day per month. It remained at approximately this value until June 1926, when the clock stopped as a result of the failure of the release of the lever which resets the impulse arm of the free pendulum. This failure was caused by two steel surfaces jamming, and to avoid a recurrence of the fault a jewel was introduced at the locking surface.

The clock was restarted in July 1926, since which time its performance has been remarkable. The rate showed the previous change of about 0·012*s*. per day per month, but apart from this the going appeared nearly uniform. During October and November 1926, when special time determinations were being made for longitude purposes, the temperature was subject to unusually large fluctuations, and it appeared that there might be a temperature term of the order of 0·003*s*. per day per 1° F. Consequently thermostatic control was introduced, and the clock rate became very steady. This continued until May 1927, when the clock error commenced to depart from the predicted value, but this was traced to an irregularity in sidereal time and not in the clock rate. For those not acquainted with the exact definition of sidereal time, we may state that sidereal time is defined by the hour angle of the first point of Aries measured westward from the meridian. The motion of the first point of Aries is for convenience divided into two parts, the uniform part called precession and the non-uniform part called nutation. The principal part of the latter is given by the formula

$$-1{\cdot}06s.\sin\Omega - 0{\cdot}08s.\sin 2L.$$

The period of the first of these terms is 18·6 years, and this term can with sufficient accuracy be expressed in the form $\alpha + \beta t + \gamma t^2$ for an interval of a year or two. The second term, though of much smaller amplitude, runs through its period in six months, and this term cannot be expressed in quadratic form for more than four or five months. The clock error was therefore analysed in the form $\alpha + \beta t + \gamma t^2$ + nutation, and this satisfactorily explained all the observations while the temperature was approximately constant. The temperature of the clock room had been maintained near 55° F., but in the summer of 1927 it rose to about 62° F., and by comparison of the observed clock error with the formula, it was found that there was a temperature term of very nearly 0·0030*s.* per day per 1° F. When this effect was allowed for, a formula was obtained which fitted all the observations from March 1927 to December within 0·1*s.* The formula was extrapolated backwards and found to leave residuals of about three-quarters of a second in the autumn of 1926 and to fit the observations again in July 1926. Extrapolation forwards fits the observations to 0·1*s.* at the end of March 1928.

It should be stated that although the temperatures were not known with great accuracy in 1926, the residuals must be due to change in γ or some other irregularity.

The two diagrams (Figs. 1 and 2) show how

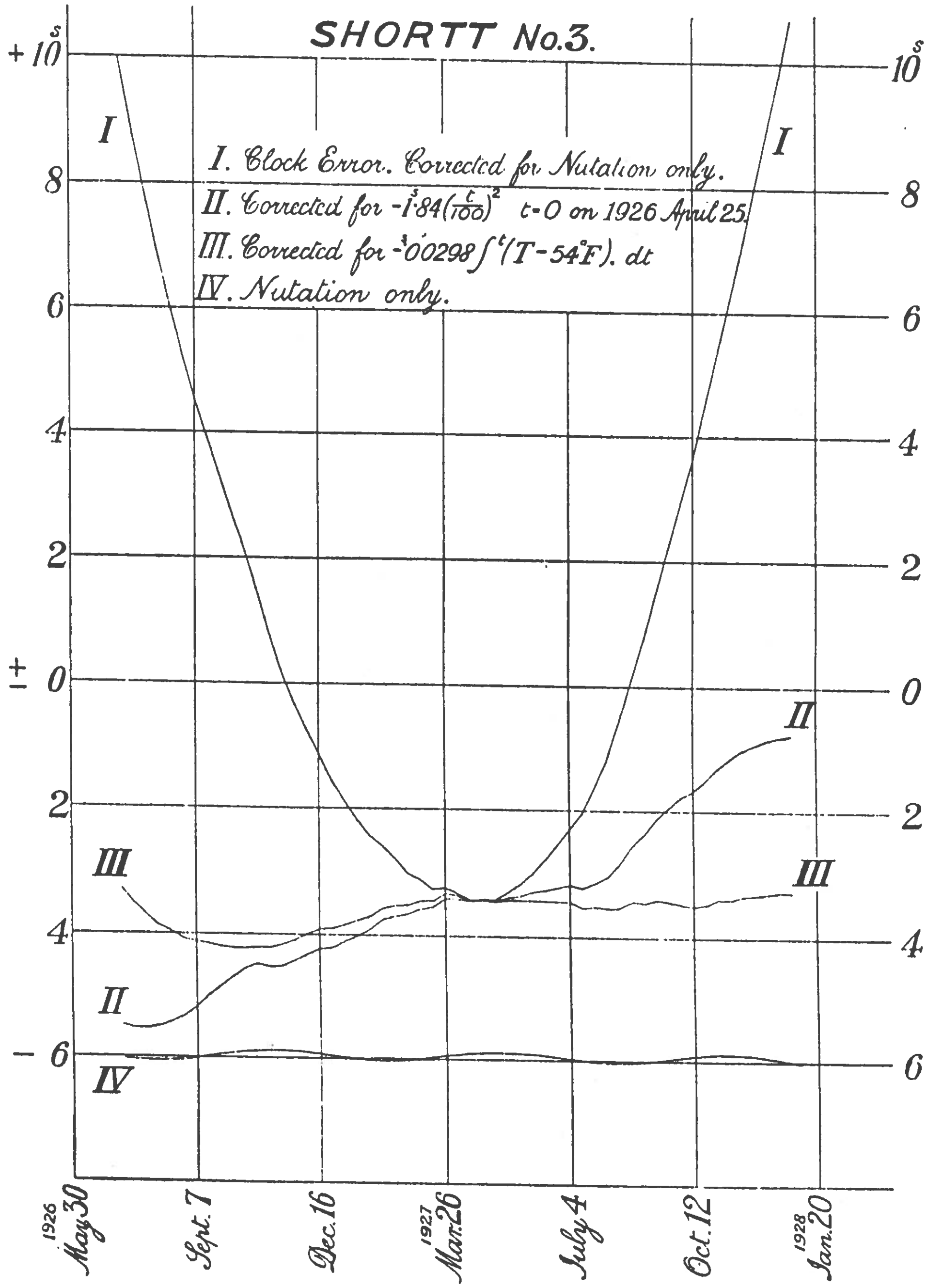
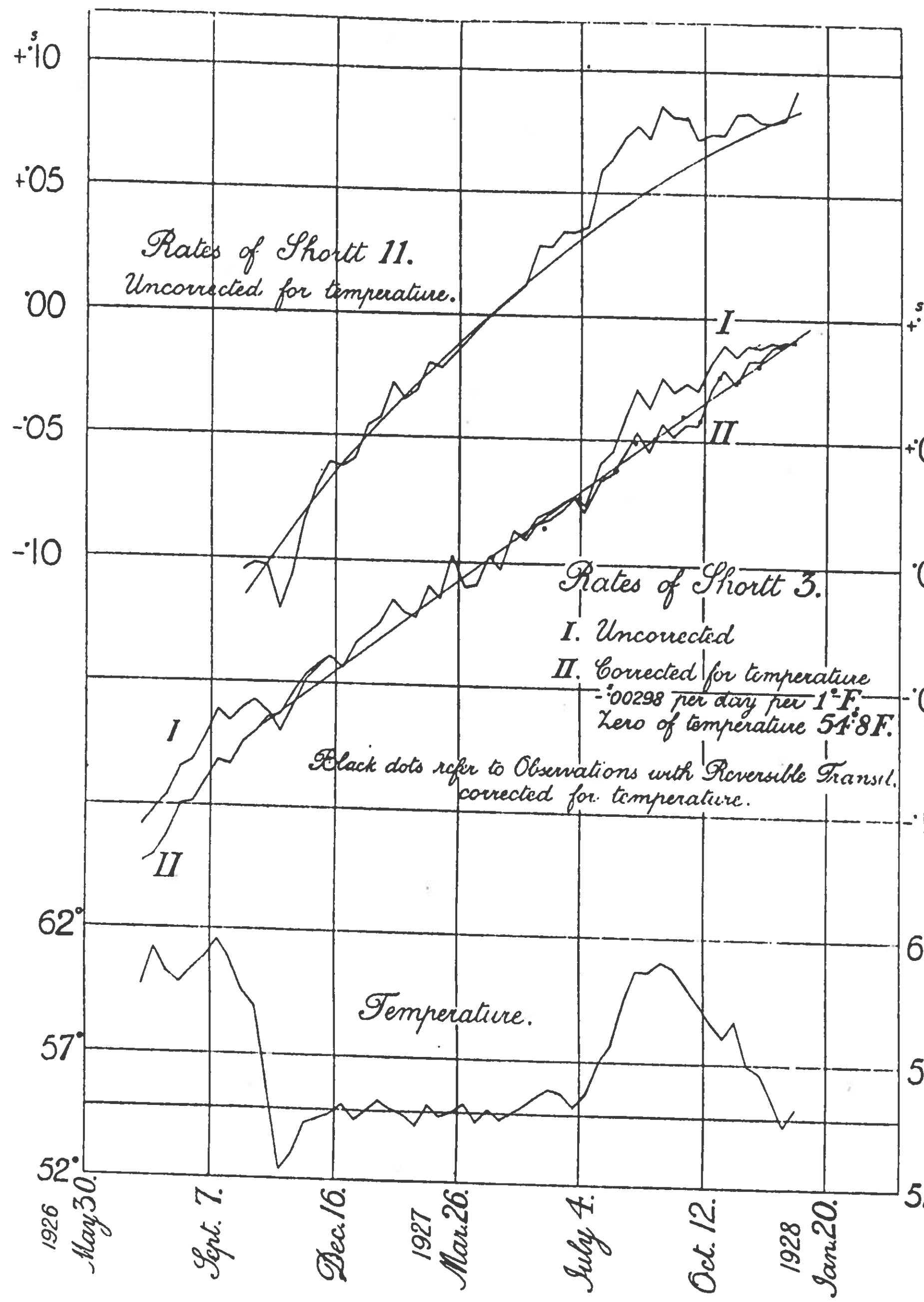

SHORTT No.3.
+10s
8
6
4
2
± 0
2
4
− 6
10s
8
6
4
2
0
2
4
6
I
I
II
II
III
III
IV
I. Clock Error. Corrected for Nutation only.
II. Corrected for -1s84(t/100)² t-0 on 1926 April 25.
III. Corrected for -s0·00298∫t(T-54°F). dt
IV. Nutation only.
1926 May 30
Sept. 7
Dec. 16
1927 Mar. 26
July 4
Oct. 12
1928 Jan. 20

Fig. 1.



+·10
+·05
·00
-·05
-·10
+·10
+·05
·00
-·05
-·10
Rates of Shortt 11.
Uncorrected for temperature.
I
II
Rates of Shortt 3.
I. Uncorrected
II. Corrected for temperature -·00298 per day per 1° F. Zero of temperature 54·8 F.
Black dots refer to Observations with Reversible Transit, corrected for temperature.
62°
57°
52°
Temperature.
1926 May 30.
Sept. 7.
Dec. 16.
1927 Mar. 26.
July 4.
Oct. 12.
1928 Jan. 20.

Fig. 2.

24

closely the observed clock errors can be explained when the irregularities are allowed for. The points in the diagrams are based on curves drawn through all the errors determined with the transit circle. A more detailed comparison of the observed and computed clock errors is given in the *Monthly Notices of the Royal Astronomical Society* for March 1928.

The temperature term of 0·0030*s*. per day per 1° F., or 1·1*s*. per year per 1° F., is much smaller than that for most high-grade clocks, but it was not expected to exist. It is said by the makers to be larger than would arise from uncertainty in the coefficients of expansion of the materials used in the construction of the pendulum. The second Shortt clock which was erected in the same clock room in May 1926 shows a temperature coefficient of similar amount.

The temperature term in the clock error is, however, of comparatively small importance. The important term for long-distance forecasting of the clock error is γt^2, γ being 1·84*s*. when t is in units of 100 days. This term will amount to more than three minutes in 3 years. There can be little doubt that it is due to growth in the length of the pendulum. It is known that invar grows for years after its manufacture, and that the growth may be irregular. To explain the above coefficient the growth in the length of the pendulum (994 mm.) is 0·001 mm. in 118 days. Changes in the rate of growth of the pendulum do not affect the prediction of clock errors for a month or so, but may become serious when a formula fitting the observations for a year or more is considered.

Possible changes in the rate of rotation of the earth have recently attracted the attention of astronomers. Observations of the positions of the moon, supported fairly well by observations of more slowly moving bodies in the solar system, indicate that the rotation of the earth may be subject to variation amounting in extreme cases to about 1*s*. per year. One second a year is only 1 part in 30 millions, and if residuals of this order in the relative times shown by the earth and the free pendulum are demonstrated, the question will arise as to whether they are caused by :

(*a*) Residual secular change in the length of the pendulum.

(*b*) Variation of gravity.

(*c*) Variation in the actual rate of rotation of the earth.

(*d*) Seismic disturbances.

(*b*) and (*c*) may be inseparable, as changes in the earth's moment of inertia may be accompanied by changes in gravity as well as in the earth's angular velocity.

The real difficulty in the clocks is (*a*). It appears that the principle of their construction is such that they could be used to check the uniformity of the earth's rotation if only material stable for several years to 1 part in 100 millions could be obtained for the manufacture of the pendulums. At present the two sidereal Shortt clocks at Greenwich have been running continuously for 20 months, and a run of a few years would possibly suffice for errors of 1*s*. to accumulate in the earth's rotation, but a variation of 1 per cent. in the rate of growth of the pendulums would introduce greater irregularity in the clock error. It appears impossible to be certain that any piece of material has the required degree of stability, and until pendulums of different materials in different parts of the earth agree in supporting the motion of the moon and planets against the earth's rotation, clocks will not play an important part in checking the uniformity of the earth's rotation.

Printed in Great Britain by R. & R. Clark, Limited, *Edinburgh.*

--- MART ---

All MART Ads are FREE, Send copy to the attention of the Editor:
Harvey Schmidt, 75-80 179th St., Flushing, NY 11366. Limit 3 lines.

WANTED: HOROLOGICAL LITERATURE, Repair info, Catalogs, etc. for the Journal
PORTESCAP Secticon Clock or Movement. (718) 969-0847
Harvey Schmidt, Editor, 75-80 179th St., Flushing, NY 11366

Junker EARLY BATTERY CLOCKS, Movements, Parts, etc, send details.
Martin C. Feldman, 6 Stewart Pl., Spring Valley, NY 10977

Motor for a "CALCULAGRAPH" clock. (This clock was made by the CALCULAGRAPH CO., New York. It was used for timing telephone calls). Paul Hopkins, 2717 Millwood Rd., Birmingham, AL 35243

Pendulum support casting, suspension spring, pendulum rod, and bob for a 1 second GENTS
Richard B. Pridham, 10402 Bellman Ave., Downey, CA 90241

Plans, drawings to build a SETH THOMAS No. 2 Case
K. C. Denney, 3819 E. 55th Street, Tulsa, OK 74135

F.L. GREGORY (SEMPIRE) Movement, & like to know if you have a clock with "F.L. Gregory Clock Company, Electric Gravity, Chicago, Illinois" on dial. Early Bipolar Motors, & Early Electric Fans. A complete DARCHE Medical Clock as shown on pg. 19 of "150 Years of Electric Horology" (817) 267-9851
Steve Cunningham, 3200 Ashland Dr., Bedford, TX 76021

N.Y. STANDARD WATCH CO. movement, short pendulum type (approx. 120 beat), any repairable condition. Would also like dial, hands, and pendulum if available. (713) 554-7387
Kenn L. Koerber, 105 Royal Dr., League City TX 77573

ELECTRO-MECHANICAL CLOCKS, preferably fancy cased and exposed pendulum clocks. Elliot Siegel, 103 East Neck Road, Huntington, NY 11743, Day or Night (516) 541-2400 or (516) 351-5869

F. L. GREGORY movement for a SEMPIRE; a SWCC type F 120 beat movement; anything made by HOLTZER-CABOT; nice wood cased slaves; very early electric motors and fans. (817) 267-9851
Steve Cunningham, 3200 Ashland Dr., Bedford TX, 76021

REPAIR: ALL EARLY BATTERY CLOCKS Specializing in BULLE using orig. parts.
Martin C. Feldman, FNAWCC, 6 Stewart Pl., Spring Valley, NY 10977

FOR SALE: TIFFANY NEVER WINDS, Double Contact, Wood & Dome Cases; Single Contact, Dome Case. (718) 969-0847
Harvey Schmidt, 75-80 179th St., Flushing, NY 11366

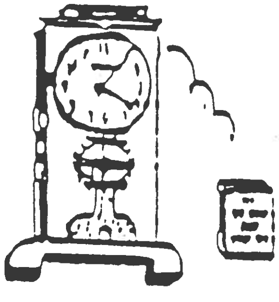
Repair Parts for TIFFANY NEVER-WIND Clock Co., CLOISTER Mfg. Co., & NATIONAL MAGNETIC Clock Co.
David Lee, P.O. Box 171, Knox, NY 12107

REVERE Electric (Herschede) Grandfather Clock, 7 ft. Mahogany Case w/glass 3 sides. 9 tubes, 3 chimes. Circa 1928. $900.00
(201) 652-1025 Mon, Wed, Fri. 9am to 9pm, other 9am to 5pm.
Roger Sanford, 12 Godwin Plaza, Midland Park, NJ 07432

Hi-Grade Electromechanicals such as: MONARCH with Mercury Pendulum, MERCER Chronometer in a Carved Mahogany Case, Early Wall Regulator in Carved Mahogany Case (6 ft.) maker unknown, etc. (617) 599-4171 or 598-3881, Evenings and Weekends.
Steve Lefkowitz, 13 Puritan Park, Swampscott, MA 01907

RADIOCHRON, scallop top cathedral style tube radio with built in manual start clock on matching table. Radio and clock work, $200
Terry Willett, 10306 Ky 815, Utica KY 42376, (502) 785-4808

SYNCHRONOME (Hope-Jones) Master Clock, as on p. 72 of "150 Years of Electric Horology" w/ separate slave & multiple relay for control of large system of slaves. ITR (predecessor of IBM) elect. rewound master clock w/ mercury pendulum. (206) 842-5835
Alan Seymour, 10847 Bill Pt. Bluff, N.E., Bainbridge Is. WA 98110



The JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY Chapter No 78

VOLUME XVIII, 3, SEPTEMBER 1993

Fellow Horologists:

The August 1st meeting at the home of Dr. & Mrs. Levy was attended by 9 members who enjoyed a bountiful repast provided by our very generous hosts, along with a tour of their most interesting collection. Our heartfelt thanks for their hospitality...

On August 20th, during the EASTERN STATES REGIONAL in Syracuse, 14 members of chapter 78 met and enjoyed a fascinating program presented by ANTHONY PRASIL, curator of the HOFFMAN CLOCK MUSEUM of Newark, New York. The slide show, entitled, "FROM FROGS LEGS TO CESIUM ATOMS" began with the twitching of frog's legs, continued with the search for a perpetual motion machine, and culminated with the Cesium Atom Clock! Additionally, those in attendance examined 4 movements that were brought for identification and a lively discussion followed. It is hoped that chapter 78's participation will become an annual event at this regional, joining those at Fort Mitchell, KY; Dearborn, MI; Orlando, FL; and the annual National Conventions.

Our journal for this quarter contains a varied assortment of material including a biography of MATTHAUS HIPP, appearing for the first time in ANY English language publication, thoughtfully provided by CHARLES AKED. A most informative article about a legend in horology whose HIPP TOGGLE switch and precision regulators remained unchallenged for some fifty years! We are fortunate to be the recipients of this rare document, and we offer our gratitude to Mr. Aked for his consideration.

JAY MCALLISTER of chapter 133, WESTERN ELECTRICS, has generously provided us with a copy of his article, " MAGNETIC PRINCIPLES" which discusses the principles of magnetism from the very basics into the more advanced areas. Jay also invites your comments which we hope will encourage additional future material...

MARTIN SWETSKY has provided us with "WHEN IS A VOLT NOT A VOLT"... -about the use of power supplies to replace batteries, with a review of conditions governing their choice, the regulation and control of their output, and the application of inexpensive and easily available units to clock use.

Our condolences to the family of ALAN MARX, whose recent demise due to heart failure leaves us with a void that will be hard to fill. Alan was a charter member of chapter #78, an advanced collector with an appreciation of design and workmanship, a gentle and caring man.

Enjoy this issue... good reading ahead...

Martin Swetsky, FNAWCC... President
Harvey Schmidt }
Dr. George Feinstein } Co-Editors

Matthäus Hipp in Reutlingen

The Development Years of a Great Inventor (1813-1893)

By Professor Helmut Kahlert

I Among the documents concerning the founding of the Grand Duchy of Baden Clockmakers School at Furtwangen [1] are two which state that the clockmaker Matthäus Hipp from Reutlingen was awarded the prize (mechanical) of the Württemburg Central Economic Association in 1840 and 1842, firstly for the new principle of ensuring regular motion of a pendulum (1840), and secondly for an important turret clock movement (1842). The Karlbruhe Professor of Physics, Wilhelm Eisenlohr (1799-1872), as the representative of the Baden Government for the establishment of the new clockmaking school, whom Hipp had already met, wanted to make him the head of the workshop for "Stockuhren" [Spring driven clocks fitted with short pendulums]. He visited Hipp for this purpose in Reutlingen and arranged an interview for the end of October 1849 in connection with the matter. The business went well, the authority for installation in the post now only needed "higher approval".

The May Revolution in Baden in 1849, put down with the help of the Prussian Army, radically altered the political situation, and the highest technical qualifications could not outweigh the political considerations. In a declaration from the Baden Ministry of the Interior of 20 November 1849, it was stated that "in view of the great influence that the instructors at the Clockmaking School at Furtwangen will have on all the clockmaking in the Black Forest, not only on the technical training but also on the ethical and political scene", reliable information on the candidate was required.

The Württemburg foreign office in reply to the enquiry had given Matthäus Hipp a good character reference in the technical and ethical sense, but the sentence that he was "politically inclined to democracy without being excessively so" made Karlsbruhe sit up. "Democratic" meant in the language of the day that Matthäus Hipp adhered to Republican rather than Monarchist principles. The decision brought a letter of denouncement from Reutlingen. A contract letter is found in the establishment records of the Clockmakers school:

"In the case of the enquiry concerning M Hipp in Reutlingen, I inform you that the said person no longer possesses the trust of the most intelligent and level-headed inhabitants of Reutlingen because he has devoted himself to the support of a man who possesses all the bad qualities that one can presently find, and namely has brought out badness in the social relationships of the town of Reutlingen". (5 December 1849).

The Baden Ministry of the Interior laconically declared after this that Matthäus Hipp was not suitable as an instructor in the clockmaking school. "Hipp must therefore be told that his application cannot be considered". Apparently it was considered unnecessary to return his application documents. In the opinion of today, the contents of the letter certainly speak for the political and personal qualities of Hipp. Apparently as clockmaker and mechanic he had not stood so aloof from the political life of his time as many of his biographers assert. The Association of Citizens of Reutlingen Politicians, of which he was a member, had increasingly stood up for democratic ideas [2].

On a further occasion the application for a particular post was shattered by political considerations, in Vienna in 1851 [3]. Hipp had applied for a leading technical job in the Austrian Telegraphic service and with the approval of the technical people had demonstrated his writing telegraph. Yet as a citizen of Reutlingen he appeared to be unacceptable to the authorities for this position. People apparently remembered the Reutlingen Whitsuntide gathering of 1849, which certainly did not have the far-reaching consequences of the previous county gathering in the Badische town of Offenburg, when the resolutions taken there - revision of the Constitution, arming of citizens, and a citizens' army left reverberations of revolution in the minds of the Viennese authorities [4].

That Mathäus Hipp was at that time already widely known as an inventor and knowledgeable clockmaker is shown by an announcement of the demonstration of his apparatus on his journey from Vienna in Regensburg. His chronoscope, an instrument for measuring the very shortest intervals of time, and his writing telegraph created attention amongst the experts and the laity, even admiration. In a newspaper announcement it is stated - "with the writing telegraph the neccessary letters of the small Latin alphabet, 120 to the minute, were not only clearly but beautifully printed with normal ink on fine paper. This apparatus will also transform normal letters into telegraph characters and vice-versa" [5].

In the year 1852, Matthäus Hipp at last found employment more suitable to his talents. The well known physicist Karl August von Steinheil (1801-70), who had already supported Hipp in Vienna, was appointed adviser to the Swiss Telegraph Administration. It was probably due to his influence that Hipp, although a foreigner, was chosen to be Head of the Machine Shop of the Telegraph Administration in July 1852, for a period of three years and with a salary of 2100 Swiss Francs [6]. He soon broadened his activities so that he in fact became, in modern parlance, a technical director. So began a new chapter in the life of Matthäus Hipp, therefore a glance back at his youth and training, especially in the Reutlingen period, seems indispensable.

II The decisive biographical details about Matthäus Hipp are taken from an obituary published 1893 in Elektronischen Zietschrift. The author, Dr. Robert Weber (1830-1915) was Professor of Physics at the Neuchâtel Academy between 1879-1907, and Matthäus Hipp also lived there from 1860-1889 as director of the "Telegraph Factory" from 1860 to 1889. Even when stronger documentary evidence does not support it, Professor Weber must have known Hipp well personally, this is not only suggested by their living in the same place and working in the same field of interest, but also by the quoting of personal experiences and anecdotes from Hipp's life [7].

Mathäus Hipp was born 25 October 1813, a few days after the battle of Leipzig, in Blaubeuren. His father, Friederich Hipp, the son of a farmer, was baker to the monastery and a mill owner; he operated a flour, oil and/or sawmill. His mother, neé Friederiche Hauser came from Wittlingen; her father was an "innkeeper and judge" [8]. A four year period of illness overshadowed the early life of the boy, then at eight years of age he had an accident climbing in the neighbouring hills and badly injured his left ankle. A shortening of his leg became a problem which remained with him for the rest of his life.

The parents wished to see their son take up a post as a government official, schoolmaster or clergyman, but natural science interested him much more than the Latin taught to him by the master in the local church school. Hipp always later regretted that he did not have better training in mathematics and drawing. His ability with his hands soon showed itself. Hipp later related with pleasure from his early days that he once built a mill wheel whose noise disturbed the sleep of the severe Herr Ephorus - Jeriamias Friedrich Reuss - and that at the bidding of his father he had to stop it working.

In choosing a job, young Matthäus could now apply himself. In his 16th year, somewhat late according to the custom then, he began to learn clockmaking with Johann Eichelhofer in Blaubeuren. At this time (1832) the town had 1813 inhabitants [9]. Master Eichelhofer therefore, as most of his colleagues, busied himself with repairs, servicing, and occasionally selling a clock. The usual verge watches were ordered by the dozen from the Swiss Jura or France. They always had to be examined in the local workshop to be put into good going order and "finished" before they could be sold, which took one or two days per watch.

Therefore, as soon as his apprenticeship was over, the eager Hipp sought a workshop of his own where clocks could be made and tools developed.

His time as a journeyman began in Ulm, where from 1832-1834 he worked with the town clockmaker Valentin Stoss the younger (1782-1861). Stoss was in the group of the cleverest horologists in Württemberg. From archives it appears that he mostly dealt in mantel clocks, although turret clocks are also mentioned. Valentin Stoss is mentioned in Ulm directories from 1812-1860 [10]. "Hipp said about him", wrote Robert Weber, "that it gave him the opportunity of learning a great deal, that the business was run rationally, not simply on an established pattern, but that at the time the purpose of a machine was kept in mind, and after that the most functional means were applied". This is also mentioned in a report to the Stüttgart Trading Association in which Stoss described his improved wheel cutting engine that allowed six clock wheels to be cut and rounded up at the same time, so that no more work on them was required. Multi-production of toothed wheels had apparently laid the foundation of the American factories' lead, and also Erhard Junghans senior ordered a machine from the USA in 1864 which could cut up to 40 wheels simultaneously.

In Ulm Matthäus Hipp probably visited the Technical School, for he received a decisive impetus towards his future calling from the son of his master who had already finished his time abroad at Le Locle in the Swiss Jura. Hipp's path led him in 1834 to St Gallen, where he remained a year, and from there he went to St Aubin on Neuchâtel lake, where he worked about two years in the factory of M. Savoie.

After a brief stop in his birthplace, Blaubeuren, Matthäus Hipp settled in Reutlingen. His arrival there probably dates from 1840 as his name first appears in the town registers in 1841 [11]. Reutlingen with 12,700 inhabitants (1843) was the third largest town in Wúrttemburg, whose development, however, had stagnated until the mid-1850's. From a trade association point of view, the clockmakers in Reutlingen at that time were affiliated with the smiths. Statistics for the year 1848 give 7 independent clockmakers and 11 assistants, of which some were certainly working for Hipp [12].

Matthäus Hipp married the teacher's daughter, Johanna Plieninger from Massenbach in Reutlingen in 1841. The marriage lasted 52 years until Hipp's death in 1893, his wife outliving him by four years. They had four children. The only son, however, died when a student, from tuberculosis. In 1842 the couple took over a two-storey house with workshop in the Alpvorstat for 4,500 florins. The workshop was rebuilt, for in the records since 1843 a "smith's fire workshop" is listed. In the year 1861 Matthäus Hipp as "owner of a factory for electrical apparatus in Neuchâtel" sold the house through a representative to a clockmaker for the same price [13]. Apparently he had, at this point in time, decided to continue living in Switzerland.

At his new place of residence he must have made an impression, not only as a craftsman, but also as a personality, for already at the end of 1840 the Chairman of the Reutlingen Trade Association, the schoolmaster Dr. Ammermüller, named him as "a solid, very accomplished, and well-experienced man". Some years later Hipp had been in contact with many well-known savants through sales and travelling. The Tübingen Professor for Physics and Astronomy spoke of the "excellent instruments" that Hipp had made for the observatory and physical laboratory [14]. Already by this time Hipp had developed his typical working methods. He perceived the features of the problem, systematically thought out the necessary requirements for a solution, and worked through to completion with great ingenuity; engineer and craftsman in one person. It is continually highlighted that Hipp unreservedly, without the customary secrecy that was obligatory for many inventors, displayed his apparatus and could explain it with noteworthy clarity to a broad public.

In Reutlingen Hipp lived like any ordinary citizen but larger outpayments such as the installation of a special machine, or the arranging of a special workshop, far exceeded his financial limits. Like other progressively thinking clockmakers of his time, he was convinced that only by the division of labour and the installation of machinery could the German clock industry catch up on its technical shortcomings. Gustave Becker, who since 1850 had begun to build up a firm of world renown in a Silesian depressed area (Freiburg), could only survive the difficult beginning years by interest-free loans and State backing. Eduard Hauser, technical leader and founder of the Uhrenfabrik Lenzkirkch, found financial backing in 1851 from a great trading concern in Lenzkirch. Erhard Junghans senior must, in spite of his earnings from straw products in 1861, obtain credit from relations; and Matthäus Hipp in 1860 finally had to go to Neuchâtel financiers for the foundation of a Telegraph factory.

During his days in Reutlingen the economic pressure that prevented the realization of his plans and ideas must have been a burden to Hipp. In 1843 he wanted to give his rights as inventor of a chronometer "to someone who favourably placed for the export of the same". On many occasions he must have taken up large loans, to ensure the credit, the married couple mortgaged their house and land as security.

Hipp was always open to offers for financial help and did not lose courage with the severance of assistance from Stuttgart [15]. At the end of 1840 he requested an interest-free loan for machinery to make high precision timekeepers (chronometers), in 1845 he conceived the plan for the progressive clockmakers of Württemburg to join a cartel for the production of spring driven house clocks by division of labour. Two years later and again in 1845, Hipp proposed a "mother-factory" to provide the Württemburg makers of Black Forest weight driven clocks with parts, and at the same time, production of parts for spring driven clocks.

The last-mentioned proposal was in accordance with the efforts of the "Württemburg Association for the Promotion of Trade", which since 1831 had operated in certain districts of the areas Oberndor, Spaichingen, and Balingen, and especially in Heuberg which carried out household production of clocks. An attempt to bring skilled labour from the Badische section of the Black Forest by offers of money did not work. The second proposal, to finance training in clockmaking, either entirely or partly for promising young men, brought successful results. At the General German Trade Exhibition in Berlin in 1844, the exhibitors of the clockmaking association of Thieringen (district of Balingen) were praised on account of their functional efficiency [16].

However the problems of this new domestic business did not lie in the area of clockmaking, but with the lack of business backing in delivery, coordination of production and marketing. The raw material for wheels had to be ordered from Baden or Ulm, and the production of the dial painters often did not suffice to complete all the clocks. Whilst later, in some areas, as in Schramberg, the efforts to overcome these difficulties were apparently successful, in others the deterioration was unmistakable after 1860. Johannes Burk, the inventor of the portable watchmans' clock, in an expert opinion used the comparison "a crippled explorer on an inhospitable mountain" [17]. Matthäus Hipp wanted his proposals adopted to overcome this situation.

In addition, however, he worked on steadfastly in his workshop. To begin with he developed the possibilities of fine mechanical work, however he soon gave his major attention to electromagnetism. Wheatstone and Bain in England, Steinheil and Hipp in Germany, Louis Breguet and Garnier in France had from 1840 onwards, developed new concepts for the future in connection with clocks, telegraphs and measuring instruments. Hipp's achievements in the field of micro-time measurement aroused considerable interest in the 1840's, for he succeeded in transforming the Wheatstone chronoscope into a reliable measuring instrument, in which he took care that the weight-driven mechanical train first ran uniformly before the measuring process was electromagnetically initiated. [Wheatstone's instrument did not do this but started the measurement with the train at rest].

Hipp's early chronoscopes came in 1847/48, they could measure to 1/500th of a second and cost only 66 FL, about half the price of the English instrument. Soon afterwards the time scale was refined to 1/1000th of a second, and later (1873) Hipp showed a writing time measurer (chronograph) that astronomers had long desired for the recording of their observations. Hipp's work on telegraphy has been quoted previously, and above all this he occupied himself with making railway traffic safe through a "Signal and Control System" [18]; an indicating and registering speedometer for locomotives being patented only four years before his death.

Very little, however, is known about the early development of Hipp's ingenious invention, the "self-controlling" clock with impulsed pendulum: here speculation often replaces missing facts. To understand the concepts to which Hipp devoted his whole working life in revising and improving, and the development reaching from the mechanical "prize" clock of 1840 up to the high precision electrical astronomical observatory clock of 1881, it is necessary to make an excursion into horological history. The mechanical clock probably appeared in the second half of the thirteenth century, an instrument that divided time into regular small equal intervals, combined with a unit that prevented a wound-up train from running down rapidly, and also, at the same time, giving the regulator new driving energy; originally a foliot, later a pendulum, or the balance of a watch. The plan which gave the regulator an impulse at each half-swing, or in certain cases each whole swing, regularly in short impulses, remained an essential part in the making of mechanical time measurers until the 20th century. This stop and go system of classical time measurement, rendered audible by the tick-tock of the clock to everyone, caused Matthäus Hipp to seek another solution.

He had already been fascinated by the observation, even as an apprentice, that a well set-up pendulum set in motion continues to swing for a long time before it comes to rest. It was not necessary to give regular impulses, and so interfere with its freedom, it was sufficient to give an impulse when a certain limit of amplitude was reached, separated according to the type of pendulum, from 2-120 seconds, Hipp wrote in 1880. In his clocks, which in this respect must have constantly impressed clockmakers, remains the greatest difference between them and ordinary clocks, in that the pendulum drives the hands [19].

But how was this reduced impulsing of the pendulum to be solved? Hipp was giving this matter some thought during his journeyman period, the solution came in 1834 at St. Gallen, the problem was mentally, if not constructionally, solved. With his new "palette escapement", two parts act together, one is an easily movable piece of steel [palette] carried by and pivoted on the pendulum rod, and a fixed piece is fitted with a notch, the so-called "contra-palette". With wide arcs of the pendulum the palette slides freely over the notch, but as the arc diminishes slowly, the end of the palette finally falls into the notch of the contra-palette. As the pendulum swing reverses, the palette pushes down on the notch and a mechanical or electromagnetic impulse is given to the pendulum. This was the original form of construction; in later models [1863], the arrangement is reversed, the palette is fixed, and the contra-palette swings with the pendulum. [The principle is unaltered].

In electrical horology literature it is accepted that Hipp was using electromagnetic impulsing of pendulums in 1842, but no evidence can be found to support this. It appears certain that the solution [for electromagnetic clocks] was found in two steps, separated in time; firstly the clock with mechanical pendulum drive, later the electromagnetic impulsing. In the documents previously mentioned regarding the Prize Award of 1840 [20] is mentioned "a new principle for creating a uniform going of the pendulum", whereby the pendulum periodically receives new energy from a weight-driven train according to the measurement of the reduction of its movement.

Yet Hipp had, although scarcely noted up to now, himself described the new clock in Dingler's Polytechnic Journal for 1843. In that a movable hook ("key") is fixed to the pendulum and is caught in the notch of a lever normally holding back an toothed wheel. As the pendulum reverses its swing, the lever is pressed down and releases the wheel to move through one tooth, the impulse being conveyed to the pendulum by a rod. The other usually quoted source given as evidence for the early application of electromagnetism is that of a Hipp clock shown at the General German Trade Exhibition in Berlin in 1844 but it was mechanical in construction [21]. Contemporaries had at that time, even though later authors have doubted it, made small steps forward in the subject of electrical knowledge and under no circumstances would have overlooked a clock driven electromagnetically by a battery.

Matthäus Hipp could not have foreseen at the beginning that his system, as no other, was to be satisfactory in taking electric clocks out of the experimental stage into the the realms of practical use. His construction compensated for a number of deficiencies in the electrical techniques of that time, especially the problems of batteries and contacts: "it lent itself to the contemporary current requirements ..." (Schonberg 1931). When Hipp first drove a pendulum clock electrically has not yet been established, yet possibly the first considerations came from his time in Reutlingen, for he had already, at that time, occupied himself intensively with electromagnetic apparatus.

After 1860, the electric clocks manufactured in Neuchâtel on the Hipp system won international recognition and practical application; especially the switching arrangements for extra dials, for the efficiency of the whole system could be improved by his method. Hipp clock systems were reliable in service with master clocks, most of them after 1868 with electromagnetic pendulum drive; and many slave dials were first installed by Hipp in Switzerland - Geneva 1862, Neuchâtel 1864, and Zurich 1865; by 1880 they were in use in fifty-two European towns. [22]

In 1841 Alexander Bain had demonstrated the possibility of using electricity in time measurement - master clocks that could control numerous slave clocks and automatically correct any errors, the electric current could replace springs and weights as the driving force, and time or alarm signals could be sent over great distances. Matthäus Hipp had a decisive part to play in the realisation of these technical visions. Technical journals after 1880 state that of all the known systems, Hipp's electric clocks had the widest use [23]. The firm of Favarg, successor to the Hipp factory, built precision regulators with the echappement électrique à palette until 1975, and even today is still occupied carrying on the Hipp traditions, making electric clocks and time systems.

III. On his installation as director of the Swiss Telegraph workshop at Berne in 1852, Matthäus Hipp had already, through the Furtwangen negotiations explicitly stated, received permission to carry out private work. Yet as the income out of his activities as an inventor soon considerably overtook his salary, conflicts with the press, administration and parliament were not uncommon, all the more unusual because all official behaviour and civil service mentality was foreign to him. The fact that Hipp did not give up his original citizenship in his life added to the misunderstandings. It is. however, an irony of fate that the great-grandson of one of these foreigners, Max Petitpierre, was chosen to be President of the Swiss Confederacy many times in the middle of this century.

Mostly as a result of the influence of Matthäus Hipp, the Swiss Telegraph system developed from 1860 as an example for other European countries. Yet as well as his efficiency at his work in the narrower sense, he additionally astonished his contemporaries with his special achievements. Hipp demonstrated that a Jaquard loom [for weaving patterns in silk] with 400 hooks driven electrically was a technical possiblity, although he was doubtful about the economic use of such a system (1856). His electric piano with punched tape control excited interest in the Paris exhibition of 1867. A badly insulated cable in Lake Lucerne had led to unacceptable loss of current, so he connected the positive lead to a strong battery and earthed the other, reaching the conclusion that by oxidation the cable could again be made to function. (1857)

In the year 1860 Hipp resigned from the Swiss Government service and took over the directing of the newly founded "Telegraph Factory" in Neuchâtel, which as a centre for production and development (fabrique de télegraphes et appareils électriques) became known all over Europe. In 1889, at the age of 76, just four years before his death on 3 May 1893 in Zurich, he handed over the direction of the business to his successors, two Swiss engineers von Payer from Schaffhausen and Favarger from Neuchâtel. In 1927, the undertaking, with the established name of Favarg was absorbed into the Swiss Hasler concern.

Matthäus Hipp received recognition in his lifetime as inventor and successful businessman, especially in Italy, France and Switzerland. In the history of electrical timekeeping his rank is undisputed. Hipp exchanged experiences with many famous learned men, he liased closely in technical matters and was a personal friend of the Director of the Neuchâtel Observatory, Dr. Adolph Hirsch (1830–1901) [24]. About twenty-two articles appeared between 1840 and 1880 by or about Hipp in the most renowned technical journal of the time in the German language, Dingler's Polytechnische Journal.

In many international exhibitions, Hipp's firm was awarded the first prize. Even more pleasing to him than the award of the Cross of the Austrian Franz Josef Order was the honorary doctor's degree bestowed by the University of Zurich to the self-educated man on the grounds of "his great services to electrical technology especially to the Swiss Telegraph System". Switzerland has not forgotten Dr. Matthäus Hipp to this day, but our country also [Germany] owes him thanks and recognition.

APPENDIX

In the biographical note by Robert Weber (1893) 22 different contributions were noted. A further five are included in J C Poggendorf's Biographisch-Literarisches Handwörterbuch zur Geschticte der Exakten Naturwissenschaften (1898). Two other important publications are not included therein.

An automatically controlled clock which immediately indicates when any irregularity due to friction or the like occurs, even if it amounts to only one-thousandth part of a second, and which overcomes a hundredfold greater resistance than does any other clock. Invented by Matthäus Hipp in Reutlingen. In Dingler's Polytechnisches Journal 88 (1843), page 258 onwards and page 441 with an illustration. Also reprinted in Zeitschrift für Groß- und Klein-Uhrmacher jeder Gattung [Bulletin for clock and watchmakers of every kind], Volume 1, Weimer 1845, Page 106 onwards.

Electricity as a motor for clocks in Deutsche Uhrmacher-Zeitung (1879 and 1880), with many contributions starting in 1879, Page 87 onwards.

Translated by E J Tyler and edited by Charles K Aked with some additional material added. 22 January 1990. The original article printed in Zeitschrift für Württembergische Landegschichte [Journal for Würtemberg Local History] 1989, received 19 July 1989 in pamphlet form from Professor Helmut Kahlert: 24 footnotes are included but are not given here since they merely quote reference sources, some however are shown in the biographical notes following, eg [3].

Biographies of Matthäus Hipp in chronological order

Note: In some publications the incorrect forename of Matthias is used.

1893 R.W. [Robert Weber]: Obituary of Matthäus Hipp in Elektrotechnishe Zeiyschrift, pages 323-325 and 715.

Dr. M. Hipp - Obituary in Deutsch Uhrmacher-Zeitung page 85.

1896 Weber, R./Favre, L. : "Matthäus Hipp 1813-1893", Bulletin de la Societé des Sciences Naturelles de Neuchâtel, pages 211-239.

1898 "Hipp, Matthäus", J. C. Poggendorff's Biographisch-Literatrisches Handwörterbuch zur Geschicte der Exakten Naturwissenschaften, Leipzig, Volume 3, page 636. [3]

1902 Schulte, Carl, "Hipp, Dr. Matthias", Lexikon der Uhrmacherkunst second edition, Bautzen, page 388 following.

1911 Dietschold, C. : Matthäus Hipp, Der Cornelius Nepos der Uhrmacher, enthaltend 35 Lebensbeschreibungen, 2nd ed. Krems, page 51 following.

1913 Bauder, Karl: "Matthäus Hipp, der große Erfinder auf dem Gebiete der Uhrmacherkunst in Verbingung mit der Elektrotechnik", Dingler's Polytechnisches Journal, pages 724-727, also Leipzіger Uhrmacherzeitung, pages 336-339.

1927 "Hipp, M.", Historisch biographisches Lexicon der Schweiz, Volume 4, Neuenburg, page 229.

1940 Fink, Gertrude: "Matthäus Hipp, ein Genie aus der Ubrmacherzunft", Reutlinger Zeitung, Volume 23, No 5.

1958 Münch, Georg: "Matthäus Hipp, ein schwäbisches Uhrmachergenie", Neue Uhrmacher-Zeitung, Volume 22, page 26 following.

1961 Keller, Walter/Schmid, Hans Rudolf: "Matthias Hipp 1813-1893", Schweizer Pioniere der der Wirtschaft und Technik, Vol. 12, Zurich, pages 9-39. [3]

1963 H.W.: "Matthias Hipp 1813-1893", Bulletin des Schweizerischen Elektrotechnischen Vereins, Volume 54, page 548 following.

1972 Schmid, Hans Rudolf: "Matthäus Hipp", Neue Deutsche Biographie, Volume 9, Berlin, page 199 following. [8]

1977 Abeler, Jürgen: "Hipp, Dr. Matthäus", Meister der Uhrmacherkunst o. O, Wuppertal, page 281. [About one-third of a page in length].

1984 Attinger, Claude/Jelmini, Jean Pierre: "L'horloge de l'Hôtel de Ville de Neuchâtel. Un heritage de Mathias Hipp ...", Chronométrophilia No. 16, Summer 1984, pages 72-82.

Zschuppe, Ulrich: "Matthäus Hipp in Memoriam", History of Psychology, Volume XVI, no. 3, July 1984, pages 1-5.

1985 Favag- 125 ans 1860 - 1985, Neuchâtel, 1985, pages 11-14.

1986 Hummel, Herbert: "Schweizer Edison vom Blautopf", Blaumännle, Beilage der Sudwestpresse Ulm, for 24 September 1986. [9]

-.-.-.-.-.-.-.-.-.-.-

8th August 1993.

MAGNETIC PRINCIPALS

by

Jay McAlister # 133

Since the operation of all electromechanical clocks depends in some manner on magnetic force ,I thought a brief review of the general principals and characteristics of magnetism would be worthwhile. The information given here is presented in non-technical language and without resorting to theory or mathematics. However, in cases where terms peculiar to the subject are widely used, these have been included and explained. While much of the content of this paper will be "old hat " to many of our members, it is hoped that some may gain a little insight into the workings of their problem pieces or be stimulated to further investigation.

As every school boy knows, a magnet is an object which attracts iron, steel, and some special alloys. While magnets are found in nature, for centuries all practical magnets have been man made. Magnets are often produced by passing an electric current through a wire coiled around a bar of iron, steel, or appropriate alloy to "magnetize " it. Generally, if the bar is of a hard steel, the attracting property,"magnetism", remains in it after the current is stopped and the bar is said to be a "permanent magnet". If the bar is made of soft iron, the magnetism essentially exists only while the current is "on" and the combination of the coil and bar is called an "electro-magnet".

Natural magnets, or "lodestones", can occur in almost any shape but, the development of the mariner's compass with its long slim pointer or "needle" seems to have set the pattern for "bar" magnets. Originally, these were made by rubbing a bar with a lodestone or by aligning the bar with the earth's magnetic field while pounding on it and/or heating it.

In any magnet, the attracting force tends to be stronger in some sections than in others. These regions of concentration are called "poles". The end of a suspended bar magnet which would swing toward the north was once called the " north seeking" pole. Somewhere in time the word 'seeking' has been dropped and magnets now are said to have "north poles" and "south poles". This designation is called " polarity ". The actual areas or boundaries of a magnet's poles may not be sharply defined but, depend on the shape of the magnet. In a thick bar the pole regions may each cover a considerable part of its length but, in long slim bars the poles are concentrated at the ends. No mater how small or what shape a magnet is, it has both

Compliments of Chapter #133
Western Electrics

north and south poles.

With a piece of unmagnetized iron , either type of pole will exhibit the same attraction for it but , with other magnets the poles of like polarity repel each other while thoes of opposite polarity are attracted.

The region in space around a magnet where the attracting force can be detected is called a " magnetic field ". A magnetic field has " direction " which is defined as that line or path along which a north pole will be urged when in the field. This direction can be indicated by the alignment of a compass needle when placed in the field i.e., the north pole of the compass will point toward the SOUTH pole of the magnet creating the field.All magnetic fields form closed paths between opposite poles. Magnetic fields exist around the earth,around magnets and around any path where an electric current is flowing.

With permanent magnets the polarity, and hence the field direction, is fixed at the time of magnetization. With electro-magnets, or a flow of electric current, the field direction is determined by the direction of the current flow. Before continuing this discussion, it is necessary to assume a direction for the flow of electric current. In this review, we will use the old convention that the flow is from positive to negative or out of the positive terminal of the current source, (battery generator,etc.,), and into the negative terminal. If the electron theory is preferred, it will be necessary to substitute the word LEFT for right in the following discussions.

When a current flows in a wire, the direction of the magnetic field around the wire can be determined by grasping the wire in the right hand with the thumb extended along it in the direction of the current flow . With the fingers closed into the palm, they are encircling the wire in the,same direction as the resulting field. In the case of a coil, if the coil is grasped with the right hand in the same "thumbs-up " sort of position with the fingers wrapped around it in the direction of the current flow in the turns of the coil, the extended thumb points in the direction of the magnetic field.

Some examples of the relative directions of currents and the resulting fields are illustrated in Figures 1 & 2. In the Figures the direction of current flow is indicated by solid arrows with 'shaded' heads and magnetic field direction by dashed arrows with 'open' heads. Arrows of either type directed out of the plane of the paper are shown as dots while those going into the plane of the paper are indicated as crosses or plus signs.

Figure 1A shows a wire perpendicular to the paper with current flowing outward and the resulting magnetic field counter-clockwise around it. Figure 1B shows the direction of the field about a segment of conductor with current flow from left to right. The diagram in Figure 2 shows a coil with current flow into the left lead and out of the right lead giving the field direction as indicated.

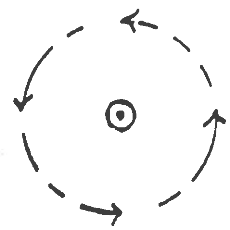


FIGURE 1A

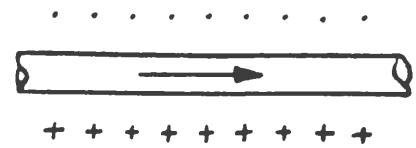


FIGURE 1 B

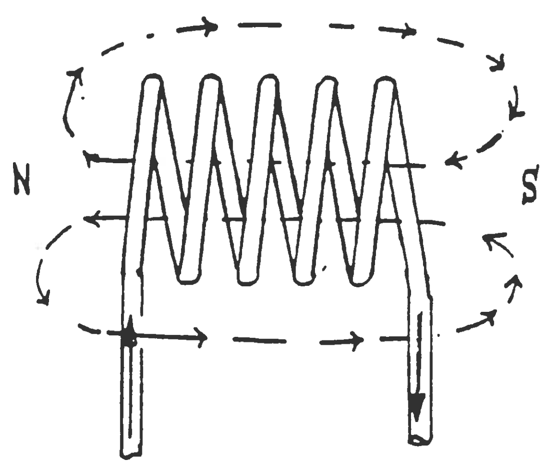


FIGURE 2

The physical changes that take place within a body when it becomes magnetized are the subject of many theories. Since these get into just about every discipline from vector calculus to voodoo, they are beyond the scope of this review! However, some observations and concepts are offered to aid in visualizing magnetic phenomenon. We know that like magnetic poles repel and opposite poles attract and that either type will attract an unmagnetized iron object. It would then seem reasonable to think that a magnetic pole of one type induces an opposite pole in the object that it attracts if such a pole is not already there.

By this concept, when an unmagnetized body, of suitable material, enters the field of a magnetic pole an opposite pole is induced in it at that portion nearest the magnet. When the body is removed from the field, this induced pole will not be retained to any great degree unless it is left in position for some time and/or some mechanical energy is expended on the body while it is in the field. The degree of magnetism retained by a body after exposure to a magnetic field depends on factors such as the composition of the material, its magnetic history and the strength of the field. Soft iron magnetizes readily but, retains poorly while hard steels are more difficult to magnetize yet retain magnetism well.

The property of a material to retain magnetism is called " hysteresis ". An object which retains magnetism indefinitely is said to be a permanent magnet. This is not to say that the magnetism will remain constant since, some materials will lose part of their magnetism over time. Also magnetism can be removed as it was imparted i.e., by heat, vibration, shock or exposure to strong magnetic fields of opposite polarity. For best retention, a magnet should be stored with a soft iron "keeper" across the poles.

The 'strength' of a magnet can be evaluated by the magnitude of its attracting force or how much weight it can lift. A permanent magnet made from some of the better alloys of aluminum, nickel and chromium can be 'charged' to such a degree as to support, in direct contact, up to 16 times their own weight while, a 3% chromium steel magnet of similar size and shape can only support about twice its weight and over time will lose about half its lifting strength. The attracting force of any magnet drops off with distance from the pole faces. Any given magnet will pull 4 times as hard on an object situated 1 inch away as on the same object situated 2 inches away.

As stated early on, a magnet always has both types of poles. If a north pole is induced on one end of a bar a south pole is induced on the other. For example, in Figure 3, when a rod of iron is placed in contact with a north pole face, a new north pole is induced on the opposite end of the rod. It can therefor be supposed that the magnetism from the magnet's north pole flows through the rod much as an electric current flows in a wire.

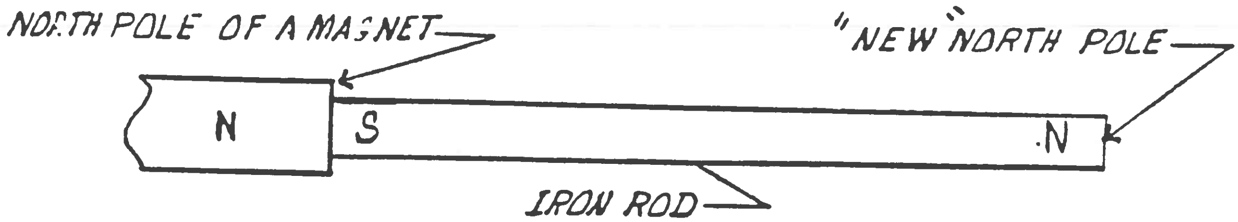


FIGURE 3

To carry this analogy further, just as an electrical circuit carrying current from the positive terminal of a battery to the negative terminal can be formed of wire, a magnetic circuit is formed from the north pole of a magnet to its south pole through a path of iron or any other magnetic material. In fact the magnetic field through the air between the poles of a magnet is a magnetic circuit although, not as 'good' as one of iron would be.

The characteristic indicating 'how good ' a material is as a path for magnetizing force, as compared to air, is called "Permeability". Materials , such as iron , which are much better than air , i.e., have higher permeability ,are called " Ferromagnetic ". Those which are not quite as good as air like wood , are said to be " Nonmagnetic " and are not affected by exposure to magnetism. " Paramagnetic" is the term applied to materials, such as aluminum , which are about equal to , or somewhat higher than air in permeability. The permeability of a material is not constant but, can change as the material becomes magnetized.

The classic experiments with magnets and powdered iron are the basis for some of the concepts and terminology of magnetic fields and circuits. As most of us have probably seen, these consist of sprinkling fine particles of iron on a sheet of nonmagnetic material, like paper or cardboard , covering a magnet and observing the resulting patterns. These patterns are a series of lines connecting the magnet's poles in loop-like formations which seem to suggest that something is flowing along definite paths or " lines ". (See Figure 4) Actually the "lines" are formed by the iron particles attaching themselves to each other as magnetic poles are induced in them and the location of any particular "line" is random.

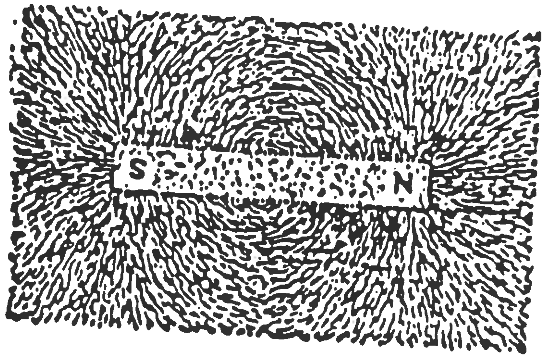


FIGURE 4

Early researchers termed the magnetic field to be " flux " and postulated, from the patterns observed, that it was made up of " lines of flux ". Also where the lines were closer together , the flux was more concentrated that is ,was of greater density. The concept of "flux density " has become very important in the analysis and design of magnetic devices.

Figure 5 illustrates the concept of flux lines about a conductor with current flowing from right to left and angled away from the page. The flux lines form concentric rings expanding out from the axis of the conductor and becoming more and more widely seperated with distance from the current path. The increasing space between successive rings indicates the decrease in flux density with distance from the connductor. Were the conductor coiled into a circle, the lines of flux would be more concentrated inside the circle. If a like conductor loop or ring , with current in the same direction , were placed on top of the first , still more lines would be concentrated inside the circle since , the flux from the current flowing

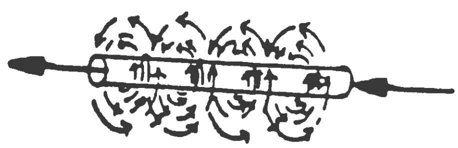


FIGURE 5

in the second loop is adding to and combining with that of the first. The addition of more such conducting loops would further increase the " magnetic field intensity " and hence, flux density within the circles. A hollow stack of such rings or turns all conducting in the same direction constitutes a magnetic coil or " solenoid ". In practice, all of the turns are continuous loops of the same conductor with the current common in all.Each turn adds to the field intensity or strength even with no increase in the amount of current flowing.

A coil as just described can impart magnetism to ferromagnetic materials by placing the object within or near it. The property producing the magnetism is called " magnetomotive force " or "mmf"and since it can be increased by adding current in the coil or turns to the coil, it is measured by the product of the current in amperes and the number of turns on the coil ,i.e.,in "ampere turns ".MMF induces flux in the air or other nearby material. In some aspects mmf is similar to "electromotive force ",or voltage . Voltage causes the flow of current in an electric circuit and mmf causes flux flow in a magnetic circuit.

The amount of flux present in a magnetic circuit is expressed quantitatively in several different units depending on the measurement system used. One common unit is the "line" or " Maxwell ". Flux density or flux per unit area, like 'lines per square centimeter ' or "Gauss " is also a useful measurement.

In electrical circuits, if the terminals of a battery are connected by a # 10 copper wire and a # 10 iron wire, current will flow in both wires but, more will flow in the copper wire since it has higher "conductance ",(lower resistance), than the iron. If two opposite poles of a magnet are connected by a soft iron bar, there will be some flux in the air between the poles but, much more will be in the connecting bar that is the flux density will be greater in the iron than in the air. This is due to the higher permeability of the iron. The flux in the air around a metallic magnetic circuit is called "leakage flux ".

Except for small resistance changes due to changes in the temperature of the conductors, direct current in a simple copper wire circuit will increase in direct proportion to any increase in voltage applied until the wire melts! If the voltage is doubled the current is doubled as described by Ohm's law. In a magnetic circuit composed of ferromagnetic material the situation is a bit more complex. Generally the more mmf applied to a ferromagnetic object the greater the flux or flux density induced in it. The exact amount of flux induced for a given number of ampere turns used to produce it depends on the permeability of the material and the permeability drops off as the flux density increases,i.e,as the object becomes more magnetized. The upshot of this is that with increasing mmf applied the flux density within a body will reach a limit called "saturation " and no amount of mmf will raise it so, there is a limit as to how 'strong' a magnet of a given size, shape and material can be made. The initial permeability and saturation characteristics of magnetic materials are determined by their chemical composition and information on them is provided by the material manufacturers.

Just as permanent magnets can be made to attract or repel each other depending on how their poles are oriented relative to each other,so can current carrying conductors attract or repel each other or be moved by an external field depending on their relative positions and the directions of the current flow. In Figure 6 is shown a conductor with current flowing into the page and at right angles to a fixed magnetic field. The flux around the wire due to the current is in the clockwise direction so as to add to the fixed field flux above the wire and to tend to oppose the flux below the wire. The result is a force tending to move the wire down or away from the stronger field above and into the weaker field below. The amount of force on the wire will increase with the length of the wire in the fixed field and with the amount of current flowing in the wire.

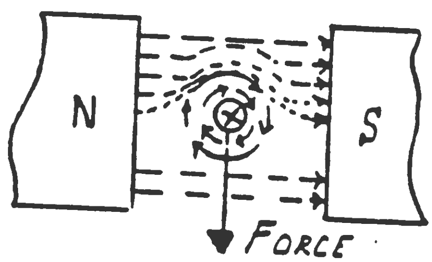


FIGURE 6

In the case of two parallel conductors not in a fixed field, if the current in each is in the same direction their respective fields in the space between them are in opposition so the resulting field is weaker than either individual field on the opposite or outsides of the the wires and the resulting mechanical force tends to force the them together. If the current in one of the wires is reversed , the individual flux fields between them are additive and the resulting force tends to push them apart.

From these principals and rules one can see how, depending on the orientation ,polarity ,and direction of current flow magnets and coils can be made to attract or repel each other in order to provide motive force to drive clock mechanisms. Hopefully, some of the subtleties involved have also been pointed out. If this paper has proved 'palitable',another article expanding on the subject can be undertaken. Comments from the membership would be appreciated.

Jay can be reached at 17823 LA ROSA LANE
FOUNTAIN VALLEY, CA 92708

WHEN IS A VOLT NOT A VOLT?

OBSERVATIONS ABOUT THE USE OF DC POWER SUPPLIES TO POWER BATTERY OPERATED CLOCKS...

by MARTIN SWETSKY, FNAWCC

When battery clocks were originally manufactured, the only power source was the cell, or battery which consisted of multiple cells. While these power sources were far from ideal with their caustic and corrosive electrolytes, and the need for frequent maintenance, they enjoyed a single advantage in that they delivered the intended output voltage.

Modern alternatives include the use of readily available and inexpensive AC Adaptors or Plug-in Wall Transformers. The output voltage of these units varies with the load placed on the device and the rated voltage is correct as indicated when the load matches the ratings. For example, a 12 volt, 300 ma. (milliamperes) power supply will deliver 12 volts **ONLY** when the current drawn is exactly 300 ma. If less, the voltage will be higher, and if greater, the output voltage will be lower. Consider what a great coincidence has to exist for the ratings to precisely match the voltage and current requirements of a clock! How important then, is the exact voltage to be applied to a clock, and what can we do about stabilizing these unregulated devices?

Battery clocks, for the purpose of this discussion, may be divided into 2 categories; the first where electricity is employed in a remontoire application... to activate a solenoid, lift a weight, or rewind a spring. Examples of this type of clock include: IMPERIAL, AMERICAN CLOCK CO., SYNCHRONOME, STROMBERG, STANDARD ELECTRIC, and ITR/IBM, to name a few. The voltage applied to this class of clock is generally not critical, as long as a minimum exists to perform the required operation with safety and reliability, but not to excess where the coil insulation may be damaged. The second group involves the interaction of an electromagnet with a permanent magnet, and in this case, the strength of the magnetic field developed is directly dependent upon the applied voltage, and is a major factor in the clock's timekeeping ability. Examples of clocks in this category include: BULLE, ATO, EUREKA, BRILLIE, VAUCASON, and others.

State-of-the-art electronics provides a solution to our problem with the inexpensive REGULATOR IC CHIP. In practice, a power source is selected that provides a minimum of 2 to 3 volts more than needed, along with adequate current ratings, and the regulator is installed at the output. The choice of regulator will then determine the actual output on a steady and unvarying basis! See the chart in figure-1 for a list of fixed voltage regulators which are readily available from Electronic Parts Distributors and Radio Shack type stores. The connections are shown in the schematic diagram in figure-2.

To go a step further in the line of regulator IC's, an additional option exists with the use of a Variable Voltage IC which provides a choice of voltages from 1.2 to 37, dependent upon the input voltage, which again must be a small amount higher than the required maximum output. Figure-3 details the connection of this device.

The use of a VARIABLE (or ADJUSTABLE) OUTPUT REGULATOR permits voltages to be obtained that are not available from the FIXED Voltage series. The availability of 1½ and 3 Volts for example, are not included in the fixed-voltage devices. Another application for this chip is in a bench-type power supply for testing and repairing clocks prior to the installation of batteries, and in the testing of clocks with unknown voltage requirements.

In the event that a special voltage is required, and the need for adjustment is unnecessary, a few methods are available to provide the desired output. See figure-4 for a chart of fixed resistor values that may be used to replace the potentiometer when 1½, 3, and 4½ volts are required. Another method of obtaining a special voltage is to replace the potentiometer with a fixed resistor to be determined by adjusting the control for the output voltage desired and the measuring its resistance,(with the power off, of course) and using a resistor of that value to replace the control.

As an additional alternative, the resistance value may be calculated using the following formula;

$$R = 240 \times \left[\left(\frac{\text{Voltage Out}}{1.25}\right) - 1\right]$$

For example, let us assume a desired voltage out of 10 volts, the calculations work out as follow;

$$R = 240 \times \left[\left(\frac{10}{1.25}\right) - 1\right] = 240 \times [8 - 1] = 240 \times [\ 7\ ] = \underline{1680 \text{ ohms}}$$

The nearest standard resistance value to 1680 ohms would then be installed which would provide an output within 10%; in practice, an acceptable value in clock applications.

The Regulator IC's that are referred to in this discourse are rated at 1 ampere which could be increased to 1½ amps by the addition of a heat-sink to assist in heat dissipation. This is a stock device that should be available at the same source of supply that provides the IC chip. Given enough space, a few square inches of copper or aluminum fastened to the IC's top tab will prove adequate, keeping in mind, the need for insulating the tab from any part of the circuitry, as it is internally connected to one of the terminals of the IC. In a practical sense, the need for an output greater than 1 ampere would be very rare, limited to a large master/slave system with many clocks in the system. Sample measurements by the author have failed to indicate a need for large currents, testing a variety of battery powered clocks over a period of a year or more. Another group of Regulator IC's exist that can provide current values to as high as 5 amperes, and this information appears in figure-5 for reference, should an unusual case exist that requires one of these units.

The entire family of 3-terminal regulators employ INTERNAL CURRENT LIMITING and THERMAL SHUTDOWN features, making the device virtually blow-out proof! In the event of excessive current drain or a short-circuited load, the output is shut off until normal conditions are restored. This feature, combined with its load stabilizing characteristics provides clear evidence of the value of regulator IC's in any power supply control application.

The information herein presented assumes the availability of a DC Power Supply, and refers to the stabilization and regulation of its output, and in consideration of the availability of these devices, does not include reference to the construction of the basic unit. Pictoral presentations of the components have been included in order to simplify the data for those without electronic backgrounds, and should be considered to be representitive of the parts depicted, but not necessarilly exact duplications. The references to the publications contained in the bibliography following, includes basic material as well as engineering data, and the reader's background should determine his selection of additional information.

A final note before closing is in order as regards the accuracy of output voltages from regulator IC's and their stability. Technical literature regarding these devices refer to a stability factor of 5%, which provides an acceptable figure of merit when applied to most battery clocks, and far exceeds the accuracy of the voltages available from unregulated transformer-type power sources which are subject to the additional variations in output resulting from power line fluctuations.

BIBLIOGRAPHY:

Sylvania ECG Semiconductors, Technical Manual, Linear Modules & IC's
Signetics Analog Manual, Signetics Corp. (1976 edition)
Sourcebook of Modern Transistor Circuits, Cowles, Prentice Hall (1976)
ECG Semiconductors, Master Replacement Guide, Philips ECG (1992)

COMPONENT IDENTIFICATION

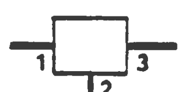
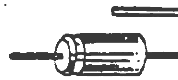
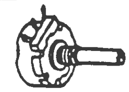
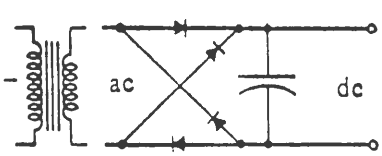
DESCRIPTION	SCHEMATIC REPRESENTATION	PHYSICAL APPEARANCE
REGULATOR IC		see FIGURES-1 & 5
RESISTOR		
CAPACITOR		 or 
POTENTIOMETER		
AC ADAPTOR (WALL TRANSFORMER)		

FIGURE-1

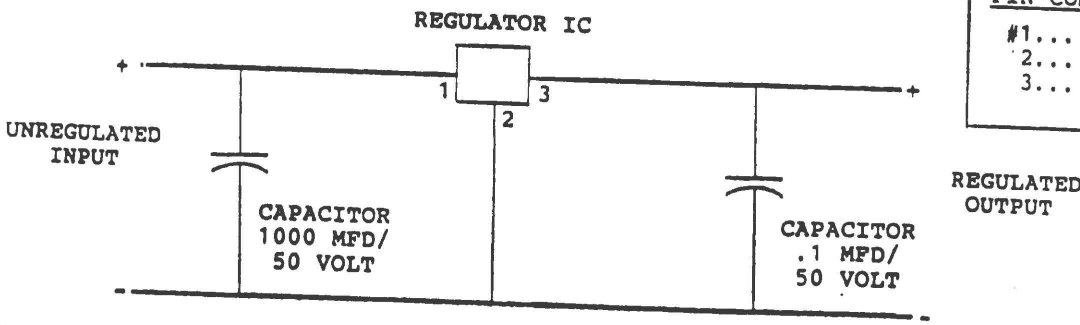
FIXED VOLTAGE REGULATORS (1 AMP)

OUTPUT VOLTAGE	ECG #	GENERIC PART #
5 VOLTS	960	7805, LM-340
6 VOLTS	962	7806
8 VOLTS	964	7808, LM-341
10 VOLTS	1932	-
12 VOLTS	966	7812
15 VOLTS	968	UPC-14315
18 VOLTS	958	AN-7818
24 VOLTS	972	7824

PIN CONNECTIONS

#1... INPUT
2... NEGATIVE
3... OUTPUT

FIGURE-2 **FIXED VOLTAGE REGULATOR**



REGULATOR IC PIN CONNECTIONS

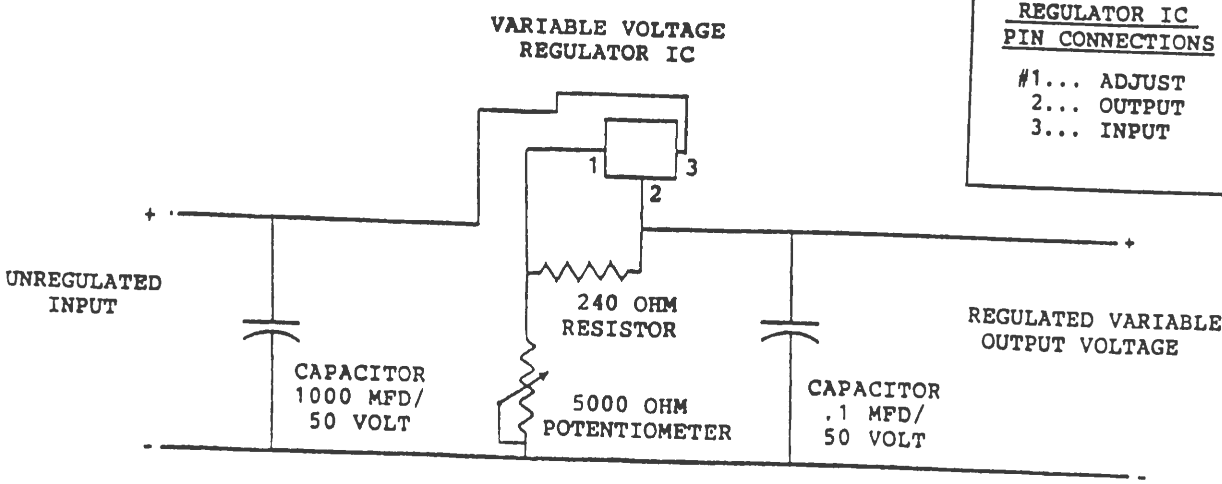
#1... INPUT
2... NEGATIVE
3... OUTPUT

NOTE: THE CAPACITORS, WHILE NOT ESSENTIAL TO THE CIRCUIT OPERATION, ACT AS STABILIZING DEVICES AND REDUCE THE EFFECTS OF TRANSIENTS, AND ARE THEREFORE RECOMMENDED, ESPECIALLY IF THE REGULATOR CIRCUITRY IS NOT LOCATED NEAR THE POWER SUPPLY.

FIGURE-3

ADJUSTABLE VOLTAGE REGULATOR

1.2 TO 37 VOLTS, ECG #956, GENERIC #LM-317-T



REGULATOR IC PIN CONNECTIONS

#1... ADJUST
2... OUTPUT
3... INPUT

NOTE: THE CAPACITORS, WHILE NOT ESSENTIAL TO THE CIRCUIT OPERATION, ACT AS STABILIZING DEVICES AND REDUCE THE EFFECTS OF TRANSIENTS, AND ARE THEREFORE RECOMMENDED, ESPECIALLY IF THE REGULATOR CIRCUITRY IS NOT LOCATED NEAR THE POWER SUPPLY.

FIGURE-4

VOLTAGE/RESISTANCE RELATIONSHIP FOR FIXED OUTPUT VOLTAGES FROM AN ADJUSTABLE VOLTAGE REGULATOR

OUTPUT VOLTAGE	FIXED RESISTOR (REPLACING POTENTIOMETER)
1½ VOLTS	47 OHMS
3 VOLTS	330 OHMS
4½ VOLTS	620 OHMS

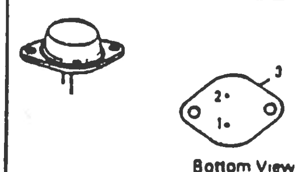
FIGURE-5

HIGH CURRENT FIXED VOLTAGE REGULATORS

OUTPUT VOLTAGE	ECG #	OUTPUT CURRENT
5 VOLTS	931	3 AMPERES
5 VOLTS	932	5 AMPERES
12 VOLTS	1912	3 AMPERES
12 VOLTS	933	5 AMPERES
13.8 VOLTS	934	5 AMPERES
15 VOLTS	1918	3 AMPERES
18 VOLTS	1920	1½ AMPERES
24 VOLTS	1924	1½ AMPERES

PIN CONNECTIONS

#1... INPUT
2... OUTPUT
3... NEGATIVE



NOTE: The ECG numbering system is used more often by local Electronic Parts Distributors while the Generic system is used more often by mail order Electronic Suppliers and Radio Shack type stores.

ELECTRICAL HOROLOGY MEETING

A meeting of those interested in electrical horology was held as a part of the 1993 Great Lakes Regional in Dearborn, Michigan. Eighteen people attended, and host Bill Ellison opened with a brief description of the three electrical horology chapters. Tony Bolek of Harper Woods, Michigan presented a very thorough description of the Kundo electronic clocks; the familiar curved rod pendulum bob type. Tony explained the basics of magnetism as applied to these clocks, and described how he analyzed the Kundo electronic circuit. He noted the that three different versions of the circuit was used aside from the mechanical switch type. Tony explained how each circuit worked, with a demonstration of one that was a self-starting type, using a mock-up and beat amplifier. The Kundo clocks all receive their impulse near the center of pendulum travel, and when compared to the Schatz electronic clocks which are impulsed at the end of the pendulum's swing, proved to be better timekeepers.

Bill Ellison, during the regional, demonstrated a new Slave Clock Controller; a battery operated device which offers quartz accuracy and minute-stepping operation for slave clocks with minute impulsing. Contact him at Horolovar Company for more information. Box 264, St. Clair Shores, MI 48080.

--- MART ---

All MART Ads are FREE, Send copy to the attention of the Editor:
Harvey Schmidt, 75-80 179th St., Flushing, NY 11366. Limit 3 lines.

WANTED: HOROLOGICAL LITERATURE, Repair info, Catalogs, etc. for the Journal
PORTESCAP Secticon Clock or Movement. (718) 969-0847
Harvey Schmidt, Editor, 75-80 179th St., Flushing, NY 11366

Junker EARLY BATTERY CLOCKS, Movements, Parts, etc, send details.
Martin C. Feldman, 6 Stewart Pl., Spring Valley, NY 10977

Motor for a "CALCULAGRAPH" clock. (This clock was made by the CALCULAGRAPH CO., New York. It was used for timing telephone calls). Paul Hopkins, 2717 Millwood Rd., Birmingham, AL 35243

Pendulum support casting, suspension spring, pendulum rod, and bob for a 1 second GENTS
Richard B. Pridham, 10402 Bellman Ave., Downey, CA 90241

Plans, drawings to build a SETH THOMAS No. 2 Case
K. C. Denney, 3819 E. 55th Street, Tulsa, OK 74135

F.L. GREGORY (SEMPIRE) Movement, & like to know if you have a clock with "F.L. Gregory Clock Company, Electric Gravity, Chicago, Illinois" on dial. Early Bipolar Motors, & Early Electric Fans. A complete DARCHE Medical Clock as shown on pg. 19 of "150 Years of Electric Horology" (817) 267-9851
Steve Cunningham, 3200 Ashland Dr., Bedford, TX 76021

N.Y. STANDARD WATCH CO. movement, short pendulum type (approx. 120 beat), any repairable condition. Would also like dial, hands, and pendulum if available. (713) 554-7387
Kenn L. Koerber, 105 Royal Dr., League City TX 77573

ELECTRO-MECHANICAL CLOCKS, preferably fancy cased and exposed pendulum clocks. Elliot Siegel, 103 East Neck Road, Huntington, NY 11743, Day or Night (516) 541-2400 or (516) 351-5869

SWCC type F 120 beat movement; anything made by HOLTZER-CABOT; nice wood cased slaves; very early electric motors and fans.
(817)267-9851 Steve Cunningham, 3200 Ashland Dr. Bedford TX 76021

AMERICAN CLOCK CO., Pendulum Rod & Bob for 80 beat Wall Regulator
W. MacAvoy, 3400 Pruss Hill Rd., Pottstown PA 19464 (215)287-8934

Antique Watch & Clockmakers Tools and Machinery. (718) 969-0847
Harvey Schmidt, 75-80 179th St., Flushing NY 11366

REPAIR: ALL EARLY BATTERY CLOCKS Specializing in BULLE using orig. parts.
Martin C. Feldman, FNAWCC, 6 Stewart Pl., Spring Valley, NY 10977

FOR SALE:

TIFFANY NEVER WIND, Double Contact Model, Replacement Castings for Pendulum Suspension & Contact Arms (Brass not Pot Metal) $2Ø each, $37 for both. (8ØØ) 221-Ø424 X2Ø6
Martin Swetsky, 191Ø Coney sland Ave., Brooklyn NY 1123Ø

Repair Parts for TIFFANY NEVER-WIND Clock Co., CLOISTER Mfg. Co., & NATIONAL MAGNETIC Clock Co.
David Lee, P.O. Box 171, Knox, NY 121Ø7

REVERE Electric (Herschede) Grandfather Clock, 7 ft. Mahogany Case w/glass 3 sides. 9 tubes, 3 chimes. Circa 1928. $9ØØ.ØØ (2Ø1) 652-1Ø25 Mon, Wed, Fri. 9am to 9pm, other 9am to 5pm.
Roger Sanford, 12 Godwin Plaza, Midland Park, NJ Ø7432

Hi-Grade Electromechanicals such as: MONARCH with Mercury Pendulum, MERCER Chronometer in a Carved Mahogany Case, Early Wall Regulator in Carved Mahogany Case (6 ft.) maker unknown, etc. (617) 599-4171 or 598-3881, Evenings and Weekends.
Steve Lefkowitz, 13 Puritan Park, Swampscott, MA Ø19Ø7

RADIOCHRON, scallop top cathedral style tube radio with built in manual start clock on matching table. Radio and clock work, $2ØØ
Terry Willett, 1Ø3Ø6 Ky 815, Utica KY 42376, (5Ø2) 785-48Ø8

SYNCHRONOME (Hope-Jones) Master Clock, as on p. 72 of "15Ø Years of Electric Horology" w/ separate slave & multiple relay for control of large system of slaves. ITR (predecessor of IBM) elect. rewound master clock w/ mercury pendulum. (2Ø6) 842-5835
Alan Seymour, 1Ø847 Bill Pt. Bluff, N.E., Bainbridge Is. WA 9811Ø

SCOTT BATTERY Electric Shelf Clock (London Stereoscopic Co.) Circa 19Ø5. Photo & Details in A. & R. Shenton "The Price Guide to Collectable Clocks." Fig. 4Ø4. (8ØØ) 221-Ø424 X2Ø6
Martin Swetsky, 191Ø Coney Island Ave., Brooklyn NY 1123Ø

Last minute additions:

WANTED:

Kundo Electric Clock with a mechanical switch (rather than transistors). I would like to buy or borrow one of these clocks for study purposes.

Brillie Clock. Dial and hands needed for a one-half seconds Brillie Clock.

Holtzer-Cabot Magneto Clock. I would like to borrow or buy some paper disks which were used in this clock for recording the watchman's stations. If there is interest, I will reproduce these disks for other Holtzer-Cabot owners. Bill Ellison, 1635 Ford Court, Grosse Pointe Woods, MI 48236. Telephone (313) 881-2906.

THE JOURNAL OF THE
ELECTRICAL HOROLOGY SOCIETY
CHAPTER #78 NATIONAL ASSOCIATION OF WATCH & CLOCK COLLECTORS

VOLUME XVIV, NUMBER 4, DECEMBER 1993

FELLOW HOROLOGISTS:

In this issue, the last one for 1993, we are pleased to once again be able to publish a reference work of lasting importance. It is our goal to provide a journal each year or two which contains material of such significance that it may stand on its own as an acknowledged reference for use by horologists for many years into the future.

With this objective in view, we are pleased to offer, in this journal, a hitherto unpublished survey by CHARLES K. AKED titled "A MILLENARY OF ELECTRICAL HOROLOGY REFERENCES", covering 1000 publications in the general listing, followed by a chronological and name listing to complete the references. We are proud to have undertaken the task of publishing this work and are greatly indebted to Mr. Aked for his kind permission to provide the means for its exposure.

You will note the change in appearance of the journal's letterhead which your editorial team has determined better exemplifies the dignity of the chapter, and is in greater keeping with its image and objectives.

The MART section, consisting of almost two pages in this issue, will once again undergo its annual revision... All material which presently appears will be ELIMINATED, UNLESS the editor is advised of the desire for continued publication. It is obvious that out-of-date material must be removed to make room for current ads, and the method chosen for the editing has met with general approval, at least insofar as we are able to tell from the correspondance received. Your views are always welcome, and the membership's comments on all aspects of the journal are given due consideration. Remember that this is YOUR chapter and YOUR journal, and is the forum for YOUR views, criticisms, and comments. Perhaps we should have a column entitled "Letters to the Editor"... food for thought...

Since it's around year-end, the news that dues are once again due should come as no surprize... If there's a notice attached, it means that you will owe $10 (NO INCREASE) for 1994, and your prompt response will be appreciated.

(continued)

--- MART ---

All MART Ads are FREE, Send copy to the attention of the Editor: Harvey Schmidt, 75-80 179th St., Flushing, NY 11366. Limit 3 lines.

WANTED: HOROLOGICAL LITERATURE, Repair info, Catalogs, etc. for the Journal
PORTESCAP Secticon Clock or Movement. (718) 969-0847
Harvey Schmidt, Editor, 75-80 179th St., Flushing, NY 11366

Junker EARLY BATTERY CLOCKS, Movements, Parts, etc, send details.
Martin C. Feldman, 6 Stewart Pl., Spring Valley, NY 10977

Motor for a "CALCULAGRAPH" clock. (This clock was made by the CALCULAGRAPH CO., New York. It was used for timing telephone calls). Paul Hopkins, 2717 Millwood Rd., Birmingham, AL 35243

Pendulum support casting, suspension spring, pendulum rod, and bob for a 1 second GENTS
Richard B. Pridham, 10402 Bellman Ave., Downey, CA 90241

Plans, drawings to build a SETH THOMAS No. 2 Case
K. C. Denney, 3819 E. 55th Street, Tulsa, OK 74135

F.L. GREGORY (SEMPIRE) Movement, & like to know if you have a clock with "F.L. Gregory Clock Company, Electric Gravity, Chicago, Illinois" on dial. Early Bipolar Motors, & Early Electric Fans. A complete DARCHE Medical Clock as shown on pg. 19 of "150 Years of Electric Horology" (817) 267-9851
Steve Cunningham, 3200 Ashland Dr., Bedford, TX 76021

N.Y. STANDARD WATCH CO. movement, short pendulum type (approx. 120 beat), any repairable condition. Would also like dial, hands, and pendulum if available. (713) 554-7387
Kenn L. Koerber, 105 Royal Dr., League City TX 77573

ELECTRO-MECHANICAL CLOCKS, preferably fancy cased and exposed pendulum clocks. Elliot Siegel, 103 East Neck Road, Huntington, NY 11743, Day or Night (516) 541-2400 or (516) 351-5869

SWCC type F 120 beat movement; anything made by HOLTZER-CABOT; nice wood cased slaves; very early electric motors and fans.
(817)267-9851 Steve Cunningham, 3200 Ashland Dr. Bedford TX 76021

AMERICAN CLOCK CO., Pendulum Rod & Bob for 80 beat Wall Regulator
W. MacAvoy, 3400 Pruss Hill Rd., Pottstown PA 19464 (215)287-8934

Antique Watch & Clockmakers Tools and Machinery. (718) 969-0847
Harvey Schmidt, 75-80 179th St., Flushing NY 11366

KUNDO ELECTRIC Clock w/ Mechanical (not Transistor) Switch. Want to buy or borrow one for study purposes. Dial & Hands for a one-half second BRILLIE CLOCK. Want to borrow or buy some paper disks used in the HOLTZER-CABOT MAGNETO CLOCK for recording the watchman's stations. If there is interest, I will reproduce the disks for others. (313) 881-2906
Bill Ellison, 1635 Ford Court, Grosse Point Woods, MI 48236

Switch Assembly & Actuating Cam w/ Arbor for ITR Master Clock. Will consider complete movement. Please state condition & price in reply. SCHOTZ, KUNDO, & other high grade electrics & electric animateds such as MASTERCRAFTER, HADDON, UNITED, etc. Also accessories and parts. (614) 759-7660
Joe R. Clark, 12954-B Stonecreek Dr., Pickerington OH 43147

REPAIR: ALL EARLY BATTERY CLOCKS Specializing in BULLE using orig. parts.
Martin C. Feldman, FNAWCC, 6 Stewart Pl., Spring Valley, NY 10977

FOR SALE: TIFFANY NEVER WIND, Double Contact Model, Replacement Castings for Pendulum Suspension & Contact Arms (Brass not Pot Metal) $20 each, $37 for both. (800) 221-0424 X206
Martin Swetsky, 1910 Coney Island Ave., Brooklyn NY 11230

Repair Parts for TIFFANY NEVER-WIND Clock Co., CLOISTER Mfg. Co., & NATIONAL MAGNETIC Clock Co.
David Lee, P.O. Box 171, Knox, NY 12107

Hi-Grade Electromechanicals such as: MONARCH with Mercury Pendulum, MERCER Chronometer in a Carved Mahogany Case, Early Wall Regulator in Carved Mahogany Case (6 ft.) maker unknown, etc. (617) 599-4171 or 598-3881, Evenings and Weekends.
Steve Lefkowitz, 13 Puritan Park, Swampscott, MA 01907

RADIOCHRON, scallop top cathedral style tube radio with built in manual start clock on matching table. Radio and clock work, $200
Terry Willett, 10306 Ky 815, Utica KY 42376, (502) 785-4808

SCOTT BATTERY Electric Shelf Clock (London Stereoscopic Co.) Circa 1905. Photo & Details in A. & R. Shenton "The Price Guide to Collectable Clocks." Fig. 404. (800) 221-0424 X206
Martin Swetsky, 1910 Coney Island Ave., Brooklyn NY 11230

THE SLAVE CLOCK CONTROLLER

Introducing the SLAVE CLOCK CONTROLLER. Do you have a few slave clocks at home and are you wondering what to do with them? Here is the device that you have been looking for. The SLAVE CLOCK CONTROLLER converts these slave clocks into precision timekeepers offering quartz accuracy along with the charm that these beautiful, old clocks offer. The SLAVE CLOCK CONTROLLER is a battery powered device that will run these slave clocks for more than one year. The clocks will run just as they were designed to run with minute stepping of the hands. Only two connections to the clock mechanism are required. No changes to the mechanism or to the wiring are necessary so that the original integrity and value of the slave clock are protected.

If interested, contact Bill Ellison, address & phone in top ad, this page.

THE JOURNAL OF THE
ELECTRICAL HOROLOGY SOCIETY
CHAPTER #78 NATIONAL ASSOCIATION OF WATCH & CLOCK COLLECTORS

Editorial, continued from page 1.

A reminder to members requesting reprints of previously published journal material... Send your requests to our chapter historian, Dr. George Feinstein at 75-19 195th Street, in Flushing, NY 11366. Please include 25¢ per page, or $3 per complete issue, plus postage. Our latest index includes 20 years of journal information, much of which is unavailable elsewhere.

Thanks to all those contributors of material for the journals throughout the past year... if we try to name all of them. we're sure to miss out on some, so please accept our combined thanks.

The 1994 Dues notice follows, and we request your very prompt attention. Remember that all of the chapter business is conducted by a few volunteers, and needless billing to late payers adds to the burden...

we apologize for our goof in numbering the journals during 1993; The volume numbers for 1993 should have been XVIV, not XVIII. Please correct your issues so that the next index will identify them properly.

With our best wishes for happiness during this Holiday Season and a Healthy and Prosperous New Year...

Martin Swetsky, FNAWCC,... President
Harvey Schmidt }
Dr. George Feinstein }.... Co-Editors

RENEWAL MEMBERSHIP or APPLICATION FORM

Please print all information:

NAME______________________________NAWCC#____________________

ADDRESS____

I wish to become a member of the Electrical Horology Society--#78 and enclose my $10.00 dues for the year 1994.

__________ check here

I wish to renew my current membership in the Electrical Horology Society--#78 and enclose my $10.00 dues for the year 1994

__________ check here

SIGNED:____________________________DATE:____________________

HARVEY SCHMIDT, SECRETARY-TREASURER 75-80 179th STREET, FLUSHING, NY 11366

JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY

VOL. # XIX #4, DECEMBER 1993

A MILLENARY OF ELECTRICAL HOROLOGY REFERENCES

COMPILED BY CHARLES K. AKED
FNAWCC C ENG MIEE

6

A MILLENARY OF ELECTRICAL HOROLOGY REFERENCES

A PRELIMINARY SURVEY OF THE PUBLISHED MATERIAL IN ELECTRICAL HOROLOGY

CHARLES K AKED FNAWCC C Eng MIEE

EXPOSITION

Many years ago the author produced the first list of electrical horology references, distributing it to members of the newly-formed Electrical Horology Group of the Antiquarian Horological Society. The list was edited and shortened to be included in the *Electrifying Time* catalogue published in 1976 as Monograph No 10, see pages 19-20. It was also included in *A Conspectus of Electrical Timekeeping*, published also in 1976 as Monograph No 12, see pages vi-vii. Both of these were intended to commemorate the centenary of the death of Alexander Bain on 2nd January 1877, and were produced for the Electrical Horology Exhibition held at the Science Museum, London, the first of its kind in the world.

In spite of prognostications by the Antiquarian Horology Society's accountant, that neither book would sell, 1,500 copies of the first, and 2,500 copies of the second book were sold, both are now out of print and the asking price is many times the original.

In order to be able to refer to his own material on the subject of Electrical Horology, the author has assembled the listing given here, actually the catalyst came from an enquirer who sought such a source of information. It was started by entering entries just as they came to hand. The intention was then to place these in chronological order, but this was soon found to be too time-consuming on a word processor, also the listing proved no more logical as a result. If an author has produced several works, it is more convenient to have these together than separated by date. Moreover the insertion of new entries would be most inconvenient if the sequence of chronological order was to be maintained, necessitating rearrangement of the whole each time the changes were introduced. The alternative of alphabetical listing of the authors' names removes the need for a name index but does not produce a more logical listing for searching when the name is not known.

A Chronological Index of entries is given, which together with the Name Index, should enable the user to find the entries of interest to him. Such well known examples as the Eureka, Murday, or Self-Winding clocks, will be found in the Name Index. A Subject Index was considered but many of the entries are of such general coverage that the index would have become over-large, thus making the work too expensive to publish.

After one thousand entries had been reached, it was decided to stop, not only for the cost, but also to keep production of the indexes to manageable proportions. A few more entries were added merely to fill the last page up, and to provide a reserve should an entry have been duplicated earlier and have to be deleted, it is not easy to avoid such duplication of entries with a large number.

When the original listing was produced, many expressed surprise at so many references, one person thinking it would be quite impossible to enlarge it much further as proposed. The reader may be assured that the present listing, much larger than anything ever produced before, is only the tip of the iceberg. For example the entire run of the *Horological Journal* needs to be searched and the electrical items extracted, only a few are included in the present list. The material published in the Electrical Horology Group of the Antiquarian Horological Society newsletter also has been omitted in general, as that of the various groups in the USA and elsewhere. It may be said that this is a foundation for others to build upon.

Many snippets of information are come across by the process of serendipity, and should the reader locate some item thus, make a note of it immediately to avoid needless searching for it later. Good luck, like lightning, very rarely strikes twice in the same place; relevant facts are often found in the most unlikeliest of places. Who would have thought that a letter on the first electrical turret clock fitted would have been found in Loughton Church, Essex; or a letter from someone whose father actually looked after one of the earliest of these, would have been found in an obscure Essex journal, written when he was in his nineties?

English electrical horologists may have been misled by the writings of Frank Hope-Jones into thinking that electrical horology acquired respectability mainly through English efforts, in particular his own. Without belittling him, it is fair to say that the progress of electrical horology was largely initiated by others, few of whom had his entrepreneurial astuteness or the ability to express themselves as clearly and concisely. The comparison of Langman and Ball's *Electrical Horology* with Hope-Jones' *Electrical Clocks* is sufficient to demonstrate this, yet the former were far more inventive and did not require the assistance of outsiders to inject improvements into their systems. Most of us have acquired a working knowledge of electrical horology via the writings of Frank Hope-Jones, and had he only been more tolerant of the inventions of others, and included all the relevant history of the developments in electrical horology, his book would have continued to be the "Bible" for electrical horologists all over the world. Those whose designs were comparable with those of the Synchronome system were either ignored or dismissed, whilst the vast bulk of the Continental work lay all undiscovered before him, containing many practical applications anticipating those of Hope-Jones by many years. The earliest applications of electricity to horology were completely ignored, eg that of Sir Francis Ronalds, Professor Ramis and others.

