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IBM

Saturn IB/V - Instrument Unit

Technical Manual

MSFC No. III-5-510-15

IBM No. 66-966-0015

Flight Control Computer



MSFC No. III-5-510-15

IBM No. 66-966-0015

TECHNICAL MANUAL

**SATURN IB/V INSTRUMENT UNIT
FLIGHT CONTROL COMPUTER**

Prepared under Contract

NAS 8-14000

by

International Business Machines Corporation

Federal Systems Division

Huntsville, Alabama

15 March 1966

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41	Original
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43 thru 45.	Original
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47 thru 49.	Original
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LIST OF RELATED DOCUMENTS

The following manuals have been published under NASA contracts as source and reference information on IU systems and/or components.

Title	Number		Published Date	Changed Date
	IBM	MSFC		
Saturn IB/V Instrument Unit Structure Repair Manual	65-966-0011H	III-5-510-1	1 September 1965	
Auxiliary Power Distributors	65-966-0013H	III-5-510-2	1 October 1965	
Power Distributor	65-966-0014H	III-5-510-3	1 October 1965	
Emergency Detection System Distributor	65-966-0015H	III-5-510-4	1 October 1965	
Control Distributor	65-966-0016H	III-5-510-5	1 October 1965	
Measuring Distributors	65-966-0017H	III-5-510-6	1 October 1965	
56 Volt Power Supply	65-966-0018H	III-5-510-7	1 October 1965	1 January 1966
5 Volt Measuring Voltage Supply	65-966-0019H	III-5-510-8	1 October 1965	
Saturn IB/V Instrument Unit Switch Selector, Model II	66-966-0001	III-5-510-9	1 February 1966	
Saturn IB/V Instrument Unit Component Handling Equip., Description and Operating Instructions	66-966-0005	III-5-510-10	1 February 1966	
Saturn IB/V Instrument Unit C-Band Radar Transponder Set SST-135C	66-966-0008	III-5-510-11	31 July 1964	1 March 1966
Saturn IB/V Instrument Unit Control-EDS Rate Gyro Package	66-966-0013	III-5-510-13	1 March 1966	
Saturn IB/V Instrument Unit Control Signal Processor	66-966-0014	III-5-510-14	1 March 1966	
Saturn IB/V Instrument Unit Flight Control Computer	66-966-0015	III-5-510-15	15 March 1966	
Saturn IB/V Instrument Unit Instrumentation System Description	65-966-0021H	III-5-509-1	1 April 1966	
Saturn IB/V Instrument Unit Navigation, Guidance, and Control System	66-966-0003	III-5-509-2	1 February 1966	

LIST OF RELATED DOCUMENTS (Cont)

Title	Number		Published Date	Changed Date
	IBM	MSFC		
Saturn IB/V Instrument Unit System Test Reference Manual Volume I Control System Volume II Guidance System Volume III ST-124M-3 Inertial Stabilizer System	66-966-0004	III-5-509-3	1 March 1966	
Saturn IB/V Instrument Unit System Description and Component Replacement Data	66-966-0006	III-5-509-4	1 March 1966	
Saturn IB/V Instrument Unit Environmental Control System Description	66-966-0009	III-5-509-5	15 March 1966	
Apollo-Saturn Emergency Detection System Description	66-966-0010	III-5-509-6	1 March 1966	

CONTENTS

Section		Page	Section		Page
	ILLUSTRATIONS	iii			
	TABLES	iv			
I	INTRODUCTION AND DESCRIPTION	1	2-6	Functional Operation During S-IVB Coast Mode	47
	1-1 Introduction	1	2-7	Subassembly Functional Descriptions	48
	1-2 Description	1	2-8	Detailed Description	62
	1-3 Common Names	2			
	1-4 Equipment Characteristics	2	III	PREPARATION FOR USE AND SHIPMENT	65
	1-5 Semiconductor Complement	2			
II	PRINCIPLES OF OPERATION	37	3-1	Preparation for Use	65
	2-1 Introduction	37	3-2	Preparation for Shipment	65
	2-2 General Operation	37	3-3	Packaging	65
	2-3 System Tie-In	37	3-4	Marking	65
	2-4 Functional Operation During S-IB Burn Mode	38	IV	PREVENTIVE MAINTENANCE AND REPAIR	67
	2-5 Functional Operation During S-IVB Burn Mode	44			
			4-1	Preventive Maintenance	67
			4-2	Repair	67

ILLUSTRATIONS

Number	Title	Page	Number	Title	Page
1-1	Flight Control Computer (Three-Quarter View)	1	1-17	Mother Board Printed Wiring Assembly (Typical)	9
1-2	Flight Control Computer With Housing Removed	2	1-18	Servo Inverter 50M34725	10
1-3	45V DC Amplifier 50M32575	2	1-19	12 Ma Servo Amplifier 50M34750	10
1-4	50 Ma Servo Amplifier 50M32615	3	1-20	ϕY , ϕP SI Filter 50M34805	11
1-5	Beta Command Power Supply 50M32630	3	1-21	ψY , ψP Filter 50M34811	12
1-6	Spatial Comparator 50M32635	4	1-22	ϕY , ϕP SI Filter 50M34816	12
1-7	Servo Comparator 50M32640	4	1-23	ϕY , ϕP SIV Filter 50M34821	13
1-8	Telemetry Amplifier 50M32645	5	1-24	ϕY , ϕP SIV Filter 50M34827	14
1-9	Switching Circuit A 50M32660	5	1-25	ϕR , ϕR SI Filter 50M34838	15
1-10	Continuous Attenuation Timer Inverter 50M32665	6	1-26	SI Power Distribution Module 50M34850	16
1-11	Scaling Board 50M32670	6	1-27	Spatial Synchronizer 50M34865	16
1-12	Beta Feedback 50M32675	7	2-1	Flight Control Computer, System Tie-In Functional Block Diagram	39
1-13	Continuous Attenuation Timer 50M32793	7	2-2	S-IB Burn Mode, Functional Block Diagram	41
1-14	Switching Circuit B 50M34000	8	2-3	S-IVB Burn Mode, Functional Block Diagram	45
1-15	Switching Circuit C 50M34005	8	2-4	S-IVB Coast Mode, Functional Block Diagram	49
1-16	Spatial Amplifier 50M34120	9			

ILLUSTRATIONS (Cont)

Number	Title	Page	Number	Title	Page
2-5	DC Amplifier, Functional Block Diagram	51	2-11	Servo Amplifier Comparator, Functional Block Diagram	58
2-6	12 Ma Servo Amplifier, Functional Block Diagram	52	2-12	Spatial Amplifier, Functional Block Diagram	59
2-7	Continuous Attenuation Timer (C.A.T.), Functional Block Diagram	53	2-13	Spatial Comparator, Functional Block Diagram	60
2-8	C.A.T. and Servo Inverter, Functional Block Diagram	54	2-14	Spatial Synchronizer, Functional Block Diagram	61
2-9	Beta Command Power Supply, Functional Block Diagram	55	2-15	TM Amplifier, Functional Block Diagram	63
2-10	50 Ma Servo Amplifier, Functional Block Diagram	56	3-1	Packaging Instructions for Flight Control Computer	66

TABLES

Number	Title	Page	Number	Title	Page
1-1	Common Names	17	1-3	Flight Control Computer Sub- assemblies, Leading Particulars . .	21
1-2	Flight Control Computer, Leading Particulars	19	1-4	Flight Control Computer, Semi- conductor Complement	29

SECTION I

INTRODUCTION AND DESCRIPTION

1-1 INTRODUCTION

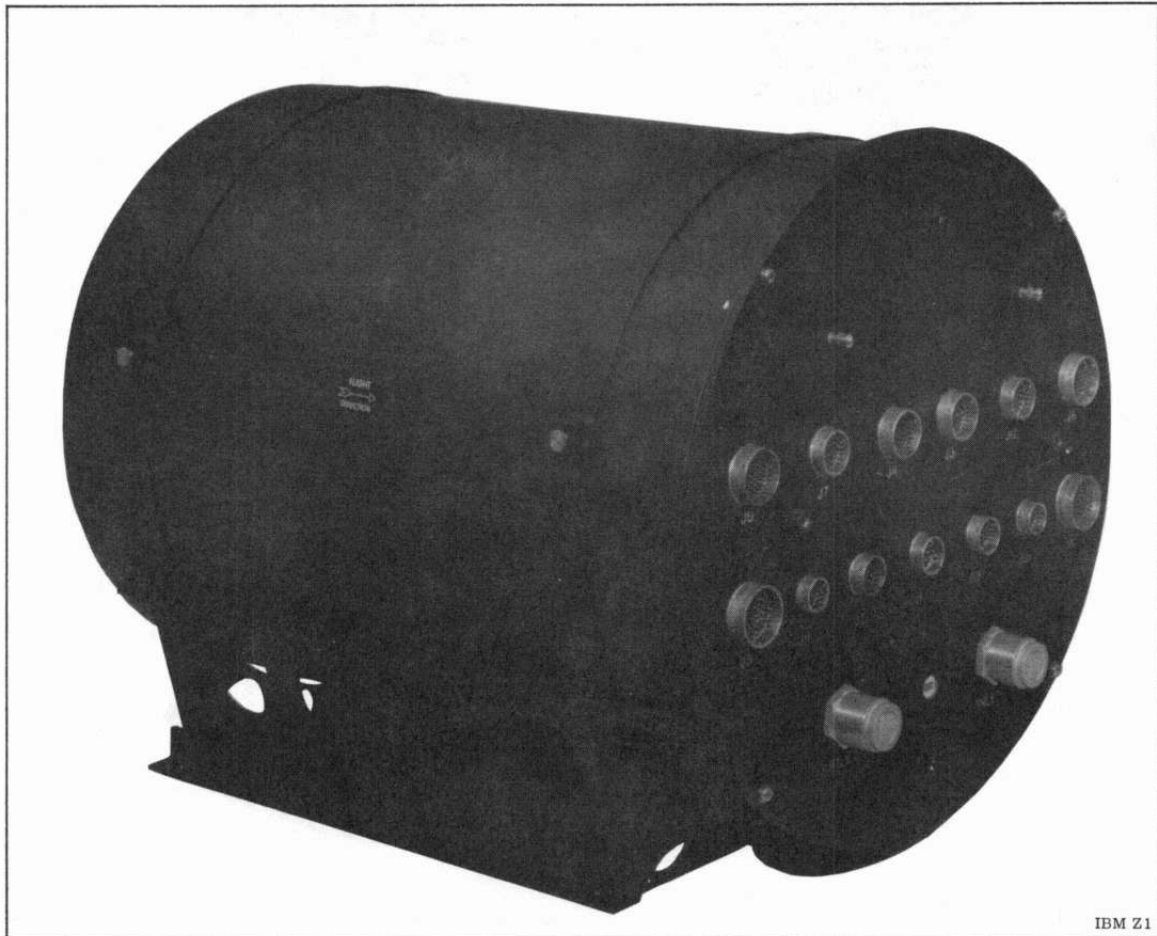
This publication contains the principles of operation, packaging instructions, and maintenance and repair instructions for the Flight Control Computer for vehicle SA-203 of the Saturn IB program. The purpose of this manual is to provide a comprehensive understanding of the physical construction and detailed operation of the Flight Control Computer.

1-2 DESCRIPTION

The Flight Control Computer (see Figure 1-1) is used to control the path of the Saturn IB during lift-off and burn of the S-IB Stage, during burn of the S-IVB Stage, and during coast of the S-IVB Stage. The Flight Control Computer is contained in the

Instrument Unit (IU) of the Saturn launch vehicle. During lift-off and flight, the Flight Control Computer receives input signals from various sensing devices within the launch vehicle. These signals include attitude correction signals from the Launch Vehicle Data Adapter (LVDA); angular rate information from the Control EDS Rate Gyro Package; lateral acceleration information from the Control Accelerometers; and timing and programming information supplied by the LVDA through the IU Switch Selector.

In addition, the circuitry that allows the Apollo Spacecraft to assume control of the input signals to the Flight Control Computer is discussed. These circuits are not used on vehicle SA-203 because of the absence of the Apollo Spacecraft; however, this information is provided as reference



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Figure 1-1. Flight Control Computer (Three-Quarter View)

material and is typical of Flight Control Computer operation on other Saturn Launch Vehicles.

1-3 COMMON NAMES

The Flight Control Computer is illustrated with its housing removed in Figure 1-2. The various electronic subassemblies that make up the Flight Control Computer are illustrated in Figure 1-3 through 1-27, and are listed in part number order in Table 1-1. Each subassembly listing includes the official nomenclature, reference designations, and common names for the subassemblies.

1-4 EQUIPMENT CHARACTERISTICS

Table 1-2 lists the overall electrical and physical characteristics of the Flight Control Computer. Table 1-3 lists the electrical and physical characteristics of the electronic subassemblies contained within the Flight Control Computer.

1-5 SEMICONDUCTOR COMPLEMENT

Table 1-4 lists the semiconductor complement for each electronic subassembly of the Flight Control Computer. Each listing includes the type, quantity, and function of the semiconductor.

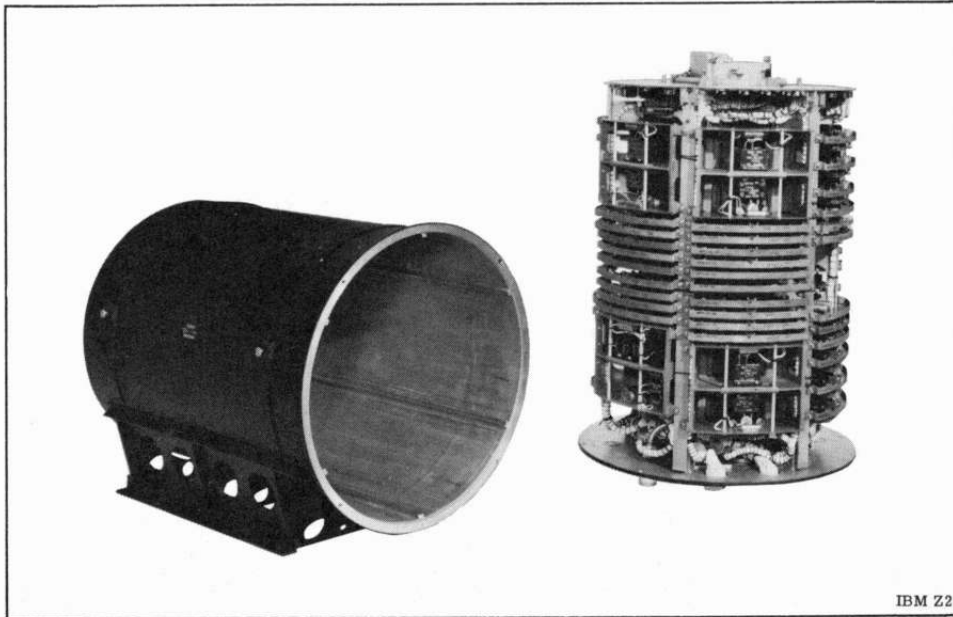


Figure 1-2. Flight Control Computer With Housing Removed

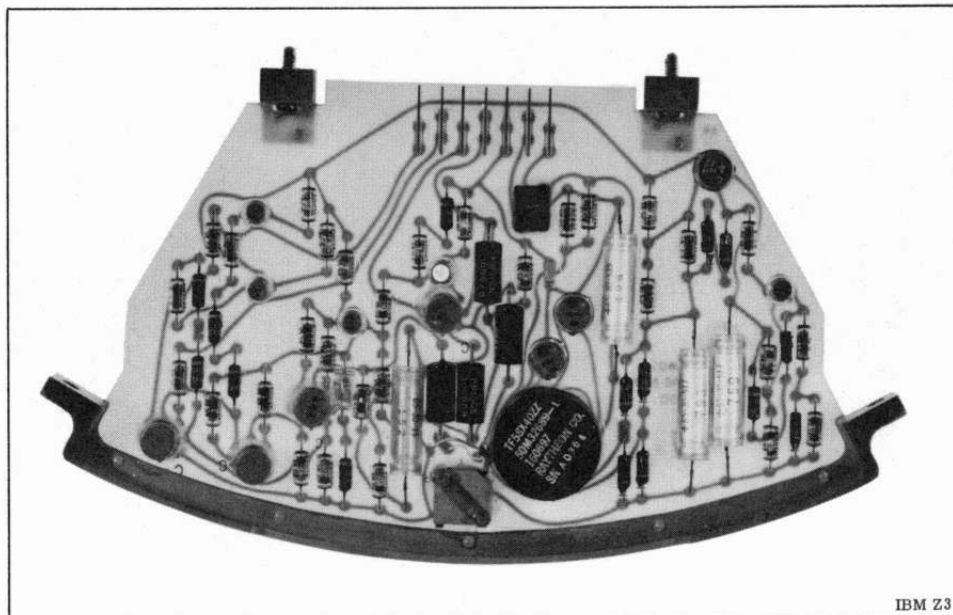
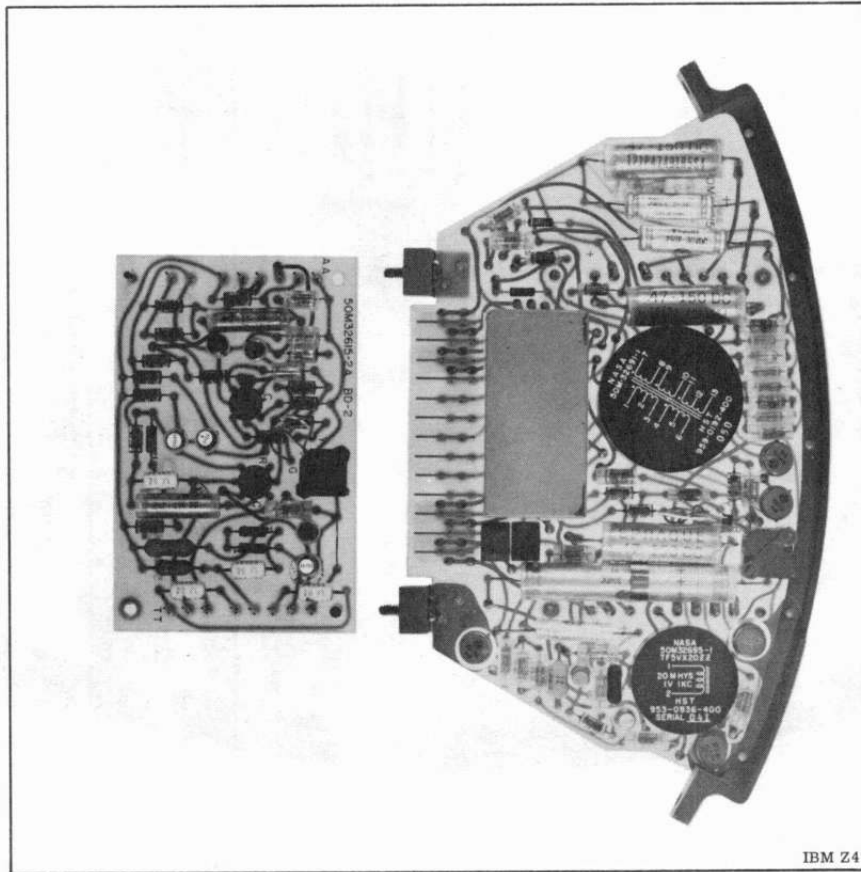
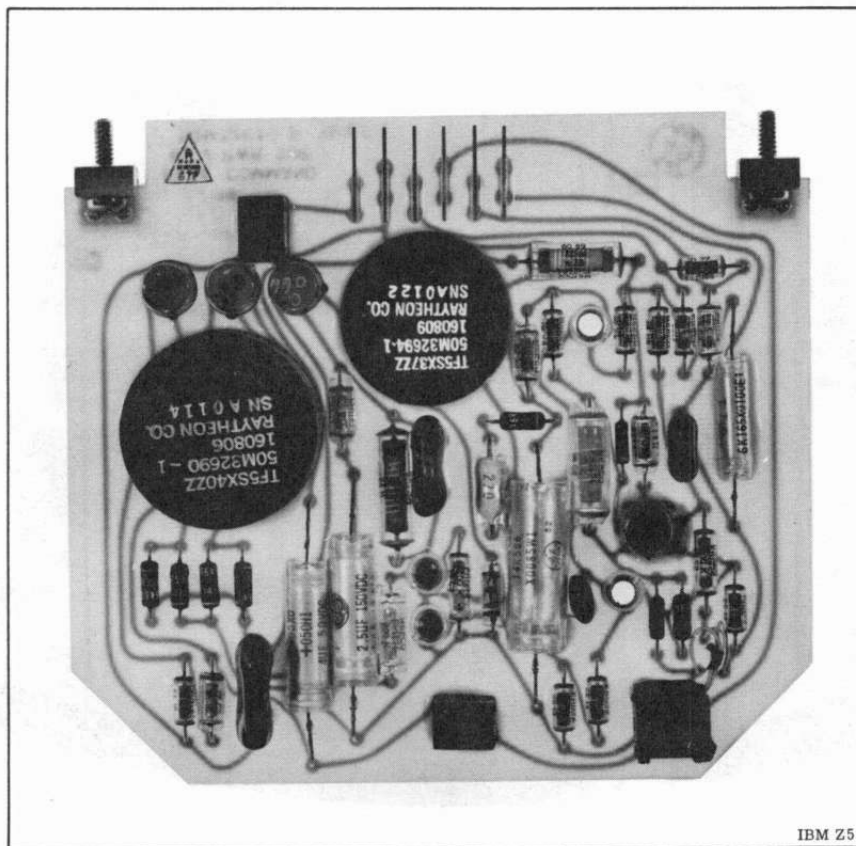


Figure 1-3. 45V DC Amplifier 50M32575



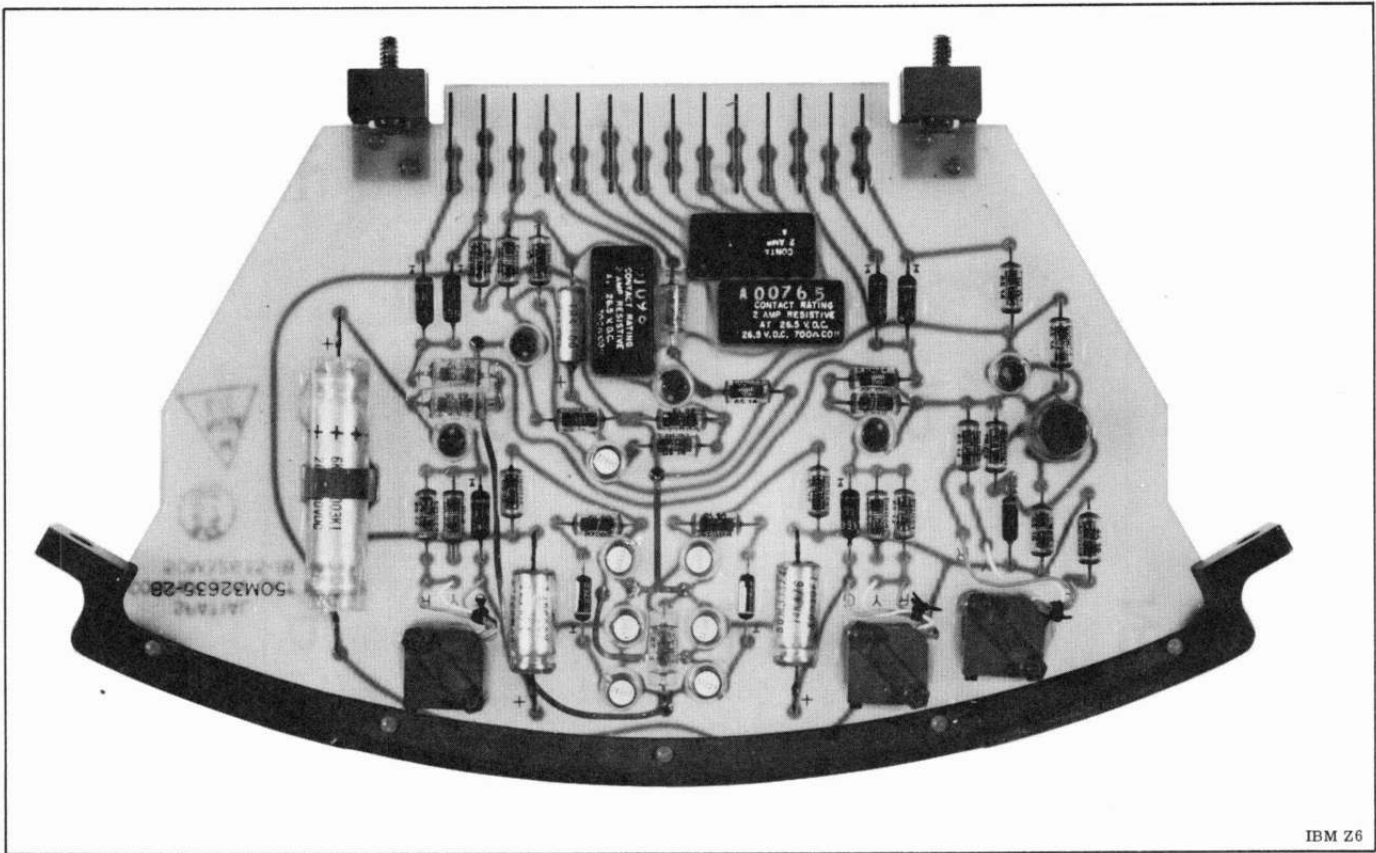
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Figure 1-4. 50 Ma Servo Amplifier 50M32615



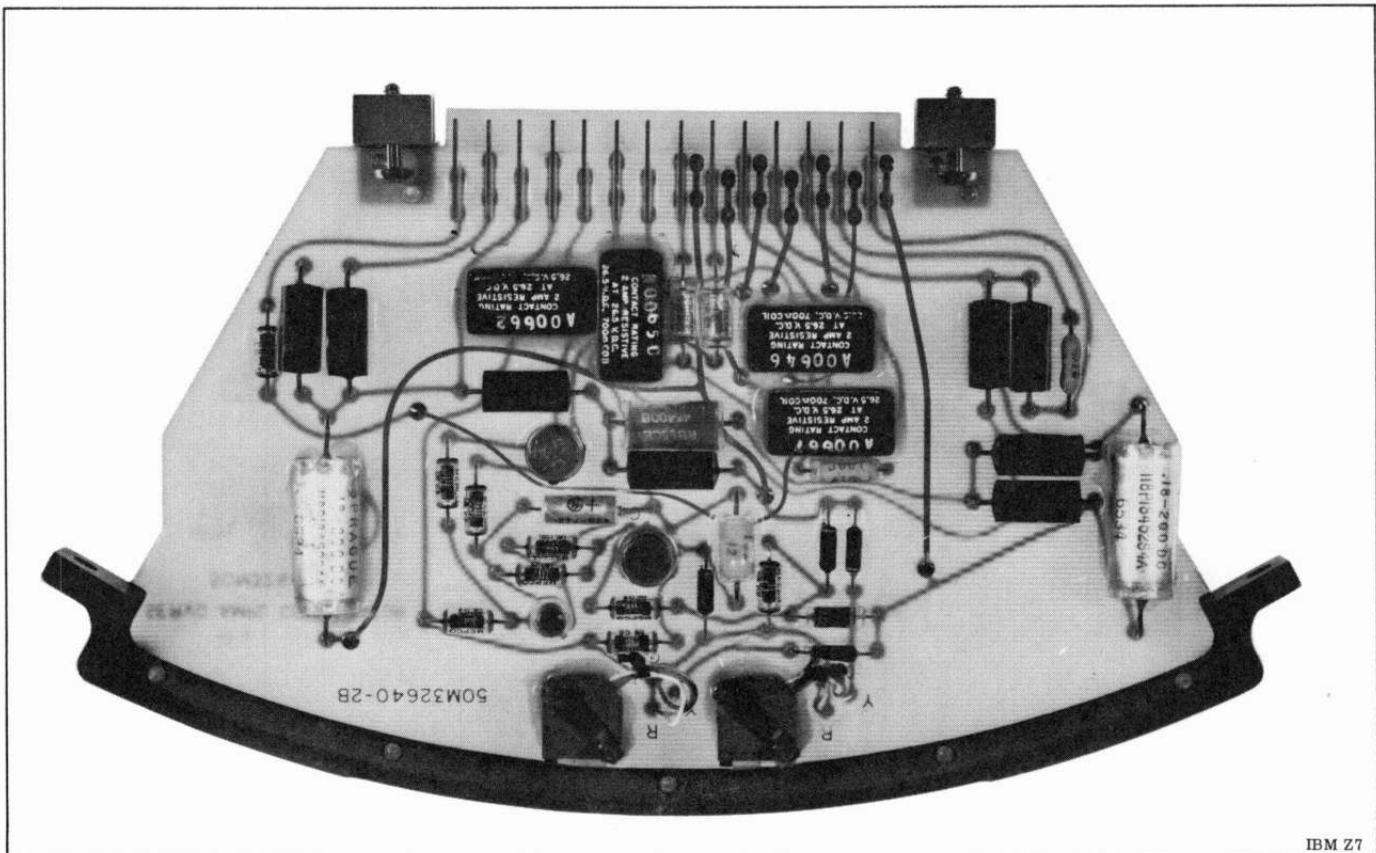
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Figure 1-5. Beta Command Power Supply 50M32630



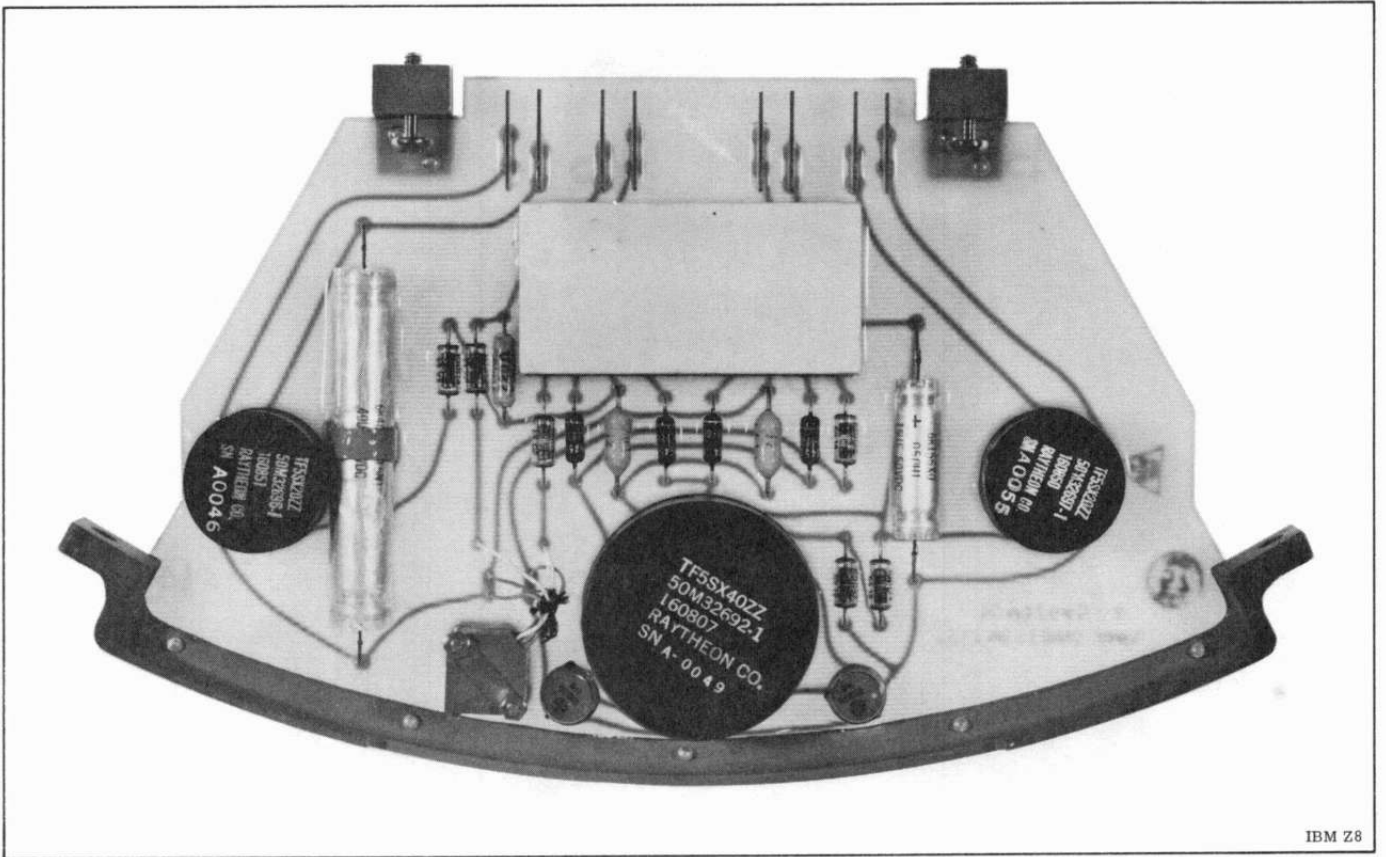
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Figure 1-6. Spatial Comparator 50M32635



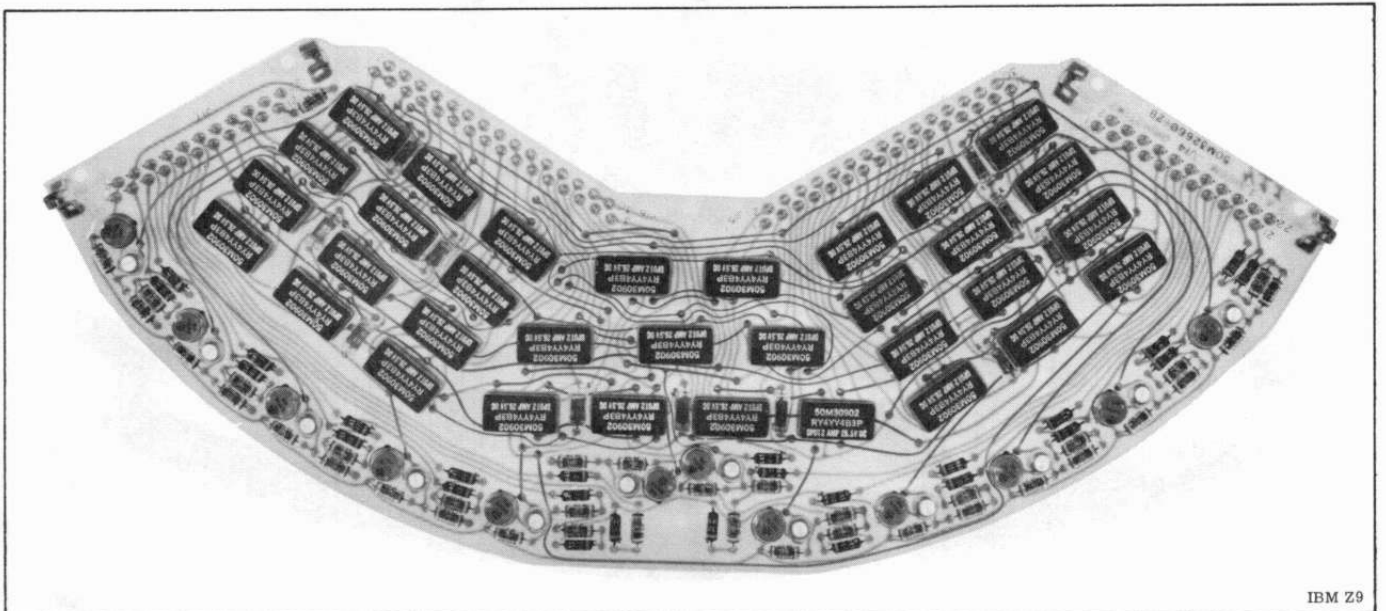
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Figure 1-7. Servo Comparator 50M32640



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Figure 1-8. Telemetry Amplifier 50M32645



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Figure 1-9. Switching Circuit A 50M32660

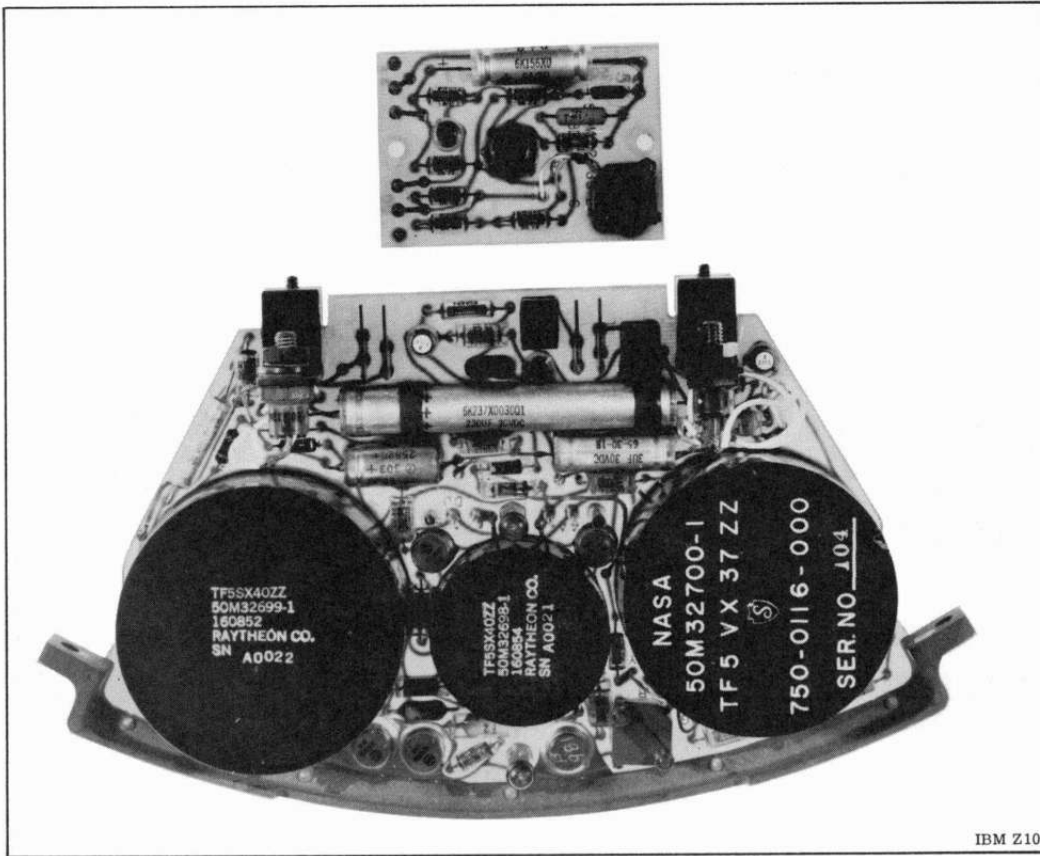


Figure 1-10. Continuous Attenuation Timer Inverter 50M32665

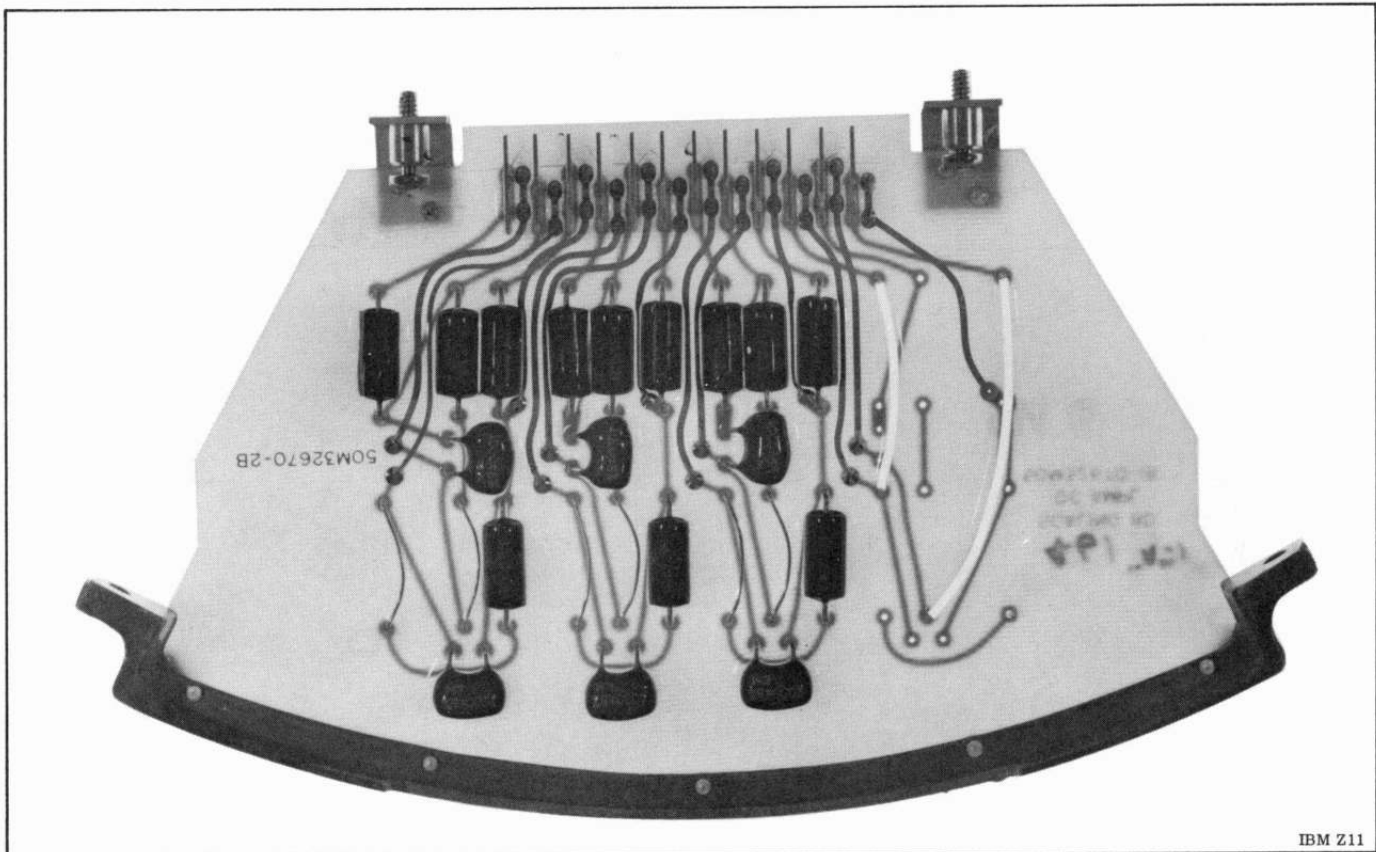
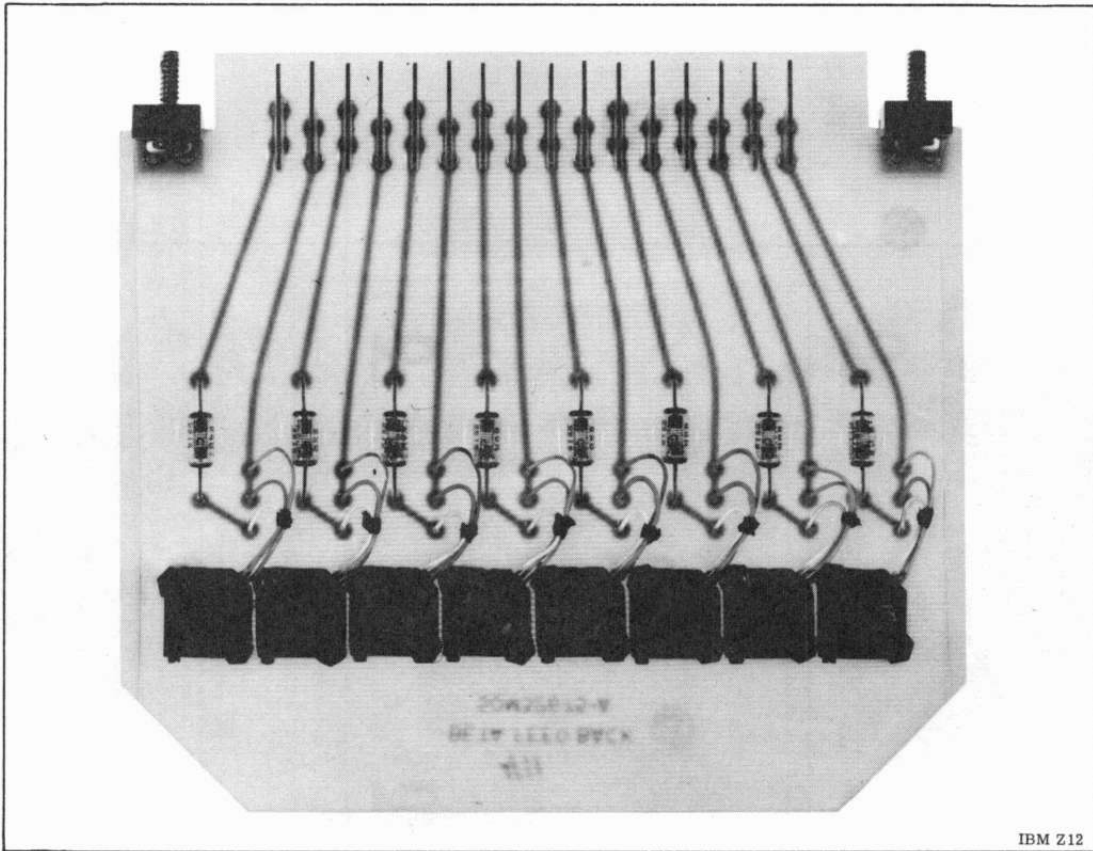
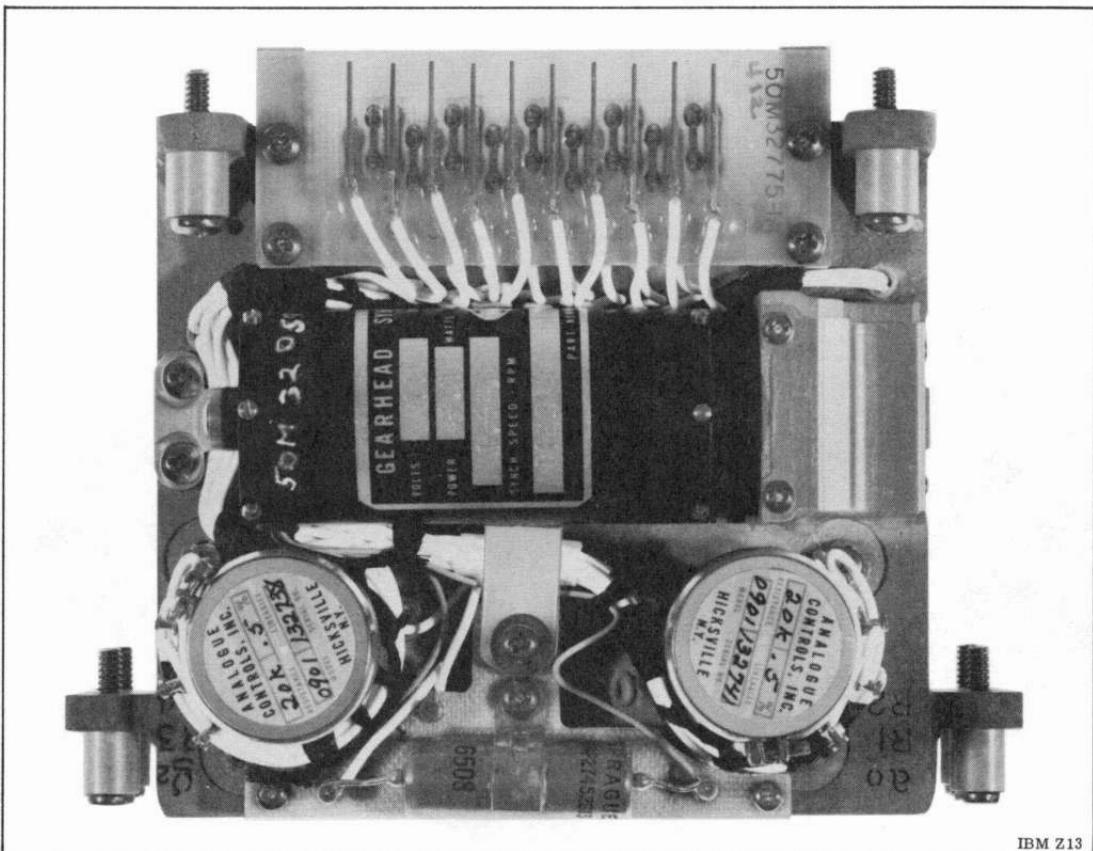


Figure 1-11. Scaling Board 50M32670



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Figure 1-12. Beta Feedback 50M32675



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Figure 1-13. Continuous Attenuation Timer 50M32793

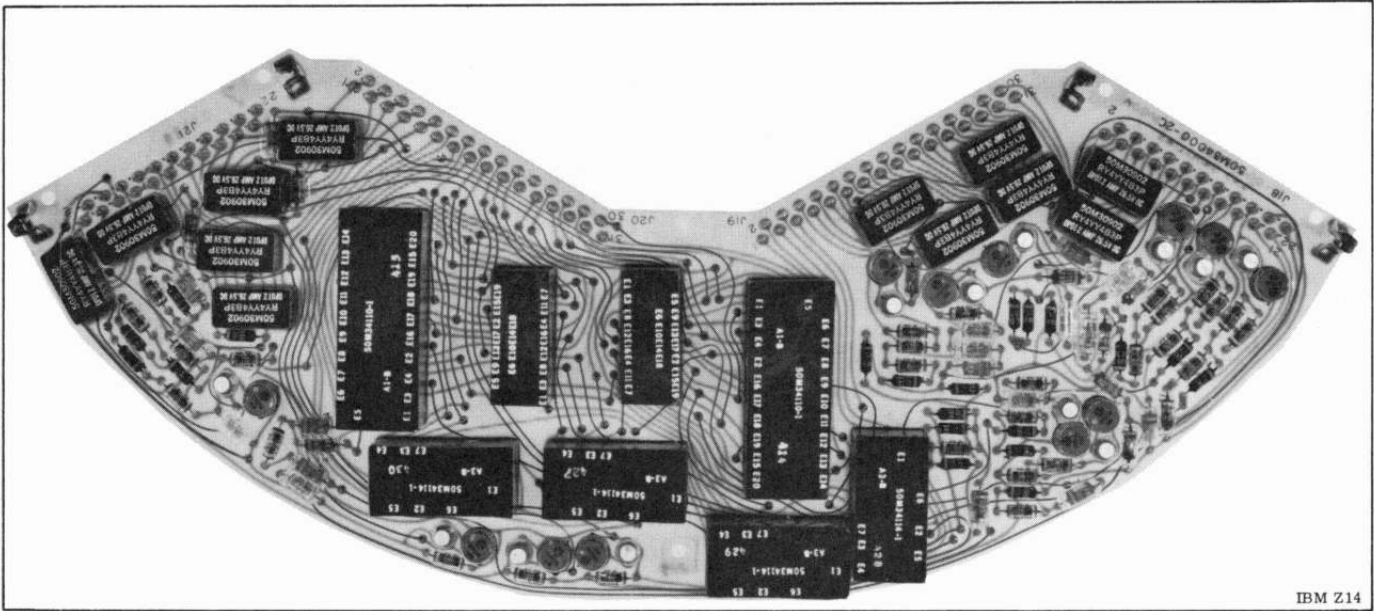


Figure 14. Switching Circuit B 50M34000

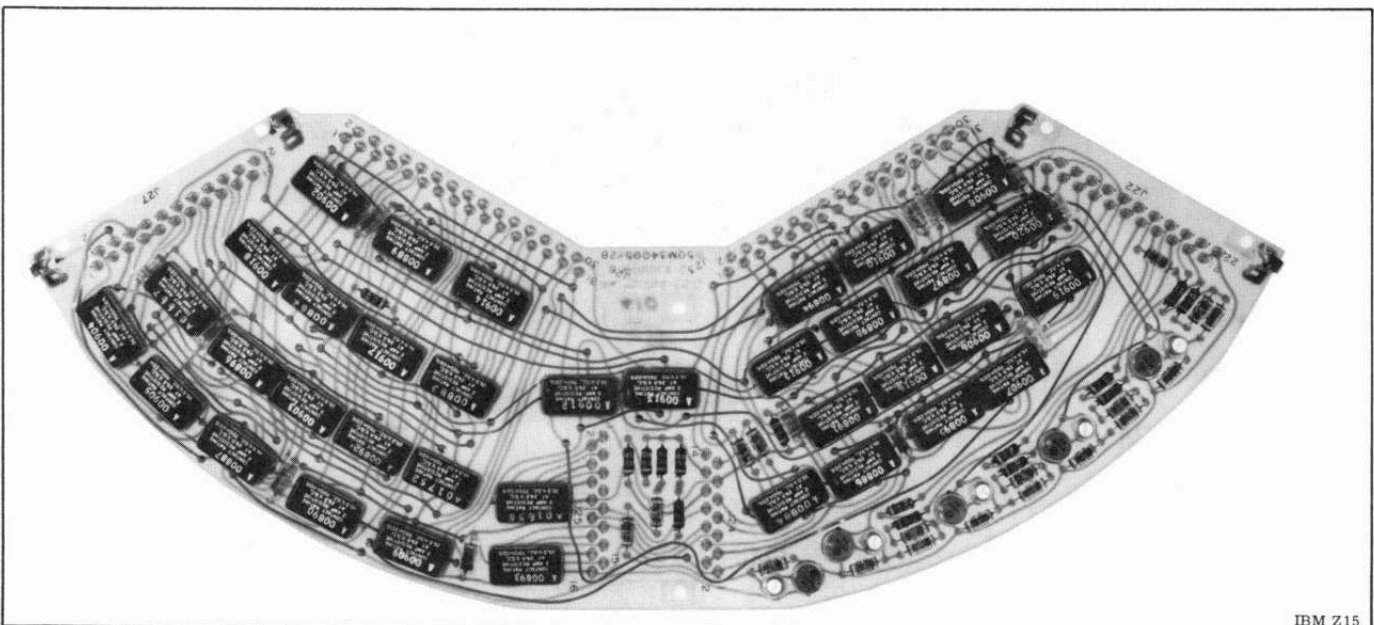
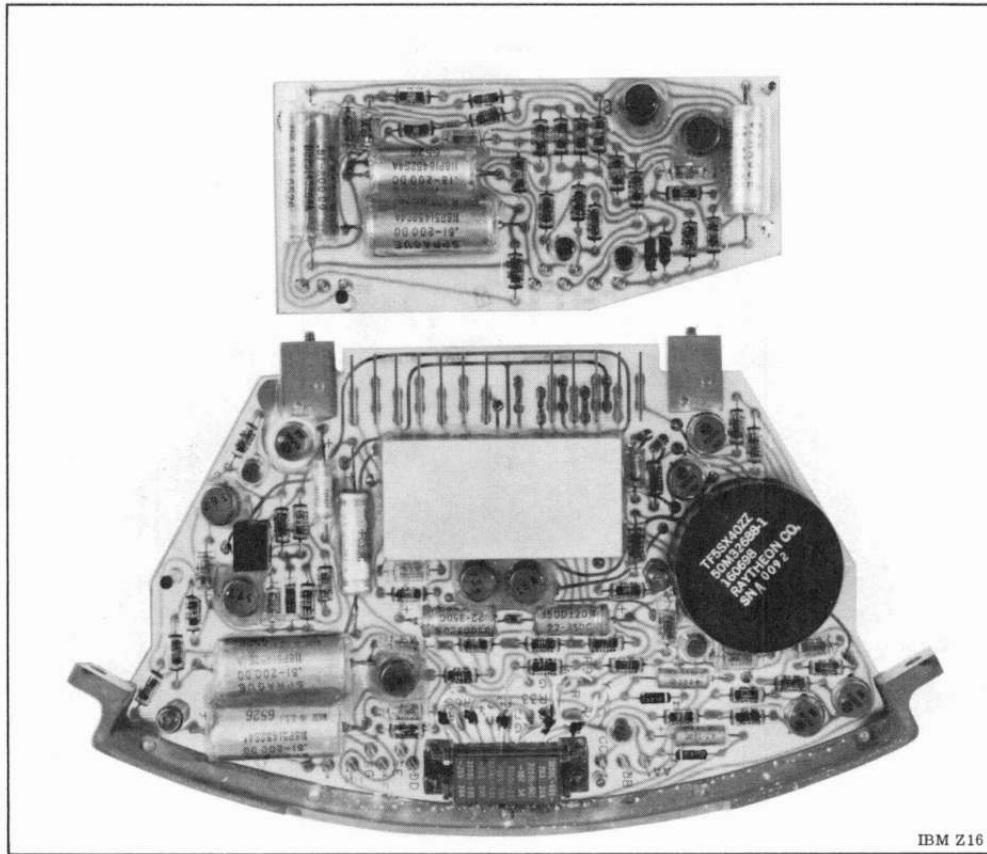
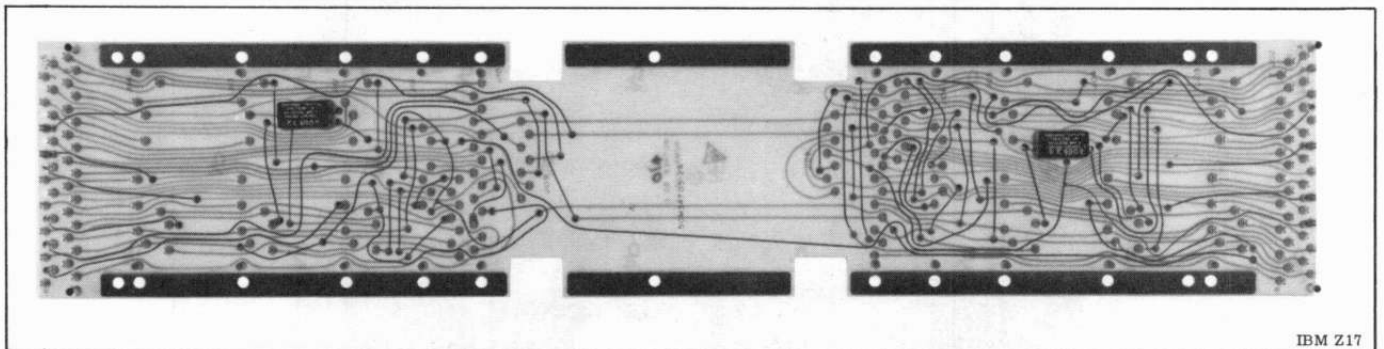


Figure 1-15. Switching Circuit C 50M34005



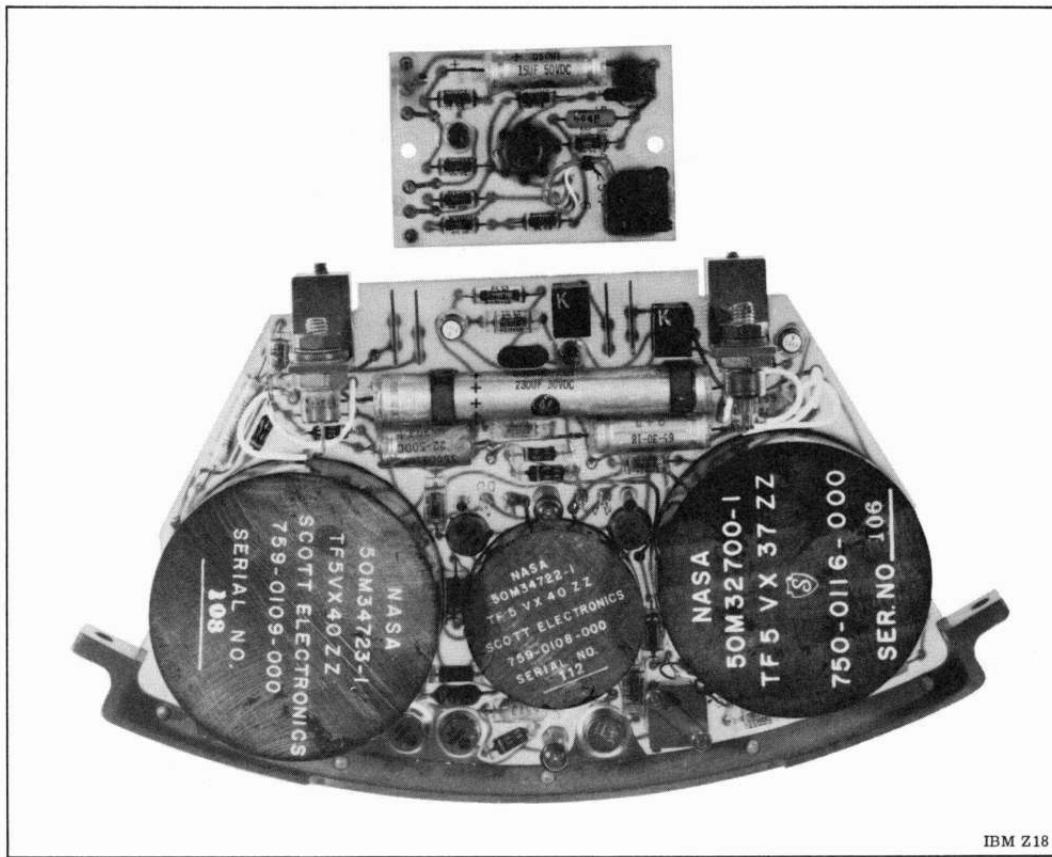
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Figure 1-16. Spatial Amplifier 50M34120



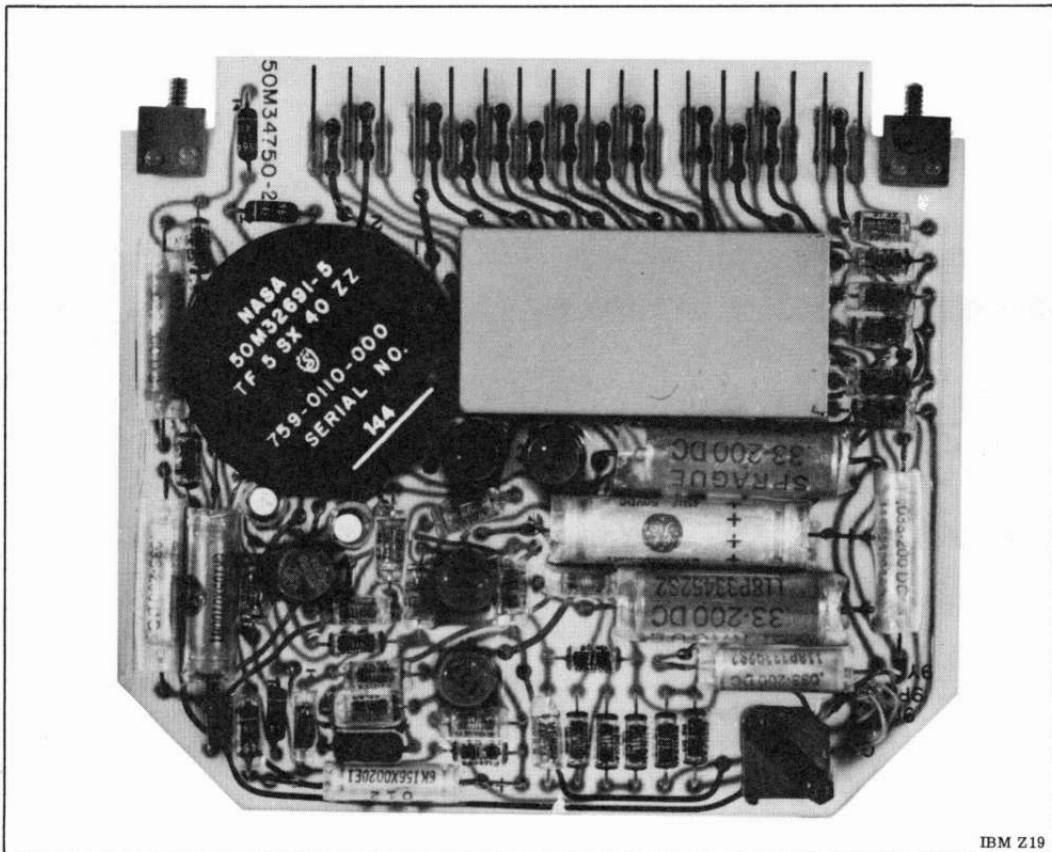
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Figure 1-17. Mother Board Printed Wiring Assembly (Typical)



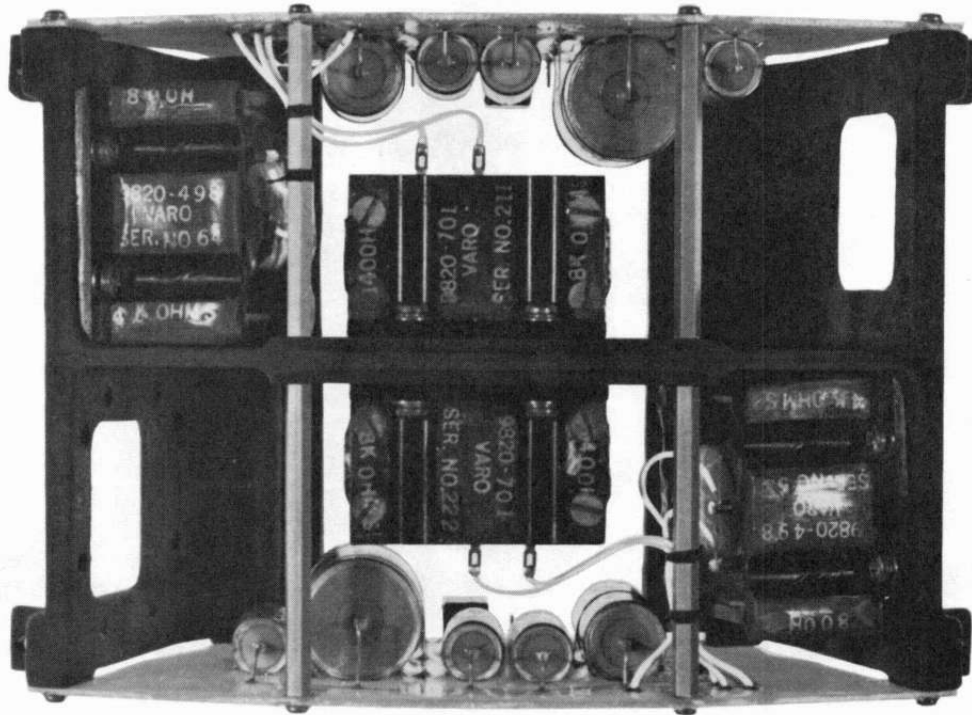
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Figure 1-18. Servo Inverter 50M34725

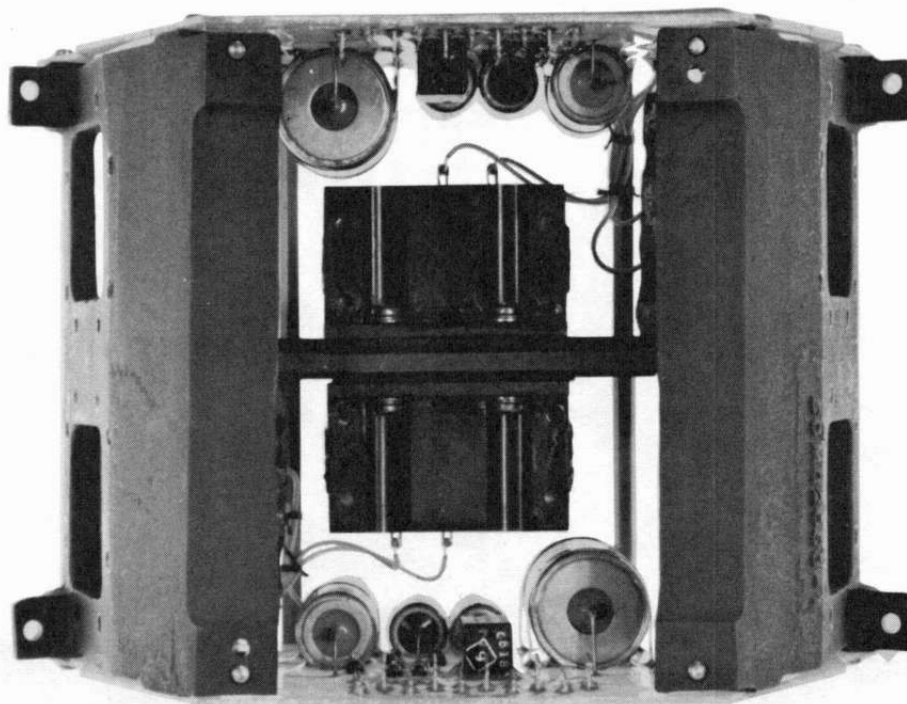


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Figure 1-19. 12 Ma Servo Amplifier 50M34750



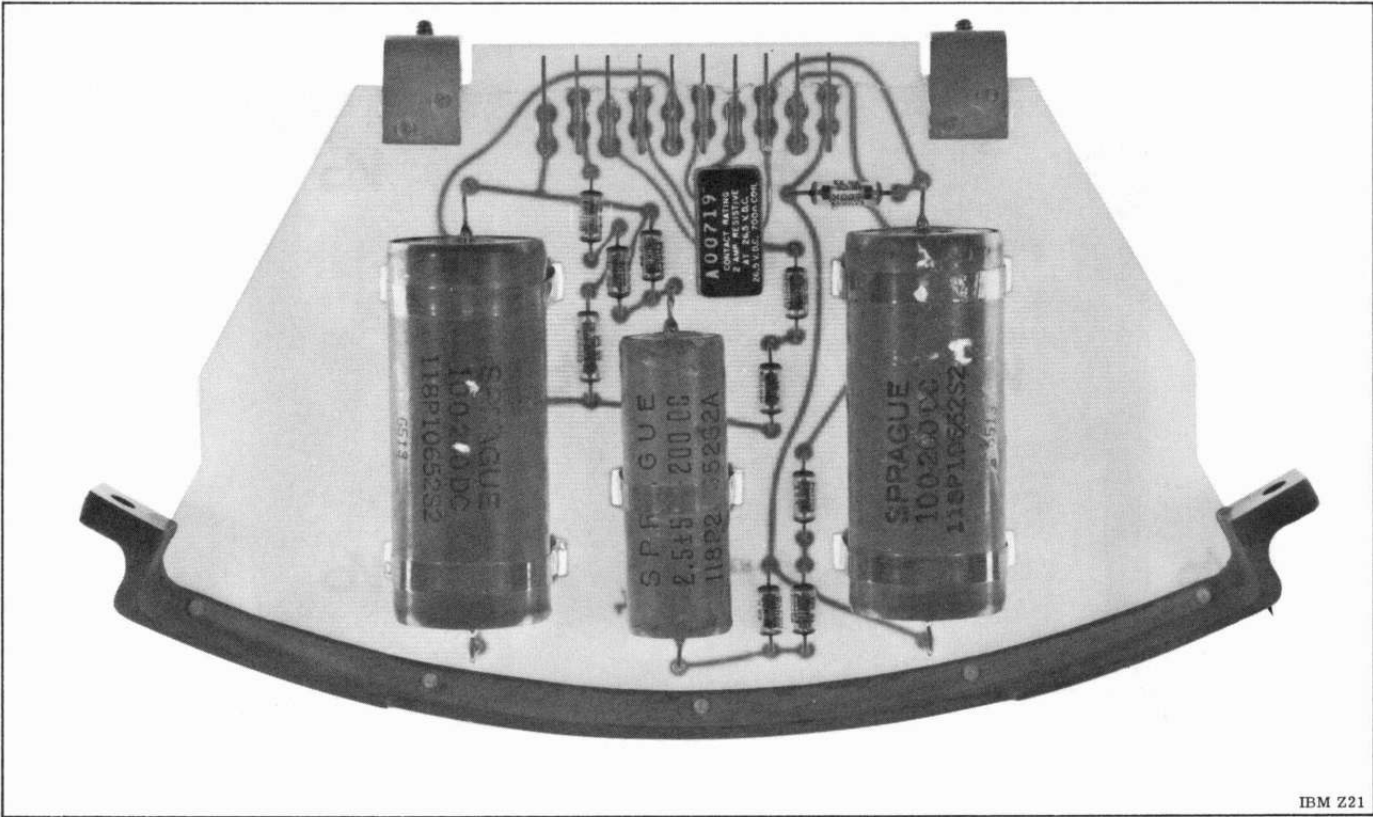
Outside View



Inside View

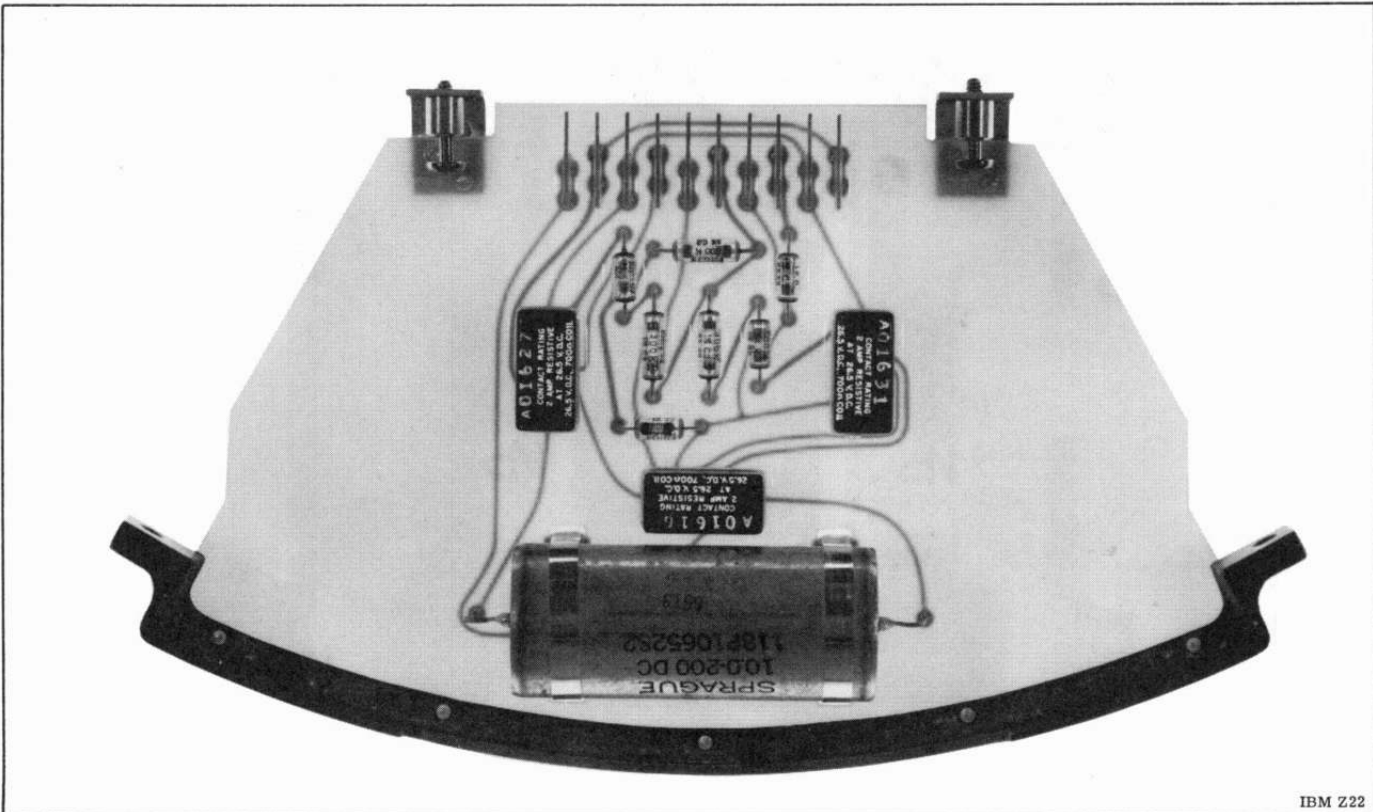
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Figure 1-20. ϕ Y, ϕ P SI Filter 50M34805



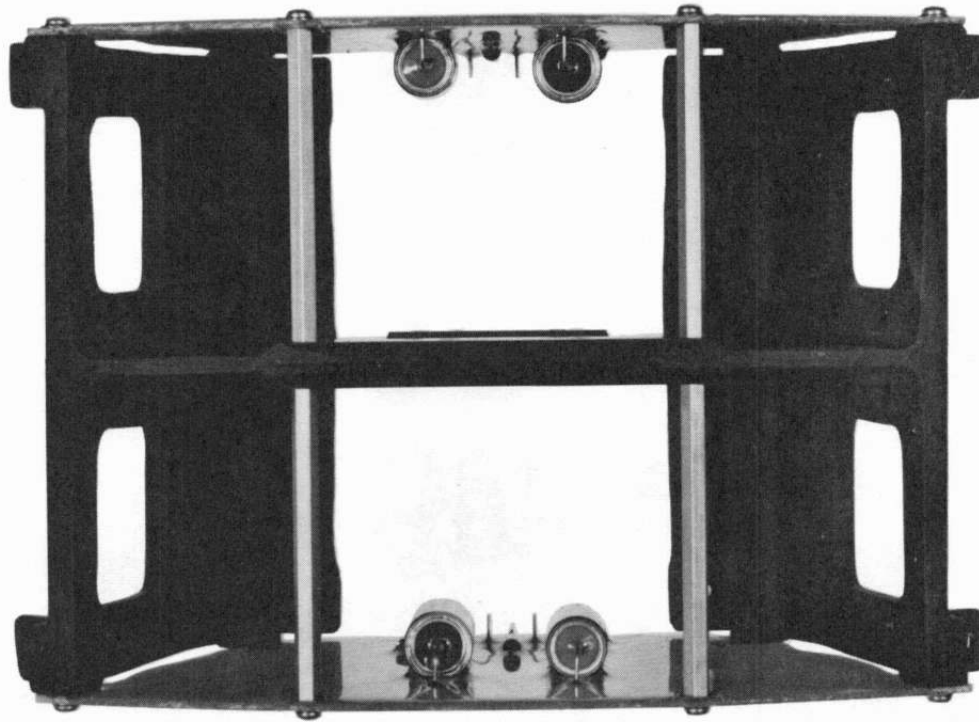
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Figure 1-21. γ Y, γ P Filter 50M34811

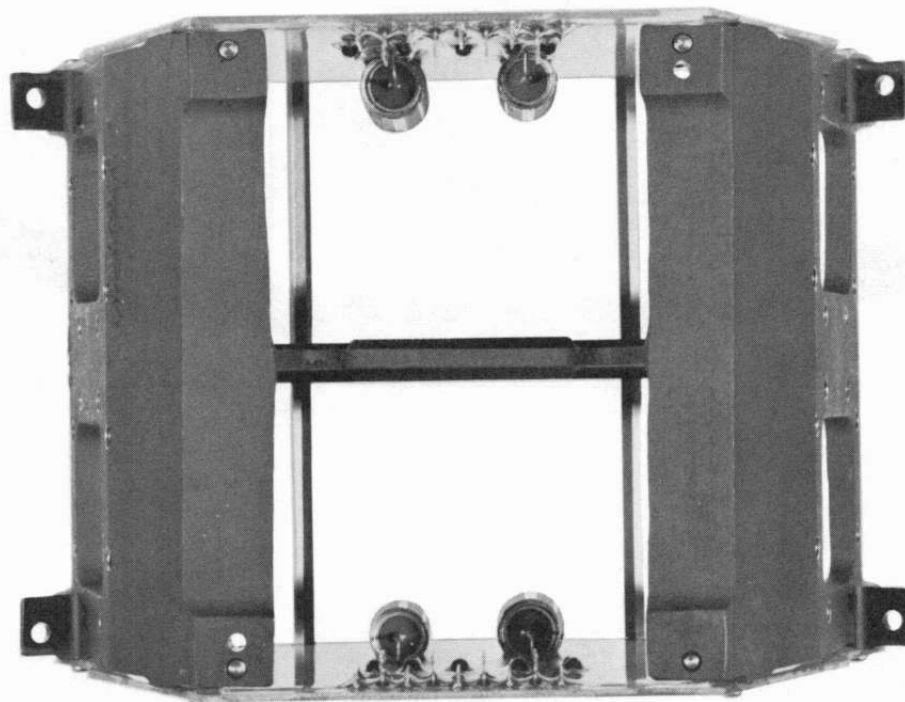


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Figure 1-22. ϕ Y, ϕ P SI Filter 50M34816



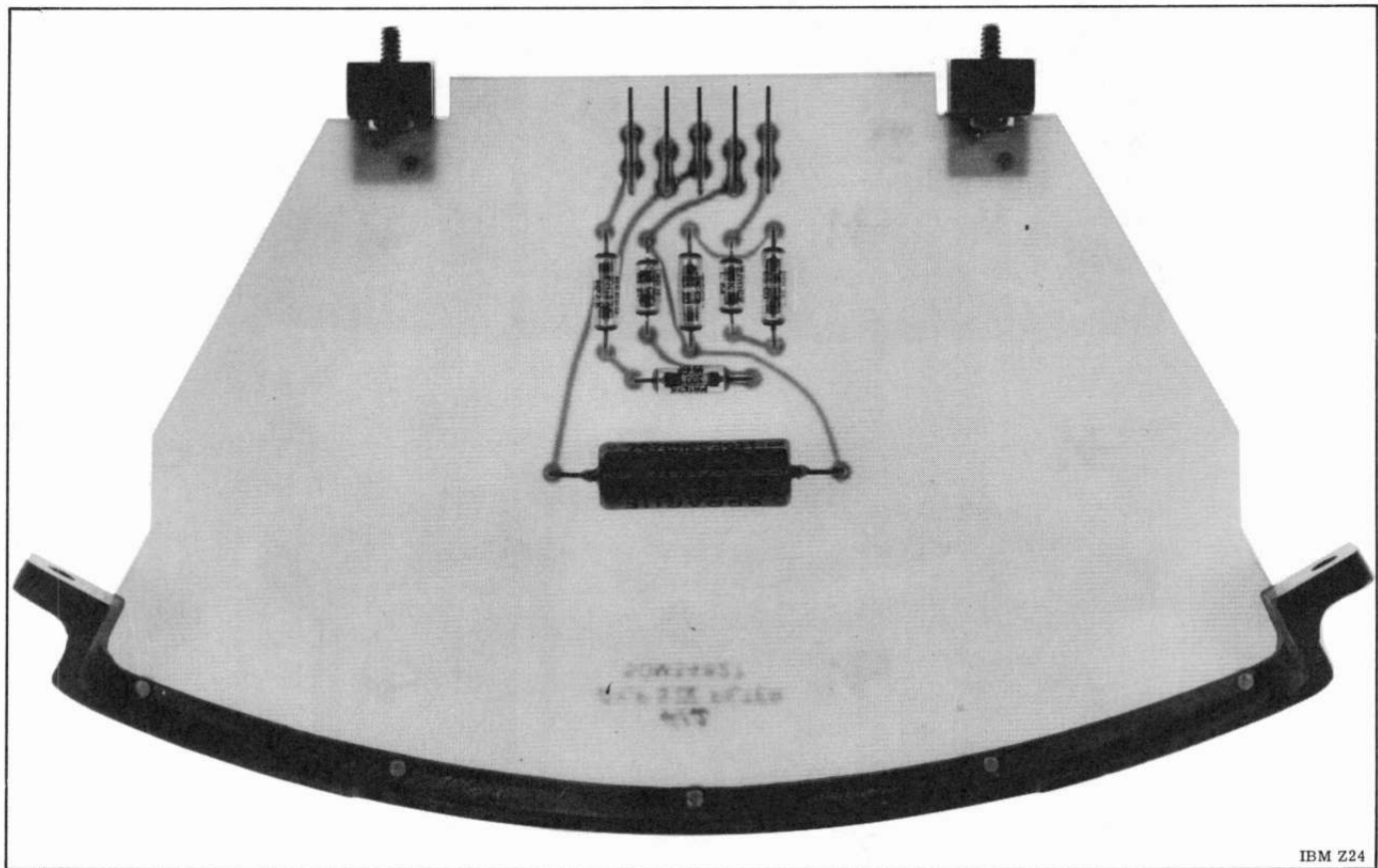
Outside View



Inside View

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Figure 1-23. ϕ Y, ϕ P SIV Filter 50M34821



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Figure 1-24. ϕY , ϕP SIV Filter 50M34827

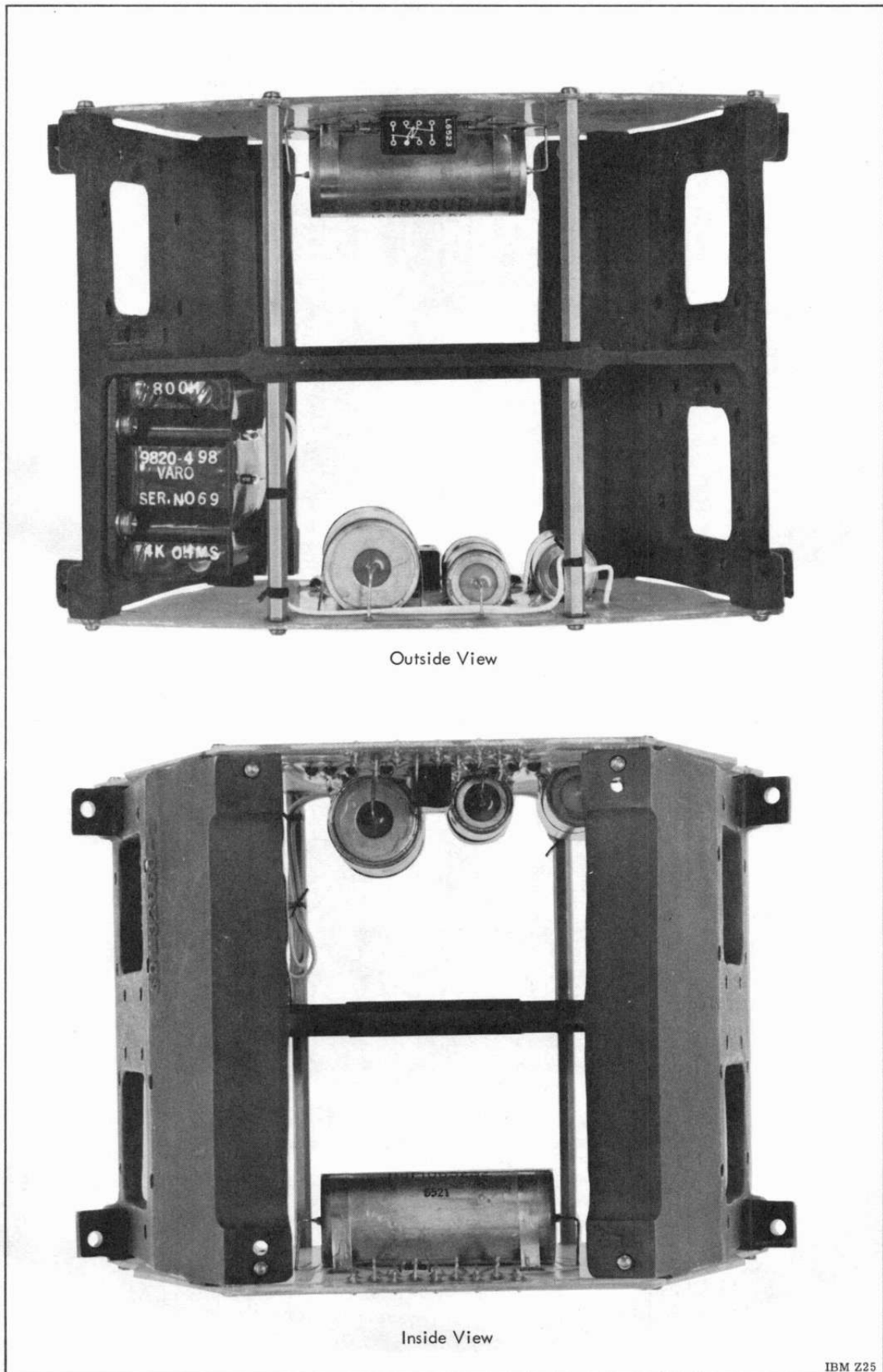
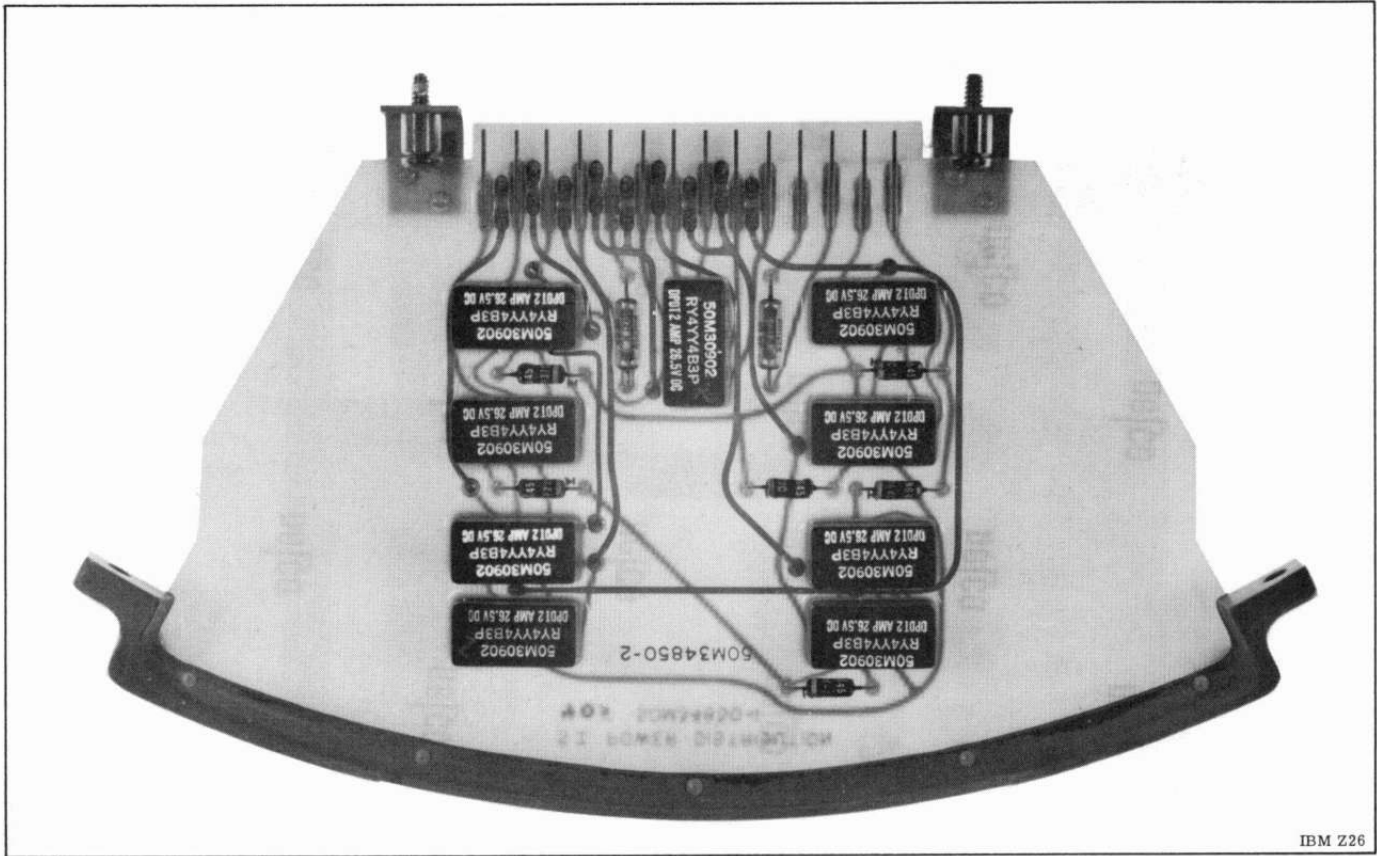


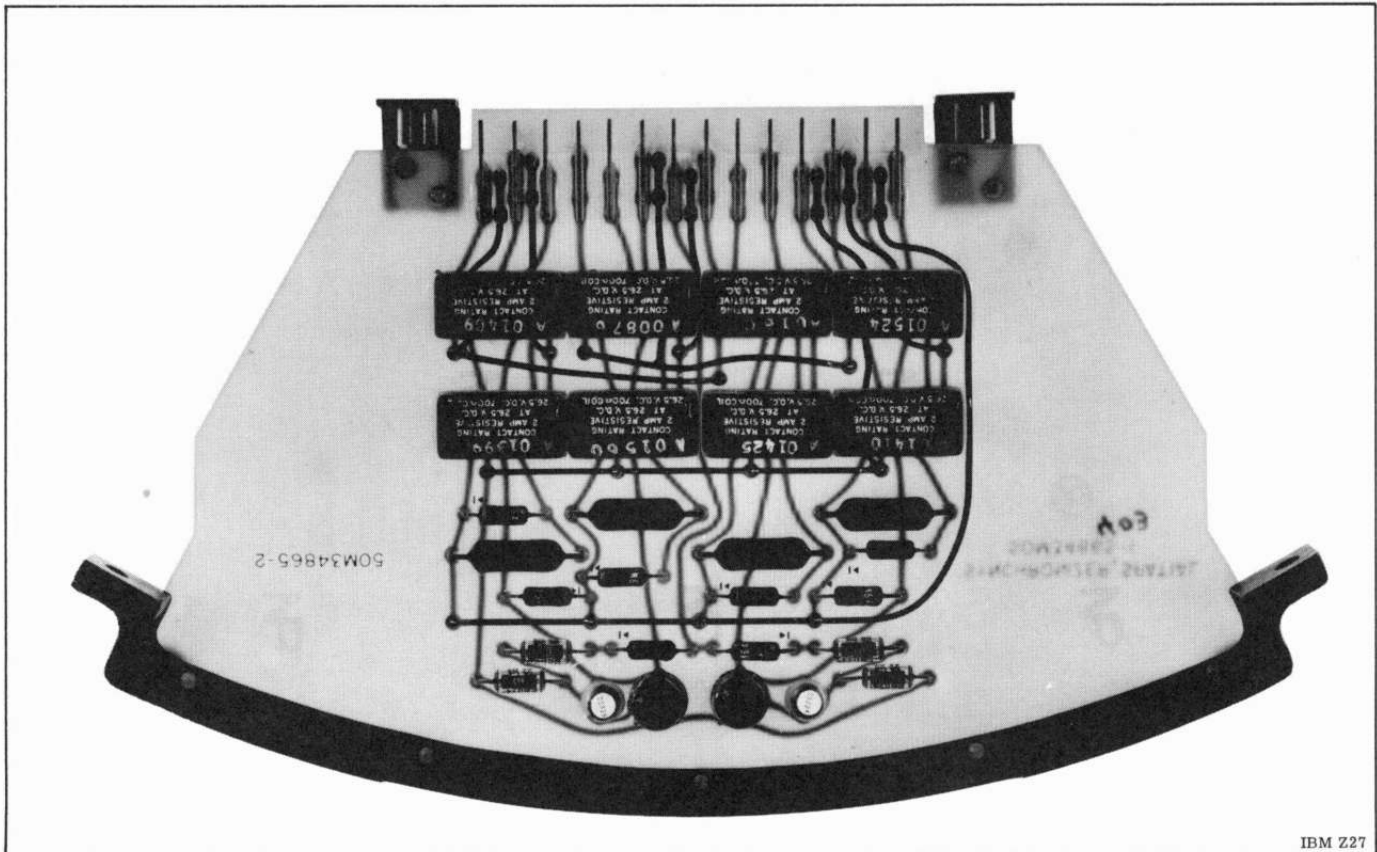
Figure 1-25. ϕR , ϕR SI Filter 50M34838

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IBM Z26

Figure 1-26. SI Power Distribution Module 50M34850



IBM Z27

Figure 1-27. Spatial Synchronizer 50M34865

Table 1-1. Common Names

Official Nomenclature	Ref. Desig.	Common Name	Official Nomenclature	Ref. Desig.	Common Name
45V DC Amplifier 50M32575 (Figure 1-3)	J32, J46, J47	DC Amplifier ($\Delta\phi Y$)	Beta Command Power Supply 50M32630 (Figure 1-5)(Cont)	J129	1 Pitch Beta Com- mand Power Supply
	J33, J48, J49	DC Amplifier ($\Delta\phi P$)		J130	2 Pitch Beta Com- mand Power Supply
	J34, J52, J53	DC Amplifier ($\Delta\phi R$)		J131	3 Pitch Beta Com- mand Power Supply
	J37, J38, J39	DC Amplifier(ϕR)		J132	4 Pitch Beta Com- mand Power Supply
	J54	DC Amplifier (γY)		J63	Pitch Spatial Comparator
	J55	DC Amplifier (γP)		J68	Roll-Yaw 1 Spatial Comparator
	J80, J88, J89	DC Amplifier (ϕP)		J74	Roll-Yaw II Spatial Comparator
	J81, J82, J87	DC Amplifier (ϕY)		J107	Pitch Servo Amplifier Comparator
	J106	DC Amplifier (Pitch Servo Comparator)		J110	Yaw Servo Amplifier Comparator
	J111	DC Amplifier (Yaw Servo Comparator)			
50 Ma Servo Amplifier (Figure 1-4)	J103, J104, J105	Pitch 50 Ma Servo Amplifier	Servo Comparator 50M32640 (Figure 1-7)	J64	Pitch TM Amplifier
	J112, J113, J114	Yaw 50 Ma Servo Amplifier	Telemetry Amplifier 50M32645 (Figure 1-8)	J69	Roll-Yaw I TM Amplifier
				J75	Roll-Yaw II TM Amplifier
Beta Command Power Supply 50M32630 (Figure 1-5)	J125	1 Yaw Beta Com- mand Power Supply	Switching Circuit A 50M32660 (Figure 1-9)	A1	Switching Circuit A
	J126	2 Yaw Beta Com- mand Power Supply			
	J127	3 Yaw Beta Com- mand Power Supply		J90-A	C. A. T. Inverter
	J128	4 Yaw Beta Com- mand Power Supply		Continuous Attenuator Timer Inverter 50M32665 (Figure 1-10)	

Table 1-1. Common Names (Cont)

Official Nomenclature	Ref. Desig.	Common Name	Official Nomenclature	Ref. Desig.	Common Name	
Scaling Board 50M32670 (Figure 1-11)	J35	φ Roll SI Scaling Board	Mother Board No. 5 Printed Wiring Assembly 50M34712 (Figure 1-17)	J56-A	Mother Board 5	
	J50	φ Yaw Scaling Board			Servo Inverter	
	J51	φ Roll Scaling Board			50M34725 (Figure 1-18)	Servo Inverter
	J36	φ Pitch Scaling Board			Mother Board No. 1 Printed Wiring Assembly 50M34737 (Figure 1-17)	Mother Board 1
	J85	φ Pitch Scaling Board			Mother Board No. 7 Printed Wiring Assembly 50M34740 (Figure 1-17)	Mother Board 7
	J84	φ Yaw Scaling Board				
Beta Feedback 50M32675 (Figure 1-12)	J133	Beta Feedback	12 Ma Servo Amplifier 50M34750 (Figure 1-19)	J117	1 Yaw 12 Ma Servo Amplifier	
Continuous Attenuator Timer 50M32793 (Figure 1-13)	J134	C. A. T.		J118	1 Pitch 12 Ma Servo Amplifier	
				J119	2 Yaw 12 Ma Servo Amplifier	
Switching Circuit B 50M34000 (Figure 1-14)	A2	Switching Circuit B		J120	2 Pitch 12 Ma Servo Amplifier	
				J121	3 Yaw 12 Ma Servo Amplifier	
Switching Circuit C 50M34005 (Figure 1-15)	A3	Switching Circuit C		J122	3 Pitch 12 Ma Servo Amplifier	
				J123	4 Yaw 12 Ma Servo Amplifier	
				J124	4 Pitch 12 Ma Servo Amplifier	
					Mother Board 2	
Spatial Amplifier 50M34120 (Figure 1-16)	J60, J61, J62	Pitch Spatial Amplifier	Mother Board No. 2 Printed Wiring Assembly 50M34766 (Figure 1-17)			
	J65, J66, J67	Roll-Yaw I Spatial Amplifier				
	J71, J72, J73	Roll-Yaw II Spatial Amplifier				
Mother Board No. 6 Printed Wiring Assembly 50M34705 (Figure 1-17)		Mother Board 6	φY, φP SI Filter 50M34805 (Figure 1-20)	J78	φY S-IB Filter	

Table 1-1. Common Names (Cont)

Official Nomenclature	Ref. Desig.	Common Name	Official Nomenclature	Ref. Desig.	Common Name
φY, φP SI Filter 50M34805 (Figure 1-20) (Cont)	J79	φP S-IB Filter	φY, φP SIV Filter 50M34827 (Figure 1-24) (Cont)	J41, J94, J95	ΔφP S-IVB Filter
γY, γP Filter 50M34811 (Figure 1-21)	J56	γY Filter γP Filter	φR, φR SI Filter 50M34838 (Figure 1-25)	J29 J30	φR S-IB Filter Δ φR S-IB Filter
φY, φP SI Filter 50M34816 (Figure 1-22)	J90 J91	Δ φY S-IB Filter Δ φP S-IB Filter	SI Power Distribu- tion Assembly 50M34850 (Figure 1-26)	J100	Power Distribution Assembly
φY, φP SIV Filter 50M34821 (Figures 1-23)	J96, J97, J109	φY S-IVB Filter	Spatial Synchro- nizer 50M34865 (Figure 1-27)	J70	Spatial Synchronizer
	J98, J99, J108	φP S-IVB Filter	Mother Board No. 3 Printed Wiring As- sembly 50M34877 (Figure 1-17)		Mother Board 3
φY, φP SIV Filter 50M34827 (Figure 1-24)	J40, J44, J45	Δ φY S-IVB Filter	Mother Board No. 4 Printed Wiring As- sembly 50M34880 (Figure 1-17)		Mother Board 4

Table 1-2. Flight Control Computer, Leading Particulars

Characteristic	Specification	Characteristic	Specification
NOTE		Overall Dimensions (Cont)	
Overall dimensions are maximum, and include the Flight Control Computer case and cradle. Measurements indicated are obtained when viewing the Flight Control Computer from the connector end.		Width	20 inches
Overall Dimensions		Depth	30 inches
Height	21 inches	Overall Weight	130 pounds maximum
		Duty Cycle	100% continuous operation
		Warmup Time	30 minutes

Table 1-2. Flight Control Computer, Leading Particulars (Cont)

Characteristic	Specification
Input Power	22 to 32 vdc, 320 watts max (28 volts nominal)
Operating Temperature Range	-55 to +100 degrees C (-67 to +212 degrees F)
Acceleration	20 G's peak
NOTE	
Reliability factor is for one Flight Control Computer and includes the probability that a failure may occur in a redundant circuit.	
Reliability Factor	0.999 for a Saturn mission consisting of (1) earth orbit insertion, (2) three earth orbits, (3) translunar injection, and (4) two hours of translunar coast
NOTE	
The Flight Control Computer case assembly is constructed so that a pressure drop to less than 14.7 PSIA will not be encountered over a two-year period in a perfect vacuum environment.	
Pressurization	Gaseous nitrogen to 20 PSIA at +17 to +27 degrees C (+63 to +81 degrees F)
Cooling	Fluid coolant lines
Case	Spot welded and dip brazed aluminum alloy
Cradle	
Type	Dip brazed aluminum alloy
Lifting Lugs	4
Case Cover	
Type	Spot welded and dip brazed aluminum alloy

Characteristic	Specification
Case Cover (Cont)	
Lifting Lugs	4
Transducer	50 PSIA range motional pick up (pressure) transducer mounted on the inside of the case cover.
Timer	Elapsed time indicator mounted on the case cover (activated when 28 vdc power is applied to the Flight Control Computer)
Electrical Connectors	13
Primary Chassis	Welded and riveted aluminum alloy containing fluid coolant lines.
Dual Filter Chassis	Magnesium alloy casting.
Interconnections (Welded Modules)	
Point-to-Point Connections	Two nickel strips per connection
Spacing	Glass bead spacers used between nickel strips
Interconnecting Wiring	
Wire Material	Silver coated copper wire
AWG Wire Size	24 and 26
Strands	19 (minimum)
Insulation	Irradiated polyolefin (white)
Temperature Rating	+135 degrees C (+275 degrees F) maximum
Potential Rating	600 vrms

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars

Characteristic	Specification	Characteristic	Specification
NOTE			
Unless otherwise indicated herein, or in Table 1-2, the characteristics and specifications shown in Table 1-2 are applicable to the Flight Control Computer Subassemblies.			
DC Amplifier		DC Amplifier (Cont)	
Function	Dual input 45-volt differential amplifier	Electrical Characteristics (Cont)	
Construction Type	Printed circuit board	Output Impedance	100 ohms maximum
Overall Dimensions		Load Limit	5,000 ohms
Height	4.5 inches	Output Signal	A differential value between zero and 45 volts, positive or negative, as developed across a 5,000-ohm load
Width	8.0 inches	Non-linearity	Not more than 2%
Depth	0.8 inches	Dynamic Response	Not more than 5 degrees phase shift with 10 cps or lower frequency input signals
Overall Weight	7 ounces maximum	Null Offset	With no input signal applied, null offset is less than zero plus or minus 10 mvs referred to input
Warmup Time	One minute	50 Ma Servo Amplifier	
Input Power	22 to 32 vdc, 1.96 watts max (28 volts nominal)	Function	Signal amplification
External Electric Connections	Forked plug-in type connector	Construction Type	Printed Circuit Board
Electrical Characteristics		Overall Dimensions	
Input Signal	A differential value between zero and 45 volts, positive or negative, at 10 cps maximum	Height	4.75 inches
Gain	Between 0.5 and 25.0 as determined by the selected value of feedback selector	Width	8.00 inches
Input Impedance	20,000 ohms at gain of 0.5, 2 megohms at gain of 25.0	Depth	2.00 inches
		Overall Weight	16 ounces maximum
		Warmup Time	One minute
		Input Power	22 to 32 vdc, 2.8 watts max (28 volts nominal)

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification
50 Ma Servo Amplifier (Cont)	
External Electrical Connections	Forked plug-in type
Electrical Characteristics	
Input Signal	
ϕY or ϕP	33.6 or 48.4 vdc, positive and negative
ϕY or ϕP	7.465 vdc, positive and negative
Gain	
ϕY or ϕP 33.6 vdc	0.02976 ($\pm 2\%$)
Input Signal	
ϕY or ϕP 48.4 vdc	0.02065 ($\pm 2\%$)
Input Signal	
ϕY or ϕP 7.465 vdc	0.1340
Input Signal	
Input Current	Not more than zero plus or minus 30 microamperes into 450 turns per stack for full output signal swing
Output Impedance	Greater than 40,000 ohms from zero to 20 cps
Output Current	A full output swing between zero and 50 milliamperes, positive and negative, as developed across a 100-ohm valve load
Non-linearity	Not more than 2%

Characteristic	Specification
50 Ma Servo Amplifier (Cont)	
Electrical Characteristics (Cont)	
Dynamic Response	The 3 db down frequency is 55 (± 5) cps <i>(with resistance load)</i>
Null Offset	With no input signal applied, null offset is less than zero plus or minus 50 mvs referred to input
Source Impedance	Not less than 20,000 ohms and isolated by at least 150,000 ohms from the 28 vdc supply voltage
Beta Command Power Supply	
Function	Power conversion (dc to dc) to supply 60 vdc ($\pm 1\%$) to yaw channels 1Y through 4Y and to pitch channels 1P through 4P
Construction Type	Printed circuit board
Overall Dimensions	
Height	4.75 inches
Width	5.25 inches
Depth	1.25 inches
Overall Weight	8 ounces maximum
Warmup Time	One minute
Input Power	22 to 32 vdc, 3 watts max (28 volts nominal)
External Electrical Connections	Forked plug-in type connector

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification	Characteristic	Specification
Beta Command Power Supply (Cont)		Spatial Com-parator (Cont)	
Electrical Characteristics		Overall Dimen-sions (Cont)	
Output Voltages		Width	8.00 inches
Position In-dicator Po-tentiometers Source Voltage (pins 1 and 5)	-60.0 (± 0.6) vdc when the output load is a 5,000-ohm ($\pm 1\%$) 1 watt resistor	Depth	1.00 inches
Telemeter-ing Voltage (pins 3 and 6)	-1.0 (± 0.03) vdc	Overall Weight	7 ounces maximum
Output Ripple	Not greater than 20 mv rms	Warmup Time	One minute
Output Spikes	Not greater than 400 mvs peak-to-peak at 8 kc/s	Input Power	22 to 32 vdc, 7 watts max (28 volts nominal)
Overload Protection	(1) With the output load re-duced to 1.0 ($\pm 1\%$) ohms, the maximum load current is not greater than 80 milliamperes, and (2) when the output load returns to 5,000 ohms ($\pm 1\%$) normal output voltages are re-established.	External Electrical Connections	Forked plug-in type connector
Spatial Comparator		Electrical Characteristics	
Function	To monitor and switch the outputs from two associ-ated Spatial Amplifier Subassemblies	Input Signal	The output signals supplied by two Spatial Amplifier Subassemblies
Construction Type	Printed circuit board	Input Impedance	Not available
Overall Dimensions		Output Impedance	Not available
Height	4.75 inches	Load	One 600-ohm relay coil
		Output Signal	Output pulse width in milli-seconds/total period is (nominal) 100/200 for 50% duty cycle at 5 cps
		Switching Accuracy	10% or less
		Telemetry Output	A discrete signal at the switch point
		Servo Amplifier Comparator	
		Function	To switch ϕY channels A and B or ϕP channels A and B

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification
Servo Amplifier Comparator (Cont)	
Construction Type	Printed circuit board
Overall Dimensions	
Height	4.5 inches
Width	8.0 inches
Depth	1.0 inches
Overall Weight	7 ounces maximum
Warmup Time	One minute
Input Power	22 to 32 vdc, 1.4 watts max (28 volts nominal)
External Electrical Connections	Forked plug-in type connector
Electrical Characteristics	
Input Signal	8.0 milliamperes differential input current to produce trip point)
Input Impedance	Not less than 20,000 ohms
Load	One 600-ohm relay coil
Output Signal	(1) ϕ Y channel A or B or (2) ϕ P channel A or B
Switch Point Tolerance	$\pm 1\%$ of the differential input signal
Telemetry Output	A discrete signal at the switch point
TM Amplifier Function	To produce a 1.52 ($\pm 3\%$) dc output voltage in response to a spatial full-on condition

Characteristic	Specification
TM Amplifier (Cont)	
Construction Type	Printed circuit board
Overall Dimensions	
Height	4.75 inches
Width	8.00 inches
Depth	1.25 inches
Overall Weight	7 ounces maximum
Warmup Time	One minute
Input Power	22 to 32 vdc, 3.5 watts max (28 volts nominal)
External Electrical Connections	Forked plug-in type connector
Electrical Characteristics	
Input Signal	Zero to 215 milliamperes
Gain	11.9 volts per ampere (voltage gain)
Input Impedance	0.5 ohms maximum
Output Impedance	Not available
Load Limit	5,000 ohms minimum
Output Signal	1.52 ($\pm 3\%$) vdc excursion, positive or negative
Cut-off Frequency	500 cps minimum
Null Offset	With no input signal applied, null offset is less than zero plus or minus 10 mvs re- ferred to input

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification	Characteristic	Specification
Switching Circuit A		C. A. T. Inverter (Cont)	
Function	Establishes switching combinations	Overall Weight	22 ounces maximum
Construction Type	Printed circuit board	Warmup Time	One minute
Overall Dimensions		Input Power	22 to 32 vdc, 10 watts (28 volts nominal)
Height	15.00 inches	External Electrical Connections	Forked plug-in type connector
Width	6.00 inches	Electrical Characteristics	
Depth	1.25 inches	Input Signal	22 to 32 vdc
Overall Weight	18 ounces maximum	Efficiency	60% minimum
Warmup Time	One minute	Regulation	±1% (voltage and frequency)
Input Power	22 to 32 vdc, 14 watts max (28 volts nominal)	Power (pins 4 and 3)	6 to 10 watts
External Electrical Connections	Forked plug-in type connector	Output Voltage	115 vrms, 400 cps (±1%)
Electrical Characteristics		Scaling Board	
Input Signal	22 to 32 vdc	Function	Used with DC Amplifier Subassemblies to permit varied usage
Output	Resistance and voltage combinations	Construction Type	Printed circuit board
C. A. T. Inverter		Overall Dimensions	
Function	Power conversion (dc to 400 cps)	Height	4.75 inches
Construction Type	Printed circuit board	Width	8.00 inches
Overall Dimensions		Depth	1.00 inches
Height	4.75 inches	Overall Weight	5 ounces maximum
Width	8.50 inches	Warmup Time	None
Depth	2.00 inches		

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification	Characteristic	Specification
Scaling Board (Cont)		Continuous Attenuation Time (C.A.T.) (Cont)	
Input Power	None required	Overall Dimensions	
External Electrical Connections	Forked plug-in type connector	Height	3.500 inches
Beta Feedback		Width	4.875 inches
Function	Provides adjustment of feedback signal	Depth	2.250 inches
Construction Type	Printed circuit board	Overall Weight	29 ounces maximum
Overall Dimensions		Warmup Time	None
Height	4.5 inches	Input Power	115 (± 1.15) vac, 400 cps, single-phase
Width	5.2 inches	External Electrical Connections	Forked plug-in type connector
Depth	0.8 inches	Switching Circuit B	
Overall Weight	4.8 ounces maximum	Function	Establishes switching combinations
Warmup Time	None	Construction Type	Printed circuit board
Input Power	4 volts dc (max) at 50 microamperes (max)	Overall Dimensions	
External Electrical Connections	Forked plug-in type connector	Height	15.00 inches
Continuous Attenuation Timer (C.A.T.)		Width	6.00 inches
Function	Creates variations in gain as a function of time and activates microswitches as preset intervals	Depth	1.25 inches
Construction Type	Gearbox type construction using precision aluminum alloy castings with all rotating shafts turning on ball bearings	Overall Weight	20 ounces maximum
		Warmup Time	One minute
		Input Power	22 to 32 vdc, 14 watts max (28 volts nominal)
		External Electrical Connections	Forked plug-in type connector

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification	Characteristic	Specification
Switching Circuit B (Cont)		Spatial Amplifier (Cont)	
Electrical Characteristics		Construction Type	Printed circuit board
Input Signal	22 to 32 vdc	Overall Dimensions	
Output	Resistance and voltage combinations	Height	4.75 inches
Switching Circuit C		Width	8.00 inches
Function	Establishes switching combinations	Depth	1.00 inches
Construction Type	Printed circuit board	Overall Weight	13.6 ounces maximum
Overall Dimensions		Warmup Time	One minute
Height	15.00 inches	Input Power	22 to 32 vdc, 7.28 watts max (28 volts nominal)
Width	6.00 inches	External Electrical Connections	Forked plug-in type connector
Depth	1.25 inches	Electrical Characteristics	
Overall Weight	17 ounces maximum	Input Signal	210 (± 10) microamperes into 300 turns to produce trip point; 320 (± 15) microamperes into 300 turns to produce full-on condition
Warmup Time	One minute	On Time	65 milliseconds (for 210 microampere input)
Input Power	22 to 32 vdc, 14 watts max (28 volts nominal)	Load	Four 600-ohm relay coils in parallel and one 1200-ohm counter in parallel with the relays
External Electrical Connections	Forked plug-in type connector	Output	0.840 (± 0.04) vdc (positive and negative) trip output; 1.28 (± 0.06) vdc (positive and negative) full output
Electrical Characteristics		Switch Rate	5 pulses per second at 50% duty cycle
Input Signal	22 to 32 vdc		
Output	Resistance and voltage combinations		
Spatial Amplifier Function	To produce trip and full-on output conditions		

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification	Characteristic	Specification
Servo Inverter		12 Ma Servo Amplifier (Cont)	
Function	Power conversion (dc to ac)	Overall Weight	14 ounces maximum
Construction Type	Printed circuit board	Warmup Time	Five minutes
Overall Dimensions		Input Power	22 to 32 vdc, .56 watts max (28 volts nominal)
Height	4.75 inches	External Electrical Connections	Forked plug-in type connector
Width	8.00 inches	Electrical Characteristics	
Depth	1.75 inches	Input Signal	Current levels, in microamperes: 20.00; 21.20; 14.13; 84.80; 42.40
Overall Weight	26 ounces maximum	Load	Dual 1000-ohm resistive load
Warmup Time	Five minutes	Output Signal	12 milliamperes
Input Power	22 to 32 vdc, 10 watts max (28 volts nominal)	Linearity	Within 2%
External Electrical Connections	Forked plug-in type connector	Null Offset	With no input signal applied and the input terminated by 50,000 ohms, null offset is less than zero plus or minus 20 mvs
Electrical Characteristics		ϕY S-IB and ϕP S-IB Filter	Not available
Input Signal	22 to 32 vdc, 300 milliamperes (maximum)	\ddot{Y} and \ddot{P} Filter	Not available
Output Signal	1200 cps 66-volt peak-to-peak square wave	$\Delta \phi Y$ and $\Delta \phi P$ S-IB Filter	Not available
12 Ma Servo Amplifier		ϕY and ϕP S-IVB Filter	Not available
Function	Signal amplification	$\Delta \phi Y$ and $\Delta \phi P$ S-IB Filter	Not available
Construction Type	Printed circuit board	ϕR and $\Delta \phi R$ S-IB Filter	Not available
Overall Dimensions			
Height	4.75 inches		
Width	5.00 inches		
Depth	1.75 inches		

Table 1-3. Flight Control Computer Subassemblies, Leading Particulars (Cont)

Characteristic	Specification	Characteristic	Specification
Power Distribution Assembly		Power Distribution Assembly (Cont)	
Function	Applies +28 vdc power to subassemblies	Warmup Time	None
Construction Type	Printed circuit board	Input Power	None
Overall Dimensions		External Electrical Connections	Forked plug-in type connector
Height	4.75 inches	Electrical Characteristics	
Width	8.00 inches	Input Signal	+28 vdc
Depth	1.00 inches	Output Signal	+28 vdc
Overall Weight	7 ounces maximum	Spatial Synchronizer	Not available

Table 1-4. Flight Control Computer, Semiconductor Complement

Location	Reference Designation	Type	Quantity	Function
DC Amplifier	CR1, CR3	S1N645	2	Temperature Compensating
	CR2, CR4	1N4120	2	Voltage Reference
	CR5 thru CR9	S1N645	5	Bridge Rectifier
	CR10 thru CR15	S1N645	6	Steering
	Q1, Q2	2N2034A	2	Inverter
	Q3	2N3907A	1	Comparator-Amplifier
	Q4	S2N657A	1	Regulator
	Q5	2N2920	1	Differential Amplifier
	Q6	S2N910	1	Temperature Compensator
	Q7	2N2920	1	Push-Pull Amplifier

Table 1-4. Flight Control Computer, Semiconductor Complement (Cont)

Location	Reference Designation	Type	Quantity	Function
DC Amplifier (Cont)	Q8	2N2907A	1	Temperature Compensator
	Q9	SD435	1	Push-Pull Amplifier
	Q10	2N2920	1	1/2 Bridge-Connected Complementary Symmetry Amplifiers
	Q11, Q12	2N2907A	2	1/2 Bridge-Connected Complementary Symmetry Amplifiers
Pitch and Yaw 50 Ma Servo Amplifiers	CR1	S1N645	1	Inductor Discharge
	CR2	S1N939A	1	Voltage Reference
	CR3	S1N645	1	Temperature Compensating
	CR4 thru CR7	S1N645	4	Bridge Rectifier
	CR8 thru CR11	S1N645	4	Bridge Rectifier
	CR12 thru CR15	1N4311	4	Magnetic Amplifier
	CR16 thru CR18	S1N645	3	Temperature Compensating
	Q1	2N2907A	1	1/2 Comparator-Multivibrator
	Q2	S2N2034A	1	Chopper
	Q3	S2N910	1	1/2 Comparator-Multivibrator
	Q4, Q5	S2N2034A	2	Inverter
	Q6	2N2920	1	Push-Pull Amplifier
	Q7	S2N657A	1	1/2 Complementary Symmetry Amplifier
	Q8	S2N910	1	Temperature Compensation
	Q9	S2N1132	1	1/2 Complementary Symmetry Amplifier
	Q10, Q11	2N2907A	2	Differential Amplifier
	Q12	2N2920	1	Differential Amplifier
	Q13	2N910	1	Temperature Compensation

Table 1-4. Flight Control Computer, Semiconductor Complement (Cont)

Location	Reference Designation	Type	Quantity	Function
Pitch and Yaw 50 Ma Servo Amplifiers (Cont)	Q14	S2N722	1	1/2 Driver
	Q15	S2N910	1	1/2 Driver
Beta Command Power Supplies	CR1 thru CR4	S1N645	4	Bridge Rectifier
	CR5	S1N645	1	Inductor Discharge
	CR6	S1N645	1	Isolation
	CR7, CR8	S1N939A	2	Voltage Reference
	CR9	S1N645	1	Temperature Compensating
	Q1, Q2	S2N2034A	2	Inverter
	Q3	S2N657A	1	Chopper
	Q4	2N2907A	1	Driver
	Q5	2N2907A	1	1/2 Multivibrator
	Q6	S2N910	1	Overload Protection
	Q7	S2N910	1	1/2 Multivibrator
	Q8	2N920	1	Differential Amplifier
	Spatial Comparator	CR1	S1N939A	1
CR2, CR3		S1N645	2	Isolation
CR4, CR7		S1N645	2	Clamping
CR5, CR6		S1N645	2	Isolation
CR8, CR9		1N756	2	Voltage Reference
Q1		2N2907A	1	Regulator
Q2		2N2920	1	Comparator-Driver
Q3, Q4		2N2907A	2	Amplifier
Q5, Q8		S2N910	2	Driver
Q6, Q7, Q9, Q10		S2N910	4	Comparator-Amplifier

Flight Control Computer
Section I

Table 1-4. Flight Control Computer, Semiconductor Complement (Cont)

Location	Reference Designation	Type	Quantity	Function
Spatial Comparator (Cont)	Q11, Q12	2N2907A	2	DC Amplifier
	Q13	2N2907A	1	Relay Driver
Pitch and Yaw Servo Comparators	CR1 thru CR4	S1N939A	4	Comparator
	CR5	S1N939A	1	Voltage Reference
	Q1	2N2920	1	Schmitt Trigger
	Q2	2N2907A	1	DC Amplifier
	Q3	S2N657A	1	Relay Driver
Pitch and Roll Telemetry (TM) Amplifiers	CR1 thru CR4	S1N645	4	Magnetic Amplifier
	Q1, Q2	S2N2034A	2	Inverter
Switching Circuit A	A1CR1, A1CR2, A1CR4, A1CR5, A1CR7, A1CR8, A1CR10, A1CR11, A1CR13, A1CR14, A1CR16, A1CR17, A1CR19, A1CR20, A1CR22, A1CR23, A1CR25, A1CR26, A1CR28, A1CR29, A1CR31, A1CR32, A1CR34, A1CR35	S1N645	24	Steering
	A1CR3, A1CR6, A1CR9, A1CR12, A1CR15, A1CR18, A1CR21, A1CR24, A1CR27, A1CR30, A1CR33, A1CR36	S1N645	12	CEMF Suppression
	A1Q1, A1Q3, A1Q5, A1Q7, A1Q9, A1Q11, A1Q13, A1Q15, A1Q17, A1Q19, A1Q21, A1Q23	2N910	12	Relay Driver

Table 1-4. Flight Control Computer, Semiconductor Complement (Cont)

Location	Reference Designation	Type	Quantity	Function
Switching Circuit A (Cont)	A1Q2, A1Q4, A1Q6, A1Q8, A1Q10, A1Q12, A1Q14, A1Q16, A1Q18, A1Q20, A1Q22, A1Q24	2N2034	12	Relay Driver
Continuous Attenuator Timer (C.A.T.) Inverter and Servo Inverter	CR1	S1N939A	1	Voltage Reference
	CR2, CR3	S1N645	2	Temperature Compensating
	CR4	1N1204A	1	Inductor Discharge
	CR5	S1N939A	1	Voltage Reference
	CR6	S1N645	1	Isolation
	CR7, CR8	S1N645	2	Full Wave Rectifier
	Q1, Q2	S1N645	2	Inverter
	Q3	2N2920	1	Frequency Adjust
	Q4	2N2907A	1	Comparator Driver
	Q5	S2N657A	1	Regulator
	Q6, Q7	S1N645	2	Driver-Amplifier
Switching Circuit B	Q8	2N2880	1	Chopper
	Q9	S2N910	1	Driver
	Q10	2N2907A	1	1/2 Comparator-Multivibrator
	Q11	S2N910	1	1/2 Comparator-Multivibrator
	1A1CR1 thru 1A1CR23	S1N645	23	Matrix
	2A1CR1 thru 2A1CR23	S1N645	23	Matrix
	1A2CR1 thru 1A2CR23	S1N645	23	Matrix

Table 1-4. Flight Control Computer, Semiconductor Complement (Cont)

Location	Reference Designation	Type	Quantity	Function
Switching Circuit B (Cont)	2A2CR1 thru 2A2CR23	S1N645	23	Matrix
	1A3CR1, 1A3CR2, 2A3CR1, 2A3CR2, 3A3CR1, 3A3CR2, 4A3CR1, 4A3CR2	S1N967B	8	Steering
	1A3Q1, 1A3Q2, 2A3Q1, 2A3Q2, 3A3Q1, 3A3Q2, 4A3Q1, 4A3Q2	S2N910	8	Transistor Switch
	1A3Q3, 2A3Q3, 3A3Q3, 4A3Q3	2N2907A	4	Transistor Switch
	1A3Q4, 1A3Q5, 2A3Q4, 2A3Q5, 3A3Q4, 3A3Q5, 4A3Q4, 4A3Q5	S2N910	8	Transistor Switch
	A2CR1 thru A2CR3, A2CR5 thru A2CR7, A2CR9 thru A2CR11, A2CR13 thru A2CR15, A2CR18, A2CR20, A2CR22, A2CR24 thru A2CR38	S1N645	30	Steering
	A2Q1, Q2Q3, A2Q5, A2Q7, A2Q9, A2Q11, A2Q13, A2Q15, A2Q17, A2Q19, A2Q21, A2Q23	2N910	12	Relay Driver
	A2Q2, A2Q4, A2Q6, A2Q8, A2Q10, A2Q12, A2Q14, A2Q16, A2Q18, A2Q20, A2Q22, A2Q24	2N2034	12	Relay Driver

Table 1-4. Flight Control Computer, Semiconductor Complement (Cont)

Location	Reference Designation	Type	Quantity	Function
Switching Circuit C	A3CR1, A3CR2, A3CR4, A3CR5, A3CR7, A3CR8, A3CR10, A3CR11, A3CR13 thru A3CR17	S1N645	13	Steering
	A3CR3, A3CR6, A3CR9, A3CR12, A3CR18 thru A3CR23	S1N645	10	CEMF Suppression
	A3Q1, A3Q3, A3Q5, A3Q7, A3Q9	2N910	5	Relay Driver
	A3Q2, A3Q4, A3Q6, A3Q8, A3Q10	2N2034	5	Relay Driver
Pitch and Roll- Yaw Spatial Amplifier	CR1	S1N939A	1	Voltage Reference
	CR2, CR3	S1N939A	2	Feedback
	CR4, CR5	1N753A	2	Voltage Reference
	Q1	2N2034A	1	Regulator
	Q2	2N2907A	1	Driver
	Q3	2N2920	1	Comparator-Amplifier
	Q4, Q5	2N2034A	2	Inverter
	Q6, Q7	2N2920	2	Magnetic Amplifier
	Q8	2N2920	1	Differential Amplifier
	Q9	2N2920	1	Temperature Compensation
	Q10, Q11	2N2907A	2	Differential Amplifier
	Q12, Q13	2N2920	2	Schmitt Trigger
	Q14, Q15	2N2907A	2	DC Amplifier
	Q16, Q17	2N2034A	2	Relay Driver

Table 1-4. Flight Control Computer, Semiconductor Complement (Cont)

Location	Reference Designation	Type	Quantity	Function
Pitch and Yaw 12Ma Servo Amplifier	CR1 thru CR4	S1N645	4	Bridge Rectifier
	CR5	1N939A	1	Voltage Reference
	Q1, Q2	2N2920	2	Magnetic Amplifier
	Q3	2N2920	1	Bias Control Amplifier
	Q4	2N2920	1	Push-Pull Amplifier
	Q5	50M32559-1	1	Push-Pull Amplifier
	Q6, Q7	S2N910	2	Push-Pull Amplifier
Power Distribution	CR1 thru CR6	S1N645	6	Steering

SECTION II

PRINCIPLES OF OPERATION

2-1 INTRODUCTION

This section contains the principles of operation of the Flight Control Computer and is divided into two parts; General Operation and Detailed Operation. The General Operation position (paragraphs 2-2 through 2-7) is limited to the functional block diagram theory of the Flight Control Computer. The Detailed Operation portion contains the detailed circuit analysis of each component of the Flight Control Computer. The Detailed Operation portion of this manual will be supplied at a late date.

2-2 GENERAL OPERATION

General Operation of the Flight Control Computer is explained in the following paragraphs. The explanation presented, describes the manner in which the Flight Control Computer is connected to the launch vehicle systems, and how the systems function with the Flight Control Computer to provide control commands to the Saturn launch vehicle.

Paragraph 2-3 contains a general explanation of system tie-in and describes the functional and physical relationship of the Flight Control Computer with associated systems within the Saturn launch vehicle. Paragraphs 2-4 through 2-6 describes the functional relationship between the various Flight Control Computer circuits during the S-IB burn mode, the S-IVB burn mode, and the S-IVB coast mode, and how the circuits operate in order to provide control commands to the Saturn launch vehicle. Paragraph 2-7 contains functional descriptions of the various Flight Control Computer circuits.

2-3 SYSTEM TIE-IN

Figure 2-1 illustrates the functional and physical relationship of the Flight Control Computer, the various position sensing devices, and the position controlling devices. A general explanation of the system tie-in contained in the following paragraphs.

The Flight Control Computer is contained in the Instrument Unit section of the Saturn launch vehicle. The attitude control signals for the Flight

Control Computer are received from the Launch Vehicle Data Adapter (LVDA). The LVDA compares the output of the ST-124M-3 Inertial Platform Assembly with a preset program in the Launch Vehicle Digital Computer (LVDC) to produce the attitude control signals. These signals are then applied to the circuits within the Flight Control Computer. The outputs of the Flight Control Computer are applied as control signals to the various engine actuators of the vehicle.

Provisions are also made so that the Apollo Spacecraft can assume control of the launch vehicle attitude control signals to the Flight Control Computer. The three attitude control signals applied to the Flight Control Computer from the LVDA are $\Delta \theta Y$, $\Delta \theta R$, and $\Delta \theta P$. The $\Delta \theta Y$ signal is the yaw attitude error signal, the $\Delta \theta R$ signal is the roll attitude error signal, and the $\Delta \theta P$ signal is the pitch attitude error signal.

The operation of the Flight Control Computer is divided into three basic functions, control of the vehicle during S-IB Stage burn, control of the vehicle during S-IVB Stage burn, and control of the vehicle during S-IVB Stage coast.

During the S-IB burn mode, the attitude error signals are applied through contacts which are closed during S-IB burn only to the S-IB yaw servo amplifiers and S-IB pitch servo amplifiers. The $\Delta \theta Y$ error signal is applied to the S-IB yaw servo amplifiers only, the $\Delta \theta P$ error signal is applied to the S-IB pitch servo amplifiers only, and the $\Delta \theta R$ error signal is applied to both the S-IB yaw and S-IB pitch servo amplifiers.

The S-IB yaw servo amplifiers control the four gimballed engines in the S-IB Stage in the yaw and the pitch servo amplifiers control the four gimballed engines in the S-IB Stage in the pitch axis. The yaw servo amplifiers and the pitch servo amplifiers, operating simultaneously, control the four gimballed engines in the roll axis.

The Control Rate Gyro, contained in the S-IVB Stage, provides angular rate error signals in

the roll, yaw, and pitch axes. These signals are designated δR , δY , and δP respectively. The angular rate error signals are coupled through relay contacts which are closed during S-IB burn only, and through jumpers, to the S-IB yaw and pitch servo amplifiers. These signals are added algebraically with the attitude error signals to control the rate of response of the vehicle and to eliminate overshoot at the end of the correction. The jumpers provide for selection of angular rate signals from the Control Signal Processor or from the Control Rate Gyro. However, this selection must be made prior to launch.

Yaw and Pitch Control Accelerometers are contained in the S-IB Stage and in the Instrument Unit. They measure the lateral accelerations of the launch vehicle. Selection of the Control Accelerometers to be used during the flight is also made by jumpers and must be selected prior to launch. The output of the Yaw Control Accelerometer is called $\dot{\gamma}Y$, and the output of the Pitch Control Accelerometer is called $\dot{\gamma}P$. The acceleration error signals are applied through jumper selection to the Control Attenuation Timer (C. A. T.) which adjusts the amplitude of the signals in relation to the phase of the flight. The acceleration error signals are applied through contacts which are closed during S-IB burn only to the yaw servo amplifiers and to the pitch servo amplifiers where they are algebraically added with the attitude error signals from the LVDA.

After the S-IB Stage burns out and is jettisoned, relays switch within the Flight Control Computer and the yaw and pitch attitude error signals ($\Delta\delta Y$ and $\Delta\delta P$) are applied through contacts closed during S-IVB burn only to the S-IVB yaw servo amplifiers and S-IVB pitch servo amplifiers. The resultant drive signals from the S-IVB yaw and pitch servo amplifiers position the gimballed engine of the S-IVB stage to control the yaw and pitch attitude of the vehicle during burn of the S-IVB stage. The roll attitude error signal ($\Delta\delta R$) is applied through contacts open during S-IB burn only to the Roll-Yaw I and Roll-Yaw II spatial thruster amplifiers. The resultant control signals are applied to the control relay packages in the S-IVB Stage and operate the spatial thrusters as required to provide roll control during S-IVB burn mode.

The angular rate error signals, $\dot{\gamma}Y$ and $\dot{\gamma}P$ are applied from the Control Signal Processor through contacts which are closed during S-IVB burn only to the S-IVB yaw servo amplifiers and S-IVB pitch servo amplifiers. These angular rate signals algebraically add with the attitude error signals from the

LVDA to produce the drive signals for the Gimballed Engine in the S-IVB Stage. The roll angular rate error signal, $\dot{\gamma}R$, is applied through contacts which are open during S-IB burn only to the Roll-Yaw I and Roll-Yaw II spatial thruster amplifiers. The roll angular rate error signal algebraically adds with the attitude error signals from the LVDA to produce the roll control signals.

At the completion of the S-IVB burn mode, relay contacts transfer the yaw and pitch attitude error signals from the S-IVB yaw servo amplifiers and S-IVB pitch servo amplifiers to the spatial thruster amplifiers. The yaw attitude error signal ($\Delta\delta Y$) is simultaneously applied to Roll-Yaw I and Roll-Yaw II spatial thruster amplifiers. The pitch attitude error signal ($\Delta\delta P$) is applied to the pitch spatial thruster amplifiers. These attitude error signals are applied through closed contacts which are open only during S-IB burn and S-IVB burn modes. The yaw and pitch angular rate error signals ($\dot{\gamma}Y$ and $\dot{\gamma}P$) from the Control Signal Processor, are also transferred to the spatial thruster amplifiers.

When the S-IVB coast mode function is completed, the Flight Control Computer is no longer needed and the S-IVB stage, together with the Instrument Unit are jettisoned.

2-4 FUNCTIONAL OPERATION DURING S-IB BURN MODE

Figure 2-2 illustrates the functional operation of the Flight Control Computer during the S-IB Burn Mode. At missile lift-off, the LVDA through the Switch Selector initiates a first motion signal which is applied to the Flight Control Computer to control the application of power to the Continuous Attenuation Timer (C. A. T.).

The $\Delta\delta Y$, $\Delta\delta R$, and $\Delta\delta P$ attitude error signals are applied to the Flight Control Computer from the LVDA. In the Flight Control Computer, each of these error signals are routed through redundant, closed relay contacts to three identical dc amplifiers. (When the Saturn-IB is under Spacecraft control these relay contacts are open and the $\Delta\delta Y$, $\Delta\delta R$, and $\Delta\delta P$ error signals are received from the Spacecraft.) During the S-IB burn mode, only the amplifier $\Delta\delta Y$ error signal from dc amplifier J46 is used. The outputs of dc amplifiers J46, J47, and J32 are used during the S-IVB burn mode (paragraph 2-5) and during the S-IVB coast mode (paragraph 2-6).

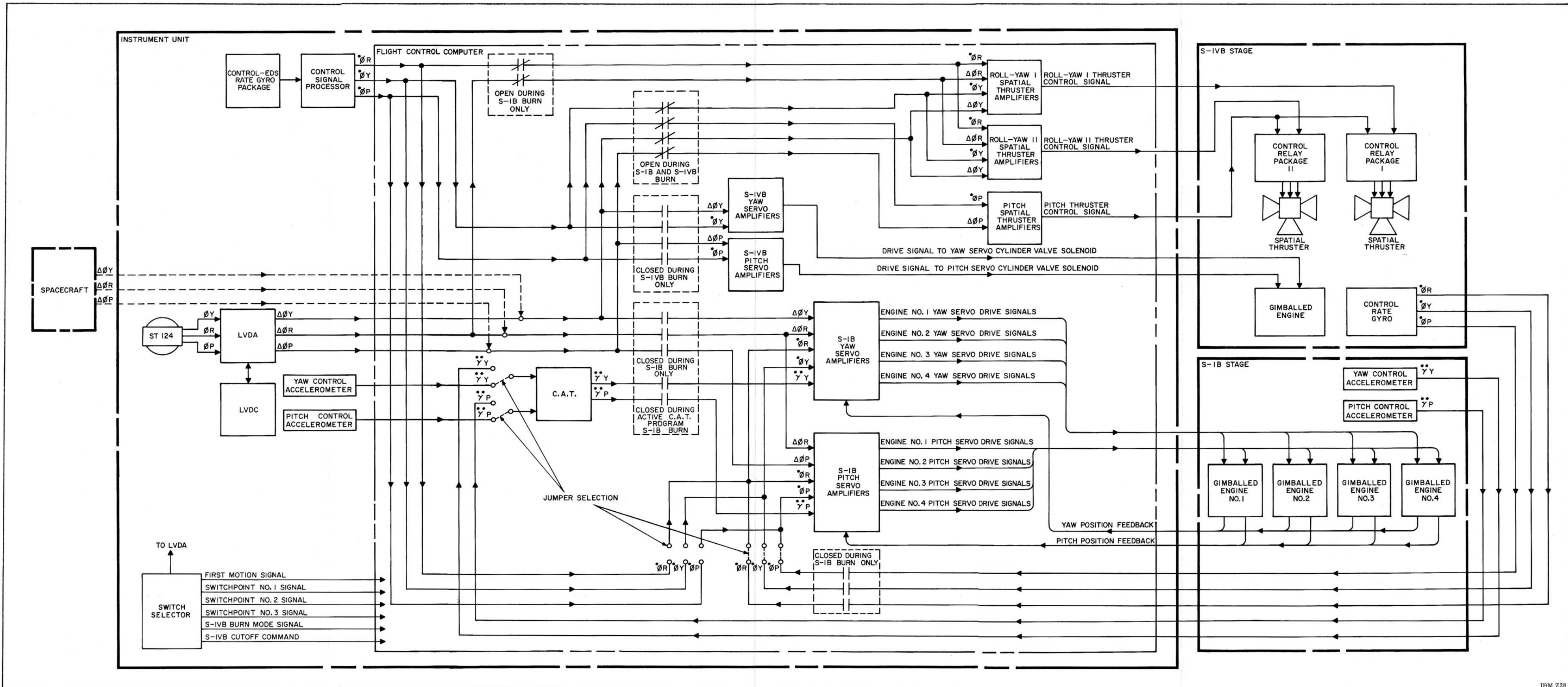


Figure 2-1. Flight Control Computer, System Tie-In Functional Block Diagram

IBM 228

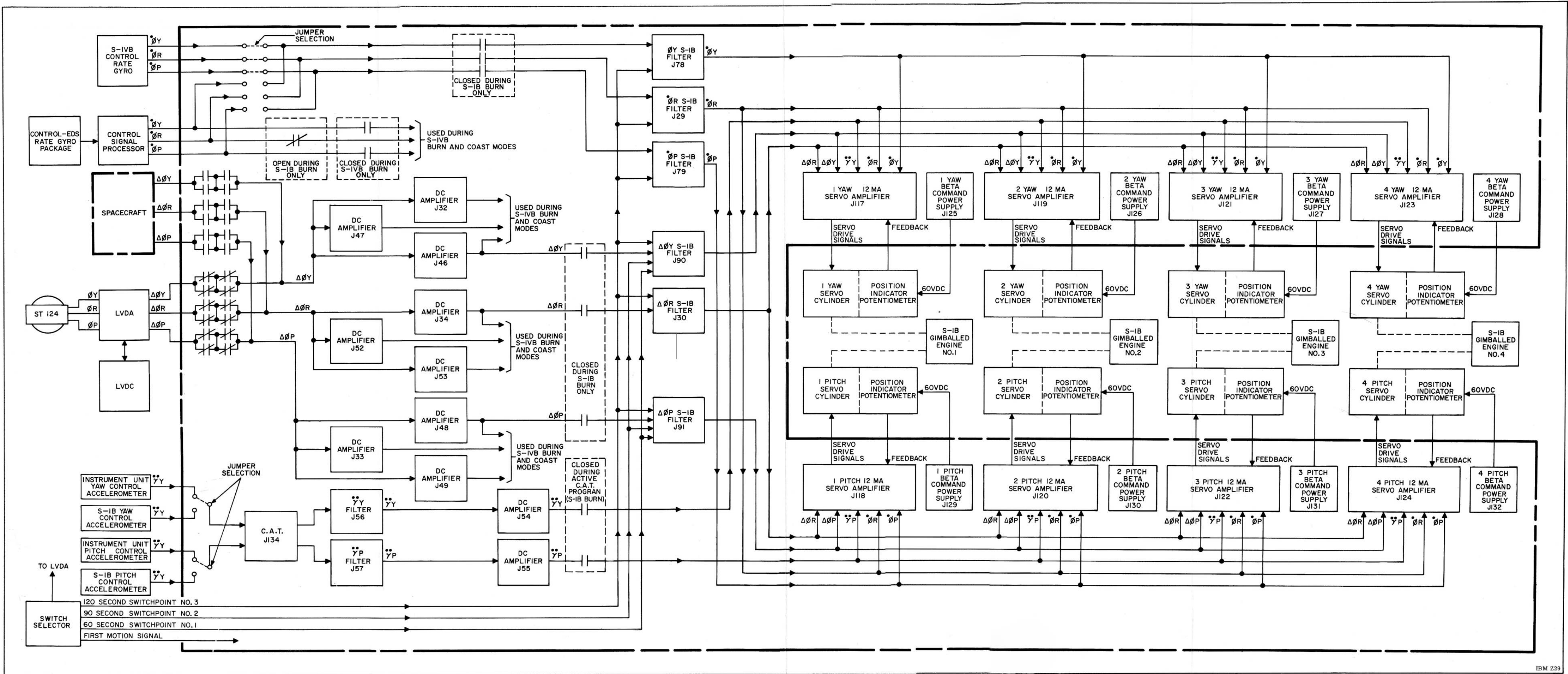


Figure 2-2. S-IB Burn Mode, Functional Block Diagram

IBM 229

The amplified $\Delta\theta Y$ error signal from dc amplifier J46 is routed through relay contacts that are closed during S-IB burn only to $\Delta\theta Y$ S-IB filter (J90). This filter is a bending mode filter which filters out angular yaw errors resulting from physical deflections of the missile structure. These deflections occur when the missile frame vibrates at its resonant frequency during high thrust loadings. By means of signals from the LVDA (applied through the Switch Selector) the $\Delta\theta Y$ S-IB filter (J90) also adjusts the amplitude of the $\Delta\theta Y$ attitude error signal in relation to the phase of the flight.

The $\Delta\theta Y$ attitude error signal from $\Delta\theta Y$ S-IB filter J90 is then coupled to the four yaw 12 ma servo amplifiers J117, J119, J121, and J123. The resultant drive signals from the 12 ma yaw servo amplifiers are applied to the four yaw servo cylinders in the S-IB Stage. Each drive signal causes the associated yaw servo cylinder to mechanically position the four gimballed engines of the S-IB Stage as required to correct for errors in the yaw axis. The yaw servo cylinders are also mechanically linked to position indicator potentiometers, which supply the position feedback signal for the 12 ma yaw servo amplifiers. Each position indicator potentiometer receives its source voltage from an associated yaw beta command power supply (J125 through J128).

The amplified $\Delta\theta P$ attitude error signal from dc amplifier J48 is routed through relay contacts which are closed during the S-IB burn mode only and through $\Delta\theta P$ S-IB filter (J91) to the four pitch 12 ma servo amplifiers J118, J120, J122, and J124. The $\Delta\theta P$ filter is a bending mode filter which also adjusts the amplitude of the $\Delta\theta P$ attitude error signal in relation to the phase of the flight. The amplitude adjustment is controlled by the LVDA through the Switch Selector. The resultant drive signals from the 12 ma pitch servo amplifiers are applied to the four pitch servo cylinders in the S-IB Stage. The drive signals cause the associated pitch servo cylinders to mechanically position the four gimballed engines of the S-IB Stage to correct for errors in the pitch axis. The pitch servo cylinders are also mechanically linked to position indicator potentiometers, which supply the position feedback signal for the 12 ma pitch servo amplifiers. The pitch position indicator potentiometers receive their source voltage from an associated pitch beta command power supply (J129 through J132). The amplified $\Delta\theta P$ attitude error signals from dc amplifiers J48, J49, and J33 are used during the S-IVB burn and coast modes.

The amplified $\Delta\theta R$ attitude error signals from dc amplifier J34 is coupled through relay contacts which are closed during the S-IB burn mode and

through $\Delta\theta R$ S-IB filter (J30) to the four 12 ma yaw servo amplifiers and the four 12 ma pitch servo amplifiers. The $\Delta\theta R$ filter is a bending mode filter which also adjusts the amplitude of the $\Delta\theta R$ error signal in relation to the phase of the flight. The amplitude adjustment is controlled by the LVDA through the Switch Selector. The resultant drive signals from the pitch and yaw 12 ma servo amplifiers cause the four gimballed engines in the S-IB Stage to correct for errors in the roll axis.

Angular rate error signals ($\dot{\theta} Y$, $\dot{\theta} R$, and $\dot{\theta} P$) for the S-IB burn mode are supplied by either the Control-EDS Rate Gyro Package (through the Control Signal Processor) or by the Control Rate Gyros located in the S-IVB Stage. Selection of the component to be used during flight is determined prior to lift-off by means of the jumper selector.

The $\dot{\theta} Y$, $\dot{\theta} R$, and $\dot{\theta} P$ angular rate error signals are coupled through relay contacts that are closed during S-IB burn only to filters J78, J29, and J79, respectively. Filters J78, J29, and J79 are bending mode filters which filter out angular position errors resulting from physical deflections of the missile structure. These deflections occur when the missile frame vibrates at its resonant frequency during high thrust loadings. Filters J78, J29, and J79 are also used to adjust the amplitude of the $\dot{\theta} Y$, $\dot{\theta} R$, and $\dot{\theta} P$ error signals in relation to the phase of the flight. The $\dot{\theta} Y$ signal from $\dot{\theta} Y$ filter J78 is applied to the yaw 12 ma servos, the $\dot{\theta} P$ signal from $\dot{\theta} P$ filter J79 is applied to the pitch 12 ma servo amplifiers, and the $\dot{\theta} R$ signal from $\dot{\theta} R$ filter J29 is applied to the yaw and pitch 12 ma servo amplifiers. The $\dot{\theta} Y$, $\dot{\theta} R$, and $\dot{\theta} P$ angular rate error signals are algebraically added with the $\Delta\theta Y$, $\Delta\theta R$, and $\Delta\theta P$ attitude error signals in the 12 ma servo amplifiers to produce the servo drive signals.

Switchpoint signals which control the amount of attenuation that filters J29, J30, J78, J79, J90, and J91 provide for their associated error signal is received from the LVDA through the IU Switch Selector. The Switch Selector initiates switchpoint No. 1 signal at T + 60 seconds, switchpoint No. 2 signal at T + 90 seconds, and switchpoint No. 3 signal at T + 120 seconds. Switchpoint No. 1 and No. 2 signals are applied to filters J90 and J91 only. Switchpoint No. 3 signal is applied to filters J29, J30, J78, J79, J90, and J91.

The lateral acceleration error signals ($\ddot{y} Y$ and $\ddot{y} P$) for the S-IB burn mode are normally supplied by the Yaw and Pitch Control Accelerometers located in the Instrument Unit. However, the acceleration error signals can be supplied by the Yaw and Pitch

Control Accelerometers located in the S-IB Stage by changing the jumper selectors prior to lift-off. The acceleration error signals are position error signals for yaw and pitch with respect to the lateral acceleration of the missile. The $\dot{\gamma}Y$ and $\dot{\gamma}P$ error signals are applied to the Continuous Attenuation Timer (C.A.T.) J134 which controls the amplitude of the $\dot{\gamma}Y$ and $\dot{\gamma}P$ error signals in relationship to the altitude of the missile. The $\dot{\gamma}Y$ filter J56 (bending mode filter), dc amplifier J54, and relay contacts which are closed during the active C.A.T. program to the yaw 12 ma servo amplifiers. The $\dot{\gamma}P$ error signal from the C.A.T. is coupled through $\dot{\gamma}P$ filter J57 (bending mode filter), dc amplifier J55, and relay contacts which are closed during the active C.A.T. program to the pitch 12 ma servo amplifiers. The $\dot{\gamma}Y$ and $\dot{\gamma}P$ error signals are algebraically added with the attitude and angular rate error signals in the 12 ma servo amplifiers to produce the servo drive signals.

2-5 FUNCTIONAL OPERATION DURING S-IVB BURN MODE

Figure 2-3 illustrates the functional operation of the Flight Control Computer during the S-IVB burn mode. At the completion of the S-IB burn mode, the S-IB Stage is jettisoned and the S-IVB Stage is activated. The LVDA, through the Switch Selector, then applies an S-IVB burn mode signal to the Flight Control Computer. The S-IVB burn mode signal activates the relays in the Flight Control Computer that are needed to provide control signals for the S-IVB Stages during the S-IV burn mode.

Attitude error signals ($\Delta\theta Y$, $\Delta\theta P$, and $\Delta\theta R$) for the S-IVB burn mode are supplied by the LVDA in the same manner as for the S-IB burn mode. However, triple redundancy circuits are used to achieve a high reliability for the S-IVB Stage. Basically, this means that the input signals have three paths to follow. Outputs from the normal path and a second path are continuously compared with each other. If a malfunction occurs in either of these two paths, the comparison circuit automatically detects the malfunction and switches to the third path. The probability of a malfunction occurring in two paths at the same time is very low.

The redundant $\Delta\theta Y$ error signals from dc amplifiers J46, J47, and J32 are coupled through relay contacts which are closed during S-IVB burn only to θY S-IVB filters J44, J45, and J40, respectively. The $\Delta\theta Y$ error signal outputs from the $\Delta\theta Y$ filters are applied to their respective yaw 50 ma servo amplifier. Yaw 50 ma servo amplifiers J112 through J114 will then develop servo drive signals in proportion

to the input error signals. However, only the servo drive signal from yaw 50 ma servo amplifier J113 is coupled through the normally closed contacts of the comparator relay to the yaw servo actuator in the S-IVB Stage. The yaw servo drive signal causes the yaw servo actuator to mechanically position the S-IVB gimballed engine as required to correct for errors in the yaw axis.

The outputs from yaw 50 ma servo amplifiers J112 and J113 are continuously compared by yaw servo amplifier comparator J110. When a malfunction occurs in either of the two separate and identical channels, yaw servo amplifier comparator J110 will automatically detect the malfunction and cause the normally closed relay contacts in the J113 output path to open and the open relay contacts in the J114 output path to close. The servo drive signal from yaw 50 ma servo amplifier J114 is then applied to the yaw servo actuator in the S-IVB Stage.

The redundant $\Delta\theta P$ error signals from dc amplifiers J48, J49, and J33 are coupled through relay contacts which are closed during S-IVB burn only to $\Delta\theta P$ S-IVB filters J94, J95, and J41, respectively. The $\Delta\theta P$ error signal outputs from the $\Delta\theta P$ filters are applied to their respective pitch 50 ma servo amplifier. Pitch 50 ma servo amplifier J103 through J105 will then develop servo drive signals in proportion to the input error signals. However, only the servo drive signal from pitch 50 ma servo amplifier J104 is coupled through the normally closed contacts of the comparator relay to the pitch servo actuator in the S-IVB Stage. The servo drive signal causes the pitch servo actuator to mechanically reposition the S-IVB gimballed engine to correct for errors in the pitch axis.

When a malfunction occurs in either of the two separate and identical pitch channels, pitch servo amplifier comparator J107 automatically opens the relay contacts in the J104 output and closes the relay contacts in the J105 output. The servo drive signal from pitch 50 ma servo amplifier J105 is then applied to the pitch servo actuator in the S-IVB Stage.

Roll position errors are corrected by the two spatial thrusters on the S-IVB Stage. This is necessary because the S-IVB Stage obtains its power from a single gimballed engine and roll position errors cannot be effectively corrected with a single engine.

The amplified $\Delta\theta R$ error signals from dc amplifiers J34, J52, and J53 are coupled through closed relay contacts and applied to triple redundant Roll-Yaw I spatial amplifiers J65 through J67. The Roll-Yaw I spatial amplifiers will then develop spatial

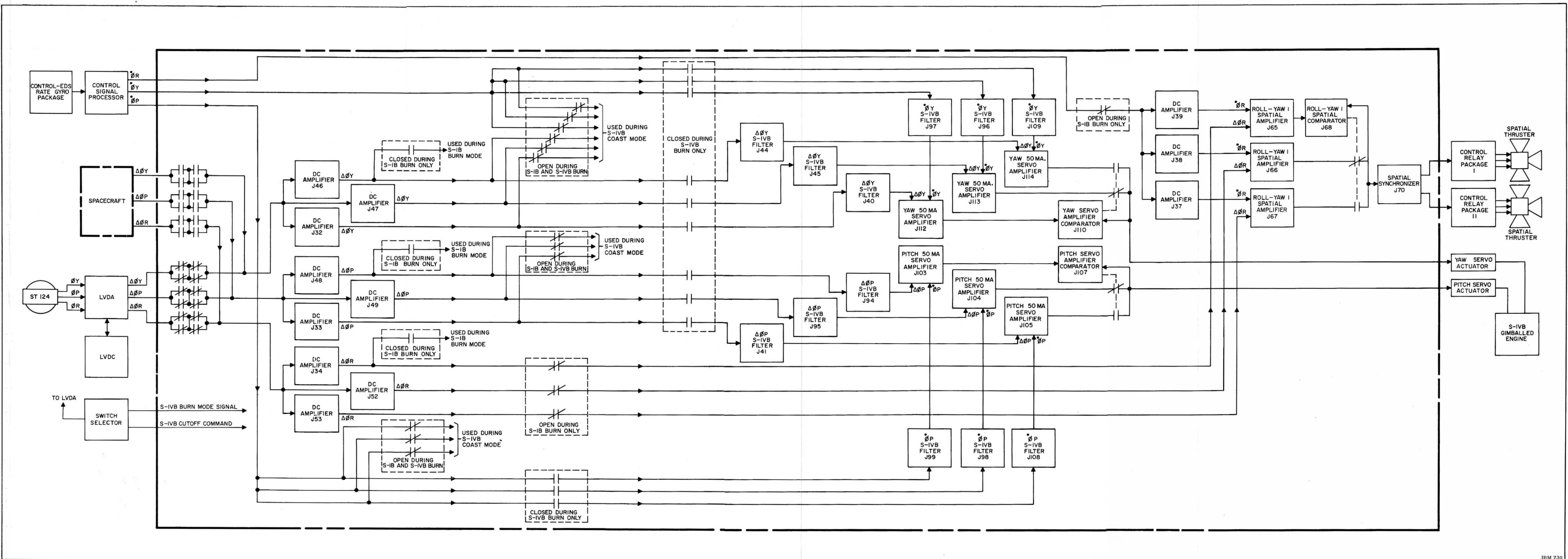


Figure 2-3. S-IVB Burn Mode, Functional Block Diagram

IBM 230

thruster control signals in proportion to the input error signals. However, only the spatial thruster control signal from Roll-Yaw spatial amplifier J66 is coupled through the normally closed contacts of the comparator relay to spatial synchronizer J70. The spatial thruster control signal is then simultaneously applied to control relay packages I and II in the S-IVB Stage by spatial synchronizer J60. The control relay packages then activate their associated spatial thruster to correct for errors in the roll axis.

Roll-Yaw I spatial comparator J68 compares the outputs of Roll-Yaw I spatial amplifiers J65 and J66. When a malfunction occurs in either of the two separate and identical channels, Roll-Yaw I spatial comparator J68 will automatically open the closed relay contact in the J66 output and close the relay contact in the J67 output. The control signal for control relay packages I and II are then applied from Roll-Yaw I spatial amplifier J67.

The angular rate error signals ($\dot{\phi}_Y$, $\dot{\phi}_P$, and $\dot{\phi}_R$) are supplied by the Control-EDS Rate Gyro Package through the Control Signal Processor. Three paths are provided for each of these inputs. The three $\dot{\phi}_Y$ error signals are coupled through relay contacts which are closed during S-IVB burn only and through $\dot{\phi}_Y$ filter J97, J96, and J109 and applied to triple redundant yaw 50 ma servo amplifiers J112 through J114. The $\dot{\phi}_Y$ angular rate error signals are algebraically added to the $\Delta\phi_Y$ altitude error signals by the yaw 50 ma servo amplifiers.

The three $\dot{\phi}_P$ error signals are coupled through relay contacts which are closed during S-IVB burn only and through $\dot{\phi}_Y$ filters J99, J98, and J108 and applied to triple redundant pitch 50 ma servo amplifiers J103 through J105. The $\dot{\phi}_P$ angular rate error signals are algebraically added to the $\Delta\phi_P$ altitude error signals by the pitch 50 ma servo amplifiers.

The $\dot{\phi}_R$ error signal is coupled through a closed relay contact to dc amplifiers J37 through J39. The amplified $\dot{\phi}_R$ error signals from the dc amplifiers are applied to triple redundant Roll-Yaw I spatial amplifiers J65 through J67. The $\dot{\phi}_R$ angular rate error signals are algebraically added to the $\Delta\phi_R$ altitude error signals by the Roll-Yaw I spatial amplifiers.

The filters shown throughout Figure 2-3 are bending mode filters which filter out angular yaw errors resulting from physical deflections of the missile structure. These deflections occur when the

missile frame vibrates at its resonant frequency during high thrust loadings.

2-6 FUNCTIONAL OