

# TELTRON'S TEL-X-OMETER® FOR X-RAY PHYSICS

- Designed for teaching.
- Complete System fits on a laboratory table.
- Lab manual includes 38 laboratory experiments.
- Complete set up and operating instructions.
- Easy to set up and use.
- Safety system and maintenance manual included.
- Complies with Federal radiation protection standards.
- Compact size, light-in-weight, easy to store.

## TEL 2580/2581 TEL-X-Ometer® With Tube

The Tel-X-Ometer x-ray machine and accessories have been designed specifically for use in teaching physics. Thirty-eight separate x-ray experiments (which begin with basic concepts of x-ray through complex experiments) are included in the laboratory manual provided with each system.

The x-ray machine can be carried easily by one person and set up on a laboratory table with all accessories conveniently at hand. Calibrations and scales on the x-ray machine and accessories are clear and easy to read, even when teaching to a group of students around the table.

We have built user safety into each machine through a number of safety switches and protective x-ray absorbing shields. Safety switches prevent operation if all covers are not closed and in the operating position. In addition, a keyed master switch gives the instructor complete control over the machine's operation.

TEL 2580M/2581

## The Experimental Zone

The Tel-X-Ometer is basically a Spectrometer which can easily be adapted to become:

1. A Broad Beam of X-rays for analysis of the General Properties of X-rays.
2. A Single Bragg Diffractometer having a scale accuracy of 5 minutes of arc.
3. A Powder Camera for Debye/Scherrer experiments to an accuracy of 30 minutes of arc.
4. A fluorescent Radiation Emitter for a study of the Moseley Theory that every element is characterized by its Atomic Number.
5. An Experimental region for the mounting of innovative studies of the teacher's choice.

The illustrations show the unit was designed to provide maximum didactic impact both for practical studies and for demonstrations. The special X-ray tube, TEL 2581 protrudes through the cast aluminum base of the spectrometer table and is mounted within a

lead-glass transparent dome. This thick lead-glass dome is held in position by a special interlock system which incorporates two micro-switches connected in series. If the dome is not completely closed the unit cannot be operated.

From one side of the dome is emitted the X-ray beam, the axis of which is parallel with the surface of the spectrometer table. The whole experimental zone is bounded by a transparent cover made of 4mm thick plastic containing a large proportion of chlorine to absorb scattered radiation. The direct beam is absorbed by a 1mm thick lead backstop permanently fixed to the plastic radiation cover. Displayed on this backstop is the international radiation symbol where the outside diameter of the trefoil represents the maximum diameter of the uncollimated X-ray tube.

Access to the experimental zone is achieved by releasing the radiation cover and lifting upwards. A fail-safe interlock comprising two micro-switches in series is incorporated in the hinge mechanism.

## Experimental Zone

### 1 TRANSPARENT PLASTIC COVER

Experimental zone covered with 4mm thick plastic cover containing high percentage of chlorine to absorb scattered radiation. Lead backstop on cover absorbs direct beam rays. Micro-switches prevent

accidental operation of x-ray when scatter shield is open.

### 2 X-RAY TUBE

Mounted in lead glass transparent dome which absorbs x-rays, except those directed into experimental zone. Held in position by special interlock which incorporates two micro-switches.

## Electronic System

### 3 20-30kV SELECTABLE SWITCH

### 4 TUBE CURRENT ADJUSTMENT

Vary from 20-100 micro-amps.

### 5 ELECTRICAL TIMER SWITCH

0-55 Minutes range.

### 6 KEY SWITCH

Allows instructor to have control over unit.

### 7 VISIBLE LIGHT

Advises operating state of x-ray machine.