The author is pleased to see that others are taking up the massive task of collating information on electrical horology. The recent three-part article by Derek Bird in *Antiquarian Horology* on the "Pulsynetic System" is a very valuable contribution to our knowledge. His observation that Parsons and Ball were the real innovators of the electrically reset gravity remontoir impulsing the pendulum, coincides with the personal views of the writer arrived at over a long period of time. Yet in spite of writing on electrical horology long before Hope-Jones began his writing career with his series of articles in the *Practical Watch and Clock Maker*, they did not have as much impact on the contemporary horological scene; nor did they assert themselves anything like so forcibly as the redoubtable Frank Hope-Jones.

We therefore have the long task of gathering information and reassessing the history of electrical horology in the light of the results of a new re-examination of the salient facts, unbiased by personal pride and prejudice; guided merely by a desire to derive a true history of electrical horology without placing individual technical merit on a pinnacle and ignoring the lesser endeavours of other workers which often served the purpose of clearly demonstrating that certain lines of approach were totally unprofitable. We often learn more from our mistakes than from our facile achievements.

Complementary to this listing is a similar listing of books on electrical horology and those connected with it, for example early batteries. This has at present over two hundred entries alone and is still being enlarged. A few works will therefore be found common to both listings, in general the present list concentrates on material rather than books on electrical horology. There is also the earlier listing of electrical horology patents - *A Parergon of Electrical Horology, Electric Clocks Patents for the period 1840-1900*, by the present author, now out of print; with similar unpublished listings of Swiss and French Patents. Thus there is a very large area of information to be searched and later collated, analyzed and prepared for recording before a correct view of the history of electrical horology can be obtained. In particular the events in Continental countries and the States need to be more closely scrutinized although progress in these areas seems to have been largely independent through ignorance of development work elsewhere.

There have been, following the first British example, the formation of several groups on the Continent and in the States devoted to the collecting of examples of electrical horology and in pursuing its history. There is no doubt that the largest amount of material on electrical horology is to be found in Europe, since it was treated seriously there from the beginning, with craftsmen of the calibre of Breguet and Hipp being interested in electrical clocks and not, as in England, ignored by most clockmakers and left to electricians. The unvarnished truth is that the majority of English clockmakers were not able to come to terms with electrical matters, and the majority of electricians did not understand the basic principles of horology. The material listed here clearly demonstrates the struggle to attain perfection of timekeeping by the use of electricity as a motive force applied to what were basically mechanical clocks, and its unique application in the distribution of time as first envisaged by that great pioneer, Alexander Bain.

The author will be pleased to hear from anyone with details of material not included in the present listing since it is too large a task for any single person to examine all the relevant literature. Details of contemporary commercial leaflets, letters between suppliers and customers, or personal correspondence would be especially welcome. Those who are looking for areas in which to search might start with the records kept by the Royal Greenwich Observatory. The personal files of W Hamilton-Shortt are also deposited here and have never been examined by a competetent electrical horologist. Complete runs of horological journals would provide another fruitful source of relevant information, including contemporary advertising.

It would have been far preferable to publish this work in proper book form, with the support of appropriate illustrations, however it is not a commercially viable proposition. Nor does the Antiquarian Horological Society publish the results of original research as laid down in its Memorandum of Association. The author has so far received little encouragement with private publication, each work so far has left him out of pocket, without taking into account the expense of producing the master copy, and the enormous amount of time involved in the preparation of the data and the indexes. However knowledge gained is of little use unless it is spread amongst those to whom it is of interest, and the author has seen too many piles of paper, which their creators fondly hoped one day would crystallize into beautiful and useful treatises, but which in reality gently mouldered into obscurity without ever seeing the light of day. Having helped many to achieve the ultimate goal of having their work published in the past at the expense of his own, the author now feels compelled to record some of his before Anno Domini dictates otherwise.

It has taken many years to acquire the literature included here, most items are very scarce because so little importance was placed on them when current. What is worse, there is no central source which may be consulted by those seeking information, electrical horological history has not been taken seriously until recently. Up to a decade or so ago, most horologists treated electrical clocks as a joke, an hilarious extension to the real horology of the master craftsmen. Now electric horology has advanced so much as to place mechanical horology firmly into the history book, the little remaining struggling to survive against the threat of total annihilation. The sneers and denigration of the opponents of electrical timekeeping were not enough to prevent the steady advances built on the experience of the early electrical horologists working under tremendous handicaps, until finally there came the day when electrical horology wrested the accurate timekeeping of the world from mechanical clocks for ever.

Much ingenuity is evident in the design of electric clocks, possibly much of it misplaced, for the great majority of electric clocks from 1840 onwards were based on the simple principle that a soft iron core becomes strongly magnetised when a coil of wire around it carries an electric current, and can attract a soft iron aramature with considerable force, yet release it almost instantly when the current is cut off. It is one of the simplest ways of transforming electrical energy into the small amounts of motive power required to energise a clock, and most convenient to those whose abilities did not stretch to producing the fine mechanical trains capable of doing the same. Yet the majority of electric clocks were really mechanical clocks, including the Free Pendulum devised by W H Shortt, and that is why the Continental examples are generally superior in quality of workmanship to those made in England, they were made by clockmakers who learnt how to understand electricity, not by electricians trying to make clocks. Possibly the attitude of clockmakers on the Continent played a large part, they regarded electrical clocks as just an extension of their trade, not as in Britain where clockmakers were violently opposed to their introduction; so the fields of endeavour in different areas diverged. Strangely enough the most successful battery electric clock of all, the Bulle, was a miniature version of the original design of Alexander Bain, it sold in the hundreds of thousands, and was developed in France.

It is hoped that this essay, imperfect though it may be, will be of service in saving much time for those who carry out research in the future.

Charles K Aked. November 1987

CHRONOLOGICAL AND NAME INDEXES

NOTE: In the Indexes following the main work, the figures given refer to the number against each entry in the main listing, these being printed in italics in the Chronological Index in order to differentiate them from the upright figures of the years in which they are grouped.

A MILLENARY OF ELECTRICAL HOROLOGY REFERENCES

1. *Time in Broadcasting*. 16 pp. 4 figs. Souvenir booklet prepared by BBC for BHI Centenary October 1958 - Pendulum to Atom Exhibition. (Visited this personally 23 October 1958, Prince Philip also there).

2. "T.M.C. Electrical Time Service in Industry". S J Smith FBHI. pp 12. 25 figs. Lecture on TMC Electrical Clock Systems to BHI Meeting 7th November 1946.

3. *Instructions for the Installation and Maintenance of Gent of Leicester Pul-syn-etic Controlled Electric Clock System*. pp 12. 8 figs. Circa 1965.

4. "Making an Electric Time Transmitter and Dial Mechanism". Charles Blazdell. pp 10. 11 figs. Published in three parts in the *Model Engineer*, 5 and 19 April 1968, and 3 May 1968.

5. "The Quartz Clock". L Essen. pp 12. 5 figs. Talk given to The Royal Astronomical Society, 8 April 1938, at Burlington House. Reprint from *Occasional Notes*, No 1, June 1938.

6. A M F Venner Catalogue of Process Timers. Many pages and illustrations. Published 1972.

7. Small Synchronous Motors Leaflets. Impex Electrical Limited. Published 1972.

8. "Electric Time Service". F Hope-Jones. pp 17-29. 14 illustrations, including portrait of author in 1901. Article in *Fielden's Magazine*, Volume 5, No 1, July 1901. (One of his first published articles).

9. *Electrical Time Service*. F Hope-Jones. pp 23. 5 figs. Read before Institution of Electrical Engineers, Thursday, 14 December 1901.

10. *Electric Clocks*. F Hope-Jones. pp 24. 15 figs. "The Electrician" Primer Section no 79. Circa 1904.

11. *Modern Electric Time Service*. F Hope-Jones. pp 67. 32 figs. Read before Institution of Electrical Engineers, 17 February 1910, and awarded a premium. Printed and published at 6d per copy by IEE.

12. *Electric Clocks*. F Hope-Jones. pp 16. 12 figs. Rewritten 1914. "The Electrician" Primer No 79.

13. *Electrical Impulse Dials*. F Hope-Jones. pp 12. 8 figs. 1914. "The Electrician" Primer no 79a.

14. *Electric Time Service*. F Hope-Jones. pp 16. 13 illustrations. Catalogue of Synchronome Clocks issued about 1915 when the firm was at 32 and 34 Clerkenwell Road, London EC.

15. *The Synchronome Catalogue*. pp 8. 12 figs. Published in 1930's.

16. *Synchronome Electrical Impulse Clocks*. Catalogue E.I. 35, published March 1939, Abbey Electric Works, Mount Pleasant, Alperton, Middlesex. Profusely illustrated.

17. *The Greenwich Observatory Free Pendulum Clocks*. pp 4. (Sidereal clocks No's 3 and 11, Mean Time clocks No's 16 and 49). Memorandum published by Synchronome March 1935.

18. Letter dated 24 June 1975 to Editor of *Antiquarian Horology* from Dr D M A Mercer, with copies of material in connection with the installation of a Synchronome electric clock in the Physics Department of Southampton University. Copy of letter from F Hope-Jones dated 17 April 1925. Papers now at Hurstmonceux.

19. *Silent Electric Clocks*. pp 7. 17 figs. Leaflet published in 1910's. (School Installations).

20. "A Clock of Precision". C O Bartrum. pp 120-149. 13 figs. Paper read to the Physical Society of London and published in their *Proceedings*, Volume 29, Part 2, 15 February 1917.

21. "On Improvements in Astronomical Clocks". David Gill. Read at the Sheffield Meeting of the Society for the Advancement of Science in 1879 and published in their Report of 1880, pp 56-61. 6 figs.

22. *The "Synchronome" Astronomical Regulator*. 4 pp. 2 figs. Description of W H Shortt's Inertia Escapement astronomical regulator. Published 16 January 1912. (It was a failure in practice).

23. *On Horological Telegraphy, etc*. J A Lund. 19pp. 2 figs. 1876. Reprinted article from the *Watchmaker and Jeweller*. This outline's J A Lund's method of distributing time and the hourly correction of clocks by an electric current, then a popular method of synchronizing a large number of clocks.

24. The Correction of Clocks by Hourly Currents of Electricity. F J Ritchie. 15 pp. 3 figs. Paper read before the Royal Scottish Society of Arts, Edinburgh, 11 March 1878. A excellent electrical horologist.

25. *Nouveautés en Electro-Chronometrie*. A Waelti. 24 pp. 10 figs. Bienne. 1921. Mainly about the new electrically impulsed precision pendulum of S A Favarger et Cie, invented by J Abegglen and A Waelti. (New improvements in Electro-Chronometry). French text.

26. Prospectus of the Kennedy Electric Clock Company. 14 pp. 1 fig. Electric Clock patented 3 December 1867 under the title of Kennedy Electric Clock. (Exact copy of Alexander Bain's clock). The clock is illustrated in an engraving which shows the sliding contact bridge and solenoids on each side of the bob. The prospectus is dated 1869, the address 482 (corrected from 481) Broadway, New York.

27. "A Novel Electric Clock". Article in *The Model Engineer and Amateur Electrician*, 15 November 1902, page 233. A description of the operating mechanism of the electric clock invented by Oscar A En Holm. Patented 17 May 1901 - this shows the winding mechanism only - mercury switch tilted by arm on weight rod.

28. Precision des Garde-Temps piézo-électriques et des Pendules astronomiques. Paul Dittisheim. Followed by Description of a *Garde-Temps contrôlé au moyen de quartz piézo-électriques*. M Armand de Gramont. 25 pp 15 figs; plus 7 pp. 4 figs. Printed from *Annales françaises de Chronométrie*, last quarter 1936, 1st and 2nd quarter 1937. Published Besançon 1937. (Accuracy of piezo-electric timekeepers and astronomical clocks), and (Description of a timekeeper controlled by means of piezo-electric quartz). French text.

29. Leaflets, dated December 1978, describing the Junghans Ato-Mat movement 736, the Scholer high frequency quartz movement W 82, Electronic battery pendulum movement W 72, and the electronic battery movement W 71.

30. *Instructions for Erection and Management of "Synchronome" Electric Time Circuits*. F Hope-Jones. 8 pp. 3 figs. Circa 1920's.

31. *Frequency Measurement in Electrical Communication*. J W Horton, N H Ricker and W A Marrison. 33 pp. 16 figs. Paper presented at Convention of AIEE, June 1923, published by Western Electric Co. June 1924.

32. *Vacuum Tube Oscillators*. J W Horton. 17 pp. 8 figs. Western Electric reprint B-88-1 dated August 1924, reprinted from *Bell System Technical Journal*, Volume III, no 3, July 1924.

33. "A swing towards understanding electrical machine instability". I E D Pickup and A P Russell. Article in *Electrical Review*, Vol 203, No 15, 20 October 1975. pp 62-3. (Electrically maintained pendulum).

34. "The Amateur Scientist". Vannevar Bush and John Early Jackson. Article in *The Scientific American*, Vol 203, No's 1 and 2, July and August 1960, pp 165-166, 168, 170, 172, 174, 176; and pp 158-159, 162, 164, 166, 168. Twin pendulum clock with photoelectric sensing. Ingenious but waste of time.

35. "The 'ATO' Battery Electric Clock". John D I Locke. pp 3. 15 figs. This was reported in *Antiquarian Horology*, Vol 12, No 6, pp 660-1, June 1981. Lecture given at Memorial Hall, Uffington, 4 April 1981.

36. *Elektriciteten*. I Bind. Section on "Elektriscke Uhr", pp 121-131. 6 figs. 1910. (Electric clocks). Simple treatment of subject and shows little new material. Norwegian text.

37. *L'Observatoire Royal de Greenwich* 1675-1925. Paul Ditisheim. pp 24 . 16 figs. Extract from the *Bulletin de la Société Astronomique de France*, December 1925. Commemoration of 250th year of foundation, visit of King George V of England, 23 July 1925. French text.

38. *Chronographe Imprimant Électrique ...* Henri Chrétien and Paul Ditisheim. pp 25. 6 figs. Extract from *Annales Françaises de Chronometrie* 1[er] trimestre 1933. Chronograph measuring and printing the time to 1/100 of a second. Pages 12-25 give a supplementary appendix dated Nice, December 1914. French text.

39. *The Magneta Time Recorder and Job Coster*. pp 2. 2 figs. June 1944. (Goblin Works, Leatherhead).

40. "Some recent developments in Electrical Clocks". Major C E Prince. 12 pp reprint, 13 figs, from *The Horological Journal* of December 1924 and January 1925. Lecture given to the British Horlogical Iinstitute, London, 19 November 1924. Gives full details of the "Princeps" system.

41. "Agreement for manufacturing Observatory Clocks ..." Contract dated 19 October 1923 for Thomas Mercer of St Albans and E T Cottingham of Thrapston for Mercer's to have sole manufacturing and selling rights.

42. *T.M.C. Time Difference Indicator*. W H Poole & S J Smith. pp 8. 4 figs. Reprint from the *T.M.C. Technical Journal*, Vol 3, No 1. Describes an instrument for indicating the time difference between two systems, generally an accurate standard and a nominal frequency power source. Circa 1950.

43. "The Shortt Clocks at the Royal Observatory, Greenwich". J Jackson and W Bowyer. pp 17. 2 figs and many tables. Reprint of *Monthly Notices of the Royal Astronomical Society*, Vol LXXXVIII, No 5, March 1928.

44. *Introduction of New Time System and Modification to BBC 6-Pips Signal*. pp 3. Changes caused by the introduction of the Atomic Time Scale, endorsed by the 14th General Conferenc of Weights and Measures, held Paris, October 1971. Date of leaflet 17 December 1971. Introduction of Leap Seconds.

45. "Personality Profile". H E (Bill) Jones MBE. An outline of Bill Jones who worked for Frank Hope-Jones. Extract from the *Newspaper of the Bath and Portland Group - Group News* Vol 1, No 3, March 1964.

46. "Some Converters of Oscillation into Rotation". Cecil F Clifford. pp 8. 3 figs. May 1969.

47. "The Electric Watch, a future problem for the repairer!". L Defossez. pp 10. 5 figs. Written at a time when there was no transistor switched watch. Circa 1950's.

48. *A Further Application of the "Synchronome" System of Electric Time-Service. SELF-WOUND CLOCKS.* F Hope-Jones. pp 8. 5 figs. Published circa 1900, just after the departure of G B Bowell.

49. "New Quartz Clock". News item in *Institution of Electrical Engineering News*. 1 February 1968. The *Cristaline* clock, accurate to 2 x 10^{-3} between 15-25°C. Acts as master clock with polarised 12v impulses.

50. "Nothing New - Electric Clocks". Letter in *Design and Components in Engineering*, written by A E Bowyer-Lowe, refuting that R J Rudd invented the Synchronome principle in 1898. (Rightly so!).

51. "Development of Watch Batteries". Item in *Electrical Review* dated 13 January 1967. Indium-Bismuth Cells for electric watches.

52. "Stable gated clock pulse generator". Described in "The Norris Column", using the then new monostable SN7421N, manufactured by Texas Instruments.

53. "Shipton Crystal Drive Chronometer". Available in three models with accuracy better than 2 parts in 10^6. Quartz crystal of 2048 Hz housed in oven. Made by Shipton Electronics, Hemel Hempstead, Herts.

54. "A Few Examples of Outdoor Clocks". A single leaf pamphlet issued by the Silent Electric Clock Company, 192 Goswell Street, Clerkenwell, London. It shows four exterior dial arrangements and other items.

55. Letter dated 23 February 1976 from Ferranti, detailing some of the electric clock items available in Ferranti museum, also correspondence and catalogues, for possible display in Science Museum Exhibtion 1976.

56. "Notes on 'A Battery-Driven Electric Clock' ". C R Jones. Article in the *Model Engineer*, for 6 July 1950. Deals with the problems involved with an electric clock design described in the issues of *M E* for 16 January, 2, 9, 16, 23 February 1950 issues; mainly the mal-operation of the Hipp Toggle switch.

57. *The Electrical Engineering Index*. Years 1951-1970. The Clocks section gives details of some of the developments in the years of issue, of some interest but very sparse details.

58. *Royal Society Index* 1800-1900. References to early Electroscopes, Galvonometers, Ammeters, Voltmeters, Electric Balances, Electric Meters (Power Measurement), Electrodynamometers.

59. Letter from Institution of Electrical Engineers dated 20 March 1970. Gives two references of F Hope-Jones' contributions, plus 9 other contributors in the Index to the *Proceedings of the IEE*, Volumes 29-115.

60. Photocopy of pages 356-7 of NAWCC *Bulletin*, Volume VIII, No 7, Whole Number 77, December 1958. Illustrates example of Walter J Dudley's Independent Electric Clock, Patent No 447105, 20 February 1891; and 465,655, 22 December 1891. Wall clock design, worked by dry cells, one of the earliest of its type known.

61. "Directions for the Management of the (Patent) Automatic Memorandum Clock". Copied from Davidson Memorandum Clock in possession of W A Gravat, 1 Clock House, Forty Hill, Enfield, Middlesex. 18 November 1972.

62. *The Illustrated London News*, 8 February 1851, page 104, "Shepherd's Electric Clock for the Great Exhibition Building". Description, with three illustrations, Dial and Hands, Pendulum, and Secondary Clock. Contains information on Bain's clocks. Copied from Robert Foulkes' copy.

63. "Properties of the Magick Alarm". Copied from an MSS in the Cumming's Folio in the Guildhall Library. No date is given but it must be in the 1770's. Not absolutely certain it refers to electric shock.

64. "Synchronome Master Clock". Charles K Aked. Article written 20 January 1973 for the Electrical Horology Group, later printed in the *Horological Journal*. Details of installation and maintenance.

65. English Clock Systems Digital Clocks Leaflet amd Price List. Models B.T. 6.30 and Model B.T. 6.59.

66. "William Hamilton Shortt". Henry Marcoolyn. Obituary in *Antiquarian Horology*, March 1971, page 236.

67. Elremco Elapsed Time Indicators and Dial Timers. List Number 800 and enclosures of many types. 1971.

68. Dual MOS Clock Driver. IM5013 monolithic dual driver, (Integrated circuit). Data sheets and circuits.

69. *Brasil Relojoeiro E Joalheiro*. Index of electric clock articles for October and November 1968.

70. Electrical Installation Details for Tower Clocks. Leaflet concerned with installation of 240 volt supply to a tower clock including hour strike and quarter strike driven by electric motors. Poor instructions preceding introduction of 13 A circuits. Date not known (circa 1960's). Smith's of Derby.

71. "Quartz Crystal Clocks". Dr K Smith. *Model Engineer*, 17 August to 5 October 1973. Constructional details on how to make a quartz crystal controlled clock using a standard synchronous clock motor.

72. "The Amateur Scientist". A venerable clock is made highly accurate by equipping it with quartz-crystal works. *The American Scientist*. 10 April 1974, pages 192-198. (Synchronization of pendulum swing). Heresy.

73. "Inventor of the Electric Clock - Alexander Bain, Watten.". Charles K Aked. Article published in *John o'Groat Weekly* at Wick. Page 5 of 19 January 1973 issue, includes illustrations from Bain's book. Complete newspaper containing article, held in Bain file.

74. "Electronic Watches". Announcement by Solidev Ltd of range of quartz-controlled electronic watches with Time and Date indications by LED display. *Electronic Components*, 28 September 1973, page 763.

75. "Electronics for Watches: Packages get Smaller". News Scope, *Electronic Design*, 17 August 1973, page 19. Introduction of field-effect liquid crystal displays developed by Gruen Watch Company, USA.

76. Illustrations of Synchronous Clocks. Three photocopied sheets, Synclock, Grimshaw and Baxter examples.

77. "Alexander Bain 1810-1877, Inventor of the Electric Clock". pp 4. 1 fig. Circa 1950, Glasgow. A pamphlet issued by the Hunterian Museum of the University of Glasgow in reference to the Bain electric clock presented to the University in 1936. Written by a non-horologist, but contains some useful facts.

78. *Electric Clocks*. pp 6. 6 figs, including portrait of William Sturgeon. Description of Steuart's System of continuous motion electric motor impulsed pendulum, manufactured by Thomas Mercer. Patent No 202139 dated 14 July 1922. (Few of these have survived, the poor quality cast base plate was easily damaged).

79. "The Steuart Patent Electric Clock - Observatory Model". pp 2. 1 fig. Description of the clock made by Messrs. J & D Meek, Edinburgh. Photocopy of an article written by Mr Meek for *The Scottish Jeweller*, 1925. Note the pendulum swings on a steel knife edge supported on an agate bed. See previous entry.

80. Letter sent to H Otto by Alexander Steuart discussing possible sales of the Steuart silent continuous motion electric clock in Europe and America, dated 6 October 1925. Mention of Meek's latest clock, also possibility of making up the Steuart clock very cheaply, although Mr Mercer is not making a cheap model.

81. "The Fedchenko Clock". Myron Pleasure. *Horological Journal*, September 1973, pp 3, 4, 7, and 55. Describes isochronous suspension and impulsing system in some detail. Eulogistic reporting.

82. Hoeft-Möller Electric Clocks. Photocopy of all relevant patent summaries on one page. An oscillating armature rewinds a spring to drive a mechanical train. Early 1900's.

83. "Piezoelectric Crystals and Devices". pp 44-54. 9 figs. *Electronic Design* 17. 16 August 1973. Characteristics of quartz crystals, and list of suppliers.

84. "Swiss Time - World Time". pp 14. Trade pamphlet. Circa late 1950's. Illustrates one of the first 'Electronic Watches' - a battery powered tuning fork watch in skeleton form, also a quartz crystal chronometer. Written just as the storm was about to break over mechanical watch makers.

85. "Atomic Clocks". Harold Lyons. Reprint from *Scientific American* for February 1957. pp 14. 18 figs. Describes the Ammonia Atomic clock, briefly mentions the Rubidium and Caesium Atomic clocks. Gives some bibliographical references.

86. "The First Electric Clock". W A Marrison. pp 6. 3 figs. Reprinted from the *Procedings of the Engineering Society* Vol 29, 1940, Queens University, Kingston, Ontario, Canada. A well written short essay to commemorate the 100th anniversary of Alexander Bain's electric clock.

87. List of additional photographs of Electric Clocks in Science Museum Collection. V Chew. pp 1. Circa 1975. 14 clocks including examples of T A Brown's synchronous clocks with balance and pendulum control. Very complicated and unnecessarily expensive clocks as a result, completely uncommercial.

88. "The 'Silent' Electric Clock". pp 1. 3 figs. Reprint from the *Electrical Review*, 4 February 1910. Hipp toggle controlled master pendulum, permanent magnet locked armature for slave dials. Mentions recent move to 192 Goswell Road, and a previous article in the 3 August 1906 issue.

89. "A Hipp Clock with a Half-Seconds Pendulum". H E Jones (F Hope-Jones's mechanic). pp 7. 6 figs. Refers mistakenly to Hipp toggle as 'Butterfly' escapement. Extracted from *Electric Clocks* edited by Frank Hope-Jones.

90. Letter dated 4 November 1974 from Zentralantiquariat der DDR offering electrical horology books, including A Favarger, 1924, and V V Trojanovskij, *Elektriceskie casy*, 2nd ed, 1952. Purchased two of the books offered.

91. Diagram of Lownes of Catford Master electric clock taken from patent. 6 figs showing the most complicated arrangement of all electric master clocks, yet these are extraordinarily reliable in use. 1901.

92. Letter, dated 3 November 1974, from Wharton Electronics, Huddersfield, offering Electronic Digital Stop Watch at a special price of £39.95. With explanatory leaflet.

93. *The Practical Watch and Clock Maker*. 15 March 1929 to 15 September 1930. "Electrical Horology" by Frank Hope-Jones in 31 parts, the material for his book *Electric Clocks*, 1931.

94. "A 'Free Pendulum' Clock for All". F Hope-Jones. pp 2. 2 figs. Article with two practical designs in *The Practical Watch and Clock Maker* for 15 November 1930. Uses magnetic contacting to release a gravity arm on to the pallet of a 'free' pendulum. Useful analysis of losses in the system.

95. *Design Electronics*. Volume 7, No 10, July 1970. Contains a number of articles under the heading of "The Time Machines".

96. "Modern Developments in Timekeeping". A course in the development of electric clocks, given by Dr J Weaver at the City University in 1975. Attended with M C Aimer. Complete set of course notes.

97. "Chronometron Quartz CQ 2001". pp 20. 22 figs, some in colour. Gebr. Staiger Clock Factory, 7742 St. Georgen (Black Forest). Very well produced booklet, excellent descriptions.

98. *Instructions for the Servicing of Junghans Ato-Mat Movement 707*. pp 8. 4 figs. March 1969. Explanations in English, French and Spanish. Gebr. Junghans GmbH, Uhrenfabriken, 7230 Schramberg, Germany.

99. *Dehl Resonic High Frequency Movement 870*. pp 4. 4 figs. Dehl Uhrenfabrik, 8500 Nürnberg, Bahnhofsplatz 6, Germany. Published 1973.

100. Technical Data for Movement AN 870. Tuning-fork electronic clock movement. pp 2. Dehl Resonic.

101. "Gent & Co Limited, Faraday Works, Leicester". Short History of firm from 1872 to celebrate Centenary year of founding of firm in 1872. pp 3. (Typewritten sheets).

102. *"The B.P. System" of Patent Silent Electric Impulse Clocks and Turret Clocks ...* pp 40. Numerous figures. Comprehensive catalogue, dated October 1909, issued by Gent & Co, Ltd, Faraday Works, Leicester. A very informative publication, including details of 'Waiting Train' clock system.

103. Almost similar catalogue to Entry No 102 but pp 42 and dated 11 April 1911.

104. *Controlled Electric Clock Systems*. Catalogue issued by Gent of Leicester. pp 30. 34 figs in colour. Covers 'Chronopher' system, 'Pulsynetic' system, Current Supply equipment, Wall, Insertion and Suspension clocks, also Time Recorders. Circa 1972. All production ceased after a few more years.

105. "The New Electric Pendulum and Balance-Wheel Clocks". Photocopy of article in *Horological Journal* for December 1910, pages 56-58. Electric clocks manufactured by the Reason Manufacturing Company Ltd at Brighton, to Murday's patents. Editor correctly points out mistaken view of compensation, this error is repeated by F Hope-Jones in his lecture to the Institution of Electrical Engineers, 17 February 1910.

106. "The Clinker Non-Synchronous Electric Clock". C A Mason. Short paper read before South Midland Section of IEE, 14 March 1933. A clock based on the work of the late R C Clinker. Printed in the *Students Journal* of the IEE. pp 163-5. The pendulum carries a soft iron armature swinging over an electromagnet whose windings carry alternating current, the detuning of the circuit results in an impulse to the pendulum.

107. "Appointment Clock with Electric Alarm". Note prepared for exhibition of clock at AHS visit to Liverpool in 1970. (The Davidson Automatic Memoranum Clock - see entry no 61).

108. "Electro-Pneumatic Clock System". pp 2. Typewritten note by Charles K Aked on the 'Elektronom' system developed by Junghans A G of Schramberg, Germany, made in the 1930's. Electrically heated compressor lamp used to rewind master clock and operate slave dials through tubing. (Very few examples remaining today).

109. "Precision Timekeeping with special reference to the new Inertia Escapement now being introduced in the 'Synchronome' Astronomical Regulator". W H Shortt. Paper read before British Horological Institution on 16 January 1912. Reprinted from *Horological Journal* by The Synchronome Company Ltd. pp 16. 10 figs.

110. Pack of catalogues and leaflets presented by Clifford Horstmann on visit to Works 14 June 1980. These cover all aspects of the Horstmann Company's developments in timers, gas pistols, History of Horstmann's in the Gas Industry, F G A Horstmann's Patent for winding clocks, also subsidiary company of Aish.

111. "Description of the Galvanic Chronographic Apparatus of the Royal Observatory, Greenwich". Forming the Appendix to *The Greenwich Observations*, 1856. pp xxi. 8 Plates (total of 20 figs). Published 1857. This was in the Bibliothèque Observatoire de Neuchâtel. Full description of the chronographic apparatus then employed at Greenwich Observatory. (This extract was a very expensive acquisition).

112. "Tempex Time Machines". Leaflet T.C. 201 issued 17 February 1933 for Battery operated models Type P.101 and N.202. (Tempex version of Bulle clock); and A.C. Mains Model Type AC 303. User leaflet only.

113. *How to Start a Bulle*. Two-page leaflet issued by Bulle Products Ltd, Bulle House, 167 Clapham Road, London S.W.9. Instructions to user on how to prepare clock for starting and getting to run correctly, both for Battery and A.C. Mains-Operated Models for 200/250 volts 50 cycles.

114. *The Atomic Clock*. Single page handout at National Physical Laboratory Open Day, October 1958. Brief outline of principle of operation of caesium beam clock.

115. "The Relation Between Rate and Arc for a Free Pendulum". E C Atkinson. Paper read to *The Physical Society*, 20 March 1936. pp 7. 3 figs. Together with "On Airy's Disturbance Integrals and Knife-Edge Supports for Pendulums", and the discussions on the previous two papers. pp 2 + 5. 1 + 1 figs. Reprinted from the *Proceedings of the Physical Society*, Vol 48, p 606, 1936. Mainly about circular error.

116. "The Dissipation of Energy by a Pendulum swinging in Air, and The Amplitude Deviation of Rate of a Pendulum; a Second Experiment". E C Atkinson. Paper read to *The Physical Society*, 24 June 1938. pp 36. 7 figs (in total). Reprinted from the *Proceedings of the Physical Society*. Vol 50. p 721, 1938.

117. *The Electric Telegraph No 4*. pp 4. 15 figs. Published by Electro-Products 3 M. October 1973. A light-hearted look at some of the early events in electrical history.

118. *Catalogue of Books and Papers relating to Electricity, Magnetism, The Electric Telegraph, &c, including The Ronalds Library*. Compiled by Sir Francis Ronalds FRS, edited by Alfred J Frost. 1880. Photocopy of pp i-xxvii, and 32-33, 132-3, 418-9, 438-9, 484-5, 510-11, 552-6. Collection in Institution of Electrical Engineers, but catalogue published by Society of Telegraph Engineers which later adopted the present title of Institution of Electrical Engineers. (Bust and portrait of Ronalds in IEE headquarters).

119. "A Millisecond Timing Unit". J E Haworth. Photocopy of article in *The Post Office Engineers Journal*. Vol 45. Part 1. pp 25-29. 9 figs. Valve operated counter with 2 kilohertz oscillator.

120. "Heating Programmer doubles as a Clock". *Engineering Materials and Design*. November 1973. pp 37-9 + front cover illustrating dismantled device. Coloured illustration plus set of figures.

121. *The Standard Time High Grade Electric Clocks*. pp 16. 19 figs. c 1920's. London. Catalogue supplied by the Standard Time Co Ltd, 19-21 Queen Victoria Street, London EC. Shows complete range of clocks made.

122. *The Synchronous Motor Electric Clock*. Edwin A Pringle. Photocopy of booklet issued by Robert Pringle and Sons (London) Ltd, being reprinted from article in *The Practical Watch and Clock Maker*, 15 December 1931. pp 8. No figs. Good explanation of operation and correct forecast of events.

123. "The Meridian Electronic Watch Computer". Article in *Horological Journal*, September 1976. pp 10-12. Description of watch timer and principle of operation written by Charles K Aked.

124. "Alexander Bain - A Commemorative Exhibition". Charles K Aked. *Horological Journal*. January 1977. page 7. Notice of the exhibition initiated by Charles K Aked then being held at the Science Museum, London.

125. "Electrifying Time". Charles K Aked. *Horological Journal*, February 1977, pp 25-27. An outline of the electric clock exhibition then in progress at the Science Museum, London.

126. "Casio Computer Quartz CQ1". Charles K Aked. *Horological Journal*, June 1977, p 31.

127. "Horologists and Static Electricity". Charles K Aked. *Horological Journal*. Part 1 in June 1977 issue pp 39-41; Part 2 in July 1977 issue, pp 45-51. The earliest connections of time and electricity.

128. "Gazing into the Quartz Crystal". Charles K Aked. *Horological Journal*, September 1977, pp 3-4. Looking at the future development of quartz crystal watches, forecasts eclipse of mechanical timekeepers.

129. "Some Observations on the Eureka Clock". Charles K Aked. *Horological Journal*, September 1977, pp 44-47. A definitive article on the principles of operation of the Eureka clock.

130. "E J Parris's Rolling Ball Clocks". Charles K Aked. *Horological Journal*, November 1977, pp 42-43. Description of the principle of Parris's use of a steel ball as a slave to a master clock.

131. *The Princeps Electrical Clock*. Leaflet with pp 6. 4 figs. Not dated, c 1920's. Shows Princeps System and the Princeps Cottage System (this was based on a much smaller size of master clock using a half-seconds pendulum. A master clock is stated to be able to run from one to one million slave clocks!

132. *The Princeps Electrical Clock*. "Facile Princeps". pp 19. 3 figs. c 1920's. London. Technical description given pages 14-19, not very scientifically presented, intended rather to impress the purchaser.

133. Princeps Minor Electrical Clocks. pp 4. 6 clocks illustrated. Pamphlet issued by Prince's Electrical Clocks Ltd, 173 New Bond Street, London W1, at the British Empire Exhibition held 1925 in the Palace of Engineering, Avenue 1 & 2, Bay 5. Shows domestic clocks in contemporary wood cases, these were less expensive than the models made by other manufacturers but surprisingly reliable for flimsy constructions.

134. *La Pendule Électrique de Precision de M. Hipp*. A Hirsch. pp 16. 1891. Neuchâtel. Second notice communicated to the Society of Natural Sciences of Neuchâtel at the meeting of 28 May 1891. Report on the performance of one of Hipp's electrically driven astronomical regulator from 1884 to 1891. French text.

135. *Rapport sur la Marche des Horloges Électriques de la Ville de Neuchâtel*. pp 13. Large folding table giving results of timing trials. 1867. Neuchâtel. An excellent account of the electric clocks installed in Neuchâtel by M Hipp in 1865, French text. Translated into English by Charles K Aked and published in the *Clocks* magazine, Volume 6, No 3, September 1983, as "A Question of Reliability", pp 35-6 and 46.

136. "A Question of Reliability". Charles K Aked. pp 35-36 and 46. 1 fig. *Clocks*, Vol 6, No 3, September 1983. Discussion on the electric clock system installed at Neuchâtel by Matthaus Hipp in 1864.

137. "A Modified Form of Electrical Control for Driving Clocks". Sir Howard Grubb. pp 3. 1 fig. Reprint from *The Scientific Proceedings of the Royal Dublin Society*, Vol XI (NS), No 4, pages 34-6, September 1905. Describes a modification of the author's system for controlling the speed of driving clocks for equatorial instruments, read before the Insitute of Mechanical Engineers, Dublin in July 1888. Paper prepared from this for publication in the Electrical Horology Group newsletter by Charles K Aked.

138. *The International Supervised Electric Time System*. pp 12. 14 figs. Second edition 1934. London. Reprint of an article published originally in Newne's *Practical Electrical Engineering*. The second edition was made necessary because of the addition of an "Impulse Accumulator" fitted to the International master clock, these being mechanical clocks of very good quality fitted with dead-beat escapements, equipped with contacts having an assortment of arrangements for operating slave dial circuits.

139. *Battery Clocks*. Glenn A Marsh. pp 33. 19 figs. 1978. Published by National Association of Watch and Clock Collectors, Inc, Chapter 75, San Fernando Valley, California, USA. Covers the most popular electric clocks such as Eureka, Murday, Bulle, and Barr. Useful for the American electric clocks.

140. "The Free Pendulum". F Hope-Jones. pp 15. 9 figs. Paper read at the Eighteenth Ordinary Meeting of the Royal Society of Arts, 9 April 1924. Published in the *Journal of the Royal Society of Arts*, 23 May 1924. Sir Frank Dyson, the Astronomer Royal, in the chair. A clear account of the invention of the free pendulum by W H Shortt, Hope-Jones' role in the development, if any, is not apparent.

141. *Standard Time throughout the World*. Prepared by Ralph E Gould (Chief of the Time Section). pp 18. 2 figs (maps). Issued 15 September 1932. Circular of the Bureau of Standards, No 399. Superseding Circular 280 issued in 1925, being a revised and enlarged version. Gives an historical sketch of the development of the Standard Time System, maps showing the Time Zone Boundaries, list of official stations transmitting time signals, legal time in most foreign countries and comparisons with Greenwich mean time and noon Eastern Standard Time. A short list of publications is given pp 17-18.

142. "On the Electric Column and Aerial Electroscope". J A De Luc. A two-part article published in *A Journal of Natural Philosophy, Chemistry and The Arts*. First part Vol XXVII, No 102. pp 81-99; second part Vol XXVII, No 103, pp 162-174. October and November issues, 1810. The apparatus described was intended to measure the electrical state of the atmosphere by the effect of temperature and humidity on the striking rate of a pith ball pendulum attracted and repelled by the voltage from a dry pile.

143. "On the Effects of Twenty Thousand Zinc and Silver Plates arranged as an Electric Column". George J Singer. *Philosophical Journal* (change of title from preceding), Vol XXVIII, No 114, pp 84-87. Details experiments with piles containing one thousand elements connected in series and used to charge Leyden jars. Singer was the best constructor of dry piles until Zamboni introduced his own versions.

144. "A magnetic time interval splitter". Z H Meikson. *Electronic Components*, 6 November 1973, pp 16-18. Uses two magnetic cores in series, a bias circuit sets the magnetic saturation levels and a square wave voltage is applied to derive specific time intervals as required.

145. *Alexander Bain of Watten*. Robert P Gunn. pp 19. 3 Illustrations plus one on cover. Published by Caithness Field Club, 1976. Information taken from articles by Charles K Aked.

146. *The Lyttelton Time-Ball Station*. pp 64. 52 illustration plus colour plate on cover. 1979. Published by the New Zealand Historic Places Trust, Wellington, New Zealand. An account of the operation, history and renovation of the time-ball station in the years 1970-1978.

147. *Die Elektrischen Uhren*. Achter Abschnitt. Photocopy pp 350-361, 6 figs; also pp 344-347 + 362-365, from another edition. Circa 1890's. Page 365 has 29 references listed. German text.

148. *Elektro-Magnetismus*. Hanzer. Circa 1880. pp 136-147 and five plates (figs 83-103). German text.

149. "Der elektromagnesische Telegraph in den Hauptstadien seiner Entwickelung und in seiner gregwartigen Ausbildung und Anwendung, nebst einem Anahange uber den Betrieb der Elektrishchen Uhren". Dr H Schellen. 1867. Vieweg und Sohn. Reference to Professor Ramis's electric clock and Professor Steinheil's electric clock, 1815 and 1838 respectively. German text.

150. "Electric Clocks for Collectors". Charles K Aked. pp 50-52. 5 figs. *Collectors Guide*, Vol 39, No 6, January 1986. A brief introduction for beginners to the more common types of electric clock available.

151. "Elektrische Tijdaanwijzing". Charles K Aked. pp 5. 15 figs. *Clocks*, April 1986. An outline of the exhibition of electric clocks held at the Goud- Zilver- en Klokkenmuseum at Schoonhoven from 20 October 1984 to 3 February 1985. Although the title is Dutch for 'Electrical Timekeeping', the text is English.

152. "A Clockmaker's Electric Clock". Charles K Aked. pp 3. 5 figs. *Clocks*, September 1986. Description of the master electrically or mechanically driven clock used for impulsing slave dials from current closing contacts fitted on the escape wheel. It was evidently successful in practice.

153. "Coup d'Oeile Electric Clocks or Collectelectric". Charles K Aked. pp 474-484. 17 figs. NAWCC Bulletin, Whole No 245, December 1986. A short historical sketch of electrical timekeeping from 1770.

154. "Echoes of the Synchronous Clock". Charles K Aked. pp 26-30. 6 figs. *Clocks*, January 1987. A brief survey of the beginnings of the synchronous clock and the reasons for its demise in the 1970's.

155. "The Balance-Wheel Clock". Charles K Aked. pp 48-51. 3 figs. *Clocks*, Vol 1, No 8, February 1978. History and description of the Murday clock made by the Reason Manufacturing Company, Brighton, Sussex.

156. "The Master and his Slaves". Charles K Aked. pp 34-37. 8 figs. *Clocks*, Vol 4, No 11, May 1982. A survey of the use of the slave clock for indicating time and for relieving the master clock of all duties.

157. "Information please". 'Interface Reply' by Charles K Aked to question about a Smith's Clocks Ltd synchronous clock in a lantern case. page 53. *Clocks*, Vol 5, No 1.

158. "Bulle Transistor Clocks". 'Interface reply' by Charles K Aked to question about Bulle clocks. page 54. *Clocks*, Vol 5, No 1, July 1983. The reader was under the impression that transistors had been applied to Bulle clocks but was really enquiring about Ato and Junghans.

159. "On from the Magick Alarm". Charles K Aked. pp 34-37. 11 figs. *Clocks*, Vol 5, No 2, August 1983. A mini-survey of the history of electrical horology from the earliest reference.

160. "Eureka Clocks". 'Interface Special Report' by Charles K Aked. pp 38-41 + p 49. 8 figs. *Clocks*, Vol 5, No 9. September 1983. Details the operation, fault-finding and repair of Eureka clocks. Full page colour illustration of M C Aimer's striking Eureka example, the unintentional publication of which caused a rift between M C Aimer and Charles K Aked, although it had been published elsewhere several times.

161. "Bulle mantel clock". 'Interface reply' by Charles K Aked. pp 45-6. *Clocks*, Volume 5, No 12, June 1983. Mainly concerned with the correct voltage to drive clock.

162. "A Matter of Momentum". 'Interface reply' by Charles K Aked. p 64. *Clocks*, Vol 7, No 4, October 1984. Remedying the faults in a defective Synchronome master clock which would run for a short time only.

163. "Eureka". 'Interface reply' by Charles K Aked. pp 61-2. *Clocks*, Vol 7, No 5, November 1984. Details of trouble-shooting with a Eureka clock in order to restore it to full working condition.

164. "Sailing Ship Clock". 'Interface reply' by Charles K Aked. pp 60-1. *Clocks*. Vol 7, No 6, December 1984. Details of the 'Clipper Ship' Synchronous Clock which had a brief popularity after World War II.

165. "Electronic textbooks". 'Interface reply' by Charles K Aked. p 64. *Clocks*, Vol 7, No 11, May 1985. Short list of books to assist those interested in the technical details of quartz watches and clocks.

166. "Battery replacement". 'Interface reply' by Charles K Aked. p 64. *Clocks*, Vol 8, No 3, September 1985. Replacement battery for the Kundo transistorised electric clock, none now made.

167. "Small Synchronome". 'Interface reply' by Charles K Aked. p 61. *Clocks*, Vol 8, No 6, December 1985. A Synchronome type electric clock with unusual pendulum driving system giving a long duration impulse to the pendulum instead of the usual gravity arm and roller acting on the pendulum pallet.

168. "Telavox". 'Interface reply' by Charles K Aked. p 62. *Clocks*, Vol 8, No 6, December 1985. A Swedish electric clock manufactured in the 1930's, self-winding with taut band suspension balance.

169. "Battery replacement". 'Interface reply' by Charles K Aked. pp 58-9. *Clocks*, Vol 8, No 7, January 1986. Diagnosing the fault in a defective 'Gensign' electric master clock.

170. "Synchronome problems". 'Interface reply' by Charles K Aked. p 57. *Clocks*, Vol 8, No 8, February 1986. Queries from an uninitiated collector.

171. "Kundo battery". 'Interface reply' by Charles K Aked. p 59. *Clocks*, Vol 8, No 9, March 1986. Details of the triggering circuit for the Kundo electric clock.

172. "Well-made master". 'Interface reply' by Charles K Aked. p 60. *Clocks*, Vol 8, No 9, March 1986. Details of the 'International Time System' made by the International Time Recording Co Ltd.

173. "Synchronome or not". 'Interface reply' by Charles K Aked. p 60. *Clocks*, Vol 8, No 10, April 1986.

174. "Restoring a Master". 'Interface reply' by Charles K Aked. p 59. *Clocks*, Vol 8, No 11, May 1986. Spare components for the International Time System master clock, none available for the amateur.

175. "Electrique Brillié". 'Interface reply' by Charles K Aked. p 54-5. *Clocks*, Volume 8, No 12, June 1986. Information on the Brillié electric clock.

176. "Joyce postscript". Charles K Aked. pp 10-11. *Clocks*, Volume 9, No 2, August 1986. This was intended to supplement the article 'A Clockmaker's Electric Clock', see item no 152 of this list, but it was inadvertently printed as a supplement to the earlier two-part article on the Joyce clockmaking firm.

177. "Electric Clock Patents from the 19th Century". Charles K Aked. pp 36-42. 9 figs + 4 coloured illustrations. *Clocks*, Vol 9, No 2, August 1986. A selection taken from the electric clock patents from 1840 to 1900, brief details being given of the more interesting, and out of the way, examples.

178. "Across the Pond". 'Interface reply' by Charles K Aked. p 59. *Clocks*, Vol 9. No 2, August 1986. A Chester H Pond movement rewound electrically by a three pole motor, description of operation.

179. "The other side". 'Interface reply' by Charles K Aked. pp 59-60. *Clocks*, Vol 9, No 2, August 1986. Queries on the National Time Recorder and the Pulsynetic electric master clock.

180. "Electric rewind". 'Interface reply' by Charles K Aked. p 62. *Clocks*, Vol 9, No 3, September 1986. Request for supplier of thirty-hour clock conversion kits to electric winding. (None known).

181. "Horological Books and Libraries". Charles K Aked. pp 15-23. *Antiquarian Horology*, Vol 6. No 1, December 1968. Pages 20-1 of this article contain references to electrical horology under the heading of *The Royal Society*, dealing with the controversy between Alexander Bain and Charles Wheatstone.

182. Advertisements for electric clocks. Page 455. *Antiquarian Horology*, Vol 6, No 7, June 1970. Timepieces Inc of New York for Eureka clocks, and G Crabtree for all kinds of early electric clocks.

183. "Electrical Horology". p 522. *Antiquarian Horology*, Vol 6, No 8, September 1970. Notice of the formation of the Electrical Horology Group and the first meeting to be held at the Science Museum 6 pm 9 October 1970, Charles K Aked, Chairman; A Mitchell, Secretary; E Lloyd Thomas, Treasurer.

184. "Murday's Electrically Driven Balance-Wheel Clock". Charles K Aked. pp 56-59. 5 figs. *Antiquarian Horology*, Vol 7, No 1, December 1970. The first full technical account of the Murday electric clock.

185. "Electricity. Magnetism and Clocks". Charles K Aked. pp 398-415. 19 figs. *Antiquarian Horology*, Vol 7, No 5, December 1971. A comprehensive survey of the history of electricity, magnetism and electric clocks drawn up from the lecture given to the Northern Section of the AHS 26 March 1971.

21

186. "Electrical Horology Group Reports". *Antiquarian Horology*, Vol 7. p 65 refers to the first meeting of the Group 9 October 1970, p 140 gives details of the first Group visit to the house of David Nettell at Uffington, p 242 gives an account of the lecture on electrical horology given by Charles K Aked to the Northern Section of the AHS 26 March 1971, p 441 gives details of visit to Dr Shenton's house 11 September 1971, p 543 reports the first Annual General Meeting of the Group and the lecture on Chronoscopes prepared by Mr V K Chew, p 635 outlines the meeting of 11 March 1972 at Uffington when H E Jones spoke about the Synchronome systems (a very meandering outline), p 733 reports the Group meeting at Leicester, 14 June 1972, and the tour of Mssrs Gent's factory.

187. "The First Electric Clock". Charles K Aked. pp 276-289. 8 figs. *Antiquarian Horology*, Vol 8, No 3, June 1973. The first complete description of Francis Ronalds' electrostatic clock and his attempts to achieve temperature compensation. (Not aware of Ronalds' own written account when preparing this account).

188. "The Earth Driven Clock". F G A Shenton. pp 63-70. 12 figs. *Antiquarian Horology*, Vol 8, No 1, December 1972. An account of the history and sequence of events of the re-invented Bain electric clock.

189. "Electricity, Magnetism and Clocks". Charles K Aked. Letter pp 316-7. *Antiquarian Horology*. Volume 8, No 3, June 1973. Pointing out error in ascribing invention of contactless system to Wheatstone.

190. "The Scott Electric Clock". G C Crabtree, rewritten for publication by Charles K Aked. pp 491-94. 4 figs. *Antiquarian Horology*, Vol 8, No 5, December 1973. The historical outline and technical details of the Scott Electric Clock of the early 20th century. It was not a successful venture, now valued at £1,000!

191. "Electrical Horology Group Reports". *Antiquarian Horology*, Vol 8. p 87 Wilding visit 16.9.1972, p 198 Second AGM and Magnetic Escapements lecture 2.12.1972, p 313 Bateman's Precision Timekeeper 24.3.1973, p 424 Good on Electric Watches 16.6.1973, p 533 Visit to Marcoolyn's house and lecture by Ken James on Precision Pendulum Clocks - Circular error and the Suspension Spring 15.9.1973, p 642 Third AGM and lecture by Charles K Aked on Alexander Bain 1.12.1973, p 767 Joint meeting of Electrical and Turret Clock Groups on the subject of 'Electrification', ie rewinding of turret clocks by electricity, p 767 'Notes on the Bulle electric clock by A Mitchell; pp 908-9 Northern Section News, p 906, 'Alexander Bain', lecture given to the Northern Section 29.3.1974, identical to that given 1.12.1973 at the Science Museum.

192. "Alexander Bain, the Father of Electrical Horology". pp 51-63. 10 figs. *Antiquarian Horology*, Vol 9, No 1, December 1974. The first true account of Alexander Bain's life and work, and his marriage to Matilda.

193. "An Early Electric Turret Clock". Charles K Aked. pp 428-442. 14 figs. *Antiquarian Horology*, Vol 9, No 4, September 1975. Details of the discovery of the site of the Bain electric clock fitted in the parish church of St John's at Loughton, Essex; Finlaison's grave, and details from the church accounts.

194. "Robert Lowne and his Electric Clock System". R K Shenton. pp 209-214 + 229. 6 figs. *Antiquarian Horology*, Vol 9, No 2, March 1975. Summary outline of the electric clock firm of Lownes of Catford.

195. "The Automatic Memorandum Clock". R K Shenton. pp 337-339. 3 figs. *Antiquarian Horology*, Vol 9, No 3, June 1975. Mostly personal details of John Davidson and his family. The clock illustrated was brought to Dr Shenton's notice by Charles K Aked after a visit to Mr Gravatt about the Kelvin free pendulum clock.

196. "Dell' Orologio Applicato All Ellettromotore Perpetuo". Charles K Aked. pp 524-539. *Antiquarian Horology*, Vol 9, No 5, December 1975. Historical treatment of the earliest electric clocks on the Continent, together with explanations of the functioning of individual examples. Much of the information was supplied by Dr Paolo Rizzardi, so his name was included as co-author although he did not write a word.

197. "Electrically rewound clock by Leroy of Paris". p 893. 2 figs. *Antiquarian Horology*, Vol 9, No 8, September 1976. The front cover shows the William Hardy clock at Greenwich, modified by Dent in 1829, and again later when electrical contacts were fitted. (Leroy of Paris well known for precision timekeepers and his electric clocks were installed at the International Bureau of Time, Paris).

198. "Pompous Hope-Jones". Mention in 'The Chamberlain File', page 900. *Antiquarian Horology*, Volume 9, No 8, September 1976. Meeting with Paul Chamberlain and his wife, mention of Sir Courtenay Ilbert, Clerk of the House of Commons, father of Courtenay Ilbert, the famous horologist.

199. "Electrifying Time". p 905. *Antiquarian Horology*, Volume 9, No 8, September 1976. Notice of the official opening of the exhibition on 15 December 1976.

200. "Electrical Horology Group Reports". *Antiquarian Horology*, Vol 9. pp 88-90, 227-8, 346-7, 462-3, 573-4, 698-700, 811-813, 930-1. p 80 Lecture on Alexander Bain by Charles K Aked, p 227 Visit to Mercer, St Albans; p 346 Fourth AGM of Electrical Horology Group and lecture on the evolution of time-switches; p 462 Members' afternoon at Letcombe Regis, Visit to Gillett and Johnston 28.6.1975, p 573 Bateman lecture on 'Comparative Performance of Clocks' at Crowthorne 13.9.1975, p 698 'Electronics in Time Measurement' - lecture after Fifth AGM of Electrical Horology Group held 6.12.1975, given by Dr J Weaver; p 811 'Public Timekeeping' at Letcombe Regis by M Maltin; p 930 Visit to National Physical Laboratory 23.6.1976 - could not attend this personally as away on official business for the Admiralty.

201. "Electrifying Time Exhibition". A Mitchell. pp 206-211. *6 figs*. *Antiquarian Horology*, Vol 10, No 2, March 1977. This exhibition was conceived and suggested to the Director of the Science Museum by Charles K Aked in 1975, who resigned the Chairmanship of the Electrical Horology Group to progress the exhibition.

202. "The Shortt-Synchronome Number 31". Thomas Terjeson. pp 217-218. 2 figs. *Antiquarian Horology*, Vol 10, No 2, March 1977. A largely non-technical account.

203. "The Synchronome Company". Included in the article "A Clerkenwell Tour of Fifty Years Ago", written by Charles K Aked on behalf of T E White, page 343. *Antiquarian Horology*, Vol 10, No 3, June 1977. Notes the National Physical Laboratory Free Pendulum Clock No 13 given to Liverpool Merseyside Museum, the Horophone and the six-pips time signal originated by Frank Hope-Jones.

204. "An Electric Turret Clock by Shepherd". A Mitchell and D F Nettell. pp 460-3. 3 figs. *Antiquarian Horology*, Vol 10, No 4, September 1977. Description of the electric turret clock installed in Hornblotton church by Charles Shepherd. This clock was mentioned to Charles K Aked by C D Belcher but insufficient details were given to pursue the matter further.

205. "Shepherd's Electric Turret Clock". p 740. *Antiquarian Horology*, Vol 10, No 6, March 1978. Correspondence from J G Trevor Owen and D F Nettell about the action of the impulsing of the time train of the Hornblotton electric clock. Mr Owen replied again in the June issue, page 864 thanking Nettell.

206. "Electrical Horology Group Reports". *Antiquarian Horology*, Vol 10. pp 91-2, Sixth AGM of Group, followed by 'Any Questions', a panel answering members' queries; pp 223-4, opening of the 'Electrifying Time' exhibition 15th December 1976, followed by remarks by Dr L Essen; pp 356-7, 'Quartz Clocks and Atomic Time', Lecture by L Essen 11.3.1977, one of three lectures in the 'Electrifying Time Exhibition' series; pp 482-3, Visit to the Royal Greenwich Observatory, Hurstmonceux, including the Chronometer Section (now defunct) and the Time Department then run by Dr Smith; pp 612-613, Making of Herbert Scott electric clock by John Wilding at Crowthorne Church Hall 24.9.1977; pp 736-7, Seventh AGM held 3.12.1977 and lecture on Bulova Tuning Fork Watches; pp 863-4, 'Electric Turret Clocks' and the 'Hornblotton Clock' by J E Plaister and D F Nettell.

207. "Electrical Horology Group Reports". *Antiquarian Horology*, Vol 11. pp 77-8, Visit to Old Royal Observatory Greenwich on 24 June 1978; p 222-3, Meeting at Crondall with three lectures, 'Turret Clock Electrification', Time Code Receiver, and 'An Earth Battery'; pp 307 and 309, Eighth AGM and lecture 'Railway Time and all That' by Cddr H D Howse; pp 405-6, lecture at Uffington, 'The Effect of the Moon on Pendulum Clocks' by M Maltin; pp 516-7, Visit to Blick International Systems at Swindon; p 621, Electric clock repair and construction, Bulle suspensions by A J Fox.

208. p 13, Vol 11, No 1. *Antiquarian Horology*. Advertisement by Keith Banham, 16 Grafton Street, London, with illustration of nineteenth century electric clock signed Frederick Bull, and a bichromate cell. A very fine specimen of an early electric clock. (Note that there are no electric clock articles in this volume).

209. Page 147. *Antiquarian Horology*, Vol 12, No 2, June 1980. Advertisement by Dial Cottage, Shere, Surrey. Electric regulator clock by H A Campiche in rosewood case. (A nice example of his work).

210. "Johnston Crawford Trotter". Letter from H.J.S about unusual electric longcase clock with synchronous motor drive and electric motor for striking side. p 210. *Antiquarian Horology*, Vol 12, No 2, June 1980.

211. Page 491. *Antiquarian Horology*, Vol 12, No 5, March 1981. Advertisement by Derek Roberts Antiques of electric wall regulator made by Henry Kerr, Edinburgh, circa 1857. (An elegant timekeeper).

212. "Electric Clocks". Letter from E.C.T of New Zealand about electric master clock made by Smiths English Clock Systems, serial number 30284. *Antiquarian Horology*, Vol 12, No 5, March 1981.

213. Electrical Horology Group Reports. *Antiquarian Horology*, Vol 12. pp 82-3 Ninth AGM and lecture on the development of batteries for clocks and watches by Dr D Vaughan; p 184 Meeting at Crondall 29.3.1980 for Bulle Clock symposium; pp 438-9 Visit to Horstmann Gear Group Ltd, Bath, 14.6.1980; pp 548-9 10th Anniversary Luncheon at Beaconsfield on 13.9.1980, followed by resumé of the history and formation of the Electrical Horology Group from December 1968, also Tenth AGM and lecture by Charles K Aked on 'Electrical Horology', 29.11.1981; pp 660-1 Lecture on the ATO Electric Clock by John D I Locke at Uffington 4.4.1981.

214. Electrical Horology Group Reports. *Antiquarian Horology*, Vol 13. p 190 Joint meeting with Restoration Group, lectures on photography by Wilding, Eureka clocks by John Harrison, and Bill Taylor's workshop; pp 287-8 Eleventh AGM of Electrical Horology Group 4.12.1981, followed by lecture on Synchronous Electric Clocks by T R Robinson; pp 379-80 meeting at Uffington 27.3.1982, lecture by D J Boullin on the development of the quartz clock; p 484 combined meeting with Turret Clock Group, radio time controlled master clock for public dials shown, p 578 meeting at Crowthorne 11.9.1982, with lecture on pendulum shapes by D A Bateman; mention on p 580 of synchronous clocks replacing scrapped turret clocks in France and Portugal.

215. "Electrical Precision". Charles K Aked. pp 172-181. Antiquarian Horology. Vol 14, No 2, June 1983. Translation of Dr Adolphe Hirsch's report on the going of one of Hipp's electrically driven astronomical regulators. Should have been in anniversary number of *AH*, but article on Oughtred substituted instead.

216. Electrical Horology Group Reports. *Antiquarian Horology*, Vol 14. pp 83-4 Twelfth AGM 4.12.1982, lecture by D Vaughan on Palmer's Electric Clock circa 1902; p 182 meeting at Science Museum, two lectures by H J Marcoolyn on quartz controlled transmitter and Gent's Chronopher master clock; pp 397-8 meeting with Restoration Group, there was no electrical horology content; pp 514-5 Thirteenth AGM followed by lecture on the 'Speaking Clock for the Telephone Service' by F A Milne; pp 623-4 Meeting at St John's Church Hall, Amersham, for lecture by M F A Maltin on 'Automatic Monitoring and Control of Turret Clocks'.

217. Advertisements showing illustrations of electric clocks. pp 330 and 353. *Antiquarian Horology*, Vol 14, No's 3 and 4, September and December 1983. The first shows an example of the Campiche electrical chronometer type - signed H A Campiche, Genève, advertised by Rafferty Huber, Kensington; the second shows an electric skeleton clock signed Paul Garnier, Horloger de la Marine, circa 1850, advertised by Mario Crijns, Breda, Holland. Both are excellent examples in good condition. See entry no 209.

218. Electrical Horology Group Reports. *Antiquarian Horology*, Vol 15. p 52 Meeting at Newbury Baptist Church Hall 16 June 1984, exhibition of master clocks; p 156 Lecture 'Some Electrical Clock Patents' by Charles K Aked, 8.9.1984; p 271 Fourteenth AGM followed by lecture on Greenwich Time Ball by B Hutchinson, mention of Deal Time Ball, 1.12.1984; p 364 Meeting at Crowthorne for lecture 'on the air we breathe and its effect on clocks' by Ken James, 23.3.1985; pp 506-7 Meeting at Newbury for one-day exhibition of electrical self-winding clocks to celebrate centenary of self-winding systems; p 628-9 Visit to Deal Time-Ball Tower to the recently restored tower and new museum. (Arrived late to the visit because of road conditions, p 629 Electrical Timekeeping, lecture by Charles K Aked to the Midlands Section 6.6.1985.

219. Advertisement showing C Vigreux & L Brillié, Levallois-Perret electrical precision regulator. p 122. *Antiquarian Horology*, Vol 15, No 2, December 1984. Advertiser - Grimaldi, 12 Royal Arcade, Old Bond Street, London. (Another excellent example of an electric clock).

220. 'Effects of the Gravitational Attractions of the Sun and Moon on the Period of a Pendulum'. P H Boucheron. pp 53-65. *Antiquarian Horology*, Vol 16, No 1, March 1986. Research conducted on Shortt Free Pendulum No 41 at the US Naval Observatory, Washington, USA. Further details by D Bateman pp 68-9.

221. Electrical Horology Group Reports. *Antiquarian Horology*, Vol 16. pp 66-8 Fifteenth AGM followed by lecture 'Charles Shepherd's Electric Clocks' by D Vaughan, 30.11.1985, display of Hornblotton electric clock; p 247 Meeting at Merstham on the subject of the Bulle Clock, lecture by E L Hansen 7.6.1986. ("Back end" induced in coil!). pp 363-4, Lecture on 'The Pulsynetic System ...' by D J Bird; p 366 Henry Marcoolyn's unit for producing synchronous power stablised by quartz crystal, and D Nettell's electric winding aid; p 367 Synchronome synchronous clock with electric motor striking illustrated, Shortt clocks in Zi-Ka-Wei Observatory, Shanghai, detailed by P Whatmoor.

222. 'Police Page', p 172. Details of stolen Eureka and Bulle electric clocks. 'Auction Prices', p 178, gives details of electrically rewound clock made by Coventry Electric Clock Co. Ltd, platform escapement, realised £374. (Firm at 12 Theobald's Road, London). *Antiquarian Horology*, Volume 16, No 2, June 1986.

223. "The 'GBB' Continuous-Motion Clock". pp 2. 1 fig. Leaflet issued by J B Joyce in the early 1930's in connection with the electric clocks produced in partnership with G B Bowell and based on Patent 327708. Joyce & Co Ltd were the sole licensees, the majority of the clocks produced went to Canada. See article written by Charles K Aked - 'The Ingenious George Bowell'. No information received from Canada on these.

224. "Electrical Horology in Late Nineteenth Century France". Charles K Aked. Translation of pages 165 to 192 of *Les Merveilles de L'Horlogerie* by Camille Portal and H de Graffigny. This gives a view of electrical horology through the eyes of 19th century French horologists. There are nine illustrations.

225. "La Suisse, Terre d'Election de Horlogerie électrique". René P Guye. pp 237-265 of *L'Horlogerie Une Tradition Helvétique*. 1948. Neuchâtel. One of the series 'Les Editions de la Bourgade Neuchâtel' published under the direction of M. Alfred Chapuis. Translated from the French by Charles K Aked. A very partisan account of the history of electrical horology which, according to the author, originated in Switzerland. There is nothing of import included in the account. (Switzerland, Chosen Country of Electrical Horology!).

226. The "Synchronome" Astronomical Regulator. See item no 22 of this list. This was reproduced together with comments, 8 August 1984, by Charles K Aked for the Electrical Horology Group. The conclusion reached was that the clock was a failure in practice, lacking in precision through not being mounted in a vacuum, nor was the impulsing mechanism for the pendulum accurate enough for astronomical regulators.

227. "Astronomical Regulators and Observatory Time Installations". F Hope-Jones. pp 16. 10 figs. Circa 1950, probably one of the last booklets issued by the Synchronome Company Ltd, Alperton. It describes the Shortt Free Pendulum and the general principles of the Synchronome System. A succinct and clear account.

228. "Improvements to Astronomical Clocks". Gill, Forbes, Grubb & Gimingham. See item no 21. The account of 1880, together with comments, was collated 24.9.1984 by Charles K Aked for the Electrical Horology Group newsletter sent out with the notice of the AGM on 30.11.1985.

229. "The History and Construction of Electric Clocks". W I Milham. pp 320-329 of *Time and Timekeepers*. 1923. New York. This is a very simple account and concentrates mainly on the Self-Winding Clock Co. system. There are eight illustrations, particularly good for the Self-Winding master and secondary clock movements. Pages 20-30 cover the story of the time service in America, determined by the Naval Observatory, Washington, USA; and the distribution of time by telegraph; plus a section on the distribution of time by wireless from fourteen stations in the USA, and the Eiffel Tower. The latter had two clocks by Leroy & Cie of Paris, no's 1116 and 1117. A well produced account for the year of publication. See item 197.

230. "Electric Clocks". D De Carle. pp 80-105 of *British Time*. 1947. London. An account based mainly upon Hope-Jones's books. The following pages give an account of 'Tim', the speaking clock of the Post Office. There are other references to electrical timekeeping elsewhere in the book. Not a profound treatment but of interest and contains facts and illustrations not published elsewhere.

231. "La Synchronisation électromagnétique". A Cornu. 1894. Paper read before the International Society of Electricians. (Electromagnetic synchronisation). French text.

232. "Nouvelle Pendule électrique". Charles Poncet. 1921. Paris and Besançon. In *La France Horlogère*, 15 June 1921. (New Electric Clock). French text.

233. "Les Progrès récents de l'Horlogerie électrique". Marius Lavet. 1922-3. In the December issues of *Revue Générale de l'Électricité*. (Recent Progress in Electrical Horology). French text.

234. "The Eureka Electric Clock". 'Artificer'. 3 February to 31 March 1949. A series of constructional articles in the *Model Engineer* enabling the reader to construct a Eureka type electric clock. Useful for making replacement parts for Eureka clocks although not an exact copy.

235. "Pendule Libre, entrenu electriquement, sans contact". H Chretien. pp 6. 5 figs. 1907. Rheims. (Free Pendulum, electrically maintained, without contact). Magnetically coupled contacts used. French text.

236. *Horological Journal*. Vol LXII, No 744, August 1920. Mainly devoted to articles on electric clocks, probably at the instigation of Frank Hope-Jones, Chairman of the British Horological Institute.

237. "A Plan for the Regulation of Timepieces in and about Boston". E N Horsford. pp 8. No figs. 1853. Boston. This pamphlet contained proposals for a Time Ball in Boston but it was never carried out. A detailed estimate for the cost of the scheme was submitted, the time ball was to be on the State House cupola. The pamphlet was reproduced for the Electrical Horology Group 4 August 1984 by Charles K Aked.

238. "Time Balls in and around Charing Cross". An extract from *The Study of Charing Cross and its Immediate Neighbourhood*. J H McMichael. p 286. 1905. London. This notes three time balls in the Strand and one at Cornhill. Noted by John Millburn and published for the Electrical Horology Group 24 September 1984 by Charles K Aked.

239. "Historical Note on the Rate of a Moving Atomic Clock". H E Ives. pp 4. 1947. New York. An early attempt using caesium beam atomic clocks to detect Einstein's predicted effects.

240. "Accuracy of Shortt Free Pendulum Clocks". J Jackson and W Bowyer. pp 868-70. Illustrated. *Nature*, 2 June 1928.

241. "Accuracy of Shortt Free Pendulum Clocks". J Jackson and W Bowyer. *Proceedings of the Royal Astronomical Society*, 1928-1931. These records are invaluable today to investigate free pendulum clock performances, see previous entry.

242. "Synchronised Clocks". J A Lund. pp 16. 1882. London. Describes the system for hourly setting of public clocks by electrical currents, mainly used in London until the outbreak of the second world war.

243. "Rapport sur la systeme d'horlogerie électrique presenté par M. Leroy". E J Maumene. pp 14. 1 plate. 1854. Rheims. (Report on the electric clock system exhibited by M. Leroy). French text.

244. "Marine Octo Electric British Chronometer Controlled". T Mercer. pp 26. 1937. St Albans. Trade pamphlet describing the Mercer electric clock system for use at sea. Excellent clocks and equipment.

245. "The Kansas City Electric Time Ball". H S Pritchett. pp 4. 1881. Kansas City. A description of the Time Ball installation.

246. "Memoire ... sur l'Horlogerie électrique". E Regnard. 1885. Paris. (Memoir ... on Electrical Horology). The French horologists wrote profusely on electrically horology at this period. French text.

247. "Making a Free Pendulum Electric Clock". J A Roberts. *Practical Mechanics*, pp 210-2, and 240-2, two-part article in the February and March 1955 issues, London. Constructional details for amateurs.

248. "Making a Simple Battery Operated Clock". *Practical Mechanics*. pp 141-2. December 1957 issue. This is the usual Hipp Toggle electric clock for making by amateurs, made example - worked well.

249. "Le Mesure Atomique du Temps". J Rossel. pp 4. 1954. Geneva. (Atomic Measureement of Time). An early account of the use of atomic phenomena for timekeeping. French text.

250. "Applications of Electromagnetism as a Motor for Clocks". Charles Shepherd. pp 24. Illustrated. 1851. London. This gives some idea of Charles Shepherd's excellent grasp of electrical timekeeping.

251. "Shepherd's Electric Clock at the Great Exhibition Building". Charles Shepherd. pp 3. 1851. London. A brief account of the electric clock system which should have instituted a new era in timekeeping. It seems there were those equally determined to prevent electrical timekeeping becoming a competitor.

252. "Electrische Uhr von Siemens und Halske". Siemens and Halske. pp 4. 1880. Berlin. (Electric clock of Siemens and Halske). A trade pamphlet describing their electric clock system.

253. "Quartz Clocks of the Greenwich Time Service". H M Smith. pp 13. 1953. London. Detailing the equipment and methods used to maintain the time standards of Great Britain.

254. "Facts about Spellier's Electric Clock". L H Spellier. pp 3. 1884. Philadelphia.

255. "An Electric Clock with Detached Pendulum". A Steuart. pp 6. 2 figs. 1923. Edinburgh. See also items no's 78-80. This was a very simple electric clock capable of great precision and had the virtue of continuous motion to the clock hands or for use with a telescope drive. The output power could be at any chosen level, the principle being an electric motor speed-controlled by pendulum action.

256. "Modern Methods of Electrical Timekeeping". pp 176-80. 4 figs. *Conquest*. February 1921. An outline of the latest methods being employed, the Free Pendulum clock had just been announced, however the greatest changes were just around the corner - synchronous clocks and quartz crystal clocks.

257. "New Type of Free Pendulum Clock". pp 41-48. *Proceedings of the Physical Society*, Vol 45, 1933, London. This was a period when everybody was inventing his own version of a free pendulum clock. Very few of these designs were of any practical use - Parriss's rolling ball was the most successful.

258. "Servicing the Eureka Clock". pp 78-82. 4 figs. B S T Wallace. *Watchmaker, Jeweller and Silversmith*. August 1955, London. The most detailed explanation of its working and hints for maintenance written up to that time. Met BST Wallace at his home several times in 1960's to discuss Eureka clocks, an outstanding personality, see next entry.

259. "The Clock that was 'Years Ahead of its Time' ". B S T Wallace. pp 364-6 and 390. *Model Engineer*, 12 September 1957. A rather less technical outline than his article in the *Watchmaker, Jeweller and Silversmith*. Contains information not available elsewhere, plus mention of the new Hamilton electric watch based on much the same principle as the Eureka clock, one of the earliest of English mentions.

260. "Ueber die Elektrische Uhr von G Riebeck". pp 6. 1 plate. 1879. Prague. (On the Electric clock of G Riebeck). German text.

261. "Thermal Operated Gravity Displacement Pendulum". W F Watkins. page 524. 1 fig. Reprint from the *Horological Journal*, Vol 90, No 1080, page 524. September 1948. Employs a bimetallic strip mounted on the pendulum to displace a small weight which maintains the motion of the pendulum. At first sight this is a completely free pendulum since there is no physical contacting, nor any interacting magnetic or electric field, however the bimetallic strip variations directly influence the pendulum's regularity.

262. "Directions of Installation and Care of Self-Winding Synchronizing Clocks". pp 32. 1910. Brooklyn. Pamphlet issued by the manufacturers of the Self-Winding Clocks, synchronised at hourly intervals, the most succesful electrical time distribution system devised.

263. "System of Electric Clocks without Batteries or Contacts". The Magneta Company. pp 32. 1911. New York. A trade booklet explaining the Magneta system. The parent firm was in Germany.

264. "Horloges Normales électrique". C Reithman. pp 4. 1867. Munich. (Standard Electric Clocks). Translation of German paper. French text.

265. *Catalogue of Eureka Electric Clocks*. pp 16. 16 figs including cover illustration. Reprint of the original catalogue by the Midwest Electrical Horology Group in 1983. Illustrates 15 different models of the Eureka Electric Clock, but not the most expensive one - the lantern clock model at 10 guineas, £10.10s.

266. "Notes upon the Installation and Maintenance of 'Silectock' Electric Clocks". pp 4. 5 diagrams. G B Bowell. Circa 1930's. Separate battery employed for Hipp toggle master clock pendulum. Mains supply used for large slave dial installations. Recommends cutting back braiding on conductor for about an inch to reduce surface leakage. (This seems a strange idea unless braiding was metallic for minimising electro-magnetic interference to other equipment). States 'Silectock' electric clocks are British Made throughout!

267. Synchronome Price List effective from 17 November 1947, with Purchase Tax on listed prices being 37½% and reduced to 25% as from June 1948. pp 16 of a 30 page catalogue (photostat copy). 12 illustrations of clocks plus programme controller. The prices ranged from £28.6.6 to £53.11.0 for master clocks (plus 37½% tax). Firm at: Abbey Electric Clock Works, Woodside Place, Mount Pleasant, Alperton, Wembley, Middlesex.

268. Letter from the Synchronome Company Ltd dated 4 April 1973 stating spare parts for old clocks no longer available, and literature supplies exhausted. Signed by A F Holbrook, Sales Office Manager. See items no's 8-18 and below.

269. Erection Notes for Synchronome Master Clock for half-minute impulse dials only. pp 4. 1 fig. The diagram showing the Synchronome switch has the Westbury, Wiltshire, address on it - Drawing No 20 007.

270. Maintenance Notes for Synchronome Master Clock for half-minute impulse dials only. pp 4. No fig. Deals briefly with maintenance, fault-finding and correction; giving procedures for doing so.

271. "The Test of Time". Advertisement in *Horological Journal* of March 1929, page vii, for the Bulle Clock at the Ideal Home Exhibition, on Stand No 42, 26 February to 23 March 1929. The exhibits were arranged by 'The British Horo Electric Limited' with Henry Bingguely as Managing Director. Over 100 styles of cases stated in Oak, Mahogany and Lacquered wood cases. The styles are pseudo Art Nouveau designs.

272. *Silent Electric Clocks*. G B Bowell. pp 16. 7 figures. Catalogue of products produced in November 1909. In this Bowell claims the patent of 1895 for the Synchronome as his first patent. The master clock uses the Hipp toggle principle. The turret clock driven directly from the master pendulum is interesting.

273. *The Development of Time Measurement*. G H Baillie. pp 30-31. 1951. London. Brief outline of the Shortt Free Pendulum Clock, claiming performance of one-thousandth of a second per day.

274. *Units and Standards of Measurement Employed at the National Physical Laboratory*. Book 1 - Mechanics, 4th Edition, 1967. Defines the second (s) as the unit of time as the interval occupied by 9 192 631 770 cycles of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the atom of caesium-133. The standard at the NPL in 1967 was the atomic beam apparatus designed and constructed at the NPL with an accuracy of 1 part in 10^{11} (1 microsecond per day). These notes were probably written by Dr L Essen.

275. "An Electronic 1,000 c/s Synchronous Clock". T Emmerson and A Watson. pp 269-273. 6 figs. *Royal Naval Scientific Service Journal* (now defunct), circa 1950. Use of a 50 Hz synchronous clock to measure the accuracy of 1 kilohertz signals over a period of days against the Greenwich Time Signals. Nine thermionic valves are used in a frequency dividing circuit to produce a 50 Hertz output to a commercial synchronous clock. The valves used were the ubiquitous EF 50, EA 50 and EB 34. Not a sound method since errors during the measuring period can cancel out even if there are intervening variations and the inertia of the rotor will smooth out small alterations. No provision was made for non-interrupted power supplies.

276. *British Horological Institute*. Catalogue of the museum at Upton Hall, Newark, Notts. pp 26. No illustrations except arms on front cover. Exhibits 174 to 204 are of electrically driven watches of various types from electric watches to quartz crystal watches. Exhibit 111 is the Alexander Bain electric clock made about 1850. Exhibits 93 to 104 are of obsolescent watch timers, all electrically operated. Exhibit 55 is a quartz ring resonator showing signs of wear on the periphery, an early type for use in the quartz crystal clock. The Institute was never enthusiastic about electrical and electronic devices.

277. *Practical Mechanics* Master Battery Clock. pp 2 plus Blueprint showing construction of Hipp toggle electric clock utilising old alarm clock mechanism for time reduction train to motion work. The count wheel is driven by a gravity arm. (Constructed one of these clocks in 1948, it kept quite good time). The text is on duplicated typewritten sheets, full of typing errors, the blueprint is of good quality.

278. "Die Erfingdung der Elektrischen Uhr in München". Georg Schindler. *Die Uhr*. pp 10-13. 10 figs. (The invention of the Electric Clock in Munich). A very good article on the clock invented by Professor Ramis in 1815, it looked much more like a clock than the electric clock of Francis Ronalds which just preceded it by a few weeks. A number of German references are given and reproduced here.

279. *Anzeiger für Kunst und Gewerbefleiss im Königreich Baiern Erster Jahrgang 1815*. Nr 1 vom 17. 6. 1815 Seite u. 12 ff. "Die elektrische Pendeluhr des Professor Ramis, Mechanikersder königlichen Akademie zu München". (The electric pendulum clock of Professor Ramis, Mechanician of the Royal Academy of Munich). German text.

280. *Polytechnische Erfingdungen und Geheime Raths Acten K Staats Ministerium des Innern*. "Privilegium für den K Akademiker, Conservator und Professor Dr. Steinheil zu München auf seine Erfingdungen von Uhren, welche durch galvanische Kräfte bewegt und reguliert werden". Bayerisches Haupstaartarchiv München, Nr M Inn. 14288. (Darin Gesuch des Dr Steinheil und Privilegiumserteilung). (Petition of Dr Steinheil for the granting of a privilege [patent] for the invention of a clock driven by galvanism). German text.

281. "Rapport sur le système de remise à l'heure des horloges publiques". Fenon. pp 11. 1 plate. *Societé d'Encouragement*. 1880. Paris. (Report on system of resetting the time of public clocks). French text.

282. *Schumacher's Jahrbuch 1844*, S 41-8; C A Steinheil "Galvanische Uhren". (Schumacher's Yearbook for 1844). Steinheil's Galvanic Clockwork. German text.

283. *Baierisches Kunst und Gewerbeblatt, Jahrgang 1843*, S 127-142. "Beschreibung und Abb. des von dem Königlichen Akademiker und Conservator Professor Dr Steinheil erfundenen galvanische Uhren, worauf derselbe am 2. X. 1839 Privilegium für das Konigreich auf 3 Jahre erhielt". (Description of the invention of the galvanic clock by Professor C A Steinheil, granted a Privilege 2 October 1839). German text.

284. *Baierisches Kunst- und Gewerbeblatt, Jahrgang 1864*. "Geschichte der Uhren" von Schafhäutl in vielen Fortsetzungen. (Continuation of History of Clockwork by Schafhäutl). German text.

285. *Die Uhrmacherkunst und die Behandlung der Präzisionsuhren*. Eugène Gelcich. 1892. Vienna. Section 607 and following. (The Clockmaker and the Managing of Precision Clocks). Entry on electric clocks. German text.

286. *Lexicon der Uhrmacherkunst*. Carl Schulte. 1902. Bautzen. Section 607 and following. (Dictionary for Clockmakers). Entries on electric clocks. German text.

287. "Before Standard Time: Distributing Time in 19th-Century America". Carlene E Stephens. pp 113-118. 1985. *Vistas in Astronomy*, Vol 28. Contains a number of references to electrical timekeeping and a full page of bibliographical references. A useful resumé of American practices, well set out.

288. "Electrical Time Service in New York". pp 627-632. *Operator*. 23 December 1882.

289. "The Mayrhofer Electro-Pneumatic System". Electro-Pneumatic Time Co. 1890. New York. U S A.

290. "The Great Exhibit of the Self-Winding Clock Co". pp 65, 68-9. *Scientific American*, Vol 65, 29 July 1893. An illustrated account of the large publicity exhibition of the Self-Winding Clock Company.

291. *Proposal for regulating the clocks of the Pennsylvania Central*. S P Langley. pp 8. 1869. Pittsburgh, U S A. (The railway network controlled by the Pennsylvania Central Line).

292. "The Allegheny System of Electric Time Signals". S P Langley. pp 433-441. *Telegraph Engineer's Journal*, Vol 1. Great difficulties were experienced by travellers since there was no universal time system.

293. *Report on the Invention of his Electro-Chronograph*. J Locke. 1850. Cincinnati, U S A.

294. *Master Retrieval Index to the Bulletin of the National Association of Watch and Clock Collectors, Inc*. Covers *Timekeepers* No's 1-6, and *Bulletin* Vols 1-27, Whole Numbers 1-239. See pages 82-3 for a listing of approximately 100 references on electric, electro-magnetic and electronic watches and clocks. On page 92 there are 16 references relating to the Eureka Clock, and probably more elswhere. These are shown in the listing from Entry No 888 onwards, except for the main 'Eureka' references which are separately collated.

295. *Time Measurement*. L Bolton. pp 125-131. 1924. London. Chapter headed "Electric Clocks". A very elementary outline of electrical horology by describing two examples! Correctly forecasts displacement of mechanical clocks by electrical clocks.

296. *The Action of Lightning*. Major Arthur Parnell R E. 1882. London. References to the effect of lightning on clocks given on pages 171, 205, 273, 275, and watches 171. See also p 57 for Clock Tower of Houses of Parliament. The information listed is very meagre.

297. *Effects of the Gravitational Attractions of the Sun and Moon on the Period of a Pendulum*. Pierre H Boucheron. pp 18. 12 figs. Using the Shortt Free Pendulum No 41 at the Naval Observatory at Washington to assess the disturbances in a gravity controlled pendulum through changes in gravitional fields.

298. *A Parergon of Electrical Horology*. Electric Clock Patents for the Period 1840-1900. Charles K Aked. pp iii + 57. No figs. Lists all the electrical clock patents for this period with a brief outline of each. List of number of patents per year, also name listing of patentees. Prefaced by introduction placing the whole area of electrical horology invention into perspective. Nearly 400 electric clock patents up to 1900!

299. *A Conspectus of Electrical Timekeeping*. pp vii + 80. 66 figs. Collation of the first six articles on electric clocks by Charles K Aked for the commemoration of the centenary of Alexander Bain's death in 1877. The articles were published in *Antiquarian Horology* as follows:

Murday's Electrically Driven Balance Wheel Clock. December 1970. Electricity, Magnetism and Clocks December 1972. The First Electric Clock June 1973. Alexander Bain, The Father of Electrical Horology December 1974. An Early Electric Turret Clock. September 1975. Dell'Orologio Applicato all Elettromotore Perpetuo. (On clockwork applied to the perpetual electro-motor). December 1975.

300. "Temco Master Clock". Sydney J Smith. pp 16-18, and 10 + 12, of *The Horological Journal* for August and September 1937. Technical description of the Temco master clock manufactured at the TMC Ltd factory at Dulwich, designed by S J Smith. Basically a pendulum clock controlled by a synchronous clock driven from the public supply, but which, in the event of power failure, continued to operate independently until the supply was restored. The slave dials thus show the time of the supply frequency, so the system is poor for use when 'load-shedding' by reduction of voltage and frequency is resorted to by the power stations. On page 18 is also mention of the electric winding of 'Big Ben'. (Visit of the BHI guided by D Buckney junior). On pages 12-3 is the description of a synchronous clock unit with Geneva stopwork, used as a means of gear reduction to drive the hands, reducing the number of wheels in the train, example never seen.

301. "Early Electrical Current Sources". Charles K Aked. pp 87-97. 8 figs. *Journal of the Royal Naval Scientific Service*, Vol 29, No 2. An outline of the development of the dry voltaic pile and primary cells.

302. Projector Night Clock. Illustration in *Alte Uhren und Geräte* XXV catalogue, Stolberg, item number 15 showing a battery operated projector which could be of English make.

303. *Automatic Winders for Turret Clocks*. D F Nettell. pp 36. 20 figs. July 1975. Uffington. Describes various methods of electrical rewinding, protection, with conclusions. Two appendixes give details of firms supplying winders, and amateurs who have made electrical rewinding gear; plus gears of various types.

304. "New Electro-Magnetic Machine Invented by the Abbot Salvatore dal Negro". Abbot Salvatore dal Negro. pp 67-80. 1 plate containing a total of 9 figs. Published in *Annali delle Regno Lombardo Veneto*. Describes several forms of electro-magnetically driven pendulums. Copper and zinc plates in dilute acid were used to provide the necessary electrical current. The machine was first made in 1831. These pendulums were not applied to clockwork or timekeeping. Translated by R Satchell and transcribed by Charles K Aked.

305. "Hammond Bichronous Electric Clock". Folder of information on the 'Bichronous' synchronous electric clocks made by the Hammond company, USA; invented by L Hammond in 1929. The main advantage was that the clock would continue to run for some time after the mains supply was interrupted, a mainspsring driving the rotor at near synchronous speed during current interruptions of short duration. The improvement also included a liquid force transmitter to allow an inertia drive to run the rotor at above synchronous speed for starting, the motor not being self-starting. (Copies of some patents included).

306. "The Darche Electric Alarm". Folder of information on the Darche Electric Alarms made in Chicago at the end of the nineteenth century up to about 1920. (Copies of patents included).

307. "The Flashlight Electric Alarm". Charles K Aked. pp 50-51. 3 figs. 'Interface Special Report'. *Clocks*. Vol 9, No 9, March 1987. Description of the operation of the Darche Electric Alarm.

308. "Date of Patent". 'Interface'. p 61. 1 fig. Clocks. Vol 9. No 9. March 1987. Brief outline of early patents and other details. Reply by Charles K Aked to A R's query about early pattern Bulle Clock.

309. "American watchman's time detector". Cleveland Electrical Manufacturing Co. pp 43. Cleveland, 1890.

310. "The Electrical Distribution of Time". Allan D Brown. *Franklin Institute Journal*. 1888. Philadelphia.

311. "Horloge électrique systeme R Thury pour la commande d'instruments astronomiques et pour la distribution de l'heure". M H Cuénod. pp 6. 1884. (Thury's electrical clock system). Geneva. French text.

312. Catalogue of electric clocks. Favag Electrical Works. pp 12. 1931. Neuchâtel. French text.

313. "Warren master clock for maintaining constant average frequency". General Electrical Company. pp 3. 1919. Schenectady, U S A. This particular clock is now in the Smithsonian Institute.

314. Catalogue No 50. Synchronous timing motors, timing machines, clock movements. Hansen Manufacturing Company. pp 20. 1950. Princeton, U S A.

315. "Elektrischer Uhrenbetrieb". Jacob Heinrich von Hefner-Alteneck. pp 4. Not dated. Berlin. (Electric clockwork). German text.

316. "A portable spark chronograph". Clarence Nicholas Hickman. pp 7. 1931. Philadelphia.

317. "Automatic time-delay relay". C Huff. pp 3. 1931. New York.

318. "An experimental study of the rate of a moving atomic clock". H E Ives and G R Stilwell. pp 28. 1938. New York.

319. "An experimental study of the rate of a moving atomic clock, II". H E Ives and G R Stilwell. pp 6. 1941. New York.

320. "An Instrument for Measuring Short Intervals of Time". Eric A Walker. pp 7. 1941. Philadelphia.

321. "The measurement of velocity with atomic clocks". Herbert Eugene Ives. pp 5. 1940. New York.

322. "An impulse counter, tallying device, and electric stopwatch". Paul Ernest Klopsteg. pp 5. 1929.

323. "Modern developments in precision clocks". Alfred L Loomis and W A Marrison. pp 30. 1932. New York.

324. "Description of the apparatus and working of the 'Magneta' clock system". The Magneta Company. pp 19. 1908. New York. See entry no 263.

325 Illustrated Catalogue of 'Magneta' electric clocks. The Magneta Company. pp 16. 1926. New York.

326. "Alexander Bain". Alexander Steuart. pp 15. 1941. Edinburgh. Centenary of electric clock invention.

327. "Instructions for the installation, care and operation of the Paulson Time-o-Graf". H Paulsen & Company. pp 53. 1948. Chicago. See reference No 165 in the Electrical Horology Book Listing.

328. "Correct time - a new Central-Station service". Philadelphia Electric Company. pp 3. 1926. New York. One of the first notifications of the maintenance of a constant frequency AC supply to the public.

329. "Printing Chronograph. Model V". Société Genèvoise d'Instrument de Physique. pp 19. 1924. Geneva.

330. "A note on the measurement of small time intervals". Philip Pollock Quayle. pp 6. 1927. Philadelphia, U S A.

331. "Time-keeping in London (instruments in, and time-signals from, the Royal Observatory)". E A Engler. pp 28. 1883. New York.

332. Parts catalogue for Revere electric clocks. Revere Clock Company. pp 17. 1949. Cincinatti.

333. "Revere electric clocks". Revere Clock Company. pp 24. 1949. Cincinatti, U S A.

334. "Die Präzisions-uhren". Sigmund Riefler. pp 53. 1894. Munich. (The Precision Clock). German text.

335. "The Time-Service at the provisional observatory of the German Museum in Munich". Sigmund Riefler. pp 5. 1911. Munich. English translation of German text.

336. "The working of astronomical time service systems". Sigmund Riefler. pp 7. 1911. Munich.

337. Catalogue of Self-Winding Clocks. Self Winding Clock Company. pp 33. 1886. New York.

338. Time Service Catalogue. Western Union Telegraph Company. pp 12. Not dated.

339. Bulletin No 1 of program clocks and bells. Seth Thomas Clock Company. pp 4. Not dated. Thomaston.

340. Catalogue No 701. Master and Secondary Clocks. Seth Thomas Clock Company. pp 24. Thomaston.

341. Catalogue No 797. Seth Thomas Clock Company. 28 leaves. 1934. Thomaston, USA.

342. "A prominent educator says ...". Standard Electric Time Company. pp 8. 1920. Springfield, U S A.

343. Catalogue No 33 Standard Electric Time System. pp 64. Not dated. Catalogue No 34 Standard Electric Time System. pp 11. 1920. Standard Electric Time Company. Springfield, U S A.

344. "The New Post Office Speaking Clocks - Time Announcement". D S Keen & D C Swynnerton. *British Communications & Electronics*. Volume X, 1963, p 522.

345. "Batteries for Wristwatches". Letter to the Editor. *British Communications & Electronics*. Volume X, 1963, p 345. On page 713, "Time-Share for Radar or Video Displays".

346. "Horloge de commutation S.A.I.A. modèle 300". pp 10. Illustrated. B. T. (Compteurs). 1943. Paris. (Switching clock SAIA, model 300). French text.

347. "Sur un pendule électrique". Carpentier. *Comptes Rendus de l'Académie des Sciences*. 1887. Paris. (On an electric clock). French text.

348. "A Superior Electric Pendulum and some Pendulum Equations". Walter P White. pp 8. 7 figs. 1924.

349. "Nouveau pendule électrique destiné à supprimer les chocs qui altèrent l'isochronisme des oscillations". A Charanon. *Comptes Rendus de l'Académie des Sciences*. 1888. Paris. (New electric clock designed to suppress the shocks which alter the isochronism of the oscillations). French text.

350. "Electric Clocks". *The Price Guide to Clocks*. Alan and Rita Shenton. 1977. pp 368-435. 48 figs. Chapter XII covers the subject of electric clocks from a style and valuation point of view, with only the briefest of technical details. The estimates must be obtained from the latest supplement to be of value.

351. "Domestic and Battery Clocks and Master Clocks". *The Price Guide to Clocks*. Alan and Rita Shenton. 1977. pp 487-488 give tables for a rapid evaluation of the value of the various models of electric clocks normally available, however supply and demand sets the price at the lower end, see previous entry.

352. "Sur la synchronisation des horloges de précision et la distribution de l'heure". Alfred Cornu. *Compte Rendus de l'Académie des Sciences*, Volume 105, pp 1106-1112. 1887. Paris. (On the synchronization of precision clocks and the distribution of time). French text.

353. "Sur le reglage de l'amortissement et de la phase d'une oscillation synchronisée, réduisant au minimum l'influence des actions perturbatrices", and "Sur les conditions de stabilité d'un systéme oscillant soumis à une liaison synchronique pendulaire". Alfred Cornu. *Comptes Rendus de l'Academie des Sciences*, Volume 104, pp 1463-1470, and 1656-1666. 1887. Paris. (On the adjustment of damping and the phase of a synchronising oscillation, to reduce the effect of perturbations to the minimum, plus: On the conditions of stability of an oscillating system linked to a synchronizing pendulum). French text.

354. "Note à une note de M. Wolf intitulée 'Comparaison des divers systémes de synchronisation des horloges horloges astronomiques". Alfred Cornu. *Comptes Rendus de l'Académie des Sciences*, Volume 105, pp 1209-1211. 1887-8. Paris. (Reply to M Wolf's note entitled: "Comparison of various systems for synchronizing astronomical clocks"). This was a controversy about the damping of synchronised systems. French text.

355. "Sur le reglage du courant électrique donnant à l'oscillation synchronisée une amplitude déterminée". Alfred Cornu. *Comptes Rendus de l'Académie des Sciences*. 1888. Paris. (On the regulation of the current to give a synchronized oscillation of fixed amplitude). French text.

356. "Sur une objection faite à l'emploi d'amortisseurs électromagnetiques dans les appareils de synchronisation". Alfred Cornu. *Comptes Rendus de l'Académie des Sciences*, Volume 106, pp 26-31. 1888. Paris. (On an objection made to the use of electromagnetic damping in synchronizing apparatus). French text.

357. "Sur le réglage de l'amortissement et de la phase d'une oscillation synchronisée réduisant au minimum l'influence des actions perturbrices. Reglage périodique". Alfred Cornu. *Comptes Rendus de l'Académie* des Sciences, Volume 105, pp 96-100. 1888. Paris. (On the regulation of damping and the phase of a synchronized oscillation reducing disturbing influences to a minimum. Periodic regulation). French text.

358. "Sur le réglage des balanciers de chronomètre et la synchronisation". Alfred Cornu. *Congrès International de Chronométrie 1889*, pp 176-182. 1890. Paris. (On the regulation of the pendulums of precision timekeepers and synchronization. The first part applies to chronometers only). French text.

359. "La synchronisation électromagnetique". Alfred Cornu. Lecture at conference held 1894. Read before the International Society of Electricians. (Electro-magnetic synchronization). French text.

360. "Télégraphie sans fil: réception de signaux horaires et des télégrammes météorologiques", Dr Pierre Corret, pp 93, 33 figs, 1913, Paris, (Wireless telegraphy: Reception of time signals and meteorological telegrams), French text,

361. "Applications de l'électricité à l'horlogerie", G Davy, *L'électricité à l'Exposition de 1900*, Vol 3, pages 81-88, 1902, Paris, (Applications of electricity to horology), French text,

362. "Temps et Fréquence", B Decaux, *Journées Internationales de Chronométrie*, 1939, Paris, (Time and Frequency), French text,

363. "Installation de mesures du Laboratoire national de Radio-électricité", B Decaux, *Journées Internationales de Chronométrie*, 1939, Paris, (Arrangements for measurements at the National Laboratory of Radio-Electricity), French text,

364. "Etude sur les chronographes électriques et recherches sur l'etincelle d'induction et les électro-aimants", Marcel Deprez, *Comptes Rendus de l'Académie des Sciences*, 1874, Paris, (Study of electric chronographs and researches on the induction spark and the inductance of electromagnets), French text,

365. "Sur un procédé permettant de compter méchaniquement les oscillations d'un pendule complètement libre", Marcel Deprez, *Comptes Rendus de l'Academie des Sciences*, Volume 102, pp 1523-4, 1886, Paris, (On a method of mechanically counting the swings of a completely free pendulum), French text,

366. "Sur un enregistreur chronométrique portatif imprimant les observations en mesurant le 1/100 seconde", Paul Ditisheim, pp 7, 1904, Paris, (On a portable printing chronograph printing the observations to 1/100 of a second), French text,

367. "Chronométrie: Chronographe électrique enregistrant en chiffres le temps au centième de seconde", Paul Ditisheim, pp 4, *Comptes Rendus de Academie des Sciences*, 1922, Paris, (Timekeeping: Electric chronograph printing the time in figures to 1/100 of a second), French text,

368. "Les signaux horaires du bureau international de l'heure", Paul Ditisheim, pp 4, 1927, Paris, (Time signals of the International Bureau of Time), French text,

369. "Précision des gardes-temps piézo-électriques et des pendules astronomiques suivi de la description d'un garde-temps contrôlé au moyen de quartz piézo-électrique par M, de Gramont", Paul Ditisheim, pp 35, 1937, Paris, Translated by Charles K Aked for Electrical Horological Group but not published, (Precision piezo-electric timekeepers and astronomical clocks connected to a timekeeper controlled by the means of piezo-electric quartz by M de Gramont), French text,

370. "Réception des signaux horaires à l'Observatoire de Poulkovo", N Dneprovsky, *Bulletin de l'Observatoire Central de Poulkovo*, 1924, (Reception of time signals at Poulkovo Observatory), French text,

371. "Appareil pour la réception de l'heure à domicile et à bord des navires par le télégraphie sans fil", F Ducretet and E Roger, *Comptes Rendus de l'Académie des Sciences*, 1910, Paris, (Apparatus for the reception of time in private houses and on board ships by wireless), French text,

372. "Système de carillon électrique propre à la sonnerie des cloches de signal dans les grands établissements aux différent heures où il en besoin", Comte Th du Moncel, *Mémoires de l'Académie des Sciences*, 1852, Paris, (Electrical carillon system suitable for sounding signal bells in large establishments at different times or as required), French text,

373. "Note sur une système de detente électrique à remontoir pouvant être employé avec advantage dans les applications de l'électricité", Comte Th du Moncel, *Mémoire de l'Académie des Sciences*, 1855, Paris, (Note on a electric remontoir detent system which can be used with advantage in applications of electricity), French text,

374. "The Valve Maintained Tuning Fork as a Precision Time Standard". D Dye. pp 21. 15 illustrations. *Proceedings of the Royal Society*, Volume 103, pp 240-260, May 1923. London.

375. "Chronograph ... with the Hipp escapement". W R Eckart. 2 plates. 1882. Philadelphia, U S A.

376. *Die elektrische Zentraluhrenlage in Dessau*. P Engel. 8 plates . 1851. (The central electric clock-station in Dessau. [A town north of Leipzig, Germany]). German text.

377. "Sur les horloges parlantes destinées à la distribution téléphonique de l'heure". Ernest Esclangon. *Comptes Rendus de l'Académie des Sciences*. 1932. Paris. (On speaking clocks intended for telephonic distribution of time). French text.

378. "La distribution téléphonique de l'heure et l'horloge parlante de l'Observatoire de Paris". Ernest Esclangon. *Annuaire des longitudes*. 1934. Paris. (Telephonic distribution of time and the speaking clock of the Paris Observatory). French text.

379. "Les horloges parlantes et la diffusion de l'heure". Ernest Esclangon. *Comptes Rendus de l'Académie des Sciences*. 1936. Paris. (Speaking clocks and the distribution of time). French text.

380. "Sur les horloges indiquant simultanément le temps solaire et le temps sidéral". Ernest Esclangon. *Comptes Rendus de l'Académie des Sciences*. 1938. Paris. (Clocks indicating mean solar time and sidereal time simultaneously). French text.

381. "A new form of frequency and time standard". L Essen. pp 11. 3 figs. *Proceedings of the Physical Society*. 1938. Cambridge. The first use of the quartz crystal for accurate timekeeping.

382. "Distribution de l'heure par les résaux à courants alternifs". J Fallou. *Journées Internationales de Chronométrie*. 1939. Paris. (Distribution of time by reversing currents through a network). French text.

383. "Mémoire sur les horloges, les telégraphes électriques". Alexander Bain. *Mémoire de l'Académie des Sciences*. 1845. Paris. (Memoir on clocks and electric telegraphs). French text.

384. "Deux modèles d'horloges électriques". Alexander Bain. *Mémoire de l'Académie des Sciences*. 1845. Paris. (Two models of electric clocks shown before the Academy). French text.

385. "Note sur la pendule électrique système Bardon pour distribution de l'heure". Etiennes Bardon. pp 4. *Congrès National de Chronometrie*. 1926. Paris. (Note on the Bardon electric clock system for the transmission of time). Bardon worked at Clichy from 1925-6. French text.

386. "On the pendulum, with a description of an electric clock, constructed by E S Ritchie of Boston". F A P Barnard. pp 20. 1 plate. 1859. New York. A well thought out design for the period.

387. "L'horlogerie électrique". M Béache. *Génie civil*, volume 57. pp 264-7, 289-291, 301-304, 316-318, 334-337. 46 figs. 1910. Paris. (Electrical Horology). French text.

388. "Sur le reglage de la fréquence par la centrale de Sequedin". Edmond Beal. *Journées internationales de Chronometrie*. 1939. Paris. (Regulation of frequency by the central station of Sequedin). French text.

389. "Sur les conditions de la synchronisation". Jules Andrade. pp 4. *Memoire Academie Royale des Sciences*. 1903. Paris. (On the conditions of synchronization). French text.

390. "La Théorie de la Synchronisation des Horloges". Jules Andrade. pp 22. *Archives des Sciences Physiques et Naturelles*. 1904. Geneva. (The theory of the synchronization of clocks). French text.

391. "La synchronisation par le fer doux". Jules Andrade. pp 4. *Congresso Internazionale dei Matematici*. 1909. Rome. (Synchronization by soft iron). French text.

392. "Les frottements et l'isochronisme". Jules Andrade. *Compte Rendus de l'Académie des Sciences.* 1920. Paris. (Friction and isochronism). French text.

393. "La dernières perturbations de l'isochronisme". Jules Andrade. *Compte Rendus de l'Académie des Sciences.* (The final disturbances of isochronism). French text.

394. "Rapport de la Commission des horloges, distribution pneumatique et électrique de l'heure à Nancy". Charles Andre. pp 58. 1884. Nancy. (Report of the Clocks Commisssion, on the pneumatic and electric distribution of time in Nancy). French text.

395. "Description du service horaire de la ville de Lyon". Charles Andre. *Bulletin Société des Sciences Industrielles* 1889. Lyon. (Description of the time service in the town of Lyon). French text.

396. "Distribution synchronique de l'heure à l'Observatoire de Lyon". Charles Andre. *Mémoire de l'Académie des Sciences de Lyon.* 1911. Lyon. (Synchronised time distribution from Lyon Observatory). French text.

397. "Précision de la connaissance de l'heure à l'Observatoire de Paris". *Comptes Rendus de l'Académie des Sciences.* B Baillaud. 1912. Paris. (Precision of the determination of time at the Paris Observatory). French text.

398. "Note sur la précision des signaux horaires émis de 1910 au 31 décembre 1919 par le bureau international de l'heure à Paris". B Baillaud. pp 3. *Notices of the Royal Astronomical Society.* 1922. Edinburgh. (Note on the accuracy of the wireless time signals transmitted by the International Bureau of Time at Paris). French text.

399. "Dispotif simple pour l'enregistrment des signaux horaires rythmés". Jules Baillaud. *Comptes Rendus de l'Académie des Sciences.* 1914. Paris. (Simple device to register the rhythmic time signals). French text.

400. "Enregistrement microphonique de la marche des chronomètres". Alphonse Berget. *Comptes Rendus de l'Académie des Sciences.* 1899. Paris. (Microphonic recording of chronometers). French text.

401. "Présentation d'un Moteur chronométrique à mouvement uniforme et continu". Alexandre Bertrand. pp 3. 1 fig. *Congrès National de Chronométrie.* 1926. Paris. (Presentation of a chronometric motor with uniform continuous movement). French text.

402. "Les horloges à fonctionnement sur les secteurs de distribution et les appareils de contrôle de fréquence". Alexandre Bertrand. pp 8. 3 figs. 1932. Besançon. (Mains supply clocks and the devices for controlling frequency). French text.

403. "Disposition d'horloge se remontant d'elle-même au moyen de courants thermo-électriques produits par les variations de la température". E Bigi. *Comptes Rendus de l'Académie des Sciences.* 1882. Paris. (Arrangement of clock which automatically rewinds itself by means of thermo-electric currents generated by variations of temperature). French text.

404. "Sur la comparaison des durées d'oscillation de deux pendules reglés sensiblement à la même période". G Bigourdan. *Comptes Rendus de l'Académie des Sciences.* 1897. Paris. (On the comparison of the duration of oscillation of two pendulums regulated sensibly to the same period). French text.

405. "Sur la distribution de l'heure à distance au moyen de la télégraphie électrique sans fils". G Bigourdan. pp 3. *Comptes Rendus de l'Académie des Sciences.* 1904. Paris. (On the distribution of time at a distance by means of wireless). French text.

406. "Sur un moyen de contrôler un système d'horloges synchronisées électriquement". G Bigourdan. *Comptes Rendus de l'Académie des Sciences.* 1906. Paris. (On a means of controlling a system of clocks sychronized electrically). French text.

407. "Sur un moyen de soustraire les horloges astronomiques à l'influence des variations de la pression atmospherique". G Bigourdan. *Comptes Rendus de l'Académie des Sciences*. 1909. Paris. (On a means of preventing the influence of atmospheric variations on astronomical clocks). French text.

408. "Description d'un appareil pour l'envoi automatique des signaux horaires". G Bigourdan. *Comptes Rendus de l'Académie des Sciences*. 1913. Paris. (Description of an apparatus for automatically sending time signals). French text.

409. "Sur l'emploi du pendule entièrement libre comme garde temps". G Bigourdan. *Comptes Rendus de l'Académie des Sciences*. 1923. Paris. (On the use of a free pendulum as a precision timekeeper). French text.

410. "Sur l'observation des signaux horaires rythmés; prècision de réception et ordre de grandeur des perturbations". G Bigourdan. 1925. Paris. (On the observation of rhythmic time signals; precision of receiving and order of magnitude of perturbations). French text.

411. "Erreurs moyennes des divers modes d'observation des signaux horaires rythmés". G Bigourdan. *Comptes Rendus de l'Académie des Sciences*. 1925. Paris. (Mean errors of several modes of observation of rhythmic wireless time signals). French text.

412. "Sur l'unification des signaux horaires radio-télégraphiques". G Bigourdan. *Comptes Rendus de l'Académie des Sciences*. 1929. Paris. (On the standardisation of radio time signals). French text.

413. "L'Horloge lumineuse de la Tour Eiffel". Alexandre Bertrand. pp 12. Illustrated. *Annales Française de Chronométrie*. (Illuminated clock of the Eiffel Tower. French text.

414. "Sur un électro-chronographe à étincelles synchronisées". A Blondell. *Comptes Rendus de l'Académie des Sciences*. 1912. Paris. (On an electro-chronogrpah with synchronized sparks). French text.

415. "Sur les chronographes électriques et les microgalvonomètres enregisteurs". A Blondell. *Comptes Rendus de l'Académie des Sciences*. 1914. Paris. (On electric chronographs and recording microgalvanometers). French text.

416. "Remontage automatique des horloges à l'aide du dispotif Martin Mayeur". Blot-Garnier and Chevalier. pp 12. 12 figs. *Societé d'encouragement*. 1913. Paris. (Automatic rewinding with the aid of the device of Martin Meyeur). French text.

417. "Le télégraphie sans fils et l'astronomie". De Bonald. pp 34. 1912. Rodez, France. (Wireless telegraphy and astronomy). French text.

418. "Instruction pour l'envoi de l'heure par la radio-télégraphie". F Boquet. pp 8. 1911. Paris. (Instruction for transmitting the time by radio). French text.

419. "Les observations méridiennes et la determination de l'heure. Exposé des procédés employés à Paris pour la distribution de l'heure en ville par la radio-télégraphie". F Boquet. pp 39. *Bulletin Societé de France*. 1911. Paris. (Meridian Observations and the determination of Time. Outline of the procedures used for the distribution of time in Paris by radio). French text.

420. "Sur l'organisation du service de l'heure à l'Observatoire de Paris". F Boquet. pp 18. 8 figs. 1 plate. 1913. Paris. (On the organisation of the time service at the Paris Observatory). French text.

421. "Les chronographes imprimants de l'Observatoire de Paris". F Boquet. pp 26. 1 plate. Not dated. Paris. (The printing chronographs of the Paris Observatory). French text.

422. "Appareil sémaphorique à signaux instantanés dit signal-horaire pour la transmission de l'heure dans les ports". Georges Borrel. pp 4. 2 figs. *Congrès Chronometrique de 1900*. 1902. Paris. (Semaphore for instantaneously signalling the time in ports, called a time-signal). French text.

423. "Regulateur électrique pour entrenir le mouvement du pendule". Bourbouze. *Compte Rendus de l'Académie des Sciences*, Volume 83, pp 482-484. 1876. Paris. (Electric regulator for maintaining the motion of a pendulum). French text.

424. "Horlogerie électro-magnetique". Louis Braun. *Bulletin Technologique*. March 1895. Paris. (Electro-magnetic clockwork). French text.

425. "Sur un appareil destiné à mesurer la vitesse d'un projectile dans différents points de sa trajectoire". Louis Breguet. *Comptes Rendus de l'Académie des Sciences*. 1845. Paris. (An apparatus designed to measure the velocity of a projectile at different points of its trajectory). French text.

426. "Note sur un chronoscope électromagnétique". Louis Breguet. *Mémoire de l'Académie des Sciences*. 1845. Paris. (Note on an electromagnetic chronoscope). French text.

427. "Note sur une nouvelle horloge électrique". Louis Breguet. pp 870-873. *Mémoire de l'Académie des Sciences*. 1857. Paris. (Note on a new electric clock). There are several works by Louis Breguet mentioning electric clocks, eg *Manuel de la télégraphie électrique*, third edition, 1856, Paris. French text.

428. "Le Chronostat III" - Chronometre Electronique à Transistor Lic ATO. pp 10. 2 figs. 3 tables. 1961. Trade pamphlet describing the new transistorised marine chronometer by L Leroy & Cie, 4 rue du Fauborg St-Honore, Paris. The details of the performance are given - error of about 1/3 second a day. A decree was obtained on 9 June 1954 to allow the electrically maintained chronometer to take part in trials and to be permitted for use at sea. A normal chronometer balance was employed. French text. See also NAWCC *Bulletin,* Volume 10, Whole Number 96, pages 111-115 for fuller technical description, also Entry No 895.

429. "Chronometry - The maintenance of chronometer balance oscillations without physical contact". M. Marius Lavet and M. Jaques Dietach. pp 2. No figs. Translated by Tony Mercer from the French, July 1959, and given to Charles K Aked, 22nd February 1974. There should be three figures with the text.

430. *Les Horloges à raies spectrales*. 'Le Temp Astronomique p Le Temps Atomique'. J Verbaandert. pp 47. 19 figs. Communications de l'Observatoire Royal de Belgique No 137. 1958. Brussells. A brief history and explanations of the recently devised ammonia and caesium clocks. French text.

431. "The Greenwich Time Ball". P S Laurie. pp 113-115. No figs. *The Observatory - A Review of Astronomy*, Vol 78, No 904. June 1958. A brief history of the Time Ball at Greenwich.

432. *Dictionnaire Professionnel Illustré de l'Horologerie*. G A Berner. 1961. La Chaux-de-Fonds. French, German, Spanish and English equivalents for electrical and electromagnetic terms are given.

434. "Electric Clocks". pp 146 ff. *Scientific American*. Vol 103. 20 August 1910.

435. "Huge Electrically-driven Clock". pp 4 ff. *Scientific American*. Vol 104. 7 January 1911.

436. "International Time and Weather Radio-Telegraph Signals". W J S Lockyer. pp 33-36. *Nature*. Vol 91.

437. "Metropolitan Life Building in New York". *Electrical Review*. 19 February 1910. Chicago.

438. "The Accutron". L Defossez. *Swiss Watch and Jewellery Journal*. No 1. February 1961.

439. "The Dye quartz ring oscillator as a standard of frequency and time". L Essen. pp 498-519. *Proceedings of the Royal Society*, series A, Volume 155. 1936. London.

440. "Die Junghans-Ato Transistor Pendleuhr. G Glaser. *Die Uhr*, Volume 21, 1959.

441. "An analysis of the electric watch". Richard Good. pp 18-23. *Horological Journal*. Vol 99, 1957.

442. "The Accutron". Richard Good. pp 340-353. *Horological Journal*. June 1961.

443. "Hamilton Pulsar". pp 14-15. *Horological Journal*, Volume 113, July 1970. An early American quartz crystal watch which was not taken seriously by the Swiss manufacturers until almost too late.

444. "Etude comparative de quelques organes electro-magnétiques moteurs applicables à l'entretien des balanciers circulaires". M Lavet. pp 69-97. *Annales françaises de chronométrie*, Volume 12. 1958. (Comparative studies of electromagnetic components applicable to maintaining balances in motion). French.

445. "Entretien électrique des balanciers de chronometrie. Nouvelle applications des transistors". M Lavet. 1959. (Electrically maintained chronometer balances. New applications of transistors). French text.

446. "Propriétés des organes electromagnétiques convenant aux petites moteurs à diapason". M Lavet. pp 183-196. *Annales françaises de chronometrie*, Volume 15, 1961. (Characteristics of electromagnetic components for small tuning fork drives). French text.

447. "Omega Watches". pp 12-13. *Horological Journal*, Volume 116, No 1, July 1973.

448. "Smith's Sectronic Battery Powered Timepiece". pp 47-50. T R Robinson. *Horological Journal*, February 1963. A good account of a widely used battery driven electro-mechanical clock movement.

449. "Anleitung zur Projektierung und Ausführung kleiner elektrischer Uhrenanlagen". Siemens and Halske. 1910. Berlin. (Instructions on a project for making small electric clocks). German text.

450. "Schaltungenund Beschreibungen elektrischer Uhrenanlagen". Siemens and Halske. 1910. Berlin. (Description of electric clock connections). German text.

451. "The Measurement of Time". H Spencer-Jones. pp 123-130. *Endeavour*, Volume 4, October 1945.

452. *Clocks and Locks*. Edmund Beckett Denison. pp 65-74. 1 fig. Second edition 1857. This is the section published in the *Encyclopædia Britannica* and enlarged. First published in 1855 from the 8th edition of the *Encyclopædia Britannica*. A good account of the state of the art at the time, he credits Bain as being the first inventor, and Shepherd's electric clock as the most reliable - invented by the son. Mentions the stopping of the dials in Shepherd's system at the Crystal Palace; Bain and his shop in Bond Street; plus the Greenwich time ball.

453. *A Rudimentary Treatise on Clocks and Watches and Bells*. Edmund Beckett. pp 156-162. 7th edition. 1883. Deals with Bain's clocks and contains the famous statement "But these clocks never answered in any practical sense ...", also in the section on Shepherd's electric clock, "... every now and then the electricity will fail to lift anything, however small; ...". Illustrates Ritchie's slave dials with compound pendulums on page 160, mentions the Royal Institution installation and failure; and finally time balls and guns. A lot of information in a small space, but strong bias against the use of electricity in clocks, yet the Westminster clock reported electrically to Westminster daily - to Shepherd's electric clock, which was then the standard mean solar clock for the whole of the British Isles.

454. *Chronométrie*. J Andrade. pp 317-358. 17 figs. 1908. Paris. Pages 317-330 cover the general phenomenon of synchronization; includes the work of Cornu, Andrade, and Foucault, see *Comptes Rendus de l'Académie des Sciences* 27 July 1903 and *Archives de Genève*, February 1904). The treatment is highly mathematical. Pages 331-358 covers the electromagnet and contact problems, (chapter 1); followed by an account of some electric clocks, (chapter 2); and finally synchronization of clocks (chapter 3). There is very little mathematics in this part of the book, and the exposition is very much out of date as it is dealing with electric clocks of the mid to late 19th century. There is a useful index of inventors pp 369-371. Andrade was a teacher at the Faculté des Sciences de Besançon. French text.

455. *Watch and Clock Making*. David Glasgow. pp 312-319. 2 figs. 1885. London. Commences with Bain's electric clock, mentions large clock factory in Edinburgh, Shepherd's electric clock, repeat of Denison's words about failure with electricity; deals with Jones's system and trial in London, Ritchie's electrical escapement, plus Barraud and Lund's system of setting clocks. There is little of value in the account.

456. *Les Automates.* Jean Prasteau. Chapter XIII, pp 161-174. 5 plates. 1968. Paris. (Automata). Four electrically driven automata described. French text.

457. *Ein Jahrhundert Junghans.* F L Neher. pp 128-132 and pp 153-156. 7 figs + 2 coloured plate showing electrical equipment and 3 electrically driven watches opened up for viewing. The ATO clock is shown in line form. Historical rather than technical, intended to laud the achievements of Junghans. 1961. Schramberg. (Junghans centenary 1861-1961). German text.

458. "Synchronous Timekeeping". p 826. *Horological Journal*, December 1953. A note from Smith's of Cricklewood on the accuracy of 'mains time'. (Alas the table gives the values in minutes instead of seconds, showing the greatest error as -49 minutes!). An apology for the error was sent to all members of the BHI.

459. "New Master Clock System". p 421. *Horological Journal*, July 1956. Letter from Mr Fred K Longley in reply to A C Webber's remarks in the May 1956 issue. Mechanical regulator which releases a counterpoised lever each minute to set an electrically driven waiting train in motion to drive the hands of a slave dial.

460. "Electric Watch Information". p 226. *Horological Journal*, April 1959. Letter from Arthur Quillam urging the BHI to give a lead in the matter of repairing electric watches. The editor points out that the *Horological Journal* was the first in the world with an article on the electric watch, and mentions a new article on the Lip watch and the manual available for the Hamilton electric watch.

461. "First Electric Watches on the Market". p 86. *Horological Journal*, February 1957. Hamilton's battery maintained, balance-driven movement, still within the realms of the mechanical watchmaker.

462. "Electric Watches". p 156. *Horological Journal*, March 1957. Letter from D Rohn of Roamer Watches denigrating the electric watch and stating its main advantage will be 'that it will indicate *precisely the time when the battery has given out*', a remark taken up parrot-fashion by George Daniels in later years.

463. "Centenary celebrations of 'Big Ben', Westminster". p 420. *Horological Journal*, July 1959. Floodlighting of orb and cross on the top of the clock tower for the first time, using Atlas fittings, first developed for the 'Son et Lumière' at Greenwich, these were mounted on buildings 100 to 200 yards away.

464. *Antique Clocks and Clock Collecting.* Eric Bruton. p 87. No illustrations. 1974. London. Passing references to Bain's electric clock, Bulle and Eureka clocks.

465. *Clocks and Watches.* Eric Bruton. 1968. London. pp 59-60, 100, 109-115. First mention of the Hamilton electric watch, the Accutron, radio watches; a view of the Hamilton watch is given on page 60. Page 100 illustrates the Tiffany 'Never-Wind'clock. Page 109 covers Grimthorpe's remarks and Alexander Bain's Electric clock, Greenwich Time Ball, Deal Time Ball, Radio time signals from Paris, tubular bells (in Marcoolyn's possession, Time 'pips' by Hope-Jones; Eureka, Bulle, Shortt Free Pendulum clock, quartz crystal clock, caesium atomic clock; with illustrations. Page 127 gives a full page colour plate of a Patek Philippe light operated clock. The first Swiss Quartz crystal watch, the Centre Electronique Horloger is illustrated full size on p 130 together with a Bulova Accutron tuning fork timer for use on the Moon.

466. *The Arts of Britain.* Edward Mullen, editor. pp 223-228. Chapter 17 - 'Clocks and Watches' by Charles Aked. 1983. Oxford. Mention of quartz crystals ending the mass production of mechanical watches.

467. *Clocks and Watches.* Cedric Jagger. 1977. London. There are a number of references to electric clocks and watches, the most important being an illustration of Alexander Bain's electric clock in the Clockmakers' Company Museum, Guildhall, page 205; and the Barraud and Lund advertisement for their patent method of synchronizing clocks at the hour, page 206. Nothing profound to be found in this book.

468. *The Clockmakers' Library.* John Bromley. 1977. London. p 1 has three articles listed by Charles K Aked. (Entries no's 5, 6, and 7 in the book); p 2 Bain's *Short History of the Electric Clocks*, (Entries no 41 & 42 in the book); p 3 the illustration of the Edinburgh to Glasgow synchronization of clocks. Other items included are shown in immediate sequence where these are not already included in this list.

469. "About the Isochronous Oscillation of a Pendulum". F M Fedchenko. pp 18. Illustrated. (Entry no 307 in the book *The Clockmakers' Library*). No details of contents given.

470. "Astronomical clock with an electromagnetically driven pendulum. F M Fedchenko. *Research in the field of Time Measurement*, Proceedings of a committee of the All Union Scientific Research Institute of Physio-techical and Radiotechnical Measurements. pp 18. Illustrated. Issue 58, 1962. (Entry no 308 in the book).

471. "Astronomical clock Ach F-1 with isochronous pendulum". F M Fedchenko. *Astronomical Journal of USSR*. pp 12. Illustrated. Account of the last of the electro-mechanical precision clocks. (Book Entry no 309).

472. "Spring Suspensions for a Pendulum". F M Fedchenko and A G Fleer. *Measurements Techniques*, No 8 , August 1966. Three-part suspension spring to give isochronous swings. Success never achieved in the past.

473. "Fedchenko's electronic-mechanical pendulum astronomical clock". pp 3. Figs. In *Elektrischkie pribory vremeni*. V A Shpolyansky and B M Chernyagin. 1964. Moscow. This Russian electrically driven pendulum disappeared without trace in the 1970's, it was supposed to be better in performance than the Shortt.

474. "Mr Fortnum and Mr Mason: the new clock". Fortnum and Mason. pp 2. 1965. This clock has automata worked by the use of relays and electric motors. [Rather an amateurish production].

475. "Catalogue of tools and materials for watchmakers, jewellers and the electronics industry". Henri Picard & Frère Ltd. pp vi + 207. Illustrated. Including price list.

476. "Proceedings of the banquet and testimonial to the Chairman Mr A Angus Croft ... at Willis's rooms on Wednesday, 22 March 1891". United Kingdom Electric Telegraph Company. pp 31. Plates.

477. *Clocks and Watches in the Collection of the Worshipful Company of Clockmakers*. Cecil Clutton and George Daniels. Item no 627 in the book listing, page 106, describes the Alexander Bain electric clock now in the collection. It was bequeathed by A W Marshall in 1973. It is like the model illustrated in Bain's *A Short History of the Electric Clocks*, page 26. Details for this given by Charles K Aked to Colonel H Quill in 1974, see also brief details on page 105 of the book.

478. *How Time is Measured*. Peter Hood. First edition 1955, second edition 1969 with details of new developments. Oxford. The relevant parts are: p 29 - A tuning fork watch, pp 33 - 35 - Time Switches, pp 36-7 - Electric Mains Clocks, p 38 - Electric Winding, p 39 - Electronic Clocks, pp 41-2 - The Electric Master Clock, pp 41 - The Free Pendulum Clock, p 43 mentions the Surveyor's Chronometer - fitted with half minute contacts, pp 50-2 - Quartz Crystal Clocks, pp 53-4 - Time Signals, pp 55-56 Atomic Time, pp 58-60 The Telephone Speaking clock. All these are dealt with at an elementary level but clearly.

479. "A Quartz Crystal Clock". C F Booth. pp 33-37. 8 figs. *The Post Office Electrical Engineers' Journal*, Volume 39, Part 2, July 1946. This is the equipment now displayed in the Science Museum, London. It consists of three identical 100 kilohertz crystal oscillators, in a temperature maintained at 50° C ± 0.005° C, the crystals are of the bar type in evacuated glass envelopes. In the same issue, p 47, is a short article by J M R reporting that on 24 July 1946, the Speaking Clock will be 10 years old and have anwered 325 million calls with the announced time accurate to within 0.1 second. It mentions the duplicate installation at Liverpool. See next entry - 480.

480. "The British Post Office Speaking Clock, Mark II". A J Forty & F A Milne, part 1; and R L Smith, part 2. *Two part article on the Speaking Clock*. *The Post Office Electrical Engineers' Journal*, p 154, Part 3; and pp 229-233, Part 4, 13 figures; Volume 48. The equipment was made for use in Australia, to be installed at Melbourne and Sydney. The article was reprinted from *The Telecommunication Journal of Australia*, Volume 10, No 2, October 1954. First part is technical, second part covers despatch operations.

481. "'TIM' the Speaking Clock". Full description in the April 1963 issue of the *Post Office Electrical Engineers' Journal*. One of these is in the Science Museum and another at the Deal Time Ball Tower Museum.

482. "An Electronic Programme Clock". A K Debbie. p 12. *The Post Office Electrical Engineers' Journal*, Volume 48, part 1.

483. "Post Office Quartz Oscillators for use in Time and Frequency Standardisation Abroad". J S McClements, p 26. *The Post Office Electrical Engineers' Journal*, Volume 48, Part 1.

484. "Electric clocks". *Time Measurement Instruments*. Richard Meyrick. 1979. Bury St Edmunds. Exhibit 21M, listed on p 42, is an electric clock made by an amateur at Clacton; Synchronome type with four slaves.

485. "Comparaison de deux pendules astronomiques à l'aide de signaux électriques transmis par un câble sous-marin à très longue portée". R Bourgeois. *Comptes Rendus de l'Académie des Sciences*. 1910. Paris. (Comparison of two astronomical clocks with the aid of electrical signals transmitted by a very long submarine cable). French text.

486. "Nouveau pendule électrique, destiné à supprimer les chocs qui altèrent l'ischronisme des oscillations". A Charanon. *Comptes Rendús de l'Académie des Sciences*. 1882. Paris. (New electric clock designed to suppress the disturbances which alter the isochronism of the oscillations). French text.

487. "Pendule libre entrenu électriquement sans contact". Henri Chretien. pp 8. 5 figs. *Comptes Rendus Association Française pour l'advancement des Sciences*. 1907. Paris. (Free pendulum maintained electrically without contact"). The use of a magnet to induce a current in a copper ring to create a mechanical force to operate electrical contacts, thus the pendulum is only apparently and not actually free. See entry no 235 - identical article published in Rheims. French text.

488. "Chronographe électrique enregistrant, en chiffres, le temps au centième de seconde". Henri Chretien. pp 4. 1 fig. *Comptes Rendus de l'Aacadémie des Sciences*. 1922. Paris. (Electrical chronograph printing times in figures to one hundredth of a second). French text.

489. "Chronographe électrique imprimant électrique à vitesse intermédaire constante". Henri Chretien and Paul Ditisheim. pp 25. 6 figs. 1933. Besançon. (Electric printing chronograph of constant intermediate speed). French text.

490. "De l'unification de l'heure". Armand François Collin. pp 6. *Societé d'encouragement pour l'industrie nationale*. 1880. Paris. (On the unification of time). The use of synchronizing signals was greatly favoured in France at this period. see Entry No 224 for full details. French text.

491. "De l'unification de l'heure dans Paris, des quatre cadrans régulateurs types, des cadrans compteurs". Armand François Collin. pp 16. c. 1880. Paris. (On the standardisation of time in Paris, four types of regulator dials, and secondary dials). French text.

492. "L'unification de l'heure à Paris et dans toute la France". Armand François Collin. pp 21. 1880. Paris. (The standardisation of time in Paris and all France). The use of hourly synchronizing signals to keep all public mechanical clocks in step. French text.

493. "L'unification de l'heure à Paris et dans toute la France avec le nomenclature et la description des appareils exposés à l'exposition d'électricité". Armand François Collin. pp 39. 1880. Paris. (The standardisation of time in Paris and in all France, with the nomenclature and description of all the apparatus shown at the Paris exhibition). French text.

494. "Les horloges électriques et la transmission de l'heure astronomique dans les centres horlogers de la Suisse occidentale". Albert Favarger. *Génie Civile*. pp 7. 20 figs. 1888. Geneva. (Electric clocks and the transmission of astronomical time in the horological centres of western Switzerland). French text.

495. "Sur la distribution de l'heure civile". Albert Favarger. *Congrès de Chronométrie de 1900*. pp 6. 1902. Paris. (On the distribution of civil time). Some of Favarger's work was included in *Histoire de la pendulerie neuchâteloise ...*, edited by Alfred Chapuis. 1917. Neuchâtel. French texts.

42

496. "Pendule astronomique destinée à l'Observatoire de Marseille". Fenon. pp 10. 3 plates. *Societé d'Encouragement*. Based on report made by Rédier. 1884. Paris. (Astronomical clock designed for the Marseille Observatory). French text.

497. "Application de TSF à l'envoi de l'heure". C Ferrie. pp 52. Circa 1912. (Application of wireless to the transmitting of time). This was translated into German, see next entry. French text.

498. "Verwendung der drahtlosen Telegraphie z. Zt. der Uebermittlung". pp 20. 1912. See previous entry. German text.

499. "L'enregistrement des oscillations d'un pendule sans liasons matèrielles". pp 6. 1 fig. 1929. *Monthly notices of the Royal Astronomical Society*. Probably Charles Féry's text. (Registering of the oscillations of a pendulum without material contact). French text.

500. "Pendule à restitution électrique constante". Charles Féry. *Comptes Rendus de l'Académie des Sciences*. 1900. Paris. (Pendulum with constant electrical restitution). French text.

501. "Pendule à restitution électrique constante". Charles Féry. pp 3. *Congrés de Chronométrie de 1900*. 1902. Paris. (Pendulum with constant electrical restitution). French text.

502. "Pendule électrique à échappement libre". Charles Féry. *Comptes Rendus de l'Académie des Sciences*. 1905. Paris. (Electric clock with free escapement). French text.

503. *Notice sur les appareils exposés par lui à l'Exposition franco-britannique, group V, électricité et instrument de précision*. Charles Féry. pp 89-100. 1908. Tours. (Notice on the apparatus shown by him at the Franco-British Exhibition, group V, electricity and precision instruments). French text.

504. "Nouveau Chronomètre électrique". pp 815-820. Charles Féry. *Journal de Physique*, 5th series, Volume 1. 1922. Paris. (New electric chronometer). French text.

505. "Les avantages de l'horlogerie électrique, ses récents progrès". Charles Féry. pp 10. 3 figs. *Congrès national de Chronométrie*. 1926. Paris. (The advantages of electrical timekeeping, its recent progress). French text.

506. "Titres et travaux de Ch Féry et description des principaux appareils exposés à l'occasion du cinquantenaire de l'école de physique et de chimie industrielle". [Horlogerie électrique pages 67-75]. 3 figs. 1933. Paris. (Titles and works of Charles Féry and description of the principal apparatus shown on the occasion of the 50th anniversary of the Industrial School of Physics and Chemistry). French text.

507. "Sur l'isochronisme d'un pendule entrenu par une impulsion agissant après la verticale". Charles Féry and N Stoyko. pp 3. 1 fig. *Comptes Rendus de l'Académie des Sciences*. 1932. Paris. (On the isochronism of a pendulum maintained by an impulse acting after the vertical [position]). French text.

508. "Note relative à un moyen de contrôler la distribution de l'heure dans les diverses stations télégraphiques". A Forel. *Comptes Rendus de l'Académie des Sciences*. 1888. Paris. (Note relative to a means of controlling the distribution of time in different telegraphic stations). French text.

509. "Etude sur le pendule à oscillations électro-continues de M. Leon Foucault. Hypothèse de la resistance de l'éther". E Gand. 1855. Amiens. (Study on M. Leon Foucault's electrically sustained pendulum. Hypothesis of the resistance of the Aether). French text.

510. "Sur un nouveau système d'horloge électrochrone". Paul Garnier. *Mémoire de l'Académie des Sciences*. 1847. Paris. (On a new system of electrochrone clock). French text.

511. "'Aron' Self-winding electric clocks". General Electric Company, Ltd. pp 1621-24. "Telephones, etc". K section. 11th edition. 1911. London.

512. "Pulsynetic impulse clocks". Gent and Co Ltd. pp 8. 1914. Leicester. See entries 102, 103 & 513.

513. "Silent electric impulse clocks and electric turret clocks". Gent and Co Ltd. pp 53. 1914. Leicester.

514. "Note sur la pendule électromoteur de Gérard". Gerard. pp 7. 1 plate. 1855. Brussels. (Note on Gérard's pendulum electromotor). French text.

515. "Description d'un petit appareil électrique destiné à entrenir les oscillations d'un pendule à demi-seconde". *Gerard. Comptes Rendus de l'Académie des Sciences.* 1864. Paris. (Description of a small electrical apparatus designed to maintain the oscillations of a half-seconds pendulum). French text.

516. "Interrupteur électrique du chronométre de marine". V Gerbeaux. *Congrès national de Chronométrie.* pp 3. Illustrated. 1923. Paris. (Marine chronometer electric switch). French text.

517. "Système d'horloge électrique". A Giraud. *Comptes Rendus de l'Académie des Sciences.* 1868. Paris. (Electric clock system). French text.

518. "Mémoire sur une horloge magneto-électrique". Gloemer. *Mémoire de l'Académie des Sciences.* 1848. Paris. (Memoir on a magneto-electric clock). French text.

519. "L'enregistrement des signaux horaires à l'Observatoire de Besançon". R Goudey. *Bulletin de l'Observatoire.* pp 32. 20 illustrations. 1925. Besançon. (Recording of the time signals at Besançon Observatory). French text.

520. "L'ajustage électrique à distance des pendules normals". A Greadenwitz. *Revue général des Sciences pures et appliquées).* 1908. Paris. (Electrical adjustment of distant ordinary clocks). French text.

521. "Recherches sur le quartz piezoélectrique". Armand de Gramont. *Revue d'Optique.* pp 113. 66 figs. 1935. Paris. (Researches on piezo-electric quartz). French text.

522. "Une procédé électrostatique pour l'entretenir les vibrations des diapasons et des verges". Pierre Grivet. pp 3. 2 illustrations. *Comptes Rendus de l'Académie des Sciences.* 1941. Paris. (An electro-static means for maintaining the vibrations of tuning forks and rods). French text.

523. "Sur la determination expérimentale du couple d'amortissment d'un oscillateur". Jules Haag. *Comptes Rendus de l'Aacadémie des Sciences.* 1932. Paris. (On the experimental determination of the damping couple of an oscillator). French text.

524. *Horology: the Science of Time Measurement.* J Eric Haswell. "Electrical Clocks". Chapter 10, pp 106-132. 16 line figs. Plates XVII-XIX. First edition 1928, second edition with supplement 1937. Commencing with Bain and Shepherd it moves on to the 'Synchronome', Pulsynetic, Lowne, Princeps, Steuart, Bentley, Hipp toggle, Féry, Bulle and Magneta systems. A short section on secondary clocks follows. The diagrams and text are excellent, especially for the time of publication. The plates illustrate the Mercer surveying chronometer and two chronographs for use with it, described in pages 255-7.

525. *Horology.* Donald De Carle. pp 68-76 and 89-101 deal with time signals, electric and electronic clocks and watches respectively at a very simple level. First edition 1965, second impression 1973. London.

526. "The present status of the use of Standard Time". Eduard Everett Hayden. *United States Naval Observatory*, Volume 4, pp 25. 1905. Washington.

527. "Information relative to the construction and maintenance of Time Balls". W B Hazen. pp 31. 4 figs. 1881. Washington.

528. "Etude préliminaire d'un diapason de quartz dans un vide élève. F Holweck and Père P Lejay. *Comptes Rendus de l'Académie des Sciences*. (Preliminary study of a quartz tuning fork in a vacuum). French text.

529. "Electrical Distribution of Time". pp 20-67. *Correct Time*. Hooke and R Myles. pp 68. 36 figs. 1912. London.

530. "Die Galvanische Pendeluhr". M H Jacobi. pp 56. 1 plate. *Mémoires physiques et chimiques*. 1856. St Petersburg, Russia. (The Galvanic Pendulum Clock). French text.

531. "Réception d'un signal horaire hertzien de la Tour Eiffel". Paul Jegou. *Comptes Rendus de l'Académie des Sciences*. 1910. Paris. (Receiving a Hertzian time signal from the Eiffel Tower). French text.

532. "Application de la T S F signaux horaires, détermination des longitudes". Paul Jegou. pp 66. 1912. Paris. (Application of the wireless time signals, determination of longitude). French text.

533. "Détermination de l'heure par T S F". Paul Jegou. Paris. (Determination of time by wireless). French text.

534. "Sur le mouvements oscillatoires subordonnés dus bout à bout". de Jonquieres. pp 68. *Comptes Rendus de l'Académie des Sciences*. 1887. Paris. (On the subordinate oscillations from beginning to end). French text.

535. "Die Elektrischen Uhren". *Bericht über die internationale elektrische Ausstellung*. F Kapaun. pp 307-344. 1885. Vienna. (The Electric Clock, report on the International Electrical Exhibition). German text.

536. "Elektrische Uhren und Chronoscope". A Kleyer. No other details. (Electric clock and chronoscope). German text.

537. "Observation of wireless time signals". Knox-Shaw. Helwan Observatory. No other details.

538. *Die Mechanik des Electro-Mechanismus, ihren grundbegriffen nach entwickelt, sowie mehrere neue elektrische Maschines und Apparatus in den Elektromechanismus als Triebkraft für Telegraph Uhren und Maschinen aller Art*. J F Koloff. Berlin. (Electro-mechanisms ... new electrical machines ... telegraph, clocks). German text.

539. "Réception radiotélégraphique de l'heure". Lachat. pp 15. 1911. Lyon. (Radio-telegraphic reception of time). French text.

540. "Champ électrique et étude des isolants". P Lang. pp 40. (Electric field and study of insulators). French text.

541. "Les progrès récents de l'horlogerie électrique". Marius Lavet. *Revue générale de l'électricité*. 1922. Paris. (Recent progress in electrical horology). French text.

542. "Recherches sur les procédés d'entretien électrique des pendules et leur application à l'horlogerie". Marius Lavert. pp 15. *Congrès national de chronométrie*. 1926. Paris. (Researches on the methods of electrically maintaining pendulums and their application to timekeeping). French text.

543. "La remise à l'heure automatique des pendules par émissions radioélectriques". Marius Lavet. pp 16. 11 illustrations. *Revue générale d'électricité*. 1928. Paris. (Automatically resetting clocks by radio transmissions). French text.

544. "Facteurs dont il convient de tenir compte dans les essais comparatifs des pendules électriques à réaction directe". Marius Lavet. pp 13. *Annales de Chronométrie*. 1932. Besançon. (Factors which must be taken into account when comparing electric clocks in direct tests). French text.

545. "Alimentation des horloges électromagnétiques par le secteur". Marius Lavet. pp 4. *Annales de Chronométrie*. 1932. Besançon. (Energising electromagnetic clocks in groups). French text.

546. "Etude des procédés de synchronisation des balanciers d'horloges et autres oscillateurs méchaniques". Marius Lavet. pp 31. 22 illustrations. *Revue générale d'électricité*. 1934. Paris. (Study of the methods of synchronising clock pendulums and other mechanical oscillators). French text.

547. "Application des nouveaux aciers à aimant à l'horlogerie; Moteurs synchrones et récepteurs horaires silencieux munis d'aimants au nickel aluminium". Marius Lavet. *Journées Internationales de Chronométrie*. 1939. Paris. (Application of new magnetic steels to horology, synchronous motors and silent secondary clocks fitted with magnets of nickel aluminium). French text.

548. "Appareil enregistreur de la vitesse dans les mouvements pendulaires". Jean & Louis Lecarme. pp 68. *Comptes Rendus de l'Académie des Sciences*. 1897. Paris. (Apparatus for recording the speed of pendular motions). French text.

549. "Chronographes électriques, horloges, compteurs". *Dictionnaire de l'électricité et du magnétisme comprenant les applications aux sciences, aux arts et à l'industrie*. E Bouty & J Lefevre. 1890. Paris. (Electric chronographs, clocks and secondary dials). French text.

550. "Sur la synchronisation à distance des pendules de précision sans l'intermédiaire d'aucun contact". Lejay. *Comptes Rendus de l'Académie des Sciences*. 1927. Paris. (On the synchronisation of remote precision timekeepers without intermediary contact). French text.

551. "Sur un chronographe enregistrant le dix millième de seconde, et son application à la mesure des irrégularités des pendules astronomiques". Lejay. *Comptes Rendus de l'Académie des Sciences*. 1929. Paris. (On a chronograph recording to one ten-thousandth of a second, and its application to the measurement of the irregularities of astronomical regulators). French text.

552. "L'horlogerie electrique et pneumatique". *Nouveau manuel complet de l'horloger*. Sixth edition of the original work by Le Normand and Janvier, edited by Stahl, in two volumes, pp 394 + 375. 15 plates. 1896. Paris. (Electric and pneumatic horology). French text.

553. "Rapport de M Maumené sur le système d'horlogerie électrique présénte par M le Roy, horloger à Reims. M Maumené. pp 134. 1 plate. 1854. Reims, France. (Report by M Maumené on the electric clock system shown by M Le Roy, clockmaker of Reims). French text.

554. "Electricité pratique. Sonnerie des heures sur les cloches". Abbé Letombe. 1888. Saint-Quentin. (Practical electricity. Sounding of the hours on bells). St Quentin is a small town halfway between Paris and Brussels.

555. "Description d'une horloge électromagnétique dans laquelle la force qui maintaient le mouvement du pendule régulateur est régulièrement constant". Emmanuel Liais. *Mémoire de l'Académie des Sciences*. 1851. Paris. (Description of an electromagnetic clock in which the maintaining force is constant). French text.

556. "Note sur la distribution électrique de l'heure". Emmanuel Liais. *Mémoire de l'Académie des Sciences*. 1857. Paris. (Note on the electrical distribution of time). French text.

557. "Sur l'entretien du mouvement du pendule sans perturbations". G Lippmann. *Comptes Rendus de l'Académie des Sciences*. 1896. Paris. (On the maintenance of the motion of a pendulum without irregularities). French text.

558. "Méthodes pour comparer, à l'aide de l'etincelle électrique, les durées d'oscillation de deux pendules réglés sensiblement à la même periode". G Lippmann. *Comptes Rendus de l'Académie des Sciences*. 1897. Paris. (Methods for comparing, with the aid of the electric spark, the durations of oscillations of two pendulums regulated sensibly to the same period). French text.

559. "Sur l'entretien du mouvement pendulaire sans perturbation, Entretien du pendule géodésique", G Lippmann, *Comptes Rendus de l'Académie des Sciences*, 1904, Paris, (On the maintenance of pendular motion without irregularity, Maintenance of a geodesic pendulum), French text,

560. "Action du magnétisme terrestre sur une tige d'acier invar destinée à un pendule géodésique", G Lippmann, *Comptes Rendus de l'Académie des Sciences*, 1904, Paris, (Action of terrestial magnetism on an invar rod intended for use as a geodesic pendulum),

561. "Washington-Paris longitude by radio signals", G Hill & Littel, *Astronomical Journal*, 1915, London,

562. "Résultats obtenus avec des pendules magnétiques", Locke, *Mémoire de l'Académie des Sciences*, 1849, Paris, (Results obtained with magnetic pendulums), French text,

563. *Die Gesammte, Literatur über Uhrmacherei und Zeitmesskunde*, M Loeske, pp 122, 1897, Bautzen, (The whole literature on clockmaking and chronometry), The title is no idle boast, and this little book has many references to electrical horology, these have all been included in this list or the accompanying electrical horology book list, Page 97 of the book lists most of the electrical horology works up to 1897, German text,

564. "Conférence internationale de l'heure", J D Lucas, 1913, Louvain, (International Conference on Time), French text,

565. "Réception photographique des radiotélégram, et comparaisons précises des pendules astronomiques et des chronomètres à distance", J D Lucas, pp 45, 3 plates, 1913, Louvain, (Receiving radiotelegrams photographically, and precise comparisons of remote clocks and chronometers), French text,

566. "The Observatory Time Ball, Cape of Good Hope", Thomas Maclear, pp 2, *Nautical Magazine*, 1852, London,

567. "Chronométrie électrobalistique", H Mahieu, 1885, Brussels and Leipzig, (Electro-ballistic chronometry), French text,

568. "Mémoire sur un projet de chronographe éléctromagnétique et son emploi dans les expériences d'artillerie", Martin de Brettes, *Mémoire de l'Académie des Sciences*, 1847, Paris, (Memoire on an electromagnetic chronograph project and its use in artillery experiments), French text,

569. "Pendule électrique", Edouard Regnard, *Mémoire de l'Académie des Sciences*, 1854, Paris, (Electric clock), French text,

570. "Mémoire sur la télégraphie électrique à courants continus et à double échappement et sur l'horlogerie électrique", Edouard Regnard, pp 46, 3 plates, 1855, Paris, (Memoir on the electric telegraph with direct and reversing currents, and on electric clockwork), French text,

571. "Mémoire sur la vitesse de propagation des ondes dans les milieux gazeus (appareil enregistreur utilisant les vibrations isochrones d'un diapason ou d'une lame vibrante ou chronoscope)", Victor Regnault, 1870, Paris, (Memoir on the speed of propagation of waves in the centre of gases, registering apparatus using the vibrations of a tuning fork, vibrating spring or chronoscope), French text,

572. "Ein elektrisches Zentraluhrensystem für Wien", M, Reithoffer, *Ver, zur Verbreit Naturw Kenntnisse*, pp 20, 2 figs, Not dated, (A centralised electric clock system for Vienna), German text,

573. "Zeitübertragung durch das Telephon, Elektrische Ferneinstellung", Clement Riefler, pp 8, 1906, Berlin, German text, Also printed in *Journal Suisse d'horologerie* as "Transmission téléphonique de l'heure, Réglage à distance des horloges par l'électricité", 1906, Geneva, (Telephone transmission of time, Regulation of distant clocks by electricity), French text,

574, "Zeitübertragung durch das Telephon, Elektrische Ferneinstellung", Clement Riefler, pp 8, 1906, Berlin, German text, Also printed in *Journal Suisse d'horologerie* as "Transmission téléphonique de l'heure, Réglage à distance des horloges par l'électricité", 1906, Geneva, (Telephone transmission of time, Regulation of distant clocks by electricity), French text,

575, "Projekt einer Uhrenanlage für Kgl, Belgische Stenwarte in Uccle", Clement Riefler, pp 27, 8 figs, 2 plates, 1904, Munich, (Project for accurate time service facilities at Uccle Observatory in Belgium), German text,

576, "An account of Mr Ronalds' pendulum doubler of electricity", Francis Ronalds, pp 3, *Edinburgh Philosophical Journal*, 1823, Makes use of a spring driven pendulum to provide electrostatic charges,

577, "On correcting the rate of an electric clock by a compensation for changes in temperature", Francis Ronalds, pp 2, *Philosophical Journal*, 1815,

578, "On electro galvanic agency employed as a moving power with a description of a galvanic clock", Francis Ronalds, *Philosophical Magazine*, pp 3, 3 figs, 1815,

579, "Transmission automatique de l'heure de l'Observatoire de Besançon à hôtel de ville, à l'Université, au domicile des fabricants d'horlogerie", A Salet, pp 7, 2 plates, Twentieth edition of *Bulletin Chronométrique de l'Observatoire de Besançon*, 1909, Besançon, (Automatic transmission of time from the Besançon Observatory to the Town Hall, University, and Manufacturers' premises), French text,

580, "On the measurement of time to the one-thousandth of a second", Ralph A Sampson, pp 23, 2 figs, 14 tables, *Monthly Notices of the Royal Astronomical Society*, 1918, Edinburgh, Sampson was the astronomer in charge of the Edinburgh Observatory,

581, "On clock errors and wireless time signals", Ralph A Sampson, *Monthly Notices of the Astronomical Society*, Volume 71, page 90, 1921, Edinburgh,

582, "On the determination of time at different observatories", Ralph A Sampson, *Monthly Notices of the Astronomical Society*, Volume 72, page 215, Edinburgh, The study of accurate timekeeping by pendulum clocks was a speciality of Sampson's and culminated in his testing of the first Free Pendulum clock installed by its maker, W H Shortt in Edinburgh Observatory, Christmas 1921, when its performance proved a sensation,

583, "On the causes of anomalous determinations of time", Ralph A Sampson, *Monthly Notices of the Astronomical Society*, Volume 85, page 560, 2 plates, Edinburgh,

584, "Mesure de temps à la Physikalisch-Technische Reichsanstalt au moyen d'Horloges à quartz", A Scheibe, *Journées internationales de Chronométrie*, 1939, Paris, (Time measurement at the Imperial Institute of Physics and Technology by means of quartz clocks), French text,

585, "Die Installation elektrischer Uhrenuanlagen", G Schonberg, 18 illustrations, Not dated, (The instalation of electric clocks), German text,

586, "Emploi du courant alternif à la transmission des indications d'appareils dont l'index peut effectuer des rotations complètes, Application à la distribution de l'heure", Pierre Sève, *Comptes Rendus de l'Académie des Sciences*, 1914, Paris, (Use of reversing currents for transmitting indications to apparatus in which the indication can be effected in complete rotations, Application to the distribution of time), French text,

587, "Wireless Time Signals observed at Ottawa 1921-1926", C Smith, *Publications of the Dominion Observatory at Ottawa*, Ottawa, 1930,

588, "Horlogerie électrique", Souchet, pp 15, 1 plate, 1902, Angoulême, (Electric clocks), French text,

589. "Das Chronoskop, Instrument zur Bestimmung der Zeit und der Polhöhe ohne Rechnung", C A von Steiheil, pp 30, 2 plates, 6 tables, 1867, Munich, (The Chronoscope, Instrument designed for measuring small intervals of time), Steinheil was the first to achieve the electrical transmission of time, German text,

590. "Wireless Time Signals observed at Ottawa", M Stewart, *Journal of the Royal Astronomical Society of Canada*, Published for the years 1923, 1924, and 1925, Ottawa,

591. "Sur la précision de l'heure des signaux rythmés du bureau international de l'heure", N Stoyko, *Comptes Rendus de l'Academie des Sciences*, 1926, Paris, (On the precision of the time of the rhythmic signals of the International Bureau of Time), French text,

592. "Sur la précision de la determination de l'heure et sur les moyens de l'améliorer", N Stoyko, *Societé des Savantes*, 1928, Paris, (On the precision of the determination of time and on the means of improving it), French text,

593. "Sur la précision de l'heure des signaux horaires et de la détermination des longitudes", N Stoyko, pp 7, *Bureau Internationale de l'heure*, 1930, Paris, (On the precision of the wireless time signals and the determination of longitude), French text,

594. "Correction définitive des pendules du BIH en 1929", N Stoyko, *Bureau Internationale de l'heure*, 1930, Paris, (Definitive correction of the International Bureau of Time clocks in 1929), French text,

595. "Thèse sur la mesure du temps et les problèmes qui s'y rattachent", N Stoyko, pp 121, 7 figs, 1931, Paris, (Thesis on the measurement of time and the associated problems), French text,

596. "Précision de la conservation de l'heure dans divers Observatoires", N Stoyko, pp 6, 1932, Paris, (Precision of the keeping of time in various Observatories), French text,

597. "Quelques remarques sur la marche des pendules", N Stoyko, pp 3, Not dated, Paris, (Some remarks on the performances of clocks), French text,

598. "Etudes des retards dans les appareils d'enregistrements des signaux horaires du BIH", N Stoyko, pp 8, *Bulletin horaire*, Volume IV, (Study of the delays in the recording equipment for the time signals of the International Bureau of Time), French text,

599. "Sur les causes d'irrégularité et d'erreurs de réception des signaux rythmés", N Stoyko, pp 11, *Bulletin horaire*, Volume IV, Paris, (On the causes of the irregularities and errors of reception of the rhythmic signals), French text,

600. "Sur l'extrapolation de la correction de la pendule directrice du BIH en 1927 et 1928", N Stoyko, pp 7, *Bulletin horaire*, Volume IV, 1930, Paris, (On the extrapolation of the correction of the controlling clock of the International Bureau of Time, in 1927 and 1928), French text,

601. "Régularité de marche des garde-temps modernes", N Stoyko, *Journées Internationales de Chronométrie*, 1939, Paris, (Regularity of rate of modern precision timekeepers), French text,

602. "Sur un chronographe piezoélectrique", Edgard Pierre Tawil, *Comptes Rendus de l'Academie des Sciences*, 1936, Paris, (On a piezo-electric chronograph), French text,

603. "Notice sur l'horlogerie électrique système Thury", M Thury, pp 15, 1884, Geneva, (Notice on the Thury electric clock system), French text,

604. "Le rôle des horloges publiques dans le problème de l'unification de l'heure", Alfred Ungerer, *pp 5, Congrès Internationale de Chronométrie 1923*, 1926, Paris, (The role of public clocks in the problem of the standardisation of time), French text, See Tardy for portrait of Alfred Ungerer,

605. "Le téléchronomètre". Ungerer. *Congrès Internationale de Chronométrie de 1889*. pp 2. 1890. Paris. (The telechronometer). French text.

606. "L'heure par téléphone". Théodore Ungerer. 1928. Strasbourg. (The time by telephone). Théodore constructed the monumental clock of Messina Cathedral in 1930, he died in 1935 aged 49 years. French text.

607. "Le remontage automatique des horloges monumentales". Théodore Ungerer. pp 16. 14 figs. 1928. Cluses. (The automatic rewinding of monumental clocks). French text.

608. "Unification de l'heure des horloges publiques ou remise à l'heure électriquement". Abbé H Vassart. pp 64. 1879. Roubaix. (Time standardisation of public clocks by hourly setting electrically. [Roubaix is a small town halfway between Calais and Brussels]. French text.

609. "Note concernant le synchronisme de divers pendules". P Verdeil. *Comptes Rendus de l'Academie des Sciences*. 1868. Paris. (Note concerning the synchronization of various clocks). French text.

610. "Description d'une pendule dont l'électricité seule est la force motrice". A L Vérité. *Mémoire de l'Academie des Sciences*. 1853. Paris. (Description of a clock in which electricity is the sole motive force). Auguste Lucien Vérité was the maker of the astronomical clock at Besançon designed between 1865-8. He sent a communication to the Académie des Sciences in 1853 about a large regulator with an electric constant force escapement, it was exhibited in 1856 and patented. He died in 1887. See Tardy page 639 for his portrait in middle age. French text.

611. "Sur un moyen d'obtenir un isochronisme parfait pour un nombre quelconque d'horloges reliées entre elles par un fil conducteur de courant électrique". A L Vérité. *Comptes Rendus de l'Academie des Sciences*. 1863. Paris. (On a means of obtaining perfect isochronism for a number of clocks connected by a wire conducting electric current). French text.

612. "Moyen d'obtenir le synchronisme des heures entre un nombre illimité d'horloges et des pendules". A L Vérité. *Revue Chronométrique*, March 1863. Paris. (Means of obtaining synchronism of time between an unlimited number of clocks and pendulums). French text.

613. "Entretien électrique d'oscillations pendulaires sans contact matériel". Pierre Vernotte and Jean Villey. *Comptes Rendus de l'Academie des Sciences*. 1925. Paris. (Electrical maintenance of pendular oscillations without physical contact). French text.

614. "Galvanic Time Signals". C V Walker. pp 235-259. *South Kensington Museum*, Science and Art Department. Special loan collection. Free evening lectures series. Not dated, circa 1880. London.

615. "Time signals for chronometers". R Wauchope. pp 2. *Nautical Magazine*. 1836. London.

616. "Plans for ascertaining rates of chronometers by an instantaneous signal". R Wauchope. pp 16. 1 plate. 1836. Edinburgh.

617. "Description of the electro-magnetic clock". Charles Wheatstone. pp 3. *Philosophical Magazine*. 1841. London. There is no diagram accompanying the text.

618. "Note sur le chronoscope électro magnetique". Charles Wheatstone. *Mémoir de l'Academie des Sciences*. 1845. Paris. (Note on the electromagnetic chronoscope [of Wheatstone]). French text.

619. "A superior electric pendulum; and some pendulum equations". Walter P White. pp 8. 7 figs. 1924.

620. "Elektrische Uhren". C Erfurth and H Wietz. pp 10. 12 figs. (Electric clocks). German text.

621. "Comparaison des garde-temps à l'aide de fréquences élevées". Vladimir Yanouchewsky. *Journées Internationales de Chronométrie*. 1939. Paris. (Comparison of precision timekeepers with the aid of high frequencies). French text.

622. "Professor Bond's clock for registering astronomical observations by electricity". Professor Bond. pp 131-134. *Chamber's Edinburgh Journal*. 1851. Edinburgh. A method of registering star transits by a trace on paper made by seconds pulses from a clock and by closing a key at the instant of transit.

623. "über das Project der Galvanischen Uhren zu Berlin". August Kramer. *Dingler's Polytechnische Journal*, Volume 121, p 111, 1851; also in *Zeitschrift für Gross- und Klein-Uhrmacher*, p 117, 1853. (On the project for Galvanic Clocks at Berlin). This was a proposal to have a central transmitting clock with the circuits divided into separate parts, each containing a limited number of clocks in series, so that a fault would only affect the connected clocks in any one circuit. German text.

624. "Étude sur les causes perturbaires de la marche des chronomètres". Ansart-Deusy. pp 30. 1858. Brest. (Study of the disturbing causes to the going of chronometers). The author ascribes electrical and magnetic disturbances as causing variations in the rates of chronometers. French text.

625. "Nouveau moyen de transmettre à distance l'heure rigoureuse". Rodier. *Comptes Rendus de l'Academie des Sciences*, Volume 50, pp 855-856. 1860. Paris. (New method of transmitting accurate time to a distance). French text.

626. "Account of some experiments showing the change of rate produced in a clock by a particular case of magnetic action". William Ellis. pp 325-331. *Philosophical Magazine*, Fourth series. 1863. London. The experiments were to determine if the rate of a pendulum could be suitably adjusted by a permanent magnet placed near it. This led eventually to the electrical method by varying the current in an electromagnet.

627. "Horlogerie électrique". L Breguet. pp 432-434. Illustrated. *Les Mondes*. 1865. Paris. (Electric clockwork). Secondary dials are operated in series by a master clock reversing the current in the circuit every minute. An installation in the street gas lamps of Lyons had worked well for several years at the time of writing. See May 1987 issue of *Clocks* magazine for details. French text.

628. "L'horlogerie dans toutes ses parties, y compris les horloges électriques". J Berlioz. pp 51. 12 figs. 3 plates. In *Annales et Archives de l'industrie au XIX siècle ...* 1867. Paris. (Horology in all its parts, including electric clocks). French text.

629. "Time-Signalling". pp 196-199. *Chambers' Journal*. 1871. London. The article includes mention of a large number of time-balls and other signalling devices installed all over the world.

630. *Wissenschaftliche Instrumente ... Autorisierter Abdruck aus dem "Amtilichen Berichte über die Wiener Weltausstellung im Jahre 1873"*. J Frick. Band 2. Heft 4. 1874. Braunschweig. Clocks are treated pages 50-65, the most interesting item being an electrically driven marine chronometer. This makes it one of the earliest electrically driven balance timepieces. German text.

631. "Controlling clocks and time-signals by electricity". F J Ritchie. pp 531 and 555. *English Mechanic and World of Science*. This is from a paper entitled "The Correction of Clocks by hourly currents of electricity" read before the Royal Scottish Society of Arts, Edinburgh, on 11 March 1878. This gives details of the early history of Alexander Bain's work, and describes a number of clocks and systems installed in the British Isles. See Entry No 24.

632. "Synchronised clocks". John A Lund. *Journal of the Society of Telegraph Engineers*. 1882. London. This was extracted and printed in *Journal of the Society of Arts*, Volume 30, page 51. See entry no. 242.

633. "On a method of measuring very small intervals of time". Robert Sabine. pp 10. Illustrated. Reprint from the *Philosophical Magazine*, May 1876. A very early suggestion for making use of the time of discharge of a capacitor through a resistor. The capacitor was then known as a condenser, and much earlier in the century Professor William Thomson had proved the oscillatory discharge conditions for a capacitor.

634. "Sur le réglage électrique de l'heure à Paris". Tresca. *Comptes Rendus de l'Académie des Sciences*, Volume 90, pp 660-665. (On the electrical regulation of time in Paris). French text.

635. "Sur l'enregistrement des battements de secondes d'une pendule au moyen du microphone" W Meyer. pp 418-432. *Archives des Sciences physiques et naturelles*. 1881. Geneva. (On the registering of the beats of a seconds pendulum by means of a microphone). A carbon microphone was fixed to the clock case and the varying current distributed to the points where the seconds' beat was required, and to a tape registering the seconds' pulses. French text.

636. "Universal Time: our future clocks and watches". Norman Lockyer. *Journal of the Society of Arts*, Volume 33, pp 172-177 and 182-189. 1885. London. Juvenile lectures delivered at the Royal Institution.

637. "Exposé sommaire des travaux qui ont été faits à l'Observatoire de Paris sur le reglage électrique des horloges". C Wolf. *Congrès International de Chronométrie 1889*, pp 183-188. (Summary of the work done at the Paris Observatory on the electrical regulation of clocks). Two systems were tested, one regulating all the clocks at the Observatory by one master clock, the other was for the public clocks of Paris. The different methods of synchronization tested are described fully. French text.

638. "Comparaison des divers systèmes de synchronisation électrique des horloges astronomiques". C Wolf. *Comptes Rendus de l'Academie des Sciences*. 1887. Paris. (Comparison of various systems of electrical synchronization for astronomical clocks). French text.

639. "Collection de Mémoires relatifes au pendule". C Wolf. pp 226. 7 plates. 1889-1891. Paris. (Collection of memoirs relating to the pendulum). French text.

640. *NAWCC Thirty-Second National Convention* Catalogue. Los Angeles Chapter. 1976. Page 59 shows an electric digital regulator made by the Thrasher Clock Co., Manchester, Connecticut, the movement is illustrated; also a Murday Balance Wheel clock with glass dial, and a wall timepiece by Leroy & Cie, circa 1890.

641. "Mesure des petits intervalles de temps". J Granier. *Annales Françaises de chronométrie*. Besançon. (Measurement of small intervals of time). French text.

642. "Les Petites Machines électriques". Henry Lanoy. No date. (Small electrical machines). French text.

643. "La pendule électrique Ato-Radiola à remise à l'heure automatique par TSF". Marius Lavet. (The Ato-Radiola electric clock reset at the hour by radio-telegraphy). Trade pamphlet. French text.

644. "New slave device for free pendulum". H H Neuville. *Horological Journal*, p 122, 4 figs. 1950.

645. "Extrait du mémorial de l'artillerie et de la marine. Notice sur le chronographe à diapason et étincelles d'induction (système Schultze)". Moisson. 1875. Paris. (Extract of a memorial of the artillery and navy. Notice on the tuning fork chronograph and induction sparks. Schultze system). French text.

646. "Thirty-hour long-case clock converted to electric rewind". F Short. p 1. *Horological Journal*, Volume 93. 1951.

647. *Manuel pour le professeur et Guide pour l'apprenti, avec preparation pour l'examen théorique*. H Sievert. pp 562. 193 figs. 14th edition, 1938. Berlin. French and German editions. (Manual for the teacher and apprentice, with preparation for the theoretical examination). Includes section on electric horology. See Entry No 678. French and German texts.

648. *Maintenance and Servicing of Electrical Instruments*. James Spencer. Second edition. Denver, USA.

649. *Correspondence Course in Horological Salsmanship*. British Horological Institute. Circa 1960. There are a number of references in this course to electric clocks, particularly lessons 2, 11 and 12, which cover the history of electrical horology quite well, plus illustrating the personalities involved and contemporary clock designs. The details on Frank Hope-Jones are good.

650. "The Time-Ball Tower - Signalling at Sea, Semaphores and Satellites, at Deal, Kent". 6 page folder. 1985. Describes the Deal time-ball tower, the exhibition of signalling and the Post Office speaking clock.

651. "Lecture on Electric Clocks". *Tokyo Electric Company*. pp 30. 1933. Tokyo. Japanese text.

652. "Electrifying Time". Admission card for two, dated 15th December 1976, for the 'Electrifying Time' exhibition held at the Science Museum, London, December 1976 to May 1977. Attendance over 100,000 visitors.

653. "Electrical Horology Group". Menu card for the 10th Anniversary Luncheon at the Bellhouse Hotel, Garden Suite, Beaconsfield, Buckinghamshire, 15th September 1980. After dinner speech by Charles K Aked, founder and first Chairman, on how the Group came to be formed and the history of its first ten years.

654. "Stable Clocks". *Gillett & Johnston*. Two page pamphlet serial number (64.5) X, illustrating a small turret clock which is driven by synchronous motor, or quartz crystal remote control GMV with battery back-up, and radio Signal Control (Rugby) RMV. Dials of fibreglass in blue or black, 22 carat gold leaf marks and hands. Not dated, but issued in the mid-1970's.

655. *Electric Clocks*. F Hope-Jones. 1931. London. In the copy held by the Institution of Electrical Engineers Library, London, was a message from the donor (F Hope-Jones) "The brutal non possumus decorated with aristocratic wit". The words are to be found also on page 9 of the book. In the second edition of the book *Electrical Timekeeping*, published May 1949, the copy is inscribed: "May 1949. For the Library of Inst. of Elec. Engineers from the Author - Frank Hope Jones. (Received 10 May 1949). Inside the book is a note written in Hope-Jones' own hand: "Just 50 years after reading my first paper before the Institution, I present another Book to the Library, telling how electrical time service has been established as a respectable branch of the Profession and how electric clocks keep the time of the world in its Observatories". All the books on electric clocks in the Institution of Electrical Engineers Library were donated by Frank Hope-Jones, and these have been placed in store and are not available on the shelves. At a visit on 7 August 1968, there were only four books on electric clocks in the whole of the IEE Library shelves!

656. "Electricity, Magnetism and Clocks". Charles K Aked. *Journal of the Royal Naval Scientific Service*, Volume 26, No 6, pages 386-400. History of electrical timekeeping from its origins to the caesium clock.

657. "Letter to the Royal Society, London, from Alessandra Volta, dated 20 March 1800, concerning his voltaic cell". This was read to the Society 26 June 1800, and printed in *Philosphical Transactions*, Volume XC, pp 403-31. This was the beginning of current electricity generation by chemical means although Volta had made his discovery almost ten years earlier, the run-on effects completely changed the world.

658. "An Account of Mr Ronalds' Pendulum Doubler of Electricity". *Edinburgh Philosophical Journal*, Volume 9, pp 322-5. 1823. Edinburgh. This uses a mechanically driven pendulum to continually double the electric charge to energise a conductor, used in Ronalds' telegraph system tested in his Hammersmith garden in 1814.

659. "à Malines. Grandes Horloges publiques réglées par électricité". Moeremans Michiels, Editor. pp 19. Not dated. (At Malines. Large Public Clocks regulated by electricity). Malines is a small Belgium town about halfway between Antwerp and Brussels. French text.

660. "German Clock and Watch Industry - Government Reports" German Quartz Clocks. No date. German text.

661. "Die Elektrische Uhr". Christopher Arzberger. pp 16. 7 figs. 1870. Brünn. (The Electric Clock). German text.

662. "über elektrische Uhren". Christopher Arzberger. pp 8. 4 figs. 1871. Brünn. (On Electric clocks). German text.

663. "A Clock-Controlled Tuning Fork as a Source of Constant Frequency". J G Ferguson. *Western Electric Company Engineering Department* reprint B.56.1, dated February 1924, from *The Bell System Technical Journal* Volume III, No 1. January 1924. pp 13. 5 figs. This deals with the method of obtaining a constant frequency from a tuning fork by synchronising it with a standard clock, in this case a Leroy et Cie, Paris, electrically driven and beating half seconds. The authors seem unaware of the work of W H Shortt. Also described is the use of a photo-electric cell for obtaining electrical impulses directly from the pendulum.

664. "The 'Pulsynetic' System and its place in the History of Electric clocks". An introductory study". D J Bird. pp 467-478. 9 figs. *Antiquarian Horology*, Volume 16, No 5. First part of two-part article.

665. Electrical Horology Group Report - Annual General Meeting 29 November 1986. *Antiquarian Horology*, Volume 16, No 5, pp 490-491. 1 illustration showing time-ball operating mechanism. Write-up of lecture by A Mitchell. (Another application of a Shepherd electric clock to provide standard time).

666. "The Electric Clock at the Great Exhibition". *Mechanics' Magazine*, Volume 54, No 1, pp 212-213. 1851. London. Brief description of the principles of Shepherd's electric clocks and the arrangements at the exhibition, the large dial had eight electromagnets wound with one hundred and forty pounds of copper wire!

667. *The Crystal Palace and its Contents. An Illustrated Cyclopaedia of the Great Exhibition of 1851.* pp 369-371. Contains an article on Shepherd's Electric Clock. 3 illustrations. 1852. London. It is believed that the connections were cut on several occasions, the actual pendulum master worked quite well.

668. *The Bashforth Chronograph.* Francis Bashforth. 1890. Cambridge. Chapters 1-III cover the Ballistic Pendulum and mention of chronographs including Wheatstone's and Breguet's, a description of Bashforth's own chronograph, and experiments with it. The only example of Bashforth's chronograph is in the Science Museum, London. A heavy flywheel is spun by hand, or by a weight, this drives a recording cylinder, the surface carries a calibrated paper chart on its surface, the trace on which is deflected by markers, one by a half-seconds pendulum, the second by electrical contacts fitted in firing screens being separated, which indicates intervals of time for the passage of projectiles. Bashforth was the most successful exponent in this field of Ballistic Science.

669. *The Mechanic's Friend; a collection of receipts and practical suggestions relating to ... horology, etc.* W E A Axon. 1875. London. pp 160-163 gives an account of Bright's perpetual motion clocks based on Bain's toggle switch model of 1843. It states that the friction of the switch is so low that eight or ten such clocks can be driven from one earth battery, the secondary clocks are preferably pendulum clocks. Four such clocks at Leamington had worked for four years on an old battery previously in use for twenty years! Another installation of three clocks worked from a gas pipe and a piece of coke, five clocks were working at the Gun Cotton Office, 173 Fenchurch Street, London. pp 303-304 details how to make an earth battery using plates of copper and zinc one foot square buried four feet deep in the ground. pp 309-310 gives details of how to make an electromagnetic clock pendulum of the Bain pattern, this uses a platinum ball for the contact switch, no details are provided for the propulsion of the clock train.

670. "Versuche über elektrische Uhren". J Brünn. pp 15. 1 plate. 1875. Opladen. (Trial upon an electric clock). Description of an electric clock made by Tiede in 1864 for the Berlin Observatory and also several of the electric clocks devised by Brünn himself. German text.

671. *Favorite Tools and Equipment.* Golay-Buchel et Cie SA, Lausanne, Switzerland. Catalogue includes demagnetisers, timing machines, and plating machines. Not dated but before quartz crystal or electrical watches appeared, mid-1950's. English text..

672. "Patent Specification 22858 - Electrically Synchronised Clocks". Bahne Bonniksen and F A Chandler. 2 plates. 1903. London.

673. *Table Clocks.* Jaeger-Le-Coultre - Makers of the world's most remarkable timepieces. A catalogue which shows electrical timepieces pp 51-58. Catalogue isued 1966. The clocks all have transistorised battery driven movements. The designs are not outstanding examples of artistry.

674. "Special types of Victorian Clock". *The Country Life Book of Clocks.* Edward T Joy. 1967. London. p 90 quotes: "... following Alexander Bain's pioneer application of electricity to horology in 1840, various systems of control from a master clock could be transmitted by electric current to towns, railway stations, etc, to synchronise regulators, until the broadcast of the Greenwich time signal by radio in the 1920's performed this function. Page 91 mentions the Shortt Free Pendulum Clock 'perfected from 1921-4' and 'receiving an impulse every half minute from an electric slave clock', also synchronous clocks.

675. "On Improvements in Electric Clocks and the means of working the Greenwich Time Signals". Charles Shepherd. *Journal of the Society of Arts*, Volume 1, pp 85-88. 1853. This outlines Shepherd's method of using an electro-magnet to lift a weight or bend a spring for impulsing the pendulum, thus making the impulse independent of the battery voltage. He also describes the devices for transmitting time up to ten miles from Greenwich, and for releasing a Time Ball at Greenwich.

676. *Exposition universelle de 1855* ... . Alexandre Mathieu. pp 12-31. 1856. Paris. (Universal Exhibition of 1855). A considerable number of electric clocks were shown by several different makers, either electrically driven or transmitting pulses of current. French text.

677. "Principes de l'emploi de la division décimale du jour, aux mesures, électromagnetiques". Dr J de Rey-Pailhade. pp 12. 1901. Toulouse. (Principle of the use of the decimal division of the day, to electromagnetic measurements) French text.

678. *Leitfaden für Uhrmacher* ... Hermann Sievert. This general book on horology from the 14th edition of 1910 onwards, and its translations into French and Dutch texts, includes a section on electric clocks. (Clockmaker's Guide). German text.

679. "Horloge électrique". M Thury. pp 7. 2 figs. *Congrès de chronométrie de 1900*. 1902. Paris. (Electric clock). French text.

680. *L'électricité dans la maison modern. Production du courant ... Horloges.* Coustet. 1900. (Electricity in the modern house. Production of electricity ... Clocks). French text.

681. *Paul Philip Barraud*. Cedric Jagger. 1968. London. pp 68-70. This outlines John Alexander Lund's system of setting clocks at the hour by electromagnetically operated clips acting on the minute hand when nominally at the hour. Alternatively the clips could act on an arm fixed to the minute hand arbor. Although most of the details come from the pamphlet *On Horological Telegraphy* ... see item no's 23 and 242; there is interesting information on the system and its use up to 1941 until destroyed by enemy bombing. It was renewed and in use until 1964. There is no illustration given in this account, a pity since it is the most complete description to be found otherwise. Patent No 3924 of 1876 covers this system of synchronization. Lund's system was taken over by the Standard Time and Telegraph Company about 1883, see next entry.

682. *Paul Philip Barraud*. Cedric Jagger. 1968. London. p 202. *The Supplement*. 1979. Ticehurst. This illustrates the Barraud and Lund's patent method for synchronizing clocks, being an advertisement taken from the *Horological Journal* for April 1878, ie near the date when the patent was granted. The system could deal with both gaining and losing rates, see next entry.

683. "Public Time Signals for Watchmakers' Shops". p 593. *Horological Journal*, Volume 100, No 1200, September 1958, Centenary Number. This is a letter from T R in the April 1891 issue, it mentions the Standard Time and Telegraph Company service and shows an engraving of the apparatus supplied to customers' premises (usually installed in the shop window to provide a service to the public). On the left side of a clock dial is an electric bell surrounded by a circular border inscribed "Hourly Greenwich Time Bell", on the right side is a similar border inscribed "Hourly Greenwich Flashing Signal"; under the clock itself is "Greenwich Mean Time". The flashing signal consisted of a red disc normally seen edgewise, on receipt of the time signal from Greenwich it was rotated through 90° and showed the full red face for two seconds. It was a version of J A Lund's patented flashing light signal. The firm is stil in existence.

684. "Cuts from Past Journals". pp 582-3. *Horological Journal*, Volume 100, No 1200, September 1958. p 582 shows the chronographer equipment at the General Post Office at St Martin's-le-Grand, this equipment distributed time signals over the Post Office wires in London and to over one thousand towns at 10 am or 1 pm, or both times. It refers here to a *zinc current* and a *copper current*. Greenwich mean time was also sent to the Westminster clock tower. Page 583 illustrates the instrument installed in 1862 for giving hourly signals to the British Horological Institute headquarters in Northampton Square. In actual fact the hours of 2 and 8 pm were reserved for the Institute, conveyed by a wire laid along the South Eastern railway track. The instrument, a simple vertical galvonometer, was installed in the Institute Council Chamber.

685. "Détermination par TSF en 1913-1914 de la différence de longitude entre les observatoires de Paris et de Washington". H Renan pp 67. *Bulletin Astronomique*. 1916. Paris. (Determination by wireless telegraphy in 1913-1914 of the longitude difference between the Paris and Washington Obervatories. French text.

686. "Time after death". *Horological Journal*, November 1898. This reports the American gentleman who had decided upon having a clock fitted in his coffin which was to be connected electrically with a public clock so as to keep it going without the need for being wound up. No details available on subsequent events.

687. "Electric Watches". p 580. *Horological Journal*, Volume 100, No 1200, September 1958. Item extracted from the March 1888 issue. 'A German paper announces that a company has been formed for the manufacture of watches to be actuated by electricity. The case contains two small cells and a small electric motor actuated by a make-and-break movement. Watches of this type have already been made, but have never hitherto been regarded as anything more than curiosities'. See next entry.

688. *Les Merveilles de L'Horlogerie*. p 165-166. Camille Portal and H Graffigny. 1888. Paris. 'The day when a watch marks the time that electricity takes to cover a kilometre, then will timekeeping have neared the summit'. (A time of 3,333 microseconds). 'The concept of applying electricity ... is, however, limited to fixed dials and clocks, and that never, for example, can it be made use of in a portable electric watch'. It took only about sixty years to prove this forecast to be completely wrong. French text.

689. "Timing Races". *Horological Journal*, August 1886. A subscriber, Charles E Eppner, enquired how the University Boat Race was timed, the reply by 'Nimrod' includes the proposal of a few years previously of having an electrically operated chronograph at the winning post, started by a current carried through a wire from the starting position. Evidently the expense of the wire put paid to the scheme.

690. "Quartz Accuracy for old Turret Clocks". p 32. *Horological Journal*, July 1983. The MCT 125 quartz master clock manufactured by Minerva SA, Villeret, Switzerland. This has a stepping unit for the crutch and an accuracy of ± 0.5 seconds a month is claimed. A display panel on the main unit indicates the time by LED's. pp 16-7 give a short history of the AVIA electric watch and later developments, with one of the early advertisments for Avia electric watches. pp 24 and 37 carry a review by Tylden Reed of the 'Versitest Electronic Multimeter' for testing quartz crystal watches.

691. *Die Uhr*. Anton Lübke. 1958. Düsseldorf. pp 379-392, and 403-407. 9 figs. A good coverage of the subject of electrical horology up to 1957. Shepherd's dial at Greenwich shown p 414. German text.

692. *Prix-Courant de la Fabrique de Télégraphes & Appareils électriques fondée par M Hipp en 1860*. Peyer, Favarger & Cie, Neuchâtel. 1890. (Current prices of the Manufactory of Telegraphs and Electrical Apparatus founded by M Hipp in 1860). A 40 page catalogue of products and prices which contains many interesting details connected with Hipp installations, the principal installations of the Hipp system pp 5-7, and over 40 illustrations of clocks and accessories. An excellent source of information. French text.

693. "Instructions générales concernant l'Entretien d'un système d'Horloges électriques (construction Hipp) actionné par un régulateur (horloge-mère) à ½ seconde". pp 7. 14 figs. (General instructions concerning the maintenance of a system of electric clocks (Hipp construction) energised by a regulator (master clock) beating half-seconds. This is a document hand written in good clear writing. It deals with A the regulator, B the cells, C the wires, breaks in the circuits, abnormal resistance, and insulation faults; D the secondary clocks. The second part covers the same ground in technical detail, describing how the pendulum is maintained in motion, the mechanism of the secondary clocks, the device for reversing the current at each minute and the commutator for switching the group circuits for the clocks, resetting of the secondary clocks, installation of the regulator, batteries and details of the interconnecting circuits. French text.

694. "Of the experiments made by some gentlemen of the Royal Society to measure the absolute velocity of electricity". Hutton et al. p 503. *Philosophical Transactions*, Volume 9, 1809. These were the experiments performed by Dr William Watson in 1748 and 1749, attended by the President of the Royal Society, Astronomer Royal, Mr Ellicott and Mr George Graham. The tests were timed by one of Mr Graham's best second-watches.

695. "A Chronoscopic Conundrum". V K Chew. pp 19. Read by Dr D Vaughan at the Science Museum, 4 December 1971, on behalf of Mr Chew. A good analysis of the chronoscopes in the Time Gallery of the Science Museum, London. 43 references are listed on pages 17-19.

696. "Handbills issued by the Great Western Railway giving the velocity of electricity in the telegraph wires". Reproduced in *The Telegraphic Journal*, Volume 4, pages 170-1. 1876. London. These were printed to exploit the fact that the railway telegraph had been responsible for apprehending the murderer Tawell by notifying Paddington station that he was on the train travelling from Slough, the message passed him on his journey. The speed of electricity was quoted as 280,000 miles per second. (Wheatstone's estimate).

697. "An account of several new instruments and processes for determining the constants of a voltaic circuit". Charles Wheatstone. pp 303-327. *Philosophical Transactions*. Volume 133. 1843. London.

698. "An account of some experiments to measure the velocity of electricity and the duration of electric light". Charles Wheatstone. p 583. *Philosophical Transactions*. Volume 124. 1834. London.

699. "Application of electromagnetism to chronoscopy". Siemens. p 48. *Fortschritte der Physik in Jahre 1845*. 1847. Berlin. In this Siemens states that General Peuker was the first to apply electromagnetism to a chronoscope for starting and stopping it. The date was 1835 but General Peuker published nothing of his work. Wheatstone claimed priority of invention for the electric chronoscope. German text.

700. "Adelaide Gallery of Practical Science". p 279. *Illustrated London News*. Volume 54. 1869. London. This was the scene of Alexander Bain's early introduction to electrical science and his triumphant exhibition of his electric clock and printing telegraph, at which John Finlaison first made Bain's acquaintance and became his champion against Wheatstone. The illustration of the gallery is as it was in its heyday.

701. "Télégraphes électriques". Quetelet. p 1313. *Bulletin de l'Académie Royale des Sciences*, Volume 2, 1840. Brussels. (Electric telegraphs). Wheatstone visited Brussels in 1840 and described his chronoscope to M Quetelet. The latter delivered a paper on it to the Brussels Academy, he thought the precision would be about 1/100 of a second when employed to measure the velocity of projectiles. French text.

702. "Wheatstone-Breguet controversy". Abbé François Napoléon Marie Moigno. *Traité de télégraphie électrique*. Second edition, 1852. Moigno suggests that the difficulties in the controversy about the chronoscope were due to Konstantinoff who had purchased a chronoscope in 1843 from Wheatstone on condition that he did not publish a description of the instrument until Wheatstone himself had done so. Konstantinoff was a captain of artillery in the Russian Imperial Guard. French text.

703. "Das Wheatstone's Chronoskop, verbessert von Uhrmacher Hipp in Reutlingen". Oelschläger. p 140. Dingler's Journal, Volume 110. 1848. Stuttgart and Tübingen. (The chronoscope of Wheatstone, improved by the clockmaker Hipp in Reutlingen). Oelschläger complained that Wheatstone's chronograph was useless for verification of the laws of gravity, the reason being that Wheatstone's chronograph was inaccurate until it had been running for at least half a second. Oelschläger obtained a better chronoscope from Hipp which could read to 1/500 second and was arranged to run before the test started, the indicating hands being connected to the movement by an electromagnetic clutch. The Hipp instrument cost 66 florins, the English, and worse in performance, cost 144 florins. Similarly Konstantinoff turned to Breguet for a better instrument, although for somewhat different reasons. German text.

704. "Das Hippsche Chronoskop, zur Messung der Fallzest eines Körpers und zu Versuchen uber die Gescwindigkest der Flintenkugen". Oelschläger. p 255. *Dinglers Journal*, Volume 114. 1849. Stuttgart and Tübbingen. (The Hipp Chronoscope, for measuring the fall of bodies and the velocity of projectiles). A second acoount by Oelschläger describing how he managed to get useful results with Hipp's chronoscope. He states 'It worked with such elegance and precision during a run that not the slighest deviation from uniform motion is perceptible, which is clear from the pitch of the note given by the characteristic escapement'. Like Wheatstone's chronoscope, a reed was used to allow the train to run at the correct speed, the vibrations of which gave an audible note. [A forerunner of the tuning fork oscillators and timepieces]. German text.

705. "Chronoscopes and Chronographs". *Time Measurement*. F A B Ward. 1966. London. pp 106-8 of the catalogue of the Time Collection deal with these devices, the Hipp Chronoscope owned by Charles Wheatstone is illustrated in plate 12 opposite page 73, a very fine piece of workmanship. The Bashforth chronoscope is also described. Most of the explanations are at the popular elementary level.

706. "über die Messung kleiner Flugzeiten von Geschossen mittelst bewegter Elektricität". p 93. Kahl. *Zeitschrift für Mathematik und Physik*, Volume 7. 1862. (On the measurement of small time intervals of projectiles in flight by means of electricity). This is a review of all the known methods of measuring the velocity of projectiles. Kahl mentions that he does not favour fast running clocks, of which Wheatstone was the originator. He states that Hipp (mispelt as Hill), improved the Wheatstone chronoscope so that one hand indicated 1/10 seconds, the other 1/1000 seconds, but that the instrument was not independent of the time for the controlling electromagnet to energise and de-energise - 'so it is doubtful if good results could be obtained with its use. Wheatstone appears to have overlooked this aspect entirely. Kahl appears to have used Martin De Brettes' articles in the *Journal des Armes Speciales* in 1853 as source material, see also Entry No 568. De Brettes also misspells Hipp as Hill. German text.

707. "Studies of the electromagnetic instruments designed for use in experiments on artillery in England, Russia, France, Prussia, Belgium, Sweden ... ". Martin de Brettes. 1853. Paris. De Brettes was a captain in the French Artillery, who in the course of studying ballistics, had invented a chronoscope. He devotes a chapter on the Wheatstone chronoscope as modified by Hipp, and gives an illustration of the Hipp instrument. There is a Hipp chronoscope in the Science Museum, London; it was part of the Wheatstone collection given to the Science Museum by King's College, and appears to have been acquired by Wheatstone in 1850. De Brettes ends his account 'Mr Wheatstone regards this apparatus as giving very precise results, ...' French text.

708. *Traite d'Électricité et de Magnetisme*. A C Béquerel & E Béquerel. p 367. Volume 3, 1856. (Treatise of Electricity and Magnetism). On this page is the statement: 'M Hipp has modified the chronometer of M Wheatstone in constructing the clock in such a way that its rate does not change whether the indicators are in motion or at rest ... With this modification M Wheatstone regards the apparatus as very exact'. This statement, almost identical to that of De Brettes', indicates a common source, possibly an unrecorded manuscript of Charles Wheatstone's. French text.

709. "Chronoscopes et Chronographes Électriques". *Exposé des Applications de l'Électricité*. Th Du Moncel. Third edition. 1885. (Electric chronoscopes and chronographs). pp 183-302 cover the subject of electrical chronographs in great detail. On page 253 is mention of trials by Wheatstone at Woolwich in 1858 to measure the initial velocity of large shells, using the latest arrangement of his chronoscope. This is believed to have had a vernier adjustment of the vibrating reed by blowing air over it to increase or decrease its frequency very slightly. There are no records now extant of these trials. French text.

710. "The Evolution of the Quartz Crystal Clock". Lecture given by W A Marrison to the British Horological Institute on 6 November 1947 and reported in full in the *Horological Journal* from the May to October 1948 issues. The relevant pages are: May - pp 274-277, June - pp 342-345, July - pp 402-407, August - pp 460-466, September - pp 529-532, October - pp 588-592. This covers the whole gamut of timekeeping up to atomic clocks and is a wonderful exposition by the man who received the Institute's Gold Medal for his achievements in precision timekeeping. There is a reference list of works totalling 140 items at the end of the series, those not already included in this list will be incorporated. Note that Marrison's listeners, in general, had no conception at the time that his work was spelling the death knell of mechanical horology.

711. "Mémoire sur l'étude optique des mouvements vibratoires". Jules Lissajous. p 727. *Comptes Rendus de l'Académie des Sciences*. Volume V, 6 April 1857. Paris. (Memoire on the optical study of vibratory movements). French text.

712. "On the characteristics of electrically operated tuning forks". H M Dadourian. pp 337-359. *Physical Review*, Volume 13, May 1919.

713. "Isochronous and Synchronous Movements for Telegraph and other Lines". Paul la Cour. US patent No 203423 filed 23 April 1878.

714. "Roue phonique pour la régularisation du synchronisme des mouvements". Paul la Cour. pp 499-500. *Comptes Rendus de l'Académie des Sciences*, Volume 87, 25 September 1878. Paris. (Phonic wheel for the regulation of the synchronism of movements). French text.

715. "Report of Physical Society Meeting of 30 March 1878". p 111. *Nature*. 23 May 1878. This includes a reference to Lord Rayleigh's impulse motor. London.

716. "Nouveaux modes d'entretien des diapasons". A & V Guillet. pp 1002-1004. *Comptes Rendus de l'Académie des Sciences*, Volume 130, 9 April 1900. Paris. (New ways of maintaining the motion of tuning forks).

717. *The Emission of Electricity from Hot Bodies*. O W Richardson. 1916. London.

718. "On electric discharge between electrodes at different temperatures in air and high vacuo". J A Fleming. p 122. *Proceedings of the Royal Society*, Volume 47, 1890. London.

719. "The Audion - A New Receiver for Wireless Telegraphy". Lee De Forest. pp 735-779. *Transactions of the American Institution of Electrical Engineers*, Volume 25, 1906. An account of the research leading to the introduction of the third electrode in a thermionic valve. It is also noted in the *Electrician*, Volume 58, 1906. pp 216-218.

720. "Device for amplifying feeble electrical currents". Lee De Forest. US Patent No 841387, issued January 1907. This employs the audion valve in an amplifying circuit.

721. "Einrichtung zur Erseugung elektrischer Schwigungen". Sigmund Strausss. Austrian Patent No 71340, filed December 1912, granted June 1915. (Regulation of electrically produced oscillations). German text.

722. "Improvements in receivers for use in wireless telegraphy and telephony". Marconi Wireless Telegraph Company and Charles Samuel Franklin. British Patent No 13636, filed June 19134, granted June 1914.

723. "The use of the triode valve in maintaining the vibrations of a tuning fork". W H Eccles. p 269. *Proceedings of the Physics Society*, Volume 31, 1919. London.

724. "Sustaining the vibration of a tuning fork by a triode valve". W H Eccles and F W Jordan. p 704. *The Electrician*, Volume 82, 20 June 1919. London.

725. "Sur l'entretien des oscillations méchaniques au moyen de lampes a trois électrodes". Henri Abraham and Eugene Bloch. pp 1197-98. *Comptes Rendus de l'Académie des Sciences*, Volume 168, 16 June 1919. Paris. French text.

726. "An electron tube tuning fork drive". E A Eckhardt, J C Karcher & M Keiser. pp 949-957. *JOSA*, No 6, November 1922. London.

727. "The valve maintained tuning fork as a primary standard of frequency". D W Dye & L Essen. pp 285-306. *Proceedings of the Royal Society*, Volume 143, 1934. London.

728. "Tuning forks". H H Hagland. US Patent No 1,715,324, filed June 1925, granted May 1929.

729. "A Mechanical Oscillator of Constant Frequency". August Karolus. US Patent 1,763,853, filed November 1927, granted June 1930.

730. "Compensated Tuning Fork". Bert Eisenhour. US Patent 1,880,923, filed September 1930, granted October 1932.

731. "Tuning Fork". S E Michaels. US Patent 2,247,960, granted 1 July 1941.

732. "A determination of some of the properties of the piezoelectric quartz resonator". Karl S Van Dyke. *Proceedings of the Institution of Radio Engineers*, Volume 23, No 4, April 1935. London.

733. "The high Q of quartz resonators". Maynard Waltz & K S Van Dyke. p 732. *Journal of the Acoustical Society of America*, Volume 19, No 4, Part 1, July 1947.

734. "Development par pression, de l'électricité polaire dans les cristeaux hemiedres a faces inclinées". Jaques & Pierre Curie. p 294. *Comptes Rendus de l'Académie des Sciences*, Volume 91, 1880. Paris. (Generation of polarised electricity by pressure in hemihedral crystals with inclined faces). French text.

735. "Déformations éléctrique du quartz". Jaques & Pierre Curie. pp 914-917. *Comptes Rendus de l'Académie des Sciences*, Volume 95, 1882. Paris. (Electrical deformation of quartz). French text.

736. "The electrical network equivalent of a piezoelectric resonator". K S Van Dyke. p 895. *Physics Review*, Volume 25, 1925. London.

737. "The piezoelectric resonator". W G Cady. pp 83-114. *Proceedings of the Institution of Radio Engineers*, Volume 10, April 1922. London.

738. "Piezoelektrische Resonanzerscheinungen". A Scheibe. *Zeitschriift für Hochfrequenztechnik*, Volume 28, No 1, 1926. (Piezoelectric resonant oscillations). German text.

739. "Bibliography on piezoelectricity". W G Cady. pp 521-535. *Proceedings of the Institution of Radio Engineers*, Volume 16, 1928. London.

740. "Quartzoszillatoren". R Bechmann. pp 36-45. *Telefunken Zeitung*, Volume 17, March 1925. (Quartz oscillators). German text.

741. "Sur un nouvel emploi des quartz piezoélectriques". G Siadbei. p 1390. *Comptes Rendus de l'Académie des Sciences*, Volume 183, May 1929. Paris. (On a new use for piezoelectric quartz). French text.

742. "An international comparison of frequency by means of a luminous quartz resonator". pp 1930-1934. S Jimbo. *Proceedings of the Institution of Radio Engineers*, Volume 18, 1930. London.

743. "An international comparison of radio wavelength standards by means of piezoelectric resonators". W G Cady. pp 805-816. *Proceedings of the Institution of Radio Engineers*, Volume 12, December 1924. London.

744. "The status of frequency standardisation". J H Dellinger. pp 579-592. *Proceedings of the Institution of Radio Engineers*, Volume 16, No 5, May 1928. London.

745. "Precision determination of frequency". J W Horton & W A Marrison. pp 137-154. *Proceedings of the Institution of Radio Engineers*, Volume 116, February 1928. London.

746. "Sur le mésure absolue des périodes des oscillations électriques de haute fréquence. Henri Abraham & Eugen Bloch. pp 1105-1108. *Comptes Rendus de l'Académie des Sciences*, Volume 168, 1919. Paris. (On the measurement of the absolute value of the period of electrical oscillations of high frequency). French text.

747. "Frequency demultiplication". Balth Van de Pol & J Van der Mark. pp 363-4. *Nature*, Volume 120, September 1927. London.

748. "über Relaxationschwingungen". B Van der Pol, Jr. pp 114-118. *Zeitschrift für Hochfrequenztechnik*, Volume 29, April 1927. (On Relaxation Oscillators). German text.

749. "Modern developments in precision clocks. Alfred L Loomis & W A Marrison. pp 527-537. *Transactions of the American Institution of Electrical Engineers*, Volume 51, June 1932.

750. "The precise measurement of Time. A L Loomis. *Monthly Notices of the Royal Astronomical Society* Volume 91, March 1931. London.

40

751. "The Spark Chronograph". W A Marrison. pp 54-7. *Bell Laboratories Record*, Volume 18, No 2, October 1939. USA.

752. "A new quartz crystal plate, designated the GT, which produces a very constant frequency over a wide temperature range". W P Mason. pp 220-3. *Proceedings of the Institution of Radio Engineers*, Volume 28, No 5, May 1940. London.

753. "The bridge stabilised oscillator". L A Meacham. pp 1278-1294. *Proceedings of the Institution of Radio Engineers*, Volume 26, No 10, October 1938. London.

754. "Electronic Counters". J E Grosdoff. pp 438-447. *RCA Review*, Volume 7, No 3, September 1946. USA.

755. "Method and Means for Indicating Synchronism". W A Marrison. US Patent No 1,762,725, filed March 1928, granted 1930.

756. "Split second time runs today's world". F Barrows & Catherine Bell Palmer. p 402. *The National Geographic Magazine,* Volume 92, No 3. September 1947.

757. "Frequency and Time Control Aided by Telephone Company". H C Forbes & F Zaugbaum. pp 117-118. *Electrical World*, 30 January 1934.

758. "Eine Quarzuhr für Zeit -und Frequenzmessung sehr hoher Genauigkeit". A Scheibe & U Adelsberger. pp 835-841. *Physikalische Zeitschrift*, Volume 33, No 21, November 1932. (A quartz clock for Time and Frequency measurement of very great accuracy). German text.

759. "Die Technischen Einrichtungen der Quarzuhren der Physikalische-Technischen Reichsanstalt". A Scheibe & U Adelsberger. pp 37-47. *Hochfrequenztechnik und Elektroakustik*, Volume 43, February 1934. (The Technical Arrangements of the Quartz Clocks in the Physics-Technical Institute). German text.

760. "Uber die ersten Erfahrungren mit den Quartzuhren des Preussischen Geodätischen Instituts". E Kohlschütter. Verhandlungen der Siebenten Tagung se Baltischen Geodätischen Kommission. 1935. (On the initial experiences with Quartz Clocks at the Prussian Geodetic Institute). German text.

761. "German Quartz Clocks". BIOS Report No 1316. HM Stationery Office. London. See also *Science Abstracts B*, September 1947, p 242; and *Electrical Engineering Abstracts B*, September 1947.

762. "Quarzuhr und Normallfrequenz-Generator". L Rohde & R Leonhardt. pp 117-122. *ENT*, June 1940. (Quartz clock and standard frequency generator). German text.

763. "Crystal clock for accurate time standard". Vincent E Heaton. p 618. *Instruments*, Volume 20, No 7, July 1947.

764. "WWV standard frequency broadcasts". W D George. pp 25-27. *F M and Television*, Volume 7, June 1947.

765. "Time Service of the US Naval Observatory". J Frederick Hellweg. pp 538-540. *Transactions of the American Institution of Electrical Engineers*, Volume 51. No 2, June 1932. USA.

766. "Quartz Crystal Clocks - How Greenwich Mean Time is determined". Humphrey M Smith. pp 448-451. *Electrical Times*, 28 March 1948. London.

767. "The Measurement of Time". H Spencer Jones. pp 1-26. *Reports on Progress in Physics*, Volume 4, 1937. Published by the University Press, 1938. Cambridge.

768. "The short term erratics of free pendulums and quartz clocks". W H M Greaves and L S T Symms. pp 196-209. *Monthly Notices of the Royal Astronomical Society*, Volume 103, No 4, 1943. London.

769. "High precision timekeeping - Quartz clock now supersedes free pendulum". F Hope-Jones. *Horological Journal*, October 1943. London.

770. "The precision timekeeping revolution - More about the Quartz Clock". F Hope-Jones. *Horological Journal*, November 1943. London.

771. "A Standard of Frequency and its applications". C F Booth & F J M Laver. pp 223-236. *The Journal of the Institution of Electrical Engineers*, Volume 93, Part III, July 1946. London.

772. "A new form of frequency and time standard". L Essen. pp 413-426. *Proceedings of the Physics Society*, Volume 50, 1938. London.

773. "Thermostat design for frequency standards". W A Marrison. pp 976-980. *Proceedings of the Institute of Radio Engineers*, Volume 16, No 7. London.

774. "The shortest continuous waves". C E Cleeton & N H Williams. p 1091. *Physics Review*, Volume 50, December 1936. London.

775. "Electromagnetic waves of 1.1 cm wavelength and the absorption spectrum of ammonia". C E Cleeton & N H Williams. pp 234-237. *Physics Review*, Volume 45, 15 February 1934. London.

776. "The ammonia spectrum and line shapes near 1.25 cm wavelength". Charles Hard Townes. pp 675-671. *Physice Review*, Volume 70, November 1946. London.

777. "The inversion spectrum of ammonia". William E Good. pp 213-218. *Physics Review*, Volume 70, August 1946. London.

778. "A new method of measuring nuclear magnetic moments". I I Rabi, J R Zacharias, S Millman & P Kusch. p 318. *Physics Review*, Volume 53, 1938. (Joint letter to the Editor). London.

779. "Molecular beam technique". I Estermann. pp 300-323. *Reviews of Modern Physics*, Volume 18, No 3, July 1946. London.

780. "The molecular beam magnetic resonance method. The radio-frequency spectra of atoms and molecules". J B M Kellog and S Millmann. pp 323-352. *Reviews of Modern Physics*, Volume 18, No 3, July 1946. London.

781. "Electrical Watch Balances". S J Wise. pp 769-772. *Horological Journal*, Volume XC, No 1083, December 1948. London. Description of the attempts by S J Wise to produce a battery driven watch at the time when the US and Swiss watchmakers were locked in battle to produce the first electrical watch.

782. "Review of the 1948 British Industries Fair - Horological Section". p 280. *Horological Journal*, Volume XC, No 1076, May 1948. London. The Regal Sectric Alarm is illustrated and several of Smith's Industries electric clock models discussed, including the 'Radio Preset' clock for switching on and off of radio sets or other electrical equipment at predetermined times. On page 283 is a mention of an exhibit by Marconi's of a low frequency quartz crystal plate bouncing a steel ball hanging on a nylon thread to show the mechanical movement of the quartz itself.

783. "Royal Liver Building, Liverpool". p 153. *Horological Journal*, Volume XC, No 1074, March 1948. London. An illustration of the Liver Building clock dials is given. New lighting arrangements were made after the war by installing six Phillips SO/H 140 lamps wih opal screens behind each dial. On the same page mention is made of the Goblin synchronous clocks and the 'Teasmade' automatic tea-maker.

784. "Watch testing by Oscillograph". p 660. *Horological Journal*, Volume XC, No 1082, November 1948. London. Description of an experimental apparatus for testing the rate of watches, consisting of a quartz crystal oscillator, simple valve oscillator and amplifier, connected to an oscilloscope. A microphone picks up the sound of the watch ticking and after amplification the strong current pulses switch a valve to give a sharp pulse displayed on the screen of the oscilloscope. An illustration of the equipment is included.

785. "Electric Clocks". Chapter 24 of *Watch and Clock Repairs*. H G Harris. pp 167-170. 2 figs. 1961. London. Gives very simple instructions on cleaning a synchronous clock. It is of some use since the two illustrations show a Smith's *Bijou* Movement in exploded form.

786. "Synchronous Electric Clocks, and Unusual Clocks". Chapters 7 & 8 of *Modern Clocks, Their Repair and Maintenance*. T R Robinson. pp 79-99. 15 figs. 1934. London. This gives details of several interesting early models of synchronous clocks, including a chiming clock and the Smith's *Batriclock*. The second edition of the book has almost the same text, pp 117-148, but mentions the Bulle electric clock. pp 172-188 illustrate 19 synchronous clock movements in addition to the 20 line diagrams in the text. Useful information on these early synchronous electric clocks. Advertisements for Smith's Sectric, also the products of the Magneta Time Company, Goblin Works, Leatherhead, are included. The Magneta master clock is a Hipp toggle type. The book was reprinted in 1943.

787. "Electric Clocks". Chapter XIV of *Clock Repairing and Making*. F J Garrard. 7th Impression, 1943. Kingston Hill. Covers the field of electrical horology but is very much out of date for the time of publication. The Gent's system is referred to as 'practically the Synchronome system'. The Eureka clock is mentioned on p 160. Of little informational value today.

788. "Electric Clocks". *Time & Clocks*. H H Cunynghame. 1906. London. In the index of this book 'Electric clocks' are given the page reference 179, however the most elementary outline of any book on electric clocks will actually be found on pages 173-5. For such a well-educated man, who was associated with F Hope-Jones, it is a pathetic performance. Pages 178-186 give an elementary account of an electrical chronograph suitable for a child to read. Cunynghame was an MA and Member of the Institution of Electrical Engineers!

789. "Electric Pendulum Clocks". *The Science of Clocks and Watches*. A L Rawlings. First edition 1943. Second edition. 1948. London. pp 103-127 cover developments of electric pendulum clocks and evidently abstracted mainly from Hope-Jones. It is of interest in the detailing of O'Leary's, Schuler's, Batrtrum's and Shortt's clocks. Some discussion of the performance of the latter is included. Chapter XIX pages 275-286 cover the synchronous and quartz crystal clock, there is also advice on buying a synchronous clock on page 270. The treatment is patchy for such a well qualified man but he was getting old.

790. "Phonic Chronometer". A B Wood & J M Ford. *Journal Scientific Instruments*, March 1924. London. A similar scheme to that of D W Dye for maintaining a phonic wheel by current interrupted by the tine of an electrically maintained tuning fork, see Entry No 374. Dr Wood was the expert on Acoustics.

791. "The Crystal Clock". L Essen. p 413. *Proceedings of the Physical Society*, Volume 35, 1938. London.

792. "Quartz Clocks". George W Pierce. *Proceedings of the American Academy of Arts and Sciences*, Volume 59, 1923, p 81; and Volume 60, 1925, p 273. Professor Pierce was the deviser of the very stable quartz crystal oscillator circuit associated with his name - the 'Pierce Oscillator'.

793. "Precision Clocks". Ralph A Sampson. *Proceedings of the Royal Society of Edinburgh*. A series of classical papers on precision pendulum clocks in Volume 38, 1918, p 75 and 169; Volume 44, 1924, p 56; Volume 57, 1936, p 55. Professor Sampson was the Astronomer Royal of Scotland.

794. Letter to Francis Ronalds from G J Singer, dated 7 January 1815, Princes Street, London. 'I send you the most powerful columns I have at present and congratulate you heartily on your success. ... and am sorry to hear you have broken your Nose, as you will be to hear my larger cylinder has cracked ...'.

795. Letter to G J Singer from Francis Ronalds, not dated, Hammersmith. ... 'The clock has been going since I received the two last capital columns which you were so obliging to pick out for me ...'.

796. Letter to Francis Ronalds from J A Deluc, dated 18 March 1815, Windsor. In answer to Ronalds' queries about Haussmann and electric columns. Deluc states: 'But to tell you my opinion in general I do not think that my large column could move what you call "Electrical clock"; it has so small a power, that the smallest particle of dust, stops my pendulum ... ' On the second page of the letter he states that Singer's columns are much more powerful than his own. See the previous entry.

797. Letter to Francis Ronalds from J A Deluc, dated 4 May 1815, Windsor. 'I have seen with great interest, in Mr Tillock's Journal for April your application on what you had sketched to me in your letter 'On the Electro-galvanic agency as a moving power, with the Description of a Galvanic Clock ...' Your clockwork is very ingeniously contrived ... but you were very fortunate to find near you an cleaver (sic) watch maker, to execute so well your ideas. See the preceding and following entries.

798. Letter from Francis Ronalds to J A Deluc, 9 May 1815, Hammersmith. 'I am very much obliged for your friendly letter of the 4th inst as it gives me an opportunity of explaining to you why the term Electro Galvanic has been affixed to the paper in Mr Tilloch's journal which you are so polite as to say interested you'. Ronalds correctly ascribes the electrical power being derived from the decomposition of the zinc used in the columns, yet does not agree with the experiment of Dr Woollaston that oxidation was the source. Woollaston placed a column in an evacuated chamber, upon which the column ceased to generate electrical power. Ronalds writes 'Mr Gotham has certainly executed and in fact invented a part of the clock very ingeniously and I fear I have not sufficiently acknowledged his share of the contrivance ...

799. Letter to Francis Ronalds from Dr G L Roberts, dated 8 May 1815, Bridport. Requesting details of the particular arrangement of the columns used for Ronalds' Galvanic Clock.

800. Letter from Francis Ronalds to Dr G L Roberts, not dated, Hammersmith. Ronalds first points out that the title Electro-Galvanic Agency and Galvanic Clock were inserted by the Editor. He goes on to describe the particular arrangements used in making the Singer electric columns. In referring to the size and shape of the discs used in the column he writes '... after which they are ready to be cut or pushed into to the required form or size which may easily be done by a servant ...'.

801. Letter to Francis Ronalds from J A Deluc, dated 11 May 1815, Windsor. 'I have received your interesting letter of the 9th explaining your ingenious contrivance to apply the electric column to a clockwork on which I shall make a few remarks'. Deluc incorrectly contradicts Ronalds' hypothesis of decomposition of the zinc discs of the columns.

802. Letter from J A Deluc to Francis Ronalds, 16 June 1815, Windsor. Mention of Priestley and Herschel in this letter. 'The journal of your Clockwork applied to the Column has very much interested me; it is a very curious application of electric power, and we cannot judge to what it will lead'. Mentions a future meeting with Ronalds at Windsor. 'I shall be very happy to see you again as I have a great estime (sic) for you'.

803. Letter from G J Singer to Francis Ronalds, 28 September 1815, Princes Street, London. In addition to a request for an account of Ronalds' electric clock for a supplement to Singer's book *Elements of Electricity*, Singer also apologises for the comments he had made earlier in the *Philosophical Magazine*.

804. Three sheets of results for the daily tests carried out by Ronalds on the Galvanic Clock from 29 July 1818 to 12 September 1818 at Hammersmith. These show a progressive improvement in the rate of the clock.

805. Drawing of proposed pendulum for electric clock by Francis Ronalds to compensate for variable voltage.

806. Letter from Francis Ronalds to J A Deluc, not dated but late in 1815, Hammersmith. Describes two methods for compensation for the voltaic pile increasing in voltage with increased temperature and causing the pendulum to change rate with the greater impulsing power.

807. Original page of results written by Francis Ronalds, also a visiting card for his Hammersmith address.

808. *Della pila elettrica a secco*. Guiseppa Zamboni. pp 55. 3 plates. Verona. 1812. (Of the dry electric pile). A full account of the principles and making of dry voltaic piles.

809. "The Dry Voltaic Pile". A Elliott. pp 317-319. *Electronic Engineering*, October 1948. An outline of the development and production of dry piles in 1942 for infra-red image converters. Data is included on the internal resistance, voltage and available current at low voltage drop - approximately 0.01 microamperes.

810. *The Dry Pile.* C E Benham. London. Describes the construction of dry voltaic piles.

811. "The Dry Pile". *Elementary Lessons in Electricity.* Sylvanus P Thompson. 1899. London. p 180. A brief description of the dry voltaic pile.

812. "The Dry Pile". F Auertach. *Handbuch der Physik*, Volume 4, 1905. Leipzig. p 185. (Physics Handbook). A brief outline of the dry voltaic pile. German text.

813. "The Dry Pile". L Graetz. *Handbuch der Elektrizität und des Magnetismus*, Volume 1, 1918. Leipzig. (Handbook of Electricity and Magnetism). Description and construction of the dry voltaic pile. German text.

814. "Pile at the Clarendon Laboratory, Oxford". *Electricity.* W L Bragg. 1936. London. p 51 details the dry pile which has been striking two bells in the Clarendon Laboratory continuously since 1840. It is supposed to have been made by the instrument makers Watkins and Hill in London, no one is certain.

815. "Voltaic Pile". Communication from Alessandro Volta to the Royal Society, printed in *Philosophical Transactions*, Volume XC, 1800. London. pp 403-431 gives details of the various arrangements, including the well known 'Couronne des Tasses' or Crown of Cups. This is illustrated on page 3 of *Electrifying Time.* Volta had devised these arrangements many years earlier but did not publish his results at the time. See Entries No 27 and 28, which include some detail of these events, in the Electrical Horology book list.

816. "Voltaic Pile". *Scientific Instruments in Art and History.* Henri Michel. English translation by R E W and F R Maddison. 1967. London. p 173 gives a passing mention of the voltaic pile, whilst Plate 103 in colour on p 104 shows two examples of Volta's piles in the Museo della Scienza e della Tecnica, Milan.
Note: the book index and plate numbering for these is slightly incorrect. The two voltaic piles are also illustrated on page 401 of *The Cambridge Illustrated History of the World's Science* by Colin A Ronan, 1983. London. Very sketchy references may be found on p 383 and p 441, the latter refers to the work done by Davy with the voltaic pile in his chemical investigations, including producing potassium metal.

817. "On the Electric Column and Aerial Electroscope". J A Deluc. *A Journal of Natural Philosophy, Chemistry and the Arts*, Volume 27, No 102, pp 81-99; No 103, pp 161-174, October and November 1810. Edinburgh. The apparatus is illustrated, see page 24 of *A Conspectus of Electrical Timekeeping.* Whilst not intended to indicate time, it was the starting point for Ronalds' electrostatic clock of 1814.

818. "Experiments on the Variable Action of the Electric Column". Francis Ronalds. pp 6. *Philosophical Magazine*, Volume XLIII, No 414, 1814. London.

819. "On Electricity". Francis Ronalds. pp 4. *Philosophical Magazine*, Volume XLIV, No 422, 1814. London.

820. "On the Electric Column of M De Luc". Francis Ronalds. pp 2. *Philosophical Magazine*, Volume XLVI, No 466, 1815. London.

821. "On correcting the rate of an Electric Clock by a compensation for changes in temperature". Francis Ronalds. pp 2. *Philosophical Magazine*, Volume XLVI, No 203, 1815. London.

822. "Account of Mr Ronalds' Pendulum Doubler of Electricity". Francis Ronalds. pp 322-5. *Edinburgh Philosophical Magazine*, Volume 9, 1823. Edinburgh. This used a mechanically driven pendulum to continually double an initial small electric charge until high potentials were reached. The electrical power was gained by the expenditure of mechanical power, and it was utilised for energising Ronalds' electrostatic telegraph.

823. *Description of an Electrical Telegraph and of some other Electrical Apparatus.* Francis Ronalds. pp 83. 8 plates. 1823. London. This was reprinted by the Chiswick Press. A second edition with only 25 pages was published in 1871. Ronalds was knighted for his telegraph work the year before his death.

824. "Description of Francis Ronalds' Electric Telegraph". *Illustrated London News*, 30 April 1870. A portrait of Francis Ronalds is illustrated as well as his telegraph system at Hammersmith.

825. "An Instrument of his own Construction, Presented to the Royal Society ... an attempt at Perpetual Motion". Guiseppa Zamboni. *Philosophical Magazine*, Volume XLV, page 67. 1815. London. See p 32 of *A Conspectus of Electrical Timekeeping* for diagram of G J Singer's version of Zamboni's electrically driven pendulum, and mention of Zamboni's device in a letter from Joseph Banks, President of the Royal Society.

826. *L'elletromotore perpetuo*. Guiseppa Zamboni. *Trattato*, Parta Prima, pp 298; and Parta Seconda, pp 361; Verona. 1820 and 1822 respectively. (The perpetual electro-motor). See *Conspectus of Electrical Timekeeping*, page 69 for details of the sections dealing with the electrically driven pendulum. Italian text.

827. "All' Accademia Reale delle Scienze di Parigi". Guiseppa Zamboni. pp 6. 1 plate. *Verona Poligrafo*, Volume V, p 87. Verona. 1831. (Royal Academy of Science of Parigi). An article describing Zamboni's electric clock. Late for an electrostatic clock with electromagnetic action being known. Italian text.

828. "Elogio dell' Abate Guiseppa Zamboni dell Ab Ant Rivato". G Passini. A letter dated 30 July 1847, from the Secretary of the Venice Institute of Science. (Eulogy of the Abbot Guiseppa Zamboni ...). Announces Zamboni's death and adds a few lines to his memory. Zamboni's life and work have almost been completely forgotten today. Biographical details on him are very difficult to obtain. Italian text.

829. "Neuere Versuche mit Trocknen". Gilbert. *Annales de Physiks*, Volume LI, p 189, 1815. (New experiments with dry piles). A short account of Professor Ramis's electrostatic clock. German text.

830. "Orologio elettrico a pendulo 'fece egli quindi sotto il 18 Marzo, 1815, l'annunzio alla Regia Accademia de Monaco' ". Professor Ramis. *Almanaco di Lipsia*, nominato Maggazino di tutte le nuove scoperte al No 64, art 11. 1815. Leipzig. (Clock with electric pendulum, which he announced to the Royal Academy of Monaco on 18 March 1815). Italian text.

831. "Illustration of Early Electric Clock". F Scarcella. p 27. *La Clessidra*, October 1953. Italian.

832. "Il primo orologio azionata (dall'elettrico) riprende a camminare dopo oltre 150 anni". Paolo Francesco Forlatti. *La Clessidra*, July 1972. (The first clock actuated by electricity goes again after more than 150 years). The English translation of this Italian text is reproduced in full on pages 72-73, of *A Conspectus of Electrical Timekeeping*.

833. "An account of a Doubler of Electricity, or a Machine by means of which the least conceivable quantity of positive or negative electricity may be continually doubled, till it becomes perceptible by common electrometers, or visible in sparks". Abraham Bennet. pp 285-296. *Philosophical Transactions*, Volume 77. London. Read before the Royal Society 10 May 1787. The precursor of Ronalds' pendulum doubler of electricity.

834. "Seine galvanische Uhren". Karl August Steinheil. *Kunst-und Gewerbsblätter*. 1843. Berlin. (His galvanic clock). German text.

835. *Early Electrical Communication*. E A Marland. 1964. London. Includes brief mentions of Francis Ronalds and Alexander Bain. Very few works give any real credit to Francis Ronalds or Alexander Bain.

836. *The Story of Electricity*. John Munro. 1898. London. Elementary details of the progress of the electrical art, and references to telegraphs up to the end of the nineteenth century.

837. *Science since 1500*. H T Pledge. 1966. London. Useful for the historical details of the advances in electrical science although much out of date through the enormous developments which took place soon after.

838. *Men and Discoveries in Electricity*. Brian Morgan. 1953. London. Historical details of the discoveries leading up to the application of electricity to horology in an easily assimilated form.

839. *A History of Wonderful Inventions*. John Timbs. 1868. (Various later editions). London.

840. *Early Electrical Machines*. Bern Dibner. pp 57. 42 illustrations. 1 large folding plate. 1957. Norwalk, Connecticut, USA. An excellent account of the early events in static electricity. Nairne's electrical apparatus and accessories shown on pages 50 and 5, include small pendulums striking bells. Page 56 gives 17 references to sources on electrical science.

841. *Luigi Galvani*. Bern Dibner. pp 24. 3 large plates. Burndy Publication No 26. 1972. Norwalk, Connecticut, USA. A definitive study of Galvani's life and work. The plates are magnificent.

842. *A History of Electricity and Magnetism*. Herbert Meyer. pp 325. 30 illustrations. Burndy Library Publication No 27. 1972. Norwalk, Connecticut, USA. This covers the history of electricity in an admirable fashion without the requirement of a deep knowledge in the subject. Pages 299-306 lists an extensive bibliography of electrical and other works.

843. *Eighteenth Century Electrostatic Measuring Devices*. W D Hackmann. pp 58. 2 figs. 31 plates. Reprint December 1978 from the *Annali dell'Istituto e Museo di Storia della Scienza di Firenze* Anno III, Fasciolo 2°. Mentions Francis Ronalds, G J Singer, W Nicholson, J A De Luc and others. Note this author is not always precise, eg the device at Clarendon is dated by him as from the 1820's when the consensus of opinion is the 1840's, he does not mention P L Maréchaux's invention of the dry pile, De Luc gets the accolade. Note that there are innumerable references in this work, but all are given in the footnotes, and tedious to find.

844. *A History of Science, Technology and Philosophy in the 16th and 17th Centuries*. A Wolf. 1950. London. Contains important sections on electricity.

845. A History of Science, Technology and Philosophy in the 18th Century. A Wolf. 1952. London. Has useful sections on electrical science.

846. "The Stroborama". Seguin. *Bulletin horaire de Bureau International de l'Heure*, Volume VI, No 91, 10 June 1936. Description of a method of obtaining very short durations of high intensity light for photographic purposes to compare quartz clock indications at frequent intervals for changes in rate and to verify absolute frequency. The forerunner of the electronic flash gun and electric stroboscope. See next entry.

847. "Timekeepers controlled by means of piezo-electric quartz". Armond de Gramont. pp 31-35. 4 figs. Translation of an article published in 1937, see also Entry No 369. This is based upon two quartz crystals, one of 1.130 MHz and a frequency variation of - 1.66 Hz per °C, the other of 2.130 MHz and - 1.56 per °C. By the use of invar and copper electrodes the variation in frequency between the two could be reduced to 0.0040 Hz per °C. Abraham-Bloch demultiplicators were used to bring the frequency to drive the clock motor down to 1000 Hz, giving time increments of one thousandth of a second. Front and rear views of one of these clocks is given, there are three dials marked for seconds, one-tenth seconds and the lowest dial into one hundred division for one-thousandth of a second readings, the indicator turning ten times a second. The results were checked with a 'stroborama' designed by Seguin which gave a flash of light lasting about one microsecond. By taking a photograph each quarter of an hour, the frequency of the quartz crystal could be determined to one part in a million or less.

848. "Swiss Patents for Electrical Horology - 1889 to 1924". Charles K Aked. pp 10. Translation of the list included in *L'Horologer-Electricien* by G Albert Berner, 1926, Berne & Besançon, Switzerland. Out of a total of 215 patents, 14 are from British applicants, including G B Bowell - no 34504 of 1906. The patent of T B Powers, USA, is no 38242 of 1907. The Continentals were more interested in rewinding mechanisms than the British. One interesting patent is for an electrically rewound watch by Favarger et Cie, patent no 101447 of 1923. See Entry No 298.

849. "United States Electric Clock Patents". *United States Clock and Watch Patents 1790-1890*. George H Eckhardt. 1960. New York. Privately printed. pp 55-72 lists the electrically horology patents in subject classification. No details of any of the patents are given except for the group heading, and the sequence ends at 1890. A total of 235 patents is listed, the corresponding figure for Britain up to 1890 is 238, see Entry No 298.

67

850. "Erfingdungen betreffend elektrische Uhren von 1877-1909". *Elektrische Uhren.* A Tobler revised by Johannes Zacharias. See Entry No 24 in the electrical horology book list. (Inventions in respect of electric clocks from 1877-1909). pp 217-247 lists the patents taken out in Germany from 1877 to 1909, these are presented under group headings, eg the first heading is Self-standing electric clocks and electric clockwork. Each patent has a very brief note. There are 314 patents in this period, several are from British inventors. See Entries No 298.

851. "The New Electronic Quartz Master Clock". Sherman M Wolf. pp 6. 3 figs. Instructions for using a master clock with quartz crystal control for pulsing secondary clocks. The master clock unit has a variety of configurations to suit all types of secondary clocks. Two models sent for trial 9 August 1982.

852. "Some optimal signals for time measurement". H Shermann. p 24. *Transactions Institute Radio Engineers*, IT-2, No 1. 1956. London.

853. "Electron-Tube Circuits for Time Measurements". Edited by A Ya Breytbart. Sovetskoye radio. 1951. Translated from an English text. English source cannot be traced. Russian text.

854. "The Propagation of Fluctuation Noise and Pulsed Signal through a Time Discriminator". B N Mityashev. *Radiotekhnicha i elektronika*, Volume 3, No 9. p 1144. 1958. Russian text.

855. "Noise Immunity in the Time Discrimination of Pulsed Signals". B N Mityashev. *Radiotekhnica i elektronika*, Volume 4, No 4, p 637. 1959. Russian text.

856. "An Optimum method of Determining the Time Position of Pulses". B N Mityashev. *Radiotekhnica i elektronika*, Volume 5, No 2, p 206. 1960. Russian text.

857. "An Analysis of the Noise Immunity of certain types of Time Discriminator". Yu M Kazarinov & Yu A Kolomenskiy. *Izv vuzov, seriya Radiotekhnika*, Volume 1, No 2, p 205. 1959. Russian text.

858. "The Noise Immunity of a Time Discrimination Method for Pulsed Signals". B N Mityashev. *Nauch. Dokl. Vyssh. Shk - Radiotekhnika i elektronika*, No 2, p 7. 1958. Russian text.

859. "Noise Immunity of a Method for Determining the Time Position of Pulses". B N Mityashev. *Radiotekhnika i elektronika*, Volume 4, No 11, p 1765. 1959. Russian text.

860. "A Method for Locating Processes in Time". V I Nikitenko. *Radiotekhnika i elektronika*, Volume 2, No 5, p 566. 1957. Russian text.

861. "Accuracy in the Time Determination of Flat Signals". V I Nikitenko. *Radiotekhnika i elektronika*, Volume 2, No 10, p 1829. 1958. Russian text.

862. "An Assessment of the Effectiveness of Data Integration Methods in the Determination of the Time Position of Weak Pulsed Signals". B N Mityashev. *Radiotekhnika i elektronika*, Volume 16, No 2. 1961. Russian.

863. "The Integration of the Output Voltage of a Receiver in the Determination of the Time Position of a Weak Pulsed Signal". Yu P Ozerskiy. *Izv. Vys. uch. seriya Radiotekhnika*, Volume 4, No 5. 1961. Russian.

864. *A History of Electrical Engineering.* Percy Dunsheath. pp 368. 71 figs. 48 plates. 1962. London. Good chapter on electrical telegraphy except Alexander Bain is omitted apart from his printing telegaph. Good set of portraits shown plates I-VI. The story of Tawell the murderer is told on page 78, also the simplification from the five wires of Wheatstone's telegraph to one by the signalling clerks!

865. *The Electric Telegraph; was it invented by Professor Wheatstone?* W F Cooke. 1855. London. Eventually the two partners fell out and recrimination arose, this book was intended to vindicate Cooke's part in the development of the electric telegraph. Charles Wheatstone was far from being an honest man.

866. "Reports on Experiments made with the Basforth Chronograph to determine the Resistance of the Air to the Motion of Projectiles", 1865-1870. London.

867. "Tables of Remaining Velocity, Time of Flight and Energy of various Projectiles, calculated from the Results of Experiments made with the Bashforth Chronograph", 1865-1870. 1871. London.

868. "A Mathematical Treatise on the Motion of Projectiles, founded chiefly on the Results of Experiments made with the Bashforth Chronograph". 1873. London. Supplement issued 1881. London.

869. "Reports on Experiments made with the Bashforth Chronograph to determine the Resistance of the Air to the Motion of Elongated Projectiles". (Part II). 1878-1879. 1879. London.

870. "Final Report on Experiments made with the Bashforth Chronograph to determine the Resistance of the Air to the Motion of Elongated Projectiles, 1878-1880". 1880. London.

871. *Buckeye Horology. A Review of Ohio Clock and Watch Makers.* James Gibbs. pp 27-29. 2 plates. The story of the venture of Mr D M Dorsey of Mount Vernon who traded a coal mine to the Mountain State Electrical Company for the patent rights of the 'No-key' clock, the company was bankrupt by 1913. A fresh start was made in 1914, when a Mr X offered to reorganize the company in return for a 51% interest. The factory had new machinery installed, but several days before the official opening X absconded with all the money deposited in the bank. There were two variations of the clocks made, differing in the contact system only. A large electromagnet was employed to raise a weight which then drove the clock train. One version was made in Wheeling, the other in Mount Vernon, Ohio. There are good illustrations shown of the two clocks. Also listed is Dr John Locke, see Entry No 293. Several electrical clock patents are included, see below.

872. Electric Timing Meter. G F Card. (Card Manufacturing Co. Cincinnati). Patent No 396,645. 22.1.1889.
Electric Clock: C F Brush. (Telegraph Supply Co. Cleveland). Patent No 189,998. 24 April 1877.
W M Davis. Patent No 120 185. 24 October 1871, also Patent No 176,740. 2 May 1876.
(U S Patents) J Happersberger. Patent No 226,401. 13 April 1880, also Patent 273,231. 27 February 1883. A Hull. Patent No 11,723. 25 September 1854. A B Jones. Patent No 419,776. 21 January 1890. A G Wooley. Patent No 369,672. 6 September 1887.
Electric Alarm: R Schmidtz. Patent No 425,004. 8 April 1890.
Electric Clock Movement: J Happersberger. Patent No 278,946. 5 June 1883.

873. *Time.* Samuel A Goudsmit & Robert Claibone. 1967. London. Plate 1, p 8, shows the quartz crystal master clock in the Washington Observatory. Electrical horology commences page 101, and the tuning fork time standard is described on pp 103-104, followed by quartz crystal and atomic clocks pp 104-107. Short time interval measurements down to 10 picoseconds is covered pp 108-120. Many illustrations. Page 193, shows the Science Museum Time Chart and illustrates the Caesium Clock of the time. A useful book for imparting knowledge of electrical horology quickly.

874. *Smith & Son's Guide to the Purchase of Clock.* First published circa 1900 and reprinted by American Reprints in 1971. It is of slight interest as the exterior clock of the Strand premises carries a sign hanging underneath which states: 'Revolves by Electric Current from Greenwich Hourly'. This is illustrated on page 21, with a full description on page 22. The electrical application was limited to an hourly correction of the weight driven turret clock movement driving the dials, this was housed in the shop below. It also had a switch fitted so that the electrical lighting of the dials took place automatically. Pages 2 and 3 illustrate the exterior clock on the shop front and the movement in the retail shop area respectively. It is of interest to note that the right-hand entrance to the manufactory bears 'AWARDED PRIZE MEDAL ELECTRICAL EXHIBITION'. This refers to the medals awarded to the firm at the 1892 Electrical Exhibition and the Paris Exhibition of 1900.

875. *The Guinness Book of Clocks.* Alan Smith. 1984. Enfield. Electric and electronic clocks are dealt with from pp 145-152, but only from a point of view of style. Ten illustrations given, including Ato, Bulle, Smiths English Clocks, Kienzle, Selticon, and the Sharp Corporation of Japan.

876. "Etic". The Watchmakers' System for Repairing Electronic Watches". pp 14. 23 figs. April 1977. The 'ETIC' system was designed for the rapid repair of quartz crystal watches, mostly battery changing, pushers and correctors. The repair was limited to replacement of a few minor parts only.

877. *Dictionnaire Technique. Pour la montre électronique.* 1977. This guide was issued by 'ETIC' to familiarise mechanical watchmakers with electronic horology as electrical and electronic watches became more popular. (Technical dictionary. For the electronic watch). French text.

878. "The Precise Measurement of Time". Alfred L Loomis. *Monthly Notices of the Royal Astronomical Society,* Volume XCI, March 1931. Loomis was an enthusiast who first detected the effect of the moon on pendulums.

879. "Analysis of Records made on the Loomis Chronograph by three Shortt Clocks and a Crystal Oscillator". E W Brown & D Brouwer. *Monthly Notices of the Royal Astronomical Society.* Volume XCI, March 1931.

880. "Variations in the Speed of Rotation of the Earth since June 1955". L Essen, Parry, Markowitz & Hall. *Nature,* No 181, p 1054, 12 April 1958. Measurements made posible by the caesium atomic clock.

881. "Comparison of Astronomical Time Measurements with Atomic Frequency Standards". J P Blaser & J Deprins. *Nature,* No 182, p 859, 19 April 1958. Human observations became too imprecise for really accurate clocks.

882. "*Shortt Clocks and the Earth's Rotation*". *J Jackson. Monthly Notices of the Royal Astronomical Society,* Volume LXXXIX, January 1929. The invariablity of the earth's period had been doubted for a long time.

883. "The Shortt Clocks at Greenwich in 1930". J Jackson & W Bowyer. *Monthly Notices of the Royal Astronomical Society.* Volume XCI, January 1931.

884. "L'Attraction Luni-Solaire et les Pendules". N Stoyko. *Bulletin Astronomique,* Volume 14, fasc. 1, pp 1-36, 1939. Paris. (The Moon-Sun Attraction and Clocks). See next entry. French text.

885. "Sur la Détermination des Termes du Jour Sidéral dans l'Attraction Luni-Solaire par l'Observation des Pendules à Gravité. N Stoyko. *Comptes Rendus de l'Académie des Sciences.* Volume 220. pp 668-669. 1945. Paris. (On the determination of the terms of the Sidereal Day in the Moon-Sun Attraction by the Observation of Gravity Pendulums). This means the mathematical terms, see Entries No 220 and 297. French text.

886. "Great Wenham Church Electric Clock". *Suffolk Clocks and Clockmakers.* Arthur L Haggar & Leonard F Miller. 1974. Ramsgate. Mention is made on page 27 of the electric clock fitted in Great Wenham Church, Suffolk, in 1852, at the instigation of the Rector, the Reverend Daniel Constable Whalley. The relevant passage is: "The clock was constructed by Mr Pipe of Ipswich, under the direction of the Rector, and the movement carried the inscription:

"This Electric Clock, invented by Alexander Bain, was given to this Church
by the Reverend D C Whalley, Rector, 1852.

Power for the clock was derived from two elements let into the ground, presumably carbon and zinc. Some years ago an elderly resident recalled the way the clock was operated, in typical Suffolk language, 'That uster go by the bowels of the earth'. The clock has been replaced by a more orthodox timekeeper, and presumably no longer exists". [Note: The clock was placed in the Ipswich museum and owing to carelessness was either stolen or destroyed. It vanished before the last war. Also a copy of Alexander Bain's *A History of the Electric Clocks* was given to the churchwarden who looked after the electric clock, this was purchased by Charles K Aked from the churchwarden's son, a man in his nineties, and sold at the same price to Dr Shenton. He mentioned that his father watered the earth battery in dry weather, otherwise the clock stopped]. Refer to Bain material for further information. L F Miller died prematurely, a brilliant researcher.

887. *English Dial Clocks.* Ronald E Rose. 1978. Woodbridge. p 13, 'It was not until the industrial master clock and its slaves began to be installed that the dial clock lost its place as the leading type of clock'. p 23, 'With the increase in mechanical knowledge and the gradual changeover to electric and battery clocks, clockwinders began to decrease (in numbers) from the 1920's but they have by no means died out and still exist in small numbers even today. See NAWCC *Bulletin,* Whole No 177, p 324, article by Charles K Aked.

888. "Galvanic Time-piece". *Edward J Dent*. Vaudrey Mercer. 1977. Ramsgate. pp 333-337. Commencing with a letter from Dent to Airy dated 17 May 1848, following a visit by Airy to Dent's home when he was absent; it discusses arrangements for synchronizing clocks from the Transit clock, mainly about supplying a suitable battery. Dent states he has had an arrangement working in his shop in the Strand for four months using a Smee's battery with pure gold and platina contacts. There are several letters between Airy and Dent, finally Dent recommends "... in my opinion no person is better informed in all matters connected with galvanic affairs than Mr Rippon". Not until 1854 were contacts fitted to the Hardy clock and it became the Sidereal Standard. The construction and erection of the clock is detailed pp 470-481, the Great Galvanic Chronograph system pp 488-489 and Plates 95-97 (wrongly indexed in book); the Radcliffe Observatory version of 1855 is mentioned p 433; p 486 another for Brussels Royal Observatory in 1877, p 487 another for Japan in 1879 (not in index). Page 315 gives details of Henry Dent Gardner's lectures at the Loan Collection, South Kensington, these were serialised in four weekly parts in *Nature* from 12 October 1876 onwards. The fourth and last lecture deals with the distribution of time by electricity. In *Nature* for 7 August 1879 H D Dent published a splendid resumé on electric clocks, detailing the Dent contacts as used on the Hardy clock at Greenwich. He finally writes of E J Dent's method of dropping a powerful magnet through a coil to generate current to operate a dial movement. The magnet was lifted each half minute by a strong tower clock movement. Details of the electrical rewinding of the Westminster Clock and other electrical arrangements, plus various Time Balls will be found in the book. Shepherd's electric clock is mentioned on page 24. Much information listed in this work. See Entry No 111 for details of the Galvanic Chronograph, and the following entry.

889. *Installation des Pendules á l'Observatoire Royal de Belgique á Uccle*. E Delporte. pp 54. 23 figs in text. 4 folding plates. 1906. Brussels. (Clock Installation at the Royal Belgium Observatory). The text lists plates which are not in the booklet. Those included are numbered XXI to XXIV and these seem to be the only ones originally included. Whilst chiefly outlining the installation, projected and executed by Dr S Riefler of Munich, the old apparatus installed by Dent, including the Great Galvanic Chronograph, is detailed. An illustration of the latter forms the frontispiece to the booklet, and shows that even after thirty years, the equipment was still considered of importance to the running of the Observatory. The material was published earlier in *Annales des Travaux Publics de Belgique*, April 1906, possibly with illustrations of the installation. Much of the book is devoted to tables of resistance and current for various ancilliary devices of little import. The description of the chronograph is by M Philippot. pp 26-27 describe a device termed *le parleur*, for giving audible beats in synchronism with the master clock. It consists of an armature attracted by an electromagnet, a resonant case amplifying the sound. French text.

890. "Electric Clocks and Ship Chronometers". *Chambers' Journal*. March 1861. Reprinted in the American magazine *Hobbies* of July 1950, see mention p 198, NAWCC *Bulletin*, Whole No 35, October 1950. Mostly concerned with the work of the Observatory at Liverpool, where merchant navy timekeepers were rated.

891. "Daniel Drawbaugh, Tragic Genius". James W Gibbs. pp 158-163, Whole No 63, NAWCC *Bulletin*, April 1956. Figure 1 illustrates an electric clock made by Daniel Drawbaugh, one of three made, and in the possession of the author. The driving source was an earth battery, two plates buried in the ground. Four reference sources are quoted and a drawing of the escapement of the magnetic clock is shown on pp 159-160, taken from the patent of 9 August 1887. It is a most cumbersome arrangement.

892. "The latest in Marine Chronometers". 'The Answer Box', pp 567-568, NAWCC *Bulletin*, Whole No 69, June 1957. Announced by the Time Facsimile Corporation of the 1957 Armed Forces Communications and Electronics Association in Washington. A tuning fork driven electronically provided power to drive a motor geared to the time indicators. It was reputed to be ten times more accurate than a normal marine chronometer.

893. "A Plea for the Electric Clock". 'Vox Temporis', p 630, NAWCC *Bulletin*, Whole No 102, February 1963. A letter from member Frederick A Babcock for others to collect electric clocks. In the same issue is an article "Time and its Inverse" by John M Richardson, pp 597-604, mainly dealing with the caesium beam atomic clock, Standard Time Signals and their frequencies. A good account.

894. "Electric Techniques" Dr F A B Ward. p 960, NAWCC *Bulletin*, Whole No 106, October 1963. Mention of the Shortt Free Pendulum, quartz crystal and caesium beam atomic clocks. Not a very profound treatment, included in an article entitled 'How Timekeeping Mechanism became Accurate', pp 950-961.

71

895. "Chronostat III, An Electronic Marine Chronometer". Paul R de Magnin. pp 111-115. 3 figs. NAWCC *Bulletin*, Whole No 96, February 1962. A good account of the principles of operation of an early transistor switched electrically operated marine chronometer. Little demand for these because of radio time signals.

896. "Some Scant Information on the Poole Clock Company". 'The Answer Box', p 1008. NAWCC *Bulletin*, Whole No 106, October 1963. 'First mention of the name of Arthur F Poole appears in the 1927 Ithaca city directory. The 1929 Ithaca directory lists Arthur F Poole as Vice-President and Treasurer of the Poole Manufacturing Co. The 1930 directory lists him as an electronic engineer of the Poole Clock Co. At this time the company was taken over by the Morse Industries with Frank B Morse as its President. There is no mention of the Poole Clock Co in the 1933 directory and Arthur F Poole is listed as retired. Research data by Paul Patten, Ithaca, letter from Gary R Moorhouse, Buffalo, New York.

897. "Who Affixed the Motor". 'The Answer Box'. pp 260-261. NAWCC *Bulletin*, Whole No 109, April 1964. A letter from F F B, Akron, Ohio, including two photographs of a self-winding electric skeleton clock, the motor being the Self-Winding Clock Company model shown in Fig 137 of Ward Goodrich's book *The Modern Clock*. The clock appears to be of the Pond pattern.

898. "Daly Time". Dorothy Severns. p 328. NAWCC *Bulletin*, Whole No 111, August 1964. This mentions 'There is a battery clock made in 1906 by Eureka Clock Co and one by Electric Specialities Co, England'.

899. "The Electric Watch Repair Manual". Jean Louis Roerhrich. p 933. NAWCC *Bulletin*, Whole No 118, October 1965. Review of the book by Henry B Fried, see Electrical Horology book listing.

900. "Eureka Clock Contact Needed". 'The Answer Box'. p 992. NAWCC *Bulletin*, Whole No 118, October 1965. Letter from Robert Phillip of Toronto requesting information, mentions he has several Eureka clocks. On page 935 of this issue is a short mention of the Holmes Electric Timelock, patented April 1872, and manufactured by Mssrs E Howard & Co, of New York. It is controlled by two chronometers energised by an electric low voltage battery, and in case of emergency, should both timers refuse to operate; can be unlocked by means of a special device. This lock could be set for the day and night by means of a dial. Supplementary patents on the improved construction of this lock were taken out in 1879 and 1880.

901. "Clockmakers and Watchmakers of Canada". Craig M Hartley. p 462. NAWCC *Bulletin*, Whole No 112, October 1964. This lists Shonbeck Clock Co of Hamilton as suppliers of American electric movements for offices; and George Hess of Zurich (1860-1890) as a supplier of electric clocks.

902. "Battery raised weight kicks pendulum". p 269. NAWCC *Bulletin*, Whole No 121, April 1965.

903. "Early Electric Synchronous Clocks". Myron Evarts. p 311. NAWCC *Bulletin*, Whole No 121, April 1966.

904. "Repair and Maintenance of Dimep Clock". p 194. NAWCC *Bulletin*, Whole No 120, February 1966.

905. "Early History of Electric Clock". p 594. NAWCC *Bulletin*, Whole No 125, December 1966.

906. "Stanilaus Fornier Pioneer". p 1233. NAWCC *Bulletin*, Whole No 153, August 1971.

907. "Query on Earth Battery Clock by Bentley". p 195. NAWCC *Bulletin*, Whole No 156, February 1972.

908. "Query on repair of Barr Clock". p 511. NAWCC *Bulletin*, Whole No 159, August 1972.

909. "Information for restoration of Tiffany Never-Wind". p 907. NAWCC *Bulletin*, Whole No 161, December 1972.

910. "A Helpful Response". p 75. NAWCC *Bulletin*, Whole No 174, February 1975. Letter from Charles W Bottom, Los Alamos, about an electric clock with sweep seconds similar to one in the February 1962 issue and another in the October 1974 issue; (Bill Burnham and Dr Harlan, respectively). The writer 'feels sure' that the clock was made by the 'New York Standard Watch Company' but does not give his reasons for thinking so.

911. "Alexander Bain". Charles K Aked. pp 345-346. NAWCC *Bulletin*, Whole No 177, August 1975. A preparatory briefing for the proposed Bain centenary exhibition in the Science Museum, London.

912. "La Bulle-Clock Horologerie Electrique". p 611. NAWCC *Bulletin*, Whole No 185, December 1976. Book review of Henry L Belmont's book on the Bulle clock by Henry B Fried. (A good critique).

913. "Electrifying Time". Charles K Aked. pp 192-194. NAWCC *Bulletin*, Whole No 187, April 1977. A description of the exhibition of electrical timekeeping held in the Science Museum, London, from 15 December 1976 until May 1977.

914. "Singer Request: Self-Winding Clock Co". p 70. NAWCC *Bulletin*, Whole No 210, February 1981. Conclusions drawn: Serial No's below 62,730 prior to 1908, below 112,956 prior to 1917, below 196,212 prior to 1929. Information from J J Singer, University Heights, Ohio 44118.

915. "Henry Warren Electric Clock made in Ashland, MA". 'Answer Box'. p 73. NAWCC *Bulletin*, Whole No 210, February 1981. Letter requesting information on the battery driven Warren electric clock. Answered by Marty C Feldman, who quoted the two US patents, No's 1,160,346 and 1,144,943. Warren later perfected the synchronous electric clock and was responsible for persuading the electric power companies to run at constant frequency.

916. "Zenith Hot Wire Electric Clocks". p 185. NAWCC *Bulletin*, Whole No 211, April 1981. Request from John Cammarata about the Zenith electric clocks using bimetallic springs based on the patents of C O J Jamin, circa 1921, of Holland. The bimetallic springs were activated by electric currents.

917. "Who is Collecting Electric Clocks?" pp 309-310. NAWCC *Bulletin*, Whole No 212, June 1981. Talk by Marty C Feldman at the Chapter meeeting of 4 April 1981. He is shown on p 309, Past-President Robert Brown is shown with his collection of electric clocks, also Dale Milsark with a Warren electric clock, p 310.

918. "Accurate timing of Grandfather, Mantel and Wall Clocks". R W Ellms. pp 234-237. NAWCC *Bulletin*, Whole No 212, June 1981. This uses a synchronous electric clock movement with a mirror fitted to the minute hand, and another strip with a mirror to the clock being rated. The author assumes that the public electricity supply has a constant frequency, this is far from the case in England. A somewhat zany conception.

919. "Report of Electrical Horology Society". pp 360-361. NAWCC *Bulletin*, Whole No 218, June 1982. An illustration of an early ATO electric clock, circa 1930, housed in a pillar and scroll case, shown on p 360!

920. "Electrical and Electronic Clocks and Watches". p 227. NAWCC *Bulletin*, Whole No 223, April 1983. Review of J D Weaver's book by Henry Fried. Points out that American reference sources are confined to Warren and Marrison. Not an over-enthusiastic critique. pp 224-225 of the same issue cover a query by John W McKenzie about a Barr electric clock answered by Marty C Feldman. This clock was manufactured in Ithaca by the company which bought out the Poole Clock Company, the Barr Manufacturing Co which was part of the Morse Chain Co and which later became part of the Borg-Warner Group. The clocks were not a financial success.

921. "An Intricate Bangor Electric". 'Answer Box'. p 499. NAWCC *Bulletin*, Whole No 214, October 1981. Enquiry from Art Bjornestad, Glendale, California. 80 beat pendulum clock driven from 3 volt battery, reset gravity arm drive, patent taken out by Walter J Dudley, Patent No 648,487 dated 1 May 1900.

922. "An English Eureka". 'Answer Box'. p 504. NAWCC *Bulletin*, Whole No. 214, October 1981. D D Corbet asking for information on the Eureka clock, answered in full detail by Marty C Feldman.

923. "South Bend Watches". D B Frye. p 654. NAWCC *Bulletin*, Whole No 239, December 1985. In an article mainly devoted to watches, it mentions that the Studebaker Watch Company was formed and electric clocks were introduced into the mail order line. 'Mr Gratzol states that Telechron motors were used at first, but a policy decision caused a switch to GE. The GE motors had stoppages and finally Westinghouse motors were used. A 16 size, 9 jewel, double roller escapement was used on the electric clocks. The ones I have seen are in wooden beehive style cases, stamped S B and numbered on the bottom'. An illustration of serial no SB 31 is shown, behind the dial view shows an 18 size watch movement. The method of rewinding is not mentioned.

924. "Electrically powered Clocks", p 313. NAWCC *Bulletin*, Whole No 224, June 1983. Brief mention of electric clocks in article by Philip E Balcomb for novices.

925."Notes on the Franklin Clock Company Mystery". Dr Benjamin J Novak, p 602. NAWCC *Bulletin*, Whole No 209, December 1980. Included in the article is a section on the electrified version of the Franklin chiming longcase clocks introduced about 1935 by Stefan Pavky. It was so-called because Pavky greatly admired Benjamin Franklin. A small electric motor was used for rewinding the time train and weights for the chiming train. Pavky was tone-deaf and the chime tubes were merely cut to length against a reference set!

926. "A Modern Tower Clock". Donald Plummer. pp 641-649. NAWCC *Bulletin*, Whole No 209, December 1980. This describes how to drive a tower clock using a shaded pole motor switched by a triac which is operated from a magnetic reed switch actuated by a small magnet on the final shaft of a synchronous clock motor. As there is no fixed amount of motion for the shaded pole motor, it seems a precarious system for accuracy.

927. "What Time is It". Wilbur L Pritchard. pp 604-618. NAWCC *Bulletin*, Whole No 209, December 1980. A good article on the measurement of time, including on pp 609-610, mention of hydrogen, rubidium and caesium atomic clocks; and again on pp 617-618, further aspects of this field of timekeeping.

928. "Railroad Station Clock". 'Vox Temporis'. p 672. NAWCC *Bulletin*, Whole No 209, December 1980. Letter from M W Bartels showing the wiring diagram for a Self-Winding Clock connected to a Morse Wire. The local clock battery circuit is actuated by a relay operated by the line current. Address of Self-Winding Company given as 205-211 Willoughby Avenue, Brooklyn, New York, in 1923. The firm's office moved several times.

929. "German Eureka Clock". 'The Answer Box'. NAWCC *Bulletin*, Whole No 209, December 1980. Enquiry from Bernard Oliff, Statsboro, about his unusual electric clock, accompanied by a very poor photograph. Answered by Marty C Feldman to the effect that it was a German Eureka clock.

930. "American Clock Company". 'The Answer Box'. NAWCC *Bulletin*, Whole No 209, December 1980. A letter from Robert A Simon, Pittsburgh about a weight-driven wall regulator rewound by an electromagnet. Marty C Feldman replied that it was made about 1900-1915, the electromagnet alternately raises two brass weighted arms. The enquirer was referred to pp 393-399 of *The Modern clock* by Ward L Goodrich.

931."Timing the Trolleys". Larry Treiman. pp 3-19. 20 figures including contemporary advertisements. NAWCC *Bulletin*, Whole No 192, February 1978. This article is about the various mechanical watches manufactured by Hamilton, Waltham, Elgin, Illinois, Rockford, South Bend and other firms specifically for use with trolley-car systems. They were generally of lower grade performance than railroad watches which had to be authorized for use. A list of references is given pertaining to the electric street railways and trolley systems, but many references are quoted in the text itself, being from journals and newspapers. An interesting article.

932. *Time Inspection Systems on Electric Railways*. Hamilton Watch Company. Electric Railway Department, Lancaster, Pennsylvania. The front cover shows an Illinois Traction System locomotive, Serial No 1202.

933. "All About Tubular Chime Clocks". Henry B Fried. pp 128-159. NAWCC *Bulletin*, Whole No 217, April 1982. On page 158 mention is made of the Bauerle and Winterhalder electrically rewound chiming clocks using a Diehl motor, Diehl being a division of the Singer Sewing Machine Co. 'The motors burned out lifting the thirty pound weights through a plantary gear system. They were set to be wound daily, manually or electrically. Winterhalder later converted these to chain-wound, with internal spring-type holding ratchet. Bauerle's clock used a one-weight system to drive the three separate train functions.

934. "Golden Hour Clock". 'Vox Temporis'. p 205. NAWCC *Bulletin*, Whole No 217, April 1982. A tip by Alfred J Perry about the Golden Hour electric clock which has hands mounted in a glass dial to make a 'mystery' clock. The glass was 1/8 inch smaller than the contrate wheel, allowing the glass to roll forward and cause a gain of up to fifteen minutes in a few days. Mr Perry's solution was to introduce a few pieces of sponge rubber between the two components, the friction then preventing the unwanted motion. The drive to this type of clock is a synchronous motor hidden in the clock base, the hands are counter-balanced to give them the illusion of being suspended in space.

935. "Watch Timer". 'The Answer Box'. p 209. NAWCC *Bulletin*, Whole No 217, April 1982. An enquiry from A A Mabson, Jefferson, LA 70121, about a Precise Watch Timer made by M J Lampert & Sons, Inc, New York 10. Henry Fried replied that the firm had not been in business since the early 1950's, the machine is a very early one with a neon lamp actuated by the amplified sound of the ticking watch, this appears to 'freeze' the motion of a disc rotated by a synchronous motor running from the 115 V supply mains when the rate of the watch is correct. Obviously the accuracy of this method is dubious except where the supply frequency is constant.

936. "Abraham K Dresher, Pennsylvania Clockmaker 1859-1942". Warren Niebling. pp 266-268. 3 illustrations. NAWCC *Bulletin*, Whole No 206, June 1980. Torsion pendulum electric clocks made by Abraham Dresher, circa 1918-20, one fitted with calendar, day of month and week indications, plus a phase of the moon indication.

937. "Self-Winding Clock Company". 'The Answer Box'. pp 290-291. NAWCC *Bulletin*, Whole Number 206, June 1980. An enquiry from S L Hicks, Louisville, about a recently acquired example. Answered by Marty C Feldman, giving the dates of the company as 1884-1952, the repair service is no longer available. Reprint booklets available from Self-Winding Publications, 622 East San Antonio Drive, Long Beach, California 90807, USA.

938. "Poole-Barr-Morse Chain Co". 'The Answer Box'. pp 287-288. NAWCC *Bulletin*, Whole Number 206, Jume 1980. Letter from Melvin S Kaye, Short Hills, New Jersey 07078, about example with Morse Chain Co, Ithaca, NY USA on dial. According to Marty C Feldman the clock was the 'Patrician' model # 70 and listed in 1935 at $35. The last patent by Arthur F Poole, inventor of the clock, was No 1,945,069, 30 January 1934. An illustration of the clock is given, a nice mahogany bracket clock case ten inches in height, the dial has a small seconds dial in the upper part.

939. "New York Standard". 'The Answer Box'. pp 292-293. NAWCC *Bulletin*, Whole Number 206, June 1980. Enquiry from Kennneth Elliott, Rossville, GA 30741, about a Vienna type wall clock with NY STD WA Co on the dial. Marty C Feldman replied stating the driving voltage was 3 volts, the Patent No was 555,313 of February 1896, with a Hipp toggle system impulsing every 30-50 seconds. The pendulum has a one second swing, not as stated by Feldman as one second period, although many models evidently were so made.

940. "Geophone". Southwestern Chapter report. p 304. NAWCC *Bulletin*, Whole Number 206, June 1980. A new use for the Geophone, employed for detecting vibrations and seismic monitoring, by Clarence Schroeder. An illustration of the instrument attached to a long case clock, plus the user himself standing by a regulator are included. The instrument was clamped to a clock and the amplified noise of the escapement used to listen to its operation. An article on this use was featured in the technical magazine *Time Break* published by Geo-Space who made the Geophone amplifier. Any simple amplifier would have done as well and have been cheaper.

941. "Henry Rempe and the Rempe Manufacturing Co". Stacey B C Wood Jr. pp 264-269. 8 illustrations. NAWCC *Bulletin*, Whole Number 212, June 1981. It is a an electromagnetically reset spring driving a train and a normal clock escapement, ie an electrically rewound system. These clocks were claimed to be better than the Self-Winding clocks of the Western Union in one advertisement by the Rempe Manufacturing Co, Danville, Pennsylvania. Much information on these clocks will be found in the *Jewelers' Circular-Weekly*: p 55, 2 December 1903; p 119, 3 February 1904; p 56, 24 February 1904; p 43, 28 September 1904; and *The Keystone*, p 1641, October 1904. The clock mechanisms were quite crudely made.

942. "Electrical Horology Society". Chapter 78. p 323. NAWCC *Bulletin*, Whole Number 212, June 1981. Reports the visit of Dr and Mrs Shenton on 7 April 1981. A photograph of the meeting outside Marty Feldman's home is shown, it includes the Levy's, Marty Feldman, Marx, De-Angelo, McGinness and Feinstein.

943. "Self-Winding Transition Clock". p 301. NAWCC *Bulletin*, Whole Number 212, June 1981. Enquiry by Robert R Schontz, Springfield, Illinois 62704. Acccording to Marty C Feldman the clock was a transition model with the movment made by Seth Thomas, and the rotary electric rewind motor made by the Self-Winding Clock Company.

944. "Leon Hatot". p 299. NAWCC *Bulletin*, Whole Number 212, June 1981. Mel Weiland, Spring Grove, Illinois 60081, enquiring what the letters A T O stand for on battery clocks. Marty C Feldman replied that it was a trademark based on Leon Hatot's name, but mistakenly ascribes it to the anglicizing of the name when it is the French pronunciation which sounds like ATO to an English ear since the French do not sound their aspirates.

945. "Tiffany Never-Wind". p 216. NAWCC *Bulletin*, Whole Number 199, April 1979. Enquiry about the Tiffany electric clocks from Steve Mullendore, Gambia, Ohio. The Tiffany Never-Wind was produced for several years by the Company of the same name under the patent 754398 granted to George Tiffany on 8 March 1904, two models being produced, similar to 400-day clocks, with torsional pendulums, the second smaller model having two weights shaped like bullets. Tiffany always housed the mechanism under a glass dome, the same mechansism was used by the Cloister Clock Co, the Niagara Clock Co, and the National Magnetic Clock Co, who placed them in wall mounted cases as well. The driving voltage is 4½ volts from three cells. A platinum finger touches a stationary contact at each revolution, this impulses the pendulum and the motion work.

946. "The Digital Watch Repair Manual". Louis A Zanoni. pp 202-203. NAWCC *Bulletin*, Whole Number 199, April 1979. Book review by Henry B Fried of the first book on the repair of digiital quartz crystal watches. The book has only 53 pages but seems a comprehensive manual for the repair of the early models of quartz watches.

947. "Chester Henry Pond who started it all". Bengte Eugene Honning. pp 136-149. 4 illustrations, including a photograph of Chester Henry Pond (1844-1912). NAWCC *Bulletin*, Whole Number 199, April 1979. This is a good account of the history and functioning of the Pond electrical self-winding clocks. There is a list of references at the end of the article. The Patent No 308,521 of 25 November 1884 is reproduced in full. Pond took out eleven patents on electrical clocks and many more on telegraph instruments, etc.

948. *Self-Winding Clocks*. pp 21. Illustrated. Catalogue issued by the Self-Winding Clock Co in 1908.

949. *The Western Union Time Service*. Western Union Corporation monograph. 1963. New York.

950. "The Self-Winding Clock Company and the Western Union Time Service". M W Bartels. pp 627-632. 7 illustrations. NAWCC *Bulletin*, Whole Number 191, December 1977. A supplement to the earlier article in the August 1975 issue of the *Bulletin*. In 1963 the Self-Winding Co sold out to the Western Union. In 1940 there were 100,000 customers but the number was rapidly shrinking in the 1960's. The master clock illustrated bears the signature J Hamblet, Electrician. Customers' clocks are shown in various styles.

951. "The Self-Winding Clock". M W Bartels. p 317. NAWCC *Bulletin*, Whole Number 177, August 1975. A brief acount based on Goodrich's book *The Modern Clock*, with a few hints on setting up. It mentions that all the clocks owned by the Western Union Telegraph Company were abandoned when they discontinued the time service, to be used or discarded at the discretion of the customer. In the Chapter Reports in the same issue is mention of a Hipp Chronoscope shown on 27 April 1975 to the Electrical Horology Group meeting at Charles Roth's house.

952. "Description of an Electric Desk Clock". Joseph J Singer. pp 535-539. 5 illustrations. NAWCC *Bulletin*, Whole Number 220, October 1982. A description of the 'Dale RM Marine Escapement Movement S/N 50089'. A flexible cord connected the clock to a synchronizing circuit for hourly correction. The clock was sold for $36 or rented for $1.50 a month. Relevant references are given, with a diagram of the mechanism.

953. "Western Union Time Service". Advertising brochure R-62 issued by the Company. 1963.

954. "Cost of Clocks and Clock Parts List". Stencilled sheet # 1490 issued 20 May 1941 from the Time Service Plant, Western Union.

955. "The Tiffany Never-Wind Clock, Description; Repairs and Adjustments". Adolph Amend Jr (CT). pp 494-505. 16 illustrations. NAWCC *Bulletin*, Whole Number 220, October 1982. Full description of the repairs and adjustments carried out on one of these clocks. The author recommends battery holders rather than solder the cells. (In practice the holders develop high resistance contacts, better to solder the cell connections).

956. "The Warren Telechron Master Clock Type A". Harry S Holcomb (VA) & Robert Webb (IA). pp 35-37. 3 illustrations. NAWCC *Bulletin*, Whole Number 234, February 1985. Description of a Warren Telechron Master Clock Type A used for maintaining the correct frequency at power stations.

957. "Warren Master clock for Maintaining Constant Average Frequency". *General Electric Company Bulletin* No 46037, May 1919. Description of the master clock enabling a close check on the frequency to be maintained.

958. "Instructions for Telechron Master Clock Type A". *Bulletin M-13*. Warren Telechron Company, Ashland, MA.

959. "Modern Electric Clocks". Henry E Warren. A paper read at the 6 February 1937 meeting of the Boston Clock Club. The first master clock fitted at the L Street Station of the Boston Edison Company is mentioned, it is now on exhibition in the Smithsonian Institution, being presented in June 1964, see *American Horologist and Jeweler*, Volume 31, No 6, June 1964, page 28.

960. "Bernard J Edwards". p 58. Portrait. NAWCC *Bulletin*, Whole Number 234, February 1985. In his biography for the 1985 NAWCC Election, it is mentioned that he has been asked by the Smithsonian Institution to help in research on Howard electrical clocks.

961. "Remembrances of Mr Bruce Haas: The Early Electric Years". Henry A Gerlach. 'Vox Temporis'. p 90. NAWCC *Bulletin*, Whole Number 234, February 1985. Criticises Warren's Telechron motor - unfairly or from ignorance, and describes the development of an electric alarm clock, 40,000 models were sold at 25 dollars each the first year. A second model with an illuminated dial and an indicator to show when the current was off was called the 711, also sold for 25 dollars, it consumed 4 watts, and was a big success.

962. "With Thanks for Services Rendered". Stacey B Wood Jr. p 78. NAWCC *Bulletin*, Whole Number 234, February 1985. Three members of Atlanta Chapter 24 spent Thanksgiving Weekend 1984 installing transformers for the wall clocks in the NAWCC Museum to use house current instead of difficult to obtain batteries. A half-page illustration shows Dr Allan F Shaw, Bernard J Tekippe, Stacey B Wood and William H Bradley.

963. "The Stanford Products Company of San Francisco, Calif." George Theobald. pp 421-423. 7 illustrations. NAWCC *Bulletin*, Whole Number 100, October 1962. Until 1962 it was forgotten that the Stanford Products Co produced electric clocks, the firm only manufactured these during the years 1931-1932. Some of the models had calendars and alarms, evidently the introduction of the Hammond Clock Co Bi-Synchronous clock was too competetive, and although the firm produced the Duokron to run the clock for about ten seconds to bridge a short interruption in the supply, only a few were made. The firm was owned by David Spector, the chief engineer was William R Browning, and the designer of the 'duokron' was Shermund. (Note the connection between 'Duokron' and 'Bi-Synchronous').

964. "The Evolution of Early Battery Driven Clocks". Tom Bosschieter. p 707. NAWCC *Bulletin*, Whole Number 239, December 1985. A 44 Minute, 28 slide discourse on the development of battery driven pendulum clocks. Further programmes are listed on pp 708-710: Early Battery Clocks - Glenn Marsh, The Electronic Watch - Armand Van Velthoven, 1982 Chicago Regional Exhibit of Electric and Battery Operated Clocks, Restoration and Additions of Electric Wind for Brown Street Clocks - Chapter #116, Electromagnetic Clocks - Dr I G M Cleator, The Evolution of Early Battery Driven Clocks - Ted Bosschieter.

965. "Car Clocks". Scott McCann. Reprinted from *Old Cars Weekly*. p 725. NAWCC *Bulletin*, Whole Number 239, December 1985. A letter from Jerry Zimmer giving an article published in *Old Cars Weekly*. The author blames the demise of old car clocks on low voltage as the battery deteriorates with long standing. Whilst the battery volts are normal the clock operates the rewind correctly, when the voltage drops to the point where the contacts do not separate, the coil is shorted across the battery. The writer considers the continuing current to burn out the coils as they were not made for such conditions. (At low voltage the current will often cause a vibratory effect similar to a buzzer since the armature cannot be attracted sufficiently strongly to step one tooth of the ratchet wheel, it depends upon the characteristics of the rewinding system).

966. "Horology of World's Columbian Exposition, Chicago, 1893. Part 3". N H Lewis. p 737-741. NAWCC *Bulletin*, Whole Number 239, December 1985. This states on p 738 that the 24 May 1893 issue of *Jewelers' Circular* on page 26 includes an outline of the 'Du Laney Electric Clocks' - 'The former has a large pavilion of ebony black relieved by lines of gold. In each corner stands a pedestal sumounted by a movement without dial, showing the mechanism. Clock parts are exhibited in cases, and at each end of the line stands a grandfather clock. A full line of the factory's products is shown all connected and synchronized, the idea being to show that any number of clocks could be controlled by a master clock. A large circular time-piece on the wall above the exhibit bears the name of the company and serves as the official time-keeper for the south of the building'. The Self-Winding Clock Co also exhibited and their stand is shown on the ground plan, whereas the Du Laney Co were placed in the electricity section in the south gallery.

967. "Electromagnetic Clocks". Ian Cleator. p 763. NAWCC *Bulletin*, Whole Number 239, December 1985. Report of the Chapter 129 Sundial, 15 August 1985 meeting when Dr Ian Cleator presented his lecture.

968. "Electrical Horology". Martin Swetsky. p 617-618. Portrait of lecturer. NAWCC *Bulletin*, Whole Number 238, October 1985. Report of the Phildelphia Chapter No 1 on the lecture given 19 May 1985, the early material seems to have been compiled from material researched by Charles K Aked.

969. "Just How Good was the Shortt Clock?". Pierre Boucheron. pp 165-173. 9 figs. NAWCC *Bulletin*, Whole Number 235, April 1985. An outline of tests conducted on Shortt No 41 at the Naval Observatory, Washington. This shows the various irregularities better than ever obtained before. An excellent analysis.

970. "Working Stiffs". Louis Auerbach (NY). pp 189-196. 20 figs. NAWCC *Bulletin*, Whole Number 235, 1985. Mentions the International Time Recording Company School Programmer, the Self-Winding Clock, Ansonia Clock Co street lamp switch for the Tork Company, another by Sauter, Switzerland called the Astronomical Time Switch; a Telephone Manufacturing Co Chronomatic rate timer, and the International Time Recording Clock Clock master clock. All are illustrated.

971. "Notes on the Nelson Post Office Clock". Henry Rodgers (NZ). pp 696-697. NAWCC *Bulletin*, Whole Number 233, December 1984. Electric rewinding of the Nelson Post Office Joyce clock, also the use of a synchronous motor in place of the pendulum which is unsuitable for use in the earthquake zone where Nelson is situated. The clock is exactly as before except that the synchronous motor releases the escape wheel teeth.

972. "Poole Gravity-Electric Clock". Victor E Grove. pp 502-503. 1 fig. NAWCC *Bulletin*, Whole Number 50, October 1950. An elementary outline of the Poole electric clock.

973. "Time". Royale G Foote. pp 380-383. No figs. NAWCC *Bulletin*, Whole Number 48, April 1953. In a general talk on Time, the quartz crystal clock, the synchronous clock, frequency check of generating stations, WWV Time Transmitting station at Eight Mile Road etc, all at an elementary level.

974. *The H I A Journal*. p 205. NAWCC *Bulletin*, Whole Number 44, June 1952. Mention of an article in this journal entitled 'A Brief History of Electrical Timepieces', about a page and a half, with four illustrations.

975. "The Chronoscope". Dr W B Stephens. pp 42-43. 1 fig. *The Timekeeper*, Volume 1, No 4, March 1945. In an article mainly concerned with mechanical chronographs, mention is made of an electric chronoscope, illustrated as fig 31 on the previous page, this is the 'Telechron' with Digital Display. The author has little idea of his subject since the title should be 'The Chronograph'. (Incidentally the Master Index only lists the illustration).

976. "A Scarce Electric Clock". pp 251-251. 1 fig. NAWCC *Bulletin*, Whole Number 18, June 1947. Letter from Mr L A Rear of Pasadena about his Eureka electric clock which he mistakenly attributed to the clock's retailer - Mappin & Webb. He has the wrong voltage applied to his clock and is under the impression the balance swings in seconds (One-metre pendulum). It swings in 1 1/3 seconds, 45 to the minute.

977. "The Eureka Clock Co (Mappin & Webb) Electric clock". pp 265-267. 1 fig. NAWCC *Bulletin*, Whole Number 19, August 1947. Replies to the earlier letter of Mr Rear from Arthur Tremayne, Walter H Bentley, and Dr Alfred G Cossidente. That by Bentley is the most informative. A Mr Pugsley and a Mr Massey also write, and Mr Raab of the Elgin Watchmaker's College quotes the Eureka in *Electrotechnik für Uhrmacher* by Johannes Zacharias. This latter is, of course, an entirely different model. Dr Cossidente's clock is illustrated.

978. "The Eureka Electric Clock". pp 329-330. NAWCC *Bulletin*, Whole Number 21, December 1947. Mr D W Case of Richmond, California, gives some previously unknown details, mentions Rawlings *Science of Clocks and Watches* which states few electric clocks run on batteries. One of the best of them was the Poole clock made by the Morse Chain Co. The Barr Manufacturing clock (the same model) is quoted as being new. A further mention is made in the next entry from Mr Joseph A Sasek who states he saw many of them in the second-hand shops on Second and Third Avenue, New York, and he remembered having many to repair in the years 1922 to 1930. 'Somehow people did not take to them, probably because they did not renew the batteries often enough'.

979. "The Eureka Electric Clock". pp 300-301. NAWCC *Bulletin*, Whole Number 20, October 1947. Letters from Malcolm Gardner, Dr F A B Ward and Omar D Fisher which add little not already known.

980. "The Evolution of Early Battery Driven Clocks". Tom Bosschieter. p 707. NAWCC *Bulletin*, Whole Number 239, December 1985. A 44 Minute, 28 slide discourse on the development of battery driven pendulum clocks.

981. *The Digital Electronic Watch*. Tom M Hyltin. pp 552-553. NAWCC *Bulletin*, Whole Number 202, October 1979. Book review by Henry Fried who states it is the first book on digital watches, a phrase he also used for Zanoni's earlier book, see Entry No 946, however Hyltin's book is a historical survey to instroduce the subject to those with little previous knowledge. It is recommended by Fried as an excellent introduction.

982. "Harrison Request: Reason Battery Clocks". p 394. NAWCC *Bulletin*, Whole Number 207, August 1980. Request for the serial numbers of Murday clocks in the possession of NAWCC members. Only about 25 known.

983. "Recent Donations and Additions". pp 672-673. NAWCC *Bulletin*, Whole Number 203, December 1979. Includes 'Mastercrafters' electric timepiece, 'Fireplace' model #272 donated by W D Bundens; Electric 'powers of 2' timepiece, G Gaspar; "Instructions for Self-Winding Synchronized Clocks 1923-R and 1900-R, "Schedule of Parts, Style F" donated by B E Honning; and photocopies of 11 patents 1874-1890 from Chapter 78.

984. "German Quartz Clocks". pp 91-92. 1 fig. NAWCC *Bulletin*, Whole Number 204, February 1980. Outlines the progress in Germany from 1954 with the introduction of the ATO pendulum clock and the first quartz clocks in 1967, by 1980 the Germans had achieved the leading position in production of quartz clocks. The item was submitted by VDU Presse Service, Postfach 1866, 7530 Pforzheim. The illustration shows girls assembling modules at benches - it shows little change from decades ago - it is not a mass production assembly line.

985. "Recent Donations". p 82. NAWCC *Bulletin*, Whole Number 204, February 1980. The electrical items include a 'Certina Biostar' electronic watch, Synchronar solar powered wristwatch, Timex quartz wristwatch, miniature electronic alarm clock on chain, Hamilton prototype electric desk timepiece made by Fred Kohler circa 1955, Darche electric searchlight alarm clock, Telechron 'G E refrigerator' timepiece.

986. "Electric Chime Clock". p 661. NAWCC *Bulletin*, Whole Number 148, October 1970. Made by Revere Clock Company circa 1935.

987. "Electric Bi-Chronous Clock". p 942. NAWCC *Bulletin*, Whole Number 150, February 1971. Query about the repair of a Hammond Bi-Chronous electric synchronous clock.

988. "Electric Synchronous Clocks". p 681. NAWCC *Bulletin*, Whole Number 160, October 1972. Gives list of manufacturers of electric synchronous clocks in Illinois. These include: Chicago Watch Co, Chicago; Clock Products Co, Chicago; Haddon Products Inc, Chicago; Hammond Instrument Co, Chicago; Hilton Manufacturing Co, Chicago; Hanson Clock Manufacturing Co, Rockford; Jefferson Electrical Co, Bellwood; Old Colony-Middlebury Clock Co, Beardstown, Mastercrafters Clock Co, Chicago; Sewing Clock Manufacturing Co, Chicago; Sheldon Clock Corporation, Chicago; Westclox (General Time Instruments Corporation), La Salle; Welby Clock Co, Elgin. Many of these had ceased trading by the time of publication of this information.

989. *Skeleton Clocks*. F B Royer-Collard. 1969. London. pp 21-22. Under the heading of 'Electrical Drive' is mention of a Shepherd Patent Electric skeleton clock, it is illustrated in Figs 1-31 and 1-32, being an ordinary looking skeleton clock mounted upon four large electromagnets. It was energised each second by each pair of magnets pulling down one end of a centre-pivoted beam which moved the thirty teeth escape wheel one tooth every two seconds. The owner was a Mr George Duncan of Norwich who stated the clock was extremely noisy in operation. Further information is given under the heading of 'Time-signal Clocks'. A clock designed to work from the Greenwich time signals is shown in Figs 1-33 and 1-34, the dial carries the legend 'The British Telegraph Manufacturing Co'. This clock was supplied by Gerry Planus to Norman Langmaid, Washington. The clock has been converted at some time to ordinary spring drive. A letter from G B Airy dated 1 December 1875, is quoted, it rejects the Telegraph Company's request for his approval for their electric clocks and he writes 'That under the circumstances, I prefer Cooke's clocks for the Post Office'.

990. "'Z' Striker Mystery". p 750. NAWCC *Bulletin*, Whole Number 173, December 1974. The case of a difficult to repair electric clock - the Ingraham Electric T and S, the dial marked 'Semtinel Strike', using an Ingraham model Z electric motor marked 115V,60C,3W. The only time J E Coleman was stumped for a reply! On page 737 an appeal for more members for the Electrical Horology Society by Marty C Feldman.

991. "An Operational Treatment of the Design of Electromagnetic Time-Base Amplifiers". M L Jofeh. *p 400. Journal of the IEE*, Volume 85, 1939, London.

992. *A Treasury of American Clocks*. Brooks Palmer. 1967. New York. pp 311-312 illustrate several early electric clocks including; Fig 546 - Battery operated timepiece made by Henry Warren, Ashland, Massachusets. Ring shaped permanent magnet pendulum bonb with electromagnet mounted to one side, battery housed in tubular column. In the General Electric Company Collection. Fig 547 - Telechron AC wall timepiece Model MI, motor no 76659A, made by the Warren Telechron Company, Ashland, Massachusets, circa 1927, James W Gibbs collection. Fig 548 illustrates the Hammond Bichronous and Synchronous timepieces circa 1931, the former runs a short time if the current fails, these were in the Brooks Palmer collection. Fig 549 shows two Telechron synchronous clocks in wooden case manufactured by Telechron in the late 1930's, these have indicators to show failure of supply; these were in the Ray Haulenbeek collection. Also p 360, American wall battery timepiece 43 inch in height in the Charles Terwilliger Collection. There is no supporting text in the book for any of these items, it is a pictorial catalogue in the main.

993. *Kelly's Directory of the Watch, Clock and Jewellery Trades*. 13th Edition. 1924. London. pp 369. Under the heading of 'Electric Clock Manufacturers', the following London firms are listed:
1. British Horo-Electric Ltd, Makers of the 'Bulle' Clock, 42 Hatton Garden, EC1. 2. A J Brown & Co (Indicators) 12 Sekforde Street, Clerkenwell EC1. 3. Coventry Electric Clock Co Ltd, 12 Theobald's Road, WC1. 4. Gent & Co Ltd, 25 Victoria Street, Westminster SW1. 5. International Time Recording Co Ltd, 57 City Road, EC1. 6. A Légé & Co Ltd, 47 Lofting Road, N1. 6. Lowne Electric Clock and Appliances Co Ltd, 108 Bromley Road, Catford SE6 and 14 Carteret Street, Westminster SW1. 7. Magneta Time Co Ltd, 14 Carteret Street, SW1. 8. Roland Neville Umfreville Pickering, 50 Upper Berkeley Street, W1. 9. Princes Electric Clocks Ltd, 173 Bond Street, W1. 10. Silent Electric Company Co Ltd, 16 Carteret Street, SW1. 11. John Smith & Sons, 42, 44 & 46 St John's Square EC1. (The 'Chronolectric' system). 12. Standard Time Co Ltd, 19 & 21 Victoria Street, EC4. 13. Stockall, Marples & Co (1912) Ltd, 6, 8 & 10 Clerkenwell Road, EC1. 14. The Synchronome Co Ltd, 32 & 34 Clerkenwell Road, EC1. 'Electric Clock Manufacturers' for the rest of the country are listed p 476:
1. Edwin Turner Cottingham, Thrapston, Northamptonshire. 2. J Dwerryhouse and Co, 30 Moorfields, Liverpool, Lancashire. 3. Gent & Co Ltd, Faraday Works, Leicester, (time discipline apparatus for industrial purposes); also at Tangent House, Blackett Street, Newcastle-on-Tyne. 4. G H Gledhill-Brook & Sons Ltd, Trinity Works, Halifax. 5. Gledhill-Brook Time Recorders Ltd, 23 Market Street, Huddersfield; 206 Corporation Street, Birmingham; 23 Manchester Street, Liverpool; and 50 Wellington Street, Glasgow. 5. E C Kemp & Co, Central Buildings, Gallowtree Gate, Leicester.

994. *The Complete Clock Book*. Wallace Nutting. Revised and enlarged by William B Jacobs, Jr. Reprinted edition 1924. Figure 503 shows the Alexander Bain electric clock in the Science Museum, London. It is not included in the previous two printings of the book in 1924 and 1935. No technical details given.

995. *Britten's Old Clocks and Watches and Their Makers*. Ninth Edition revised by Cecil Clutton. 1982. London. The edition of 1986 is exactly the same. The treatment of electric horology in England on page 225, and America on page 283 can only be described as derisory. To quote the latter in full : 'From an early date, Howard also made Regulators and clocks with electrical contacts for transmission to other clocks or warning systems'. 'Another pioneer in the field of electrical horology was John Locke of Ohio, who marketed an *electronograph* in 1840. This combined a clock with an electrical accesssory which would carry the clock beats for a considerable distance and then print them on a roll of paper'. 'Today the traditional designs of shelf clocks are being sold with electric clocks inside them'. (The author really meant electric clock movements inside the cases). The date given for Locke is far too early, he did not publish a description of his invention until 1850, see Entry No 293. His device was given the name of 'Electro-Chronograph', not as described by Clutton. To be fair the rest of the book is not of a much higher standard of scholarship and research, it merely reflects the blinkered attitude of the author to the subject of horology.

996. *Dictator Clock, 5,000 Years of Telling Time*. Roger Burlinghane. 1966. New York. Chapters 11 and 12, pp 110-134 cover the history of electrical horology very simply but go from Galvani to the tuning fork watch. Chapter 14, pp 150-160, includes the hydrogen maser atomic clock, with an illustration of the Varian Associates version. The rubidium maser with a frequency of 6,835 x 10^9 Hz, invented by Dr Paul Davidovits of Columbia, is outlined in pages 158-159.

997. *La Pendule Française*. Tardy. In three volumes, various editions, remarks here refer to the 1975 printing. Considering the great activity of French horologists in electrical clocks and systems, and that many eminent French horologists interested themselves in the subject; the treatment by Tardy is exceedingly sparse. Part II 'Du Louis XVI á nos jours', page 481 mentions a few makers - Paul Garnier 1847, Le Roy 1854, Vérité, Constant Force electric escapement, 1856; Hipp 1865. None are illustrated. On page 505, under the title of 'Modern Clock Movements', brief mentions are made of speaking clocks, Ferry in France producing a high capacity battery to run a clock for a year (the English had been obtaining three years back in 1911), synchronous clocks in the USA, quartz crystal clocks and watches, the transistor application to electric clocks by Lavet which enabled Pierre Leroy to develop a whole range of chronostats. Not a single mention of the English contribution. The significance of electrical horlogy is completely ignored by, or lost upon, the author. Not a single example of a French electric clock is illustrated! In the third volume, page 648 of the English section illustrates the mechanism of the Shortt Free Pendulum. The impact of electrical horology upon timekeeping was completely unforeseen by Tardy.

998. New Hampshire Clocks and Clockmakers. Charles S Parsons. 1976. Exeter, New Hampshire. The only reference is on page 326 to the gallery timepiece made by John Osgood for the Haverhill Church, New Hampshire, which has plates the size of those used in a longcase movement, and is now electrically driven. As with many American regional clock books, the indexing is rather poor.

999. *The Collector's Dictionary of Clocks*. H Alan Lloyd. 1964. London. There are a number of entries relating to electric clocks: p 30 Alexander Bain, p 31 illustration of Bain wall clock in the Science Museum, p 49 Butterfly for Hipp toggle contact, p 61 Edwin Craig, illustrations of his rolling ball clock - figs 150 and 151 on p 62. Hipp is mentioned p 108 with an illustration of the Hipp toggle clock at the Science Museum, mistakenly referred to as a butterfly contact, pp 109-110 briefly outlines Frank Hope-Jones' career; W H Shortt's Free Pendulum is described with an illustration of the mechanism and a line diagram. All these entries are very brief and contain little information not provided elsewhere.

1000. *The History of Clocks and Watches*. Eric Bruton. 1979. London. There are many references to aspects of electrical horology in this work, however Chapter VIII, pp 167-181, covers the whole gamut of the subject, the early part taken from Charles K Aked's articles. The usual Bain portrait is given on p 167, there is a good colour illustration of the Clockmakers' Company Bain clock on p 170, on the same page is an illustration of the Electric Telegraph Company's Time Ball in the Strand. The author is not *au fait* with electrical horology, for example he ascribes the quartz crystal ring oscillator to Essen, it was devised by Dye and improved by Essen, following Dye's death when Essen took over the research work at the National Physical Laboratory, Teddington. The Electronic watch is covered pp 198-203, with 5 illustrations, including the first Hamilton electric watch movement, the Bulova Accutron, and the Omega Chronoquartz. Useful presentation to gain a quick understanding, but of little use to anyone with a modicum of knowledge in the electrical horology field.

1001. "Comparaison des contacts des pendules commandés par Balancier et par roue à rochet". M Stoyko. pp 353-356. *Annales Françaises de Chronométrie*, 18 Année, 4me Trimestre, 2e Série Tome II, 1948, Besançon. (Comparison of the contacts operated respectively by pendulums and escape wheels). A discussion on the relative merits of using a pendulum to operate electrical contacts as against using the arbor of a wheel such as the escape wheel. The contacting by pendulum, although of a short duration, is preferred. The author states a photoelectric arrangement would be even better but for the trouble in maintaining such a complicated system. The contacting using an arbor leads to variability between the contacting periods. French text.

1002. Still More Tiffany Facts". pp 773-774. NAWCC *Bulletin*, Whole No 160, October 1972. Letter from Mr Greiner of Breckenridge, TX, disputing some of the facts given by J F Coleman in the February issue of the *Bulletin*. Mr Coleman points out that Mr Greiner's description of the operation of the Tiffany Never-Wind does not differ materially from his own, the confusion arises because Mr Greiner assumes anticlockwise rotation of the clock hands when viewed from the rear of the clock! Mr Coleman points out that they still turn clockwise.

CHRONOLOGICAL LISTING OF ENTRIES

81

8

NAME LISTING