INTRODUCTION AND DESCRIPTION

DATA SYSTEM SERIES S-1

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SECTION I

TECHNICAL DESCRIPTION

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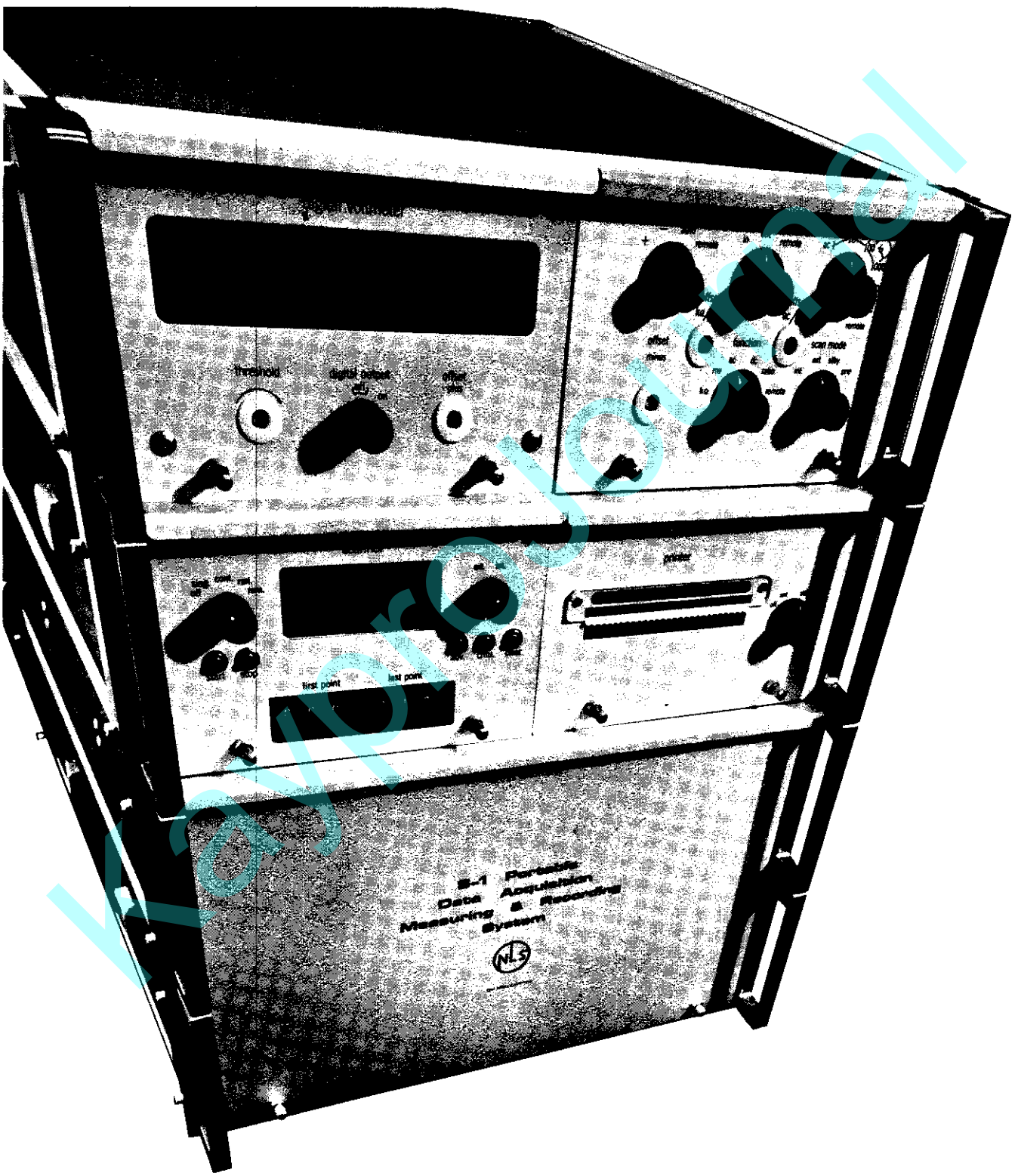

Basic S-1 Data System

DESCRIPTIVE DATA NLS S-1
For
A DATA ACQUISITION SYSTEM
Offered by
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

1.0 GENERAL SUBMITTAL

Non-Linear Systems, Inc. herewith submits its technical description of a multi-function, multi-channel S-1 Data Acquisition System. The purpose of this description is the discussion of engineering approaches relative to data acquisition and recording.

1.1 SYSTEM CONCEPT

The S-1 System will scan and accurately measure and record a wide range of input parameters, including DC voltages, AC voltages, resistance and transduced signals. Compatible output recording on a variety of devices, such as magnetic tape, punched paper tape, IBM cards, printed paper tape and printed page, or combinations of the above, is provided.

The system will be comprised of a basic data acquisition sub-system supported and expanded by the addition of optional units.

It is the intent of this description to delineate the most practical cost/performance trade-offs within the state-of-the-art. In every case, needs and accuracies, as outlined, are considered to be the dominant parameters. The methods and equipment here described are based on the requirements of general data acquisition tasks.

1.2 DESIGN CONCEPT

The design discipline of the S-1 Data System was born of experience. Recognizing the need for new technologies and methods in data acquisition, Non-Linear Systems designed and produced the S-1. Of prime importance were the consideration of accuracy, speed, versatility and physical size. To guarantee maximum reliability, STANDARD, mass produced sub-assemblies and modules are used throughout.

MEASUREMENT DEVICE

In order to achieve the highest possible accuracy and resolution, a five-digit measuring device was chosen.

One of the most important parameters in a data acquisition system is the resolving power or resolution of the digital voltmeter. Resolution is defined in terms of digits or powers of ten. For instance, a resolution of a data acquisition system is determined by two factors.

Factor 1 - The magnitude of the differences that the experimenter is attempting to discern between input channels, or changes occuring in one channel between two points in time.

Factor 2 - The accuracy to which the unknown inputs must be measured.

Both factors can be explained in terms of accepted, conservative design practices. In order to conduct a test to a specific overall system accuracy, the accuracy of the measurement device (digital voltmeter) should be five to ten times that of the overall system accuracy requirement. In turn, the resolution of the measuring device should be five to ten times that of its accuracy. Therefore, a 5-digit digital voltmeter makes an excellent base for an accurate, expandable data acquisition system

To further insure the highest possible accuracy, successive approximation logic was employed in the digital voltmeter. Successive approximation provides greater inherent accuracy and speed than integrating or tracking techniques. Higher resolution without a 1-digit count variance typical of integrate/count voltmeters, is an advantage of successive approximation. Also, the critical temperature coefficients and drift of voltage to frequency converters are avoided. Higher system speed is another advantage of scan logic. Measuring speeds, thirty times faster than integrating digital voltmeters, can be made to full 5-digit resolution.

NOISE IMMUNITY

Where noisy inputs are encountered the higher accuracy and stability of the successive approximation technique is preserved through the use of active filter circuitry. The integrating action of the active filter method incorporates all the advantages of

integrating digital voltmeters without the disadvantages of instability, temperature drift and counter error. Noise attenuation and CMR specifications are superior to integrating DMV's. A table appears in the specification section of the X-1 DVM brochure comparing integrating DVM's with active input filter techniques.

COMMON MODE CONSIDERATIONS

The design concept of S-1 maintains the higher voltmeter accuracy by fully floating and guarded input switching in the scanner. Unlike many "piece together" data systems which degrade voltmeter CMR and accuracy by incompatible interfacing, the S-1 preserves the CMR and accuracy by box-in-box switching techniques and design integrity throughout. All signal paths are fully shielded, fully floating, and fully guarded. Outputs from the DVM to the various recording mediums are fully isolated from all input circuitry.

Noise effects when measuring AC voltages or resistances are further decreased in the S-1 because the preamplifier, AC/DC and Ohms/DC converters are an integral part of the multimeter. That is, the source signals are routed directly to the multimeter from the scanner. No intermediate chassis or cables, which may degrade CRM are required.

INPUT SWITCHING

To enhance S-1 flexibility, several types of input switching methods are available. All methods provide floating, guarded box-within-box construction. The methods differ only in number of switched inputs and switching mediums. For high speed applications, reed relays and James Microscan switches are available. For medium speed and larger input arrays, XBAR switching is available. All options use the same control and drive electronics and are fully compatible with the system equipment. All inputs are easily accessible through NLS furnished mating connectors. The Standard S-1 System is supplied with crossbar switch. Options permit substitution of reed relay switches for higher speed operation. The Standard S-1 System includes a 600-point crossbar switch featuring:

* Gold plated low noise contacts
* Flexible input configurations
* 1 microvolt to 1 kilovolt switching
* Fully floated and guarded switch

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S-1 System with 100 Channel High Speed Scanner, Serializer, Digital Clock

SCANNER CONFIGURATIONS

600-Channel, One-Wire	-	Recommended where low cost-per-channel is required. For guarded or differential operation, see below.
300-Channel, Two-Wire	-	Employed where differential or isolated measurements are necessary.
200-Channel, Three-Wire	-	Best configuration for fully-floated guarded inputs.
100-Channel, Six-Wire	-	Suggested for low resistance measurements and automatic function select capability. Customer may also use one or more poles for programming equipment external to the system.

SCANNING SPEED

The switching time for the crossbar switch is 20 milliseconds. This delay is not an appreciable part of a Scan-Read Record cycle unless the magnetic tape recorder option is taken.

CHANNEL EXPANDABILITY

Up to 1000 channels may be controlled by the S-1 System. Increments of 600 points may be added to the basic 600-point system.

OPTIONAL REED RELAY SWITCHES

In applications where high speed operation precludes a crossbar switch, reed relay switches may be used. Both IBM reed relays and James Microscan relays are available. The IBM reed relay is used for high level (to 300V maximum) operation while the James Microscan relays are extremely low noise (1 microvolt) switches. Fifty 3-wire channels of Microscan relays, or 100 3-wire channels of IBM reeds may be substituted for the 600-channel crossbar at no additional charge. Either substitution reduces the basic system to 15-3/4" rack height. All switches are fully floated and guarded.

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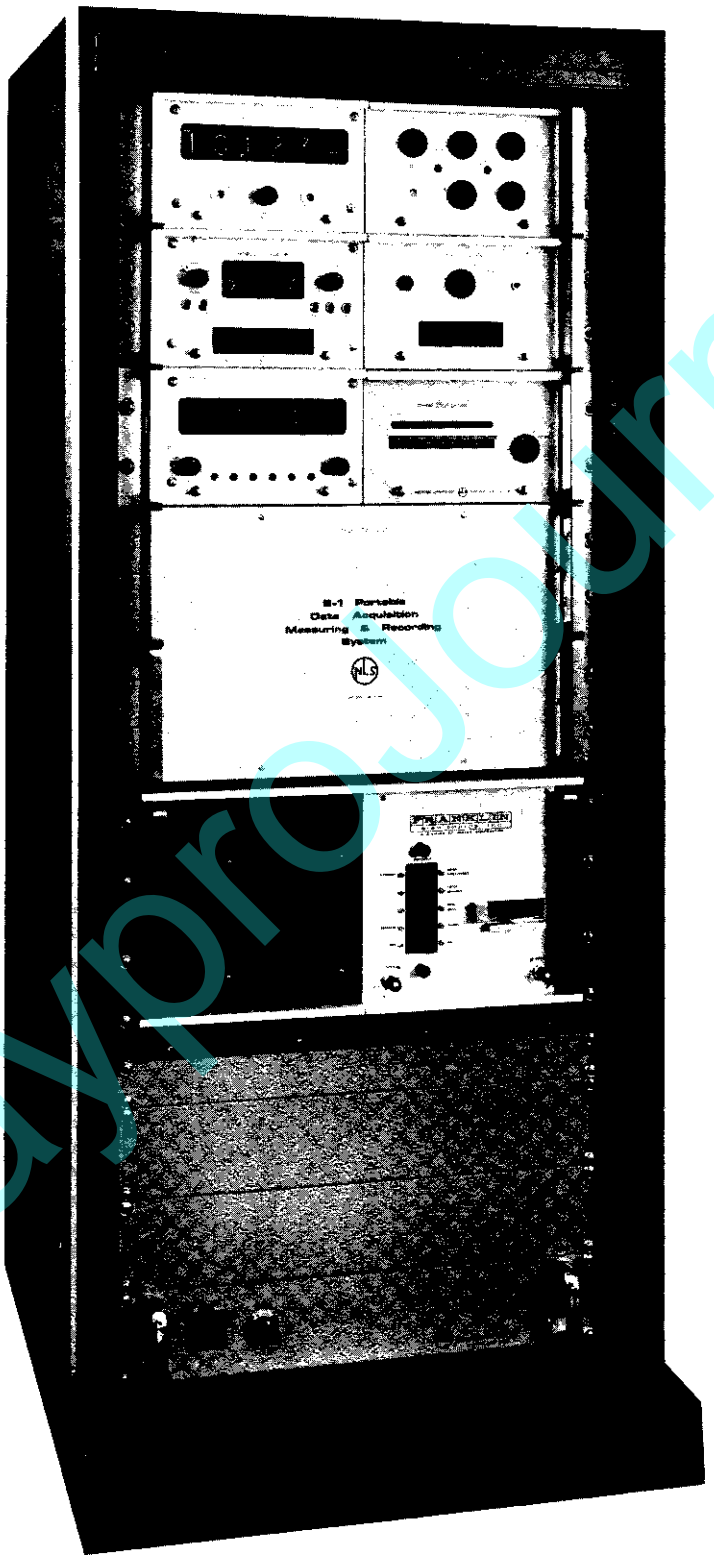

S-1 Data System with High Speed Printer Option

OUTPUT RECORDING

The S-1 Data System encompasses a variety of output recording devices. The design objective was to meet the need for an interface that would handle printed paper tape, printed page, punched paper tape, punched card, and incremental magnetic tape. S-1 provides the necessary interface and drive capabilities for all.

Printed paper tape recording at medium speeds is accomplished by our own one-half rack size 5-1/4" 12 column data printer. For high speeds, a Franklin 1200 or 2000 series printer is used. For printed page recording, the S-1 will drive Friden Flexowriters, ITT Series ASR-33 and ASR-35 Teleprinters, as well as IBM Selectric typewriters. Punch paper tape perforators include Tally 420, Tally P120. Magnetic tape transport options include Digi-Data, Kennedy and Potter units.

The output devices do not degrade the inherent accuracy, resolution, and CMR specifications of the S-1. Output from the digital voltmeter to the recording mediums is through isolating circuitry.

For serial recording devices, such as paper tape, magnetic tape, and typewriters, the output control is supplied by a one-half-rack, 5-1/4-inch high serializer module. The serializer unit is in itself a completely flexible interface. It provides output recording control, as well as fixed data thumbwheel switches for entry of heading, batch, log and data numbers. The serializer will also accept external alphanumeric keyboard inputs for magnetic tape and punched tape addressing.

EXPANSION

Digital Comparator

Versatility of the S-1 is further increased through the half-rack module concept in the area of limit detection. A digital comparator is available. The comparator is a fully compatible companion to the entire system. It has MANUAL and REMOTE limit setting, as well as controls to permit recording of the limit data within the system format. The comparator also provides selection for recording only Out of Limit HI or LO data, or both. Illuminated indicators provide visual information as to limit states.

Programming

Where channel-by-channel programming is required, another fully compatible one-half-rack module provides discrete selection. Pinboard type plug-in construction

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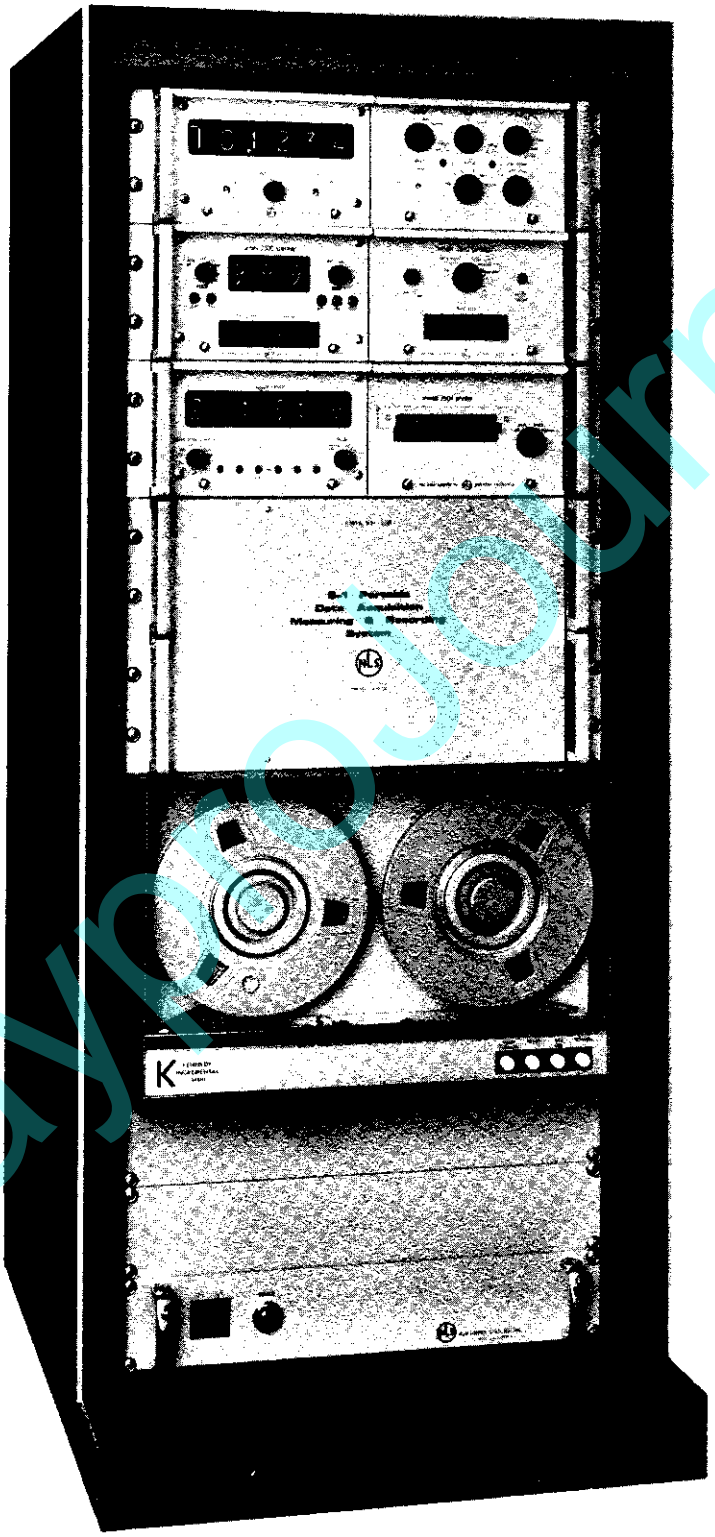

S-1 Data System with Magnetic Tape Option

programs the measuring device for function (AC, DC, Kilohms, millivolts, etc.), range (5 ranges) and polarity (+, - or AUTOMATIC). Programmed channel skipping is also a feature of this accessory.

1.3 FEATURES

The S-1 Data Acquisition System contains the following capabilities and features.

* Four wire Kelvin connectors for Ohms
* Full scale ranges for 10 Ohms to 100 Megohms with extended range ohms option
* Dual output recording options
* Automatic time start and recording option
* Ohms, AC & DC volts, and millivolts measurements and recording

2.0 SYSTEM COMPONENTS

The basic S-1 System consists of the following components and is illustrated in block form in Section II.

2.1 ONE NLS MODEL 2301 INPUT SCANNER

Model 2301 is a 200-point, 3-wire Scanner with illuminated in-line digital display of channel being monitored; recordable channel identification outputs; indicating thumbwheel switches for first and last point selection. Model 2301 is also capable of random access remote programming of any channel. Model 2301 is convertible to 100-point, 6-wire, 600-point, 1-wire, or 300-point, 2-wire.

Speed at least 25 channels/second. All channels capable of up to 1000-volt operation. With thermal EMF's less than 1 microvolt and gold contacts. Model 2301 exceeds 110 db common mode rejection and uses fully floating, fully guarded box-within-box construction. Scan modes include manual step, single scan and continuous scan, with local and remote start and stop switches and visual indication of readiness state. Further details in Section III.

2.2 ONE NLS SERIES X-1 DIGITAL VOLTMETER

Series X-1 is a solid-state, chopperless, 5-digit, digital multimeter with 6th-digit 20% over-ranging. Series X-1 contains operational amplifier active filter that integrates noisy volts or ohms inputs and makes possible better rejection characteristics

than existing integrating type DVM's. Series X-1 input impedance is 10,000 megohms on 0 to 10-volt ranges and 10 megohms on all other ranges. Series X-1 with internal and auto ranging pre-amplifier has resolution of 1 microvolt.

Series X-1 will also perform bi-polar ratio measurements. DC voltages from 1 to 1000 volts can be measured. Full scale ranges of 1199.99 ohms to 11999.9 kilohms are provided. Ranges can be selected automatically or manually. X-1 inputs are fully floating and guarded and completely isolated from the recording outputs. (Ohms specifications in paragraph 3.0.)

2.3 ONE NLS MODEL 2504, 12 COLUMN DATA PRINTER

The Model 2504 Data Printer utilizes all integrated circuit logic with inkless, ribbonless printing. Model 2504 is one-half-rack width size. For format details, see paragraph 6.0.

2.4 OPTIONAL ACCESSORIES

The following options are available as fully compatible plug-in companion to the S-1 System.

2.4.1 ONE ELECTRONIC ENCLOSURES EQUIPMENT CABINET

Cabinet contains power strip, switch, indicator lamp, power cord, blower and filter. Cabinet will be supplied with caster base and blank panels where appropriate.

2.4.2 ONE NLS MODEL DC6ST DIGITAL CLOCK

The DC6ST Digital Clock contains a 6-digit illuminated in-line digital display of hours, minutes and seconds (23 hours, 59 minutes, 59 seconds). Switch selection of timing output at intervals of 1 second to 2 hours will be provided. Time reference will be internally generated from line frequency.

The DC6ST contains recordable time outputs and interlock feature. Interlock feature permits non-ambiguous time recording. Also available is an ultra-stable XTAL time base in place of line frequency. Further details on enclosed data sheets in Section III.

2.4.3 ONE NLS MODEL 2610 SERIAL CONVERTER OUTPUT CONTROL

Model 2610 is a high speed, one-half-rack size, integrated circuit serializer making use of silicon circuits throughout. The Model 2610 contains storage memory to allow time shared system operation. The 2610 Serial Converter contains 6 decades (0-9) of indicating thumbwheel switches for entry of data. Entry of 6 decades of data can be made to form various numeric words. Model 2610 is fully compatible with incremental magnetic tape recorders, paper tape punches and typewriter/punches (ASR-33, ASR-35, etc.).

The Model 2610 Serial Converter accepts data in parallel form from devices such as digital voltmeters, digital clocks, scanners, etc. It converts the parallel input data to serial output data to drive paper tape punches, magnetic recorders, etc. The 2610 makes use of complete plug-in circuit board construction which allows change over from punch to magnetic tape by the substitution of two circuit boards. The 2610 may also be used with an external keyboard to enter alphanumeric data on magnetic or punched tape. Serial Converter will interface with Digi-Data and Kennedy magnetic recorders, Friden Flexowriters, IBM typewriters, and Tally punches and Teletype equipment. For descriptive data, see Section III.

3.0 SPECIFICATIONS

The following specifications relate to S-1 performance.

3.1 DIRECT CURRENT VOLTAGE SOURCES

3.1.1 RANGES: Manual, Automatic, Remote Ranging

±1199.99 MVDC ±119.999 MVDC	Accuracy of 0.01% reading ±1 digit or 2 microvolts in 500 milliseconds
±11.9999 VDC) ±119.999 VDC) ±1000.00 VDC)	Accuracy of ±0.001% Full Scale ±0.005% Reading (Under ASA Conditions)

3.1.2 LINEARITY: 0.001% ± 1 digit

3.1.3 INPUT RESISTANCE:

1199.99 and 119.999 MVDC	100 megohms
11.9999 VDC	10,000 megohms
119.999 and 1000.00 VDC	10 megohms

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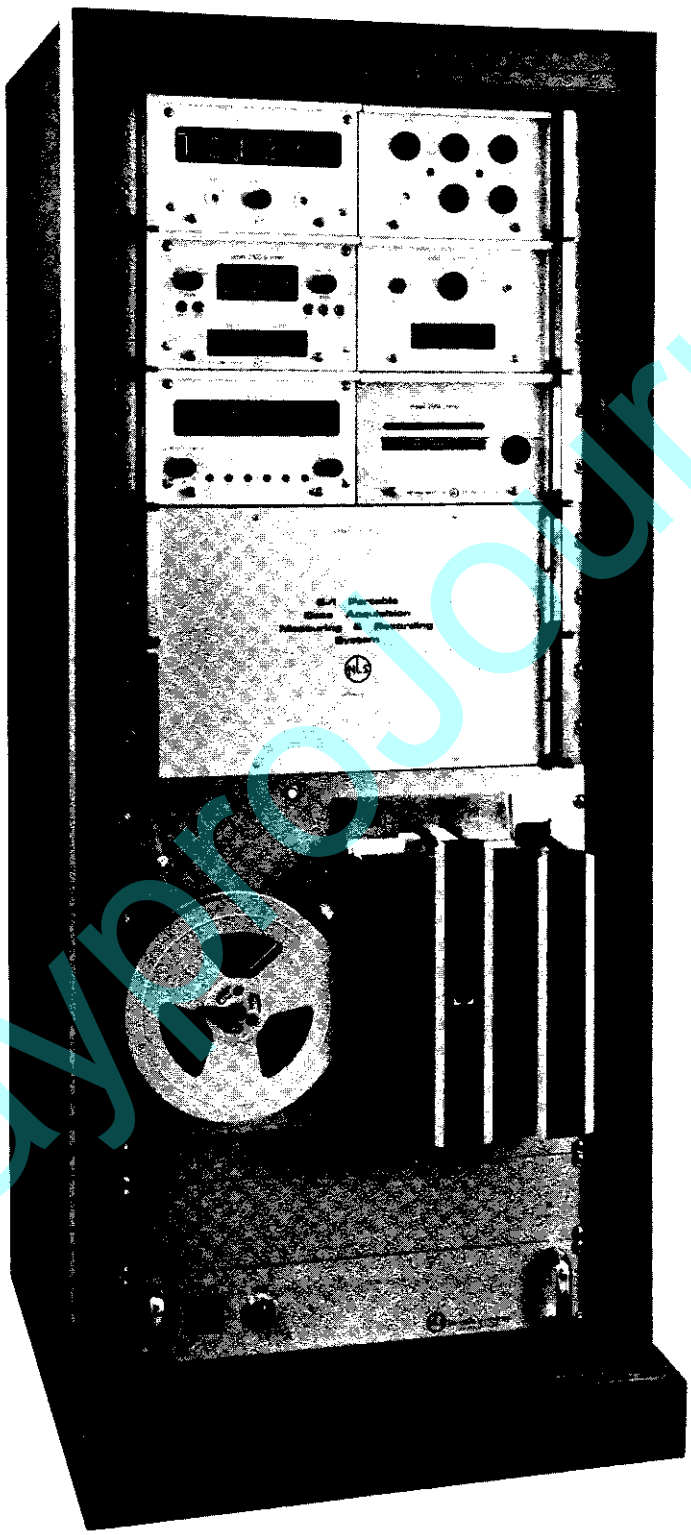

S-1 Data System with Punch Tape Option

3.1.4 NORMAL MODE REJECTION:

Two active filters available (customer's choice)

(1) 37 db at 60 Hz with 170 MS settling time.
(2) 76 db at 60 Hz with 750 MS settling time.

3.1.5 COMMON MODE REJECTION:

DC to 60 cps. In excess of 120 db filtered with up to 100 ohms unbalance in either lead; 110 db unfiltered with 25 ohms unbalance.

3.2 ALTERNATING CURRENT VOLTAGE SOURCES

3.2.1 RANGES:

1.19999 VAC	Accuracy of 0.05% reading or 0.02%
11.9999 VAC	Full Scale, 200 Hz to 3kHz
119.999 VAC	0.1% reading 0.05% to Full Scale
500.00 VAC	50 Hz to 200 Hz and 3kHz to 10kHz

3.2.2 INPUT IMPEDANCE: 1 megohm shunted by 400 pf maximum

3.2.3 SETTLING TIME: 750 MS worst case to 0.01% of final answer.

3.3 RESISTANCE MEASUREMENTS

3.3.1 RANGES:

1199.99 Ohms)	0.001% Full Scale plus
11.9999 Kilohms)	0.01% reading
119.999 Kilohms)	
1199.99 Kilohms	0.001% Full Scale 0.02% reading
11999.9 Kilohms	0.001% Full Scale 0.1% reading (typically .02%)

3.3.2 INPUT WIRING: 4-wire Kelvin

3.3.3 SETTLING TIME: 750 MS worst case to 0.01% of final answer.

3.3.4 SYSTEM SPEED:

- Ohms -	- Volts -
Up to 3 readings/ second	Up to 40 channels/second

3.3.5 SYSTEM SIZE: Basic System

21 inches high, 19 inches wide, 24 inches deep.

3.3.6 SYSTEM WEIGHT: Basic System

Approximately 80 pounds.

3.3.7 SYSTEM OPERATING ENVIRONMENT:

12 to 45° c, to 90% humidity with no condensation.

3.3.8 SYSTEM POWER: 150 watts

4.0 SYSTEM OPERATION

The following discussion will describe typical S-1 System operation and logic cycle with punch tape or magnetic tape option.

System Start

The S-1 System may be started by several independent methods. These methods are: Local Pushbutton, on scanner front panel; Remote Contact Closure, or voltage through connector on rear of scanner control unit: Clock Start by selectable time interval pulses from Model DC6ST Digital Clock. Time intervals are selectable in increments of 1, 2, 10, 20 seconds; 1, 2, 10, 20 minutes; 1 and 2 hours by selector switch on DC6ST front panel.

Assuming clock option is used and clock start method was initiated, system data cycle proceeds as follows:

Scanner Logic Cycle

Upon receipt of a start pulse from the digital clock the Model 2301 Input Scanner moves to the first point as selected by first point thumbwheel switches located on scanner control front panel. The scanner then transmits an encode command to the Series X-1 Digital Multimeter.

Measurement Cycle

Upon receipt of an encode command from the Model 2301, the Series X-1 begins a measurement operation (the ohms technique uses a four-wire Kelvin connection) and upon completion of the measurement cycle, the measured value, DC, ohms or AC, is displayed visually in the readout and electroncially through isolated circuits to the 2610 and 2504. At this time, the Series X-1 issues a record command to the recording devices.

Serialize/Record Cycle

Upon receipt of a record command from the Series X-1, the Model 2610, acting as a central processor, issues a time interlock command to the DC6ST Digital Clock and relays a print command to the Model 2504 Printer. The Model 2610 then initiates a recording process with the punch or magnetic device. The 2610 first directs recording of the time data (days, hours, minutes or hours, minutes,seconds) followed by the channel identification number, manually entered data, if any, and digital multimeter reading. The printer prints time data, channel identification number and digital multimeter reading.

Upon completion of the print/record operation, the Model 2610 signals the scanner to advance to the next channel and the data cycle repeats, excluding time recording which is entered at the initiation of a scan cycle only. Each channel is measured and recorded in sequence until recording of selected last point has been accomplished. At this time, continuation of operation depends on the scanner mode.

Operational Modes

Several modes of scanner operation are possible: Continuous Scan, Single Scan, and Manual Step. Assuming Single Scan mode was chosen (by use of mode switch on 2301 front panel), then system cycle stops after recording last point data. Scanner rests on neutral point awaiting another start command from clock or local/remote initiation. If Continuous Scan was chosen, then after recording last point data, scanner moves to first point and entire cycle repeats until halted by pushbutton stop switch or remote contact closure, or voltage.

If desired, scanner may be operated in manual step mode and advanced to any desired channel. This feature proves extremely useful during set-up and calibration routines and when monitoring particular parameters associated with a specific channel.

Random Access

The Model 2301 control unit provides for external programming of any channel. A connector mounted on the rear of the control unit gives access to "Call-In" any channel by simple Form A remote contact closures or voltage levels. This feature makes possible remote programming of scanner position in cases where system control is externally programmed by punch tape readers, etc. The Series X-1 may also be remotely programmed for function and range. It should be noted here that the 2610 discussed in the above system operation is used only when driving serial entry devices. The printer options are driven directly from the digital voltmeter, clock and scanner.

5.0 SYSTEM CONTROLS

The Model 2301 Control Unit provides the main system controls. Series X-1 and Models 2610 and 2504 provide supplementary component controls. The 2301 controls are as follows:

Mode SW:	Single Scan Continuous Scan Random Access Remote
Drive SW:	External (by system) Internal (by internal clock)
Start Pushbutton	To start system or scanner
Stop Pushbutton	To halt system or scanner
Advance Pushbutton	To manually advance scanner
Continue Pushbutton	To restart from halted position
Clear Pushbutton	To reset to neutral point
First Point Thumbwheels	To select first desired channel
Last Point Thumbwheels	To select last desired channel

Note: All Pushbutton operations are also possible by remote contact closure through rear mounted connector.

5.1 Series X-1 Controls appear in X-1 Brochure, Section III.

5.2 Model 2610 Controls are as follows:

Mode Switch

OFF	Power OFF
RUN	Power ON
RUN & RECORD	On-Line operation
SINGLE RECORD	For local control by single record pushbutton
MANUAL ENTRY	For entry of external data, 1 character at a time from external keyboard
FIXED DATA	For entry of data from local thumbwheel switches

Fixed Data Switches — 6 thumbwheels of 0 to 9 digits for entry of fixed data

5.3 Model 2504 controls provide for ON/OFF and Standby operation and print control, (manual and automatic).

6.0 FORMAT/CODE

Many format and codes are possible. A typical illustration follows.

Printer

YYY F ± XXXXXX Z

Where:
- Y = Channel Number
- ± = Input Signal Polarity
- F = DVM Function (Kilo Ohms) AC, DC, etc.
- X = DVM Digits
- Z = DVM Range Multiplier

Punch or Magnetic Tape (If Option Supplied)

First Point	Each Channel
DD HH MM	YYY T XXXXXX Z G or EF

Where:
- D = Days
- H = Hours
- M = Minutes
- Y = Channel Number
- T = Comparator Decision
- X = DVM Digits
- Z = Range Multiplier
- G = IR Gap
- EF = End of File

Note: Time data recorded at first point only. Code IBM, or other Flexowriter 8 level, or as specified. IR Gap after each reading and End of File after last scan, if desired.

For IBM punch card operation, code and format depends on IBM device. Model 1810 output adapter will supply all necessary data for IBM device/-codes.

7.0 COMMENTS AND RECOMMENDATIONS

The system, as proposed by Non-Linear, contains "off-the-shelf" standard equipment. The modular one-half-rack size units are of the most advanced design, using silicon integrated circuits throughout. Each system component is assembled from standard epoxy, plug-in printed circuit boards. All connections are made through gold contacts.

The methods employed in the design of the proposed system automatically provide compatible interfacing and built-in expandability.

The object of this proposal is to not only recommend our own equipment and techniques, but also to act as a yardstick in the evaluation of the task and to assist in the choosing of acceptable, fully qualified respondents. It is understood that the object of any engineering specification should be the procurement of the most usable, flexible and reliable device within the cost framework.

In order to guard against obsolescence and to provide for future expansion and use, we recommend that the measuring device be capable of at least 5 significant digits with a 6th digit over-range feature. Today's data acquisition requirements demand the highest resolutions, accuracies and speeds. The S-1 concept meets the most stringent demands of modern data acqusition requirements.

The material listed in this proposal is available under GSA Contract Number GS-00S-68308.

8.0 SYSTEM TESTS

Each component will be completely tested prior to installation in the system to ensure that it is functioning properly. The complete system will be checked out in its entirety at NLS to ensure proper functional operation. If desired, your personnel may participate in these tests at NLS.

9.0 INSTALLATION

Our past experience has shown that installation problems due to interface and grounding configurations can be eliminated by the use of NLS factory-trained personnel to install the system at your site and assist in training your personnel.

10.0 WARRANTY

All instruments and components in the system are warranted to be free from defects in material and workmanship for a period of one year from date of installation. Tubes, choppers and lamps are exempted from this warranty.

11.0 SERVICE

Because of the modular plug-in construction of the instruments utilized in this system, any necessary repair can normally be performed in a minimum amount of time without removing the instrument from the system. However, if it becomes necessary to replace any instrument in the system, the use of standard off-the-shelf items throughout the system allows simple plug-in replacements without modification or recalibration of the system.

12.0 CONCLUSION

The NLS system, as proposed in the preceding pages, is designed to provide extreme accuracy and a high degree of reliability. The system design has incorporated many useful features, such as

(1) SIMPLICITY through the use of standard off-the-shelf equipment,

(2) ACCESSIBILITY to components through the use of plug-in modular construction,

(3) RELIABILITY through the use of proven instruments and all solid state circuitry,

(4) ACCURACY by the use of state-of-the-art components throughout the system, and

(5) UNIFORMITY of shapes, dimensions and performance to permit interchangeability of replaceable components and assemblies. All parts in the system are available as off-the-shelf hardware.

Over and above the equipment specifications and design, it is necessary to consider the reputation and experience of the company supplying the equipment. It is important that the system perform reliably within the specifications over long periods of time without constant readjustment and maintenance. Non-Linear System, Inc. has this required experience and capabilities to fulfill this requirement and is duly qualified to supply proven and reliable equipment.

Respectfully submitted,

NON-LINEAR SYSTEMS, INC.

H. D. Talbot
Systems Sales Manager

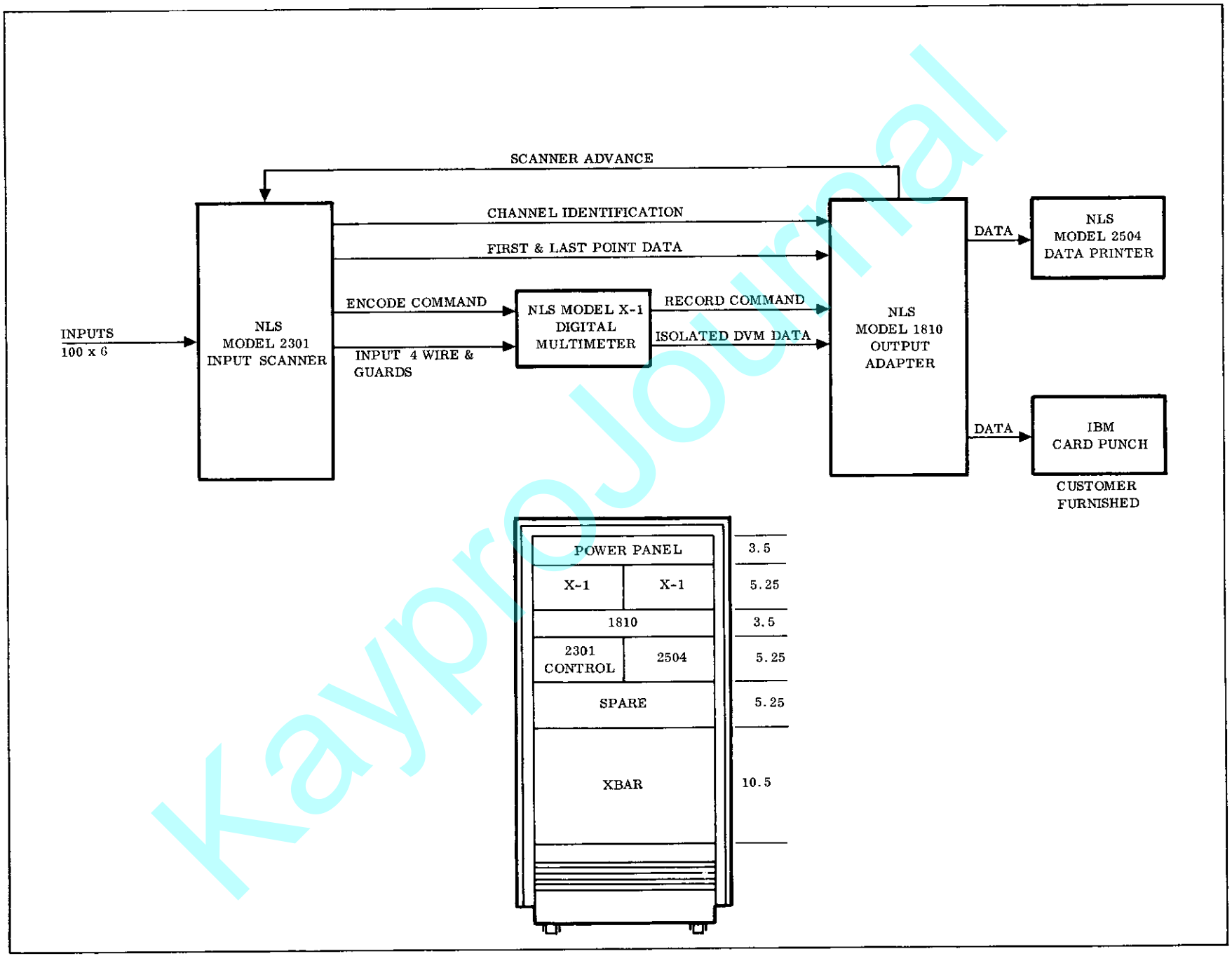

Figure 1. Block Diagram - S-1 Data System Card Punch Interface

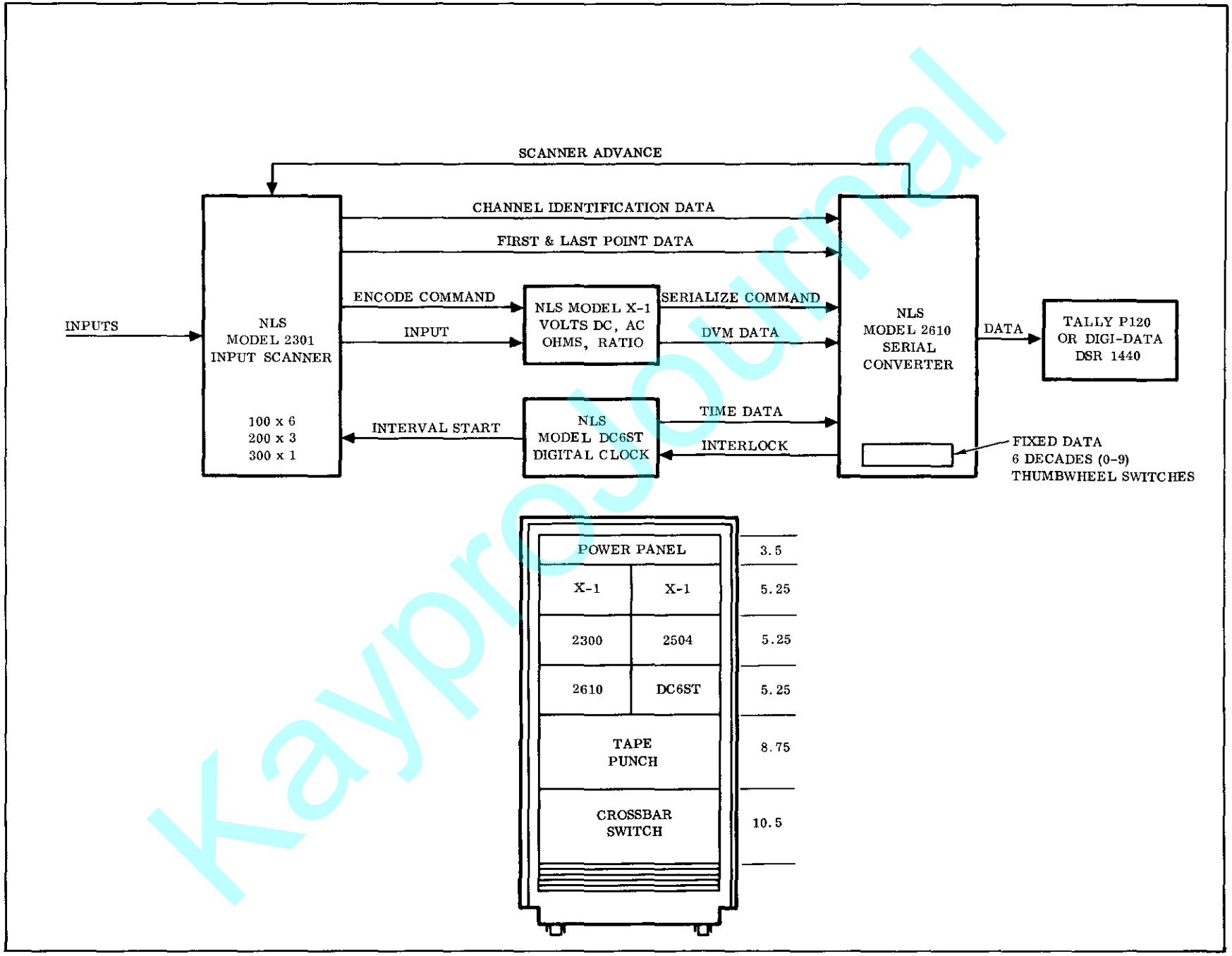

Figure 2. Block Diagram - Standard Data System S-1 with Clock and Magnetic Tape Option

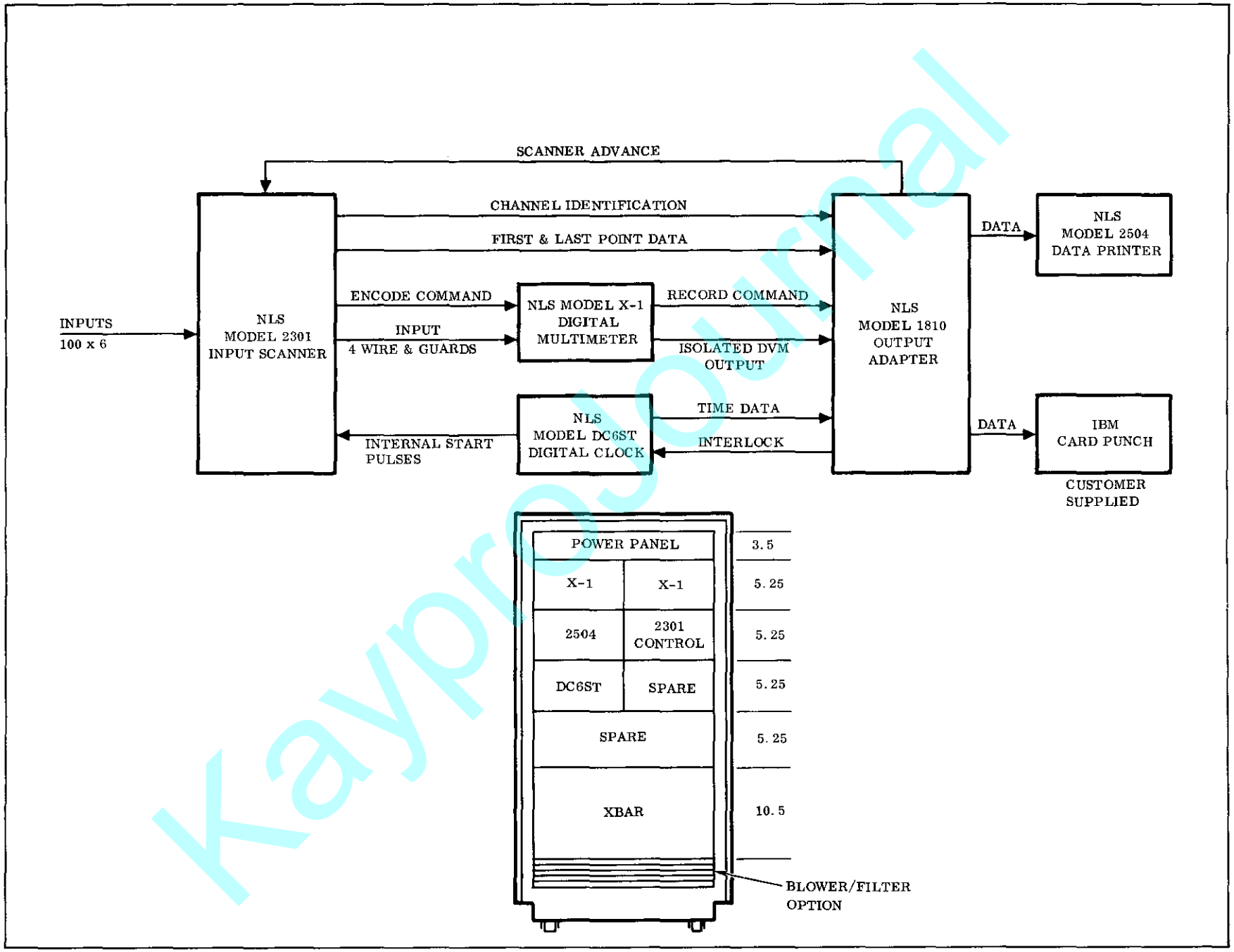

Figure 3. Block Diagram - S-1 Data System with Card Punch and Clock Options

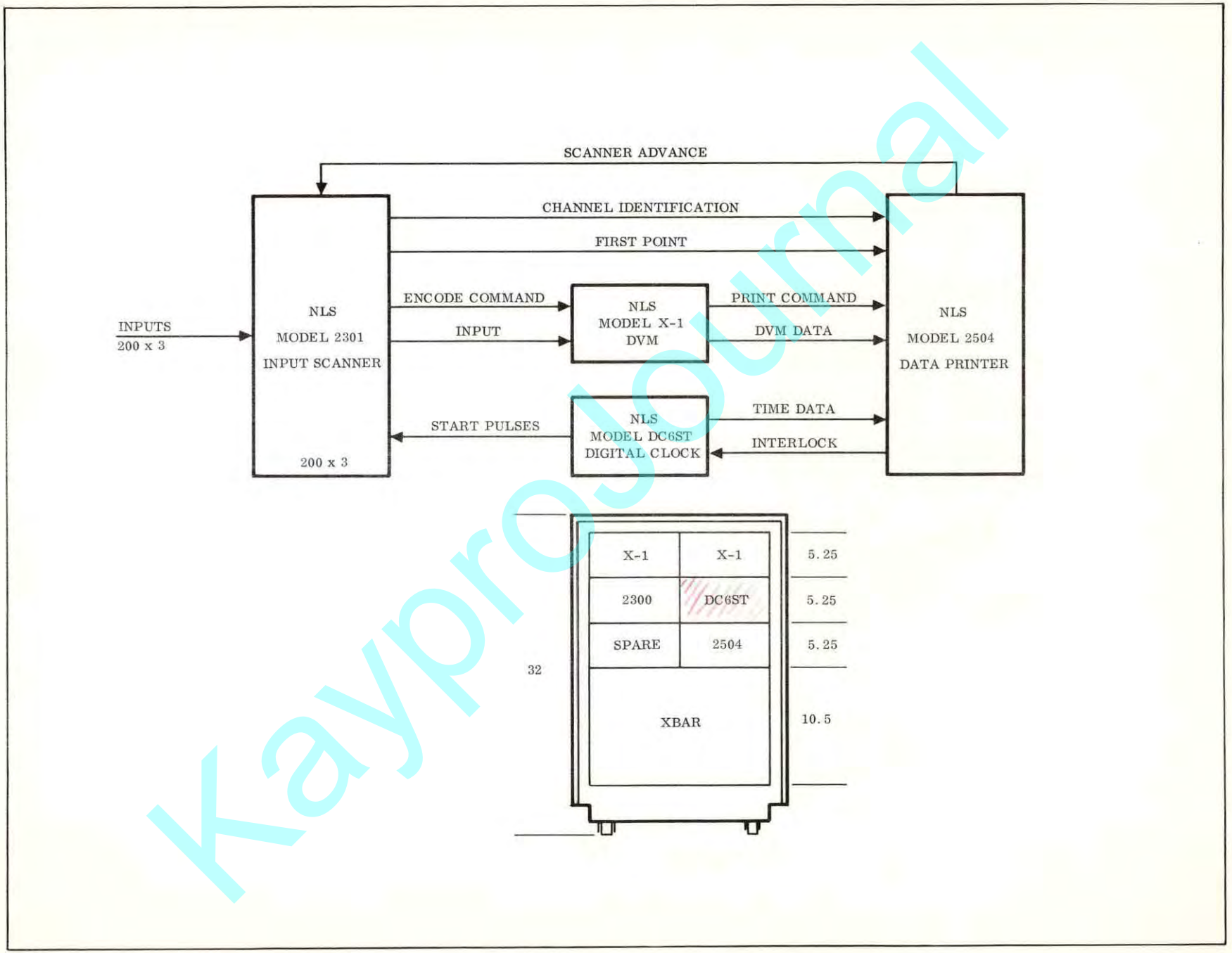

Figure 4. Block Diagram - S-1 Data Acquisition System - Basic System

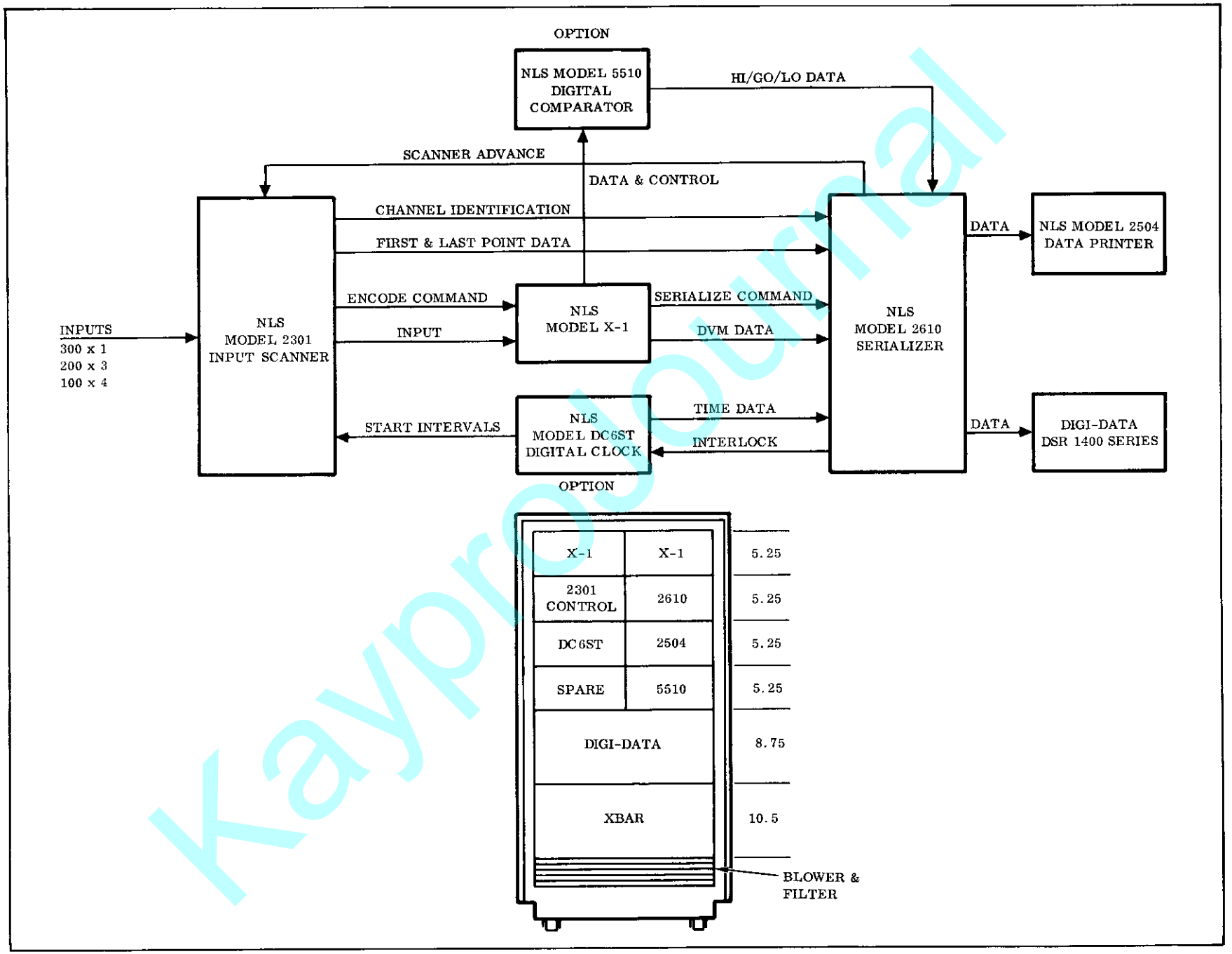

Figure 5. Block Diagram - S-1 Data System with Options

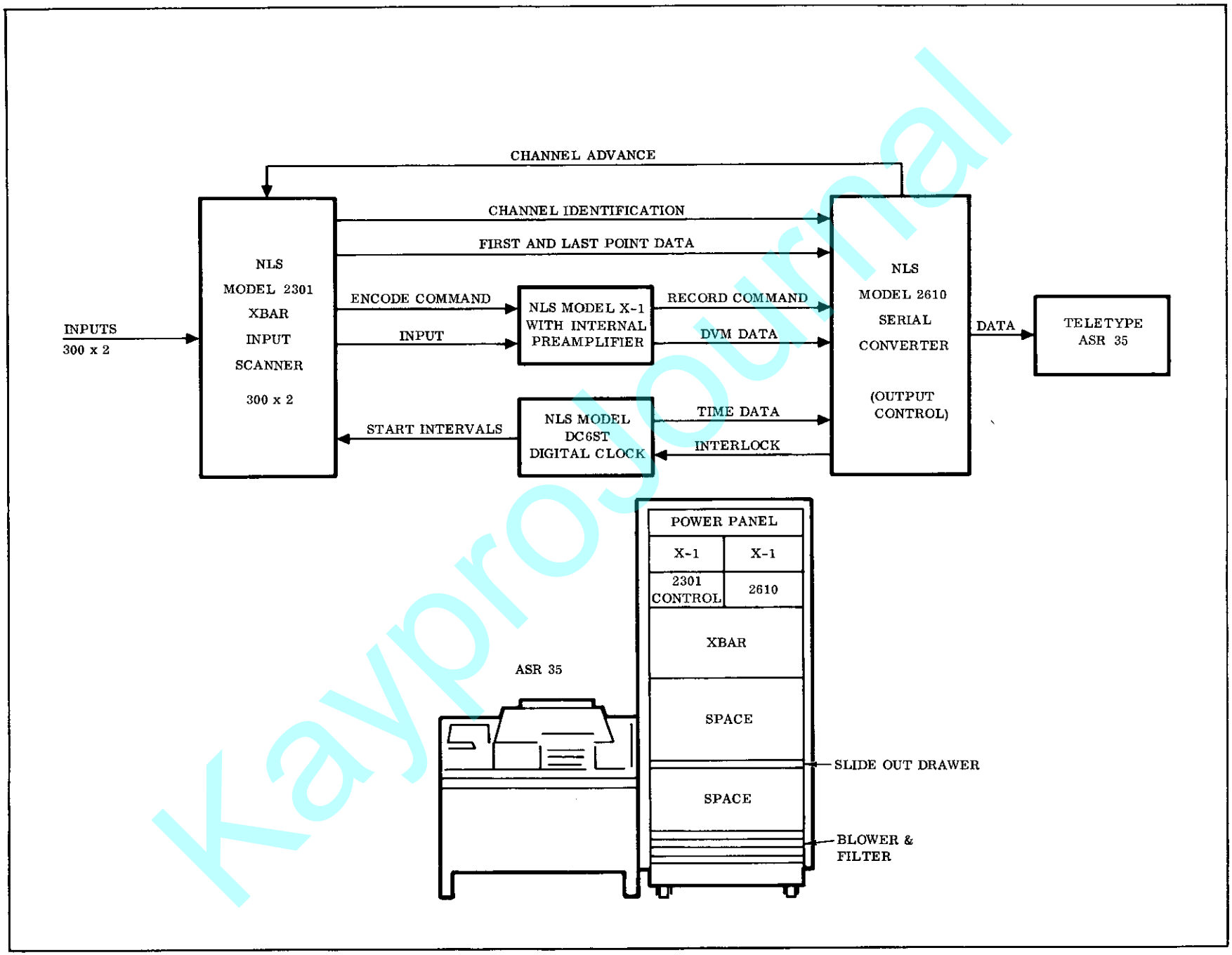

Figure 6. Block Diagram - Data System with ASR 35 Output

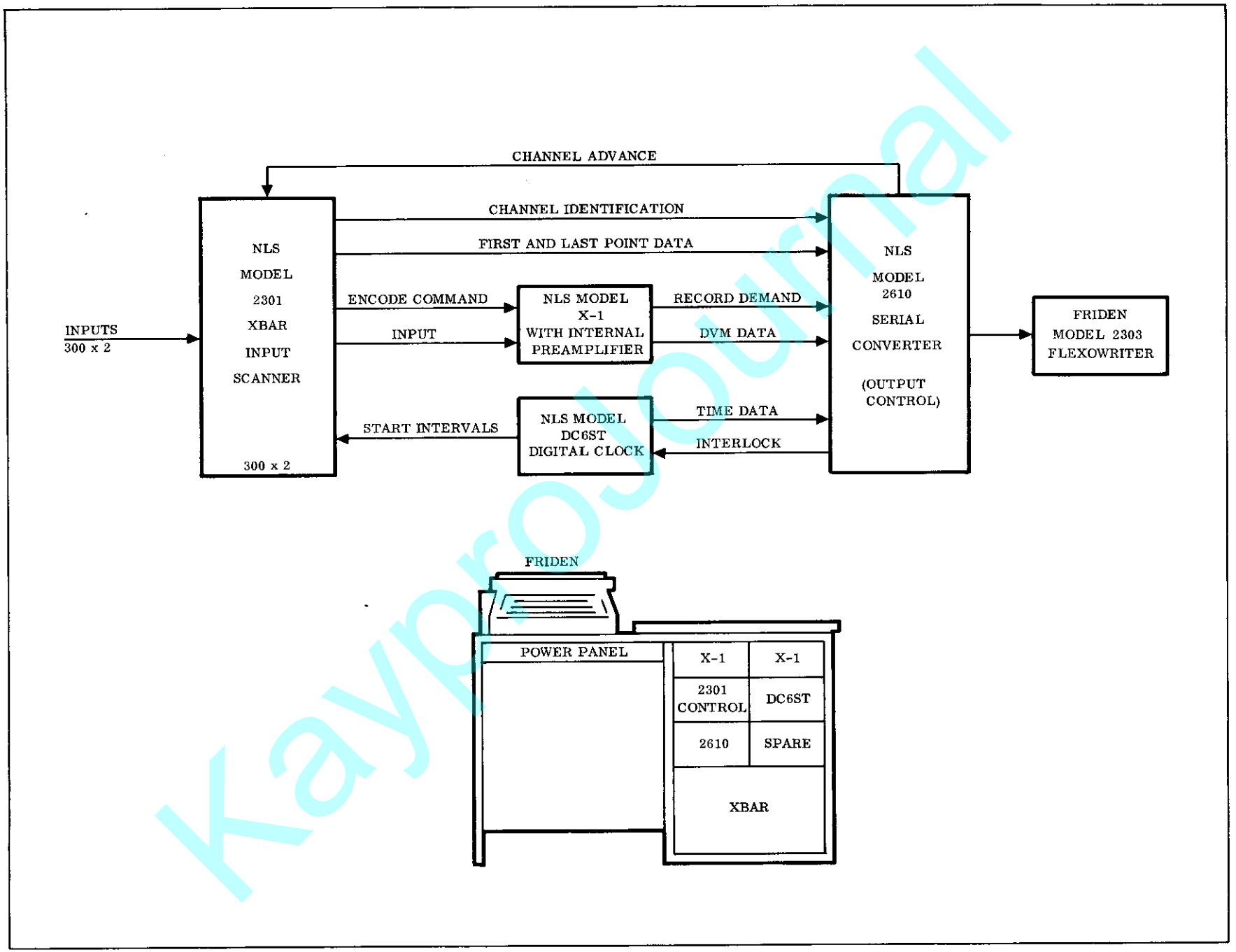

Figure 7. Block Diagram - Data System with Flexowriter Output

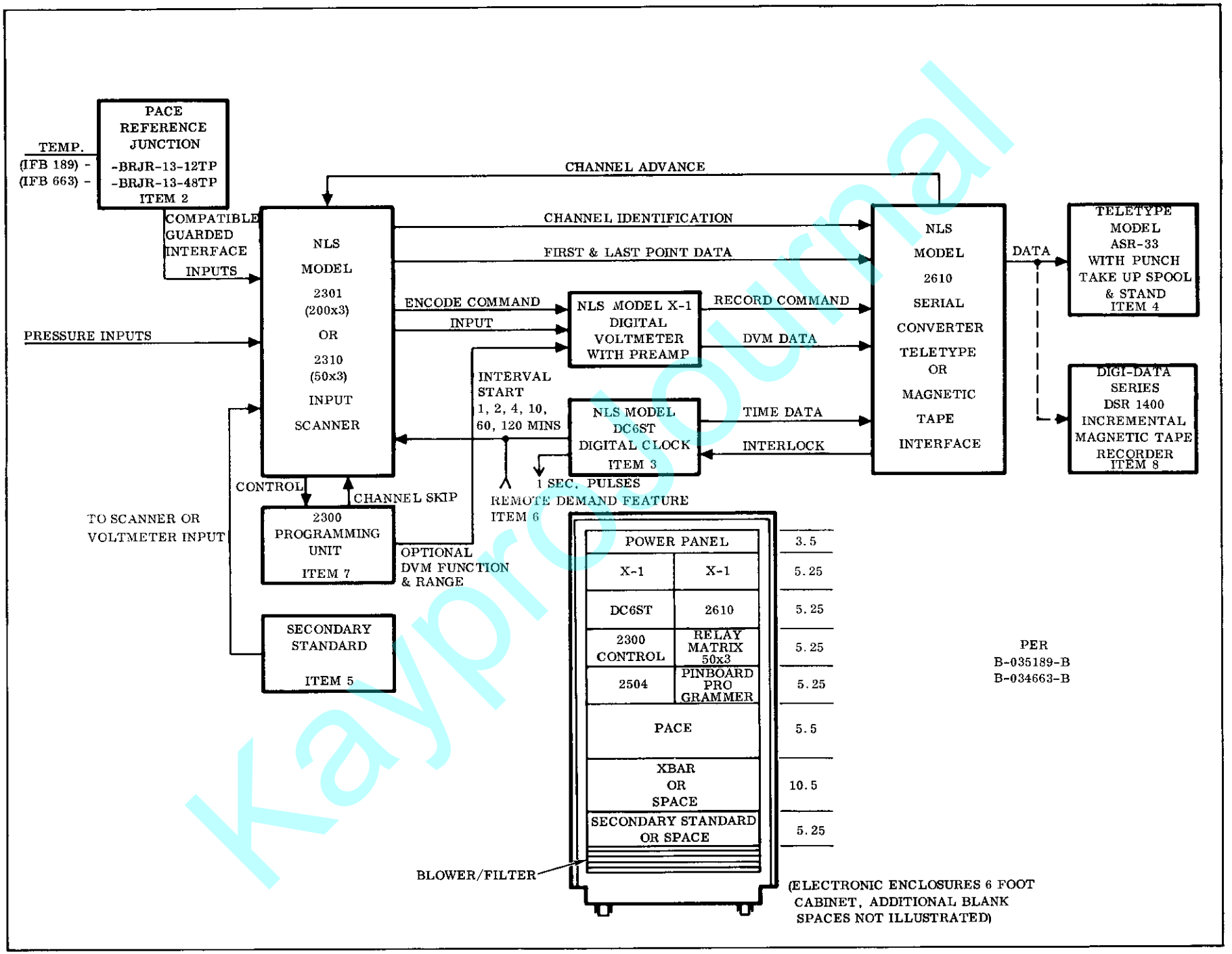

Figure 8. Block Diagram - Data Acquisition System S-1 with Options, System Expanded