## Mechanical System

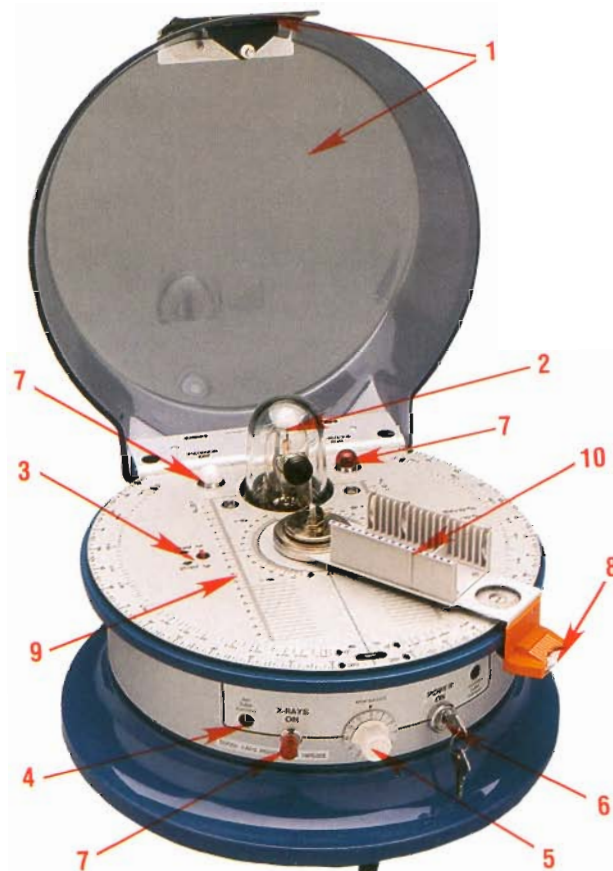
### 8 VERNIER SCALE

Reads to nearest 5 minutes of arc providing for precise data-taking.

### 9 2:1 SPECTROMETER DRIVE

### 10 SLIDE CARRIAGE

30 positions allow variety of accessories to be positioned in experimental zone.



# TELTRON'S TEL-X-OMETER® FOR X-RAY PHYSICS

## The Electronic System

The Spectrometer Table is supported in the horizontal plane by the flanged metal cylinder in which is housed all electronic circuits. On the front is located the control panel. Fuses and power supply selector switch are accessible on the underside of the cylinder.

The Tel-X-Ometer is supplied preset to operate at 30kV and 50 $\mu$  A. A small slide switch on the surface of the spectrometer table permits an alternative voltage of 20kV to be selected. High Voltage is derived from a solid state inverter circuit, followed by a Cockcroft-Walton type multiplier to provide a smooth DC output.

The regulation is such that when the optional 20kV anode voltage is selected the tube current will remain at 50 $\mu$  A. Operational characteristics of the circuit have been chosen to ensure that at both settings of the anode voltage, the tube current can be continuously varied from 20 to 80 $\mu$  A, with the high voltage remaining within 1 kV the selected values, 30 or 20kV. The control for varying the tube current is recessed in the control panel and should not be adjusted without monitoring the current using the jack-plug provided and an external 150 $\mu$  A meter.

The high voltage generator operates at high frequency which provides an audible indication that the instrument is operating. An external audible indicator can be connected if required by means of the jack-plug recessed in the control panel.

The Selector Switch on the underside of the flanged cylinder allows the Tel-X-Ometer to operate from 110, 220 or 240 volts  $\pm$  10%, 50 or 60 Hz single phase.

Power is supplied to the unit by a grounded power cord 2 meters in length.

## The Mechanical System

The rotary mechanism mounted at the axis of the spectrometer table is coupled by a planet-wheel 2:1 drive system to the spectrometer radial arm. A spring-loaded clutch permits the 2:1 drive to be disengaged.

The slide-carriage fixed to the radial arm accepts 50mm square slides, a Geiger-Muller tube holder and a variety of objects supplied in the accessory kits. The carriage arm can be rotated from 10° to 130° on either side of the beam axis—the spectrometer zero line. It can also be locked in the axis of the beam. The Manual Control for the arm and the Fine Adjustment Control are located at the extremity of the carriage arm and outside the radiation cover.

## Safety Interlocks & Indicators

When the plastic radiation cover is raised, the micro-switches interrupt the supply to the anode of the X-ray tube. Only on closing the cover and operating the spring returned "X-rays ON" push-button (RED) can the high voltage supply to the anode be reestablished. As a further safeguard an electrically operated "TIME SWITCH" is built into the system. Lapsed times can be selected up to a maximum of 55 minutes. A friction override is provided to shorten or lengthen the lapsed time as required.

The "X-rays ON" lamp (RED) and the "POWER ON" lamp (WHITE) are located on the surface of the spectrometer table where they can be readily observed.

The heater of the X-ray tube is activated by the "TIME SWITCH" and is visible through the lead-glass dome. This acts as a secondary indicator.

## Radiation Protection for Students

The Tel-X-Ometer complies fully with safety standards established by the U.S. Department of Health, Education and Welfare in the 1968 "Radiation Control for Health and Safety Act." Radiation dose rate at 0.1m from the accessible surface of the apparatus will not exceed 0.1mrem/hr. under normal operating conditions.

A card is included with each instrument for affixing to the door of the room where the Tel-X-Ometer is to be operated. This is a recommendation of the International Commission on Radiation Protection (ICRP).

A special lead-glass cover surrounds the X-ray tube itself, absorbing all X-rays, except those aimed at the experimental zone in a directed stream. A thick plastic transparent dome absorbs scattered radiation produced during system operation. The X-ray tube will only operate when both the lead-glass cover and plastic dome are closed, activating a three-contact-point interlock system. In addition, a lead backstop, attached to the dome, absorbs the X-rays that have passed through the experimental zone.

## A Comprehensive X-Ray Curriculum

With a Tel-X-Ometer X-ray System students benefit from a complete X-ray physics curriculum—beginning with simple concepts and proceeding to the most complex. Over 38

different experiments can be performed with the complete Tel-X-Ometer X-ray System. Or you can choose one of four smaller packages designed for one area of specialization. Every System comes with detailed instructions on all experimental procedures. All Systems can be upgraded by purchasing accessories separately.

## The Laboratory Manual

A comprehensive laboratory manual is included with the Tel-X-Ometer x-ray machine which provides detailed information on some 38 different experiments which can be performed with the x-ray machine and various accessories. Also included in the 50 page manual are "teacher's notes" concerning information which is not normally found in standard textbooks.

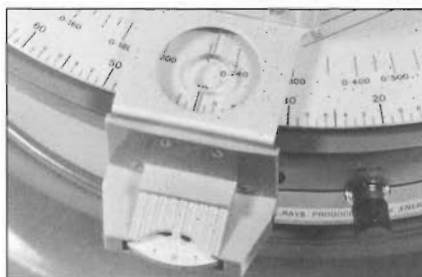
## TEL-X-Ometer® X-Ray Accessories

An effective method of purchasing the TEL-X-Ometer is with the Systems concept because the x-ray machine and various accessories are selected to perform a series of experiments. You may put together your own individualized systems by starting with the basic x-ray machine and x-ray tube and adding accessories from time to time. The Tel-X-Ometer x-ray machine and accessory components are individually priced and can be purchased separately. See page 28 for complete descriptions of all Systems.

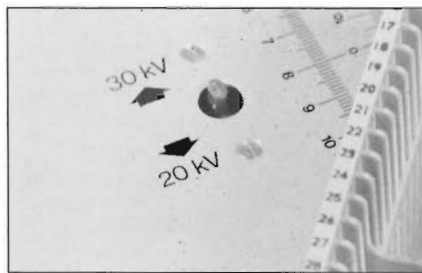
## Separate Components

**All components are also available separately.** If you wish, you can design a system yourself by choosing only the specific components you need. Complete specifications for each component are included on the following pages.

MANUAL CONTROL FOR ARM AND FINE ADJUSTMENT CONTROL ARE LOCATED OUTSIDE THE RADIATION COVER.



30 OR 20 KV SETTINGS ALLOW TUBE VOLTAGE TO BE CHANGED.



X-RAY ON LAMP, POWER ON KEY LOCK, AND TIMER ARE POSITIONED ON FRONT PANEL OF X-RAY UNIT.



POWER SELECTOR SWITCH AND FUSES LOCATED ON UNDERSIDE OF CABINET.



# TEL-X-OMETER® ACCESSORIES

## TEL 2581 Miniature X-Ray Tube

This is a hard vacuum, hot cathode X-ray tube designed for the Tel-X-Ometer. It has a copper target anode.

A thin concave bubble window of 0.25mm thickness is hand blown into the borosilicate glass envelope to transmit a high proportion of the characteristic radiation without recourse to other more expensive window techniques.

The cathode is a helical filament made of tungsten wire and the cathode/anode geometry provides a very small focal point.

Continuous rating: 30kV, 80 $\mu$  A

Heater supply: 4V 1A

Dimensions: 100mm long, 32mm diameter

Mounting: B13G type

**TEL 2581**

## TEL 582 Basic Accessory Kit

A Kit of 26 components includes Collimators, Luminescent Screen, Film Cassettes and all the items necessary to perform more than 30 experiments.

Thin foils of Nickel, Copper, Cobalt and Zinc are included which are used to evaluate the Mass Absorption Coefficient. They are also used in conjunction with a Rotary Radiator which presents these 4 elements, and in addition Iron, Vanadium, Manganese and Chromium, to the primary X-ray beam. These 8 elements are sequential in the Periodic Table and secondary emission from them is analyzed to verify Moseley's Law. The classical Bragg relationship can be established using large single crystals of Sodium Chloride and Lithium Fluoride and additionally Planck's Constant can be derived from the minimum wavelength cutoff. Small microcrystals of LiF are included to record Laue and upper layer-

line photographs. Finely divided LiF powder and copper wire strands can be used to demonstrate Debye-Scherrer analytical techniques with a special self-locating Powder Camera. The Powder Camera and Film Cassette included in Kit 582 have been designed for use with the Teltron Filmpaks.

**TEL 582**

## TEL 583 Crystallography Kit

This kit of 16 prepared elements is intended to supplement the Basic Kit.

For a more comprehensive study of Moseley's Law four more thin foil slides are included. They are Iron, Vanadium, Manganese and Chromium. Together with the 4 slides in the Basic Kit, there can now be 8 thin foil slides to be used in conjunction with the 8-element Rotary Radiator.

There are 5 vials of finely divided powders, 2 vials of drawn wire and large single crystals of Potassium Chloride and Rubidium Chloride. All of these materials are used in a carefully integrated study of the salient features of crystallographic analysis.

The Kit contains a Reciprocal Lattice Calculator for calculating at which angles of the GM tube carriage ( $2\theta$ ) reflections may be expected from each of the four single crystals.

**TEL 583**

## TEL 584 Radiography Kit

This kit is also intended to supplement the Basic Kit. It is designed for teaching X-ray applications for nondestructive testing, and for adult education courses.

It includes 16 components with which the production and properties of X-rays can be studied. Additional emphasis is given to scattering, differential absorption and linear ab-

sorption coefficients; to the relationship between penetration, resolution and exposure time, accelerating voltage and tube current.

Experimental evidence of the importance of shielding materials, half thickness and radiation terminology are all highlighted through simple practical experience involving the components of the kit.

**TEL 584**

Individual items in the 582, 583 and 584 accessory kits can be purchased separately.

## TEL 2003/2030 Autoscan and Scan Console With Bracket

The Autoscan unit with scan console is designed to rotate the powder camera sample as well as to move the Tel-X-Ometer carriage arm. When used with the powder camera it rotates the sample at 7.5°/step. If used with the carriage arm steps of .03° result. The scan console provides pulses to initiate each step. Four pulse rates are selectable 3, 12, 60, 120 PPS. Additionally, the scan console allows for clockwise or counter clockwise motion.

**TEL 2003/2030**

## TEL 750/2 and TEL 750/4 Teltron Filmpaks

The teaching impact of processing photographic film in the classroom immediately after exposure and without a dark room is obvious.

High speed X-ray film is sealed in thin, black p.v.c. envelopes with two apertures to accept the injector tube of a syringe without admitting light. After exposure to beta-, gamma- or X-rays, film is developed rapidly by injecting the processing fluids into the envelope which is thin enough to permit the necessary agitation.

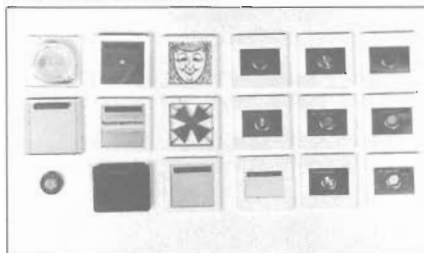
TEL 2581 MINIATURE X-RAY TUBE



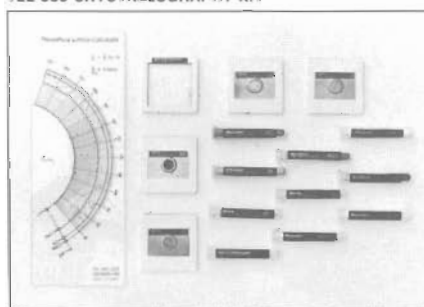
TEL 582 BASIC ACCESSORY KIT



TEL 584 RADIOGRAPHY KIT



TEL 583 CRYSTALLOGRAPHY KIT



TEL 2003/2030 AUTOSCAN AND SCAN CONSOLE



TEL 750/2 AND TEL 750/4 TELTRON FILM PAKS



# TEL-X-OMETER® ACCESSORIES

After processing is complete (about 2 minutes) the envelope is cut open and film removed with a special clip provided. Filmpaks 2 and 4 are supplied complete with syringe, injector tube, developer and fixer fluids and film clip.

## X-RAY FILM AVAILABLE IN TWO SIZES:

**TEL 750/2** Quantity 20

**For Radiographs (38 x 35mm)  
FILM AND CHEMICALS**

**TEL 750/4** Quantity 14

**For Powder Camera (150 x 12mm)  
FILM AND CHEMICALS**

**TEL 750225** Quantity 25

**For Radiographs  
FILM ONLY**

**TEL 750425** Quantity 25

**For Powder Camera  
FILM ONLY**

## TEL 588 Ionization Chamber

A simple didactic ionization chamber which can be mounted on the slide carriage of the Tel-X-Ometer to investigate the ionizing intensity of the X-ray beam. It can also be used to calibrate the G.M. Tube.

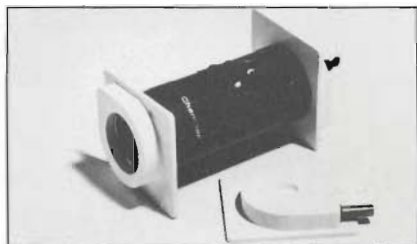
The chamber is demountable and can be used at atmospheric pressure, evacuated or gas filled. It is supplied complete with open and closed windows and connectors. Polarization is up to 2,000 volts DC. A DC amplifier capable of measuring current down to  $10^{-11}$  DC amps is required. The TEL 2808 Picoamplifier recommended.

**TEL 588**

## TEL 2546/7 Geiger-Muller Tube With Holder

The majority of experiments which can be performed with the Tel-X-Ometer require the X-rays to be detected by a GM Tube in association with a Ratemeter or Scaler.

TEL 588 IONIZATION CHAMBER



TEL 2546/7 GEIGER-MULLER TUBE WITH HOLDER



The typical intensities and recommended geometric conditions detailed in the laboratory manual are all relevant to the GM Tube TEL 2546/7. The Ratemeter TEL 2807 and the Scaler TEL 2806 have been designed to monitor Tel-X-Ometer experiments with both simplicity and maximum didactic impact.

**TEL 2546/7**

## TEL 2807 Ratemeter

The 2807 Ratemeter is designed to be used with the Tel-X-Ometer. It accepts a pulse input from a GM tube via a BNC connector. It has an adjustable audio signal.

Output channels (4):

Channel 1 - 0-2000 cps  $\tau = 1s$

Channel 2 - 0-20,000 cps  $\tau = .75s$

Channel 3 - Monitors integral GM tube polarizing supply. Supply is variable from 250-500 VDC.

Channel 4 - Monitors auxiliary current input, maximum load 200 $\mu$ A

All Channels have twin 4mm outputs of 0-200mV and 0-1V for use with a computer interface or chart recorder. Requires Power Supply TEL 2014 and Alarmed Meter TEL 2021.

**TEL 2807**

## TEL 2806 Scaler

The TEL 2806 Scaler is designed to be used with the Tel-X-Ometer. It accepts a pulse input from the GM tube via a BNC connector. It has an adjustable audio signal.

Output channels (3):

Channel 1 - Ratemeter or Scaler mode, switchable

Ratemeter mode: 0-2k,  
0-20k cps

Scaler mode: 2 ranges 0-200 cps with count time of 30 or 60 seconds, selectable; 0-2k cps with count times of 3 or 15 seconds, selectable.

Channel 3 - Monitors integral GM tube polarizing supply, variable from 250V-500V.

Channel 4 - Monitors auxiliary current input. Maximum load 200 $\mu$ A.

All Channels have twin 4mm outputs of 0-200mv, however channels 1 and 4 only have a 0-1V output for use with computer interfaces or chart recorders. Requires Power Supply TEL 2014 and Alarmed Meter TEL 2021.

**TEL 2806**

## TEL 2808 Picoamplifier

The TEL 2808 Picoamplifier is designed to be used with the Tel-X-Ometer. It accepts a current input via a BNC coaxial connector. It has a set zero control and the input circuit is shielded.

Output channels (2)

Channel 1 -  $0 \pm 200 A \times 10^x$  where "x" is switched to 9,10,11,12

Channel 2 - Monitors auxiliary input; max load 200 $\mu$ A. Both channels have twin 4mm outputs of 0-200 mV and 0-1V for use with computer interfaces or a chart recorder. Requires Power Supply TEL 2014 and Alarmed Meter TEL 2021.

**TEL 2808**

## TEL 2021 Alarmed Meter

Designed to be used with TEL 2806, 2807, 2808 it has 4 selectable input channels which reads the 4 output channels of the afore mentioned units. High and low audible alarms can be set. Meter is powered by the host instrument.

**TEL 2021**

## TEL 2014 Power Supply and TEL 2017 Input Divider

This power supply is designed to power TEL 2806, 2807, 2808 as well as the Autoscan unit. The input divider allows the power supply to be used with two units simultaneously.

**TEL 2014**

**TEL 2017**

TEL 2021 AND TEL 2014/2017



TEL 2806, TEL 2807 AND TEL 2808



# TEL-X-OMETER® X-RAY SYSTEMS

TEL-ATOMIC PACKAGED SYSTEMS  Components Listed Make Up Complete Tel-X-Ometer Packages	TEL 580 Tel-X-Ometer	TEL 2581 X-Ray Tube	TEL 582 Basic Accessory Kit	TEL 583 Crystallography Kit	TEL 584 Radiography Kit	TEL 2003 Autoscan and TEL 2030 Scan Console	TEL 588 Ionization Chamber	TEL 2546/7 GM Tube and Holder	TEL 2806 Scaler	TEL 2807 Ratemeter	TEL 2808 Picoamplifier	TEL 2021 Alarmed Meter	TEL 2014 Power Supply with Input Adaptor	TEL 750/2 Filmpak 2	TEL 750225 Extra Film for Filmpak 2	TEL 750/4 Filmpak 4	TEL 750425 Extra Film for Filmpak 4	TEL 2813 KV Power Supply	Price
	Basic System TEL TS2580B	X	X	X		X			X	X			X	X	X	X			
Crystallography System TEL TS2580C	X	X	X	X		X		X	X	X		X	X	X	X	X	X		
Electromagnetic Radiation & Quantum Theory System TEL TS2580E	X	X	X	X				X	X			X	X	X	X				
Advanced System TEL TS2580A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Radiography System TEL TS2580R	X	X	X		X									X	X				

## Designed for Teaching Physics

Tel-X-Ometer Systems provide all the apparatus required to perform a number of comprehensive x-ray experiments.

Each System includes a 50 Page lab manual which details 38 experiments in x-ray physics, crystallography, radiography, electromagnetic radiation and quantum theory.

### TEL TS580B Basic X-Ray System

With the Basic System students can perform 19 x-ray detection experiments using photographic techniques and the Geiger-Muller tube. Properties of x-ray, such as rectilinear propagation, inverse square relationship, and penetration and absorption can be shown.

TEL TS580B

TEL TS580A ADVANCED X-RAY SYSTEM

### TEL TS580C Crystallography System

With the Crystallography System all experiments in the Basic System can be performed plus 11 additional crystallography experiments. Experiments with the powder camera are included to let the student learn about Debye-Scherrer analytical techniques.

TEL TS580C

### TEL TS580E Electromagnetic Radiation & Quantum Theory System

This System allows students to perform basic x-ray physics experiments including x-ray diffraction evidence, Laue, wavelength measurement, the Bragg relationship, x-ray emis-

sions, scattering and absorption.

TEL TS580E

### TEL TS580A Advanced X-Ray System

The Advanced System includes all apparatus required to perform all 38 experiments described in the laboratory manual.

TEL TS580A

### TEL TS580R Radiography System

This package was designed for classes concentrating on radiography, especially in the medical and material sciences field. Experiments cover film techniques, contrast, definition, sensitivity and resolution.

TEL TS580R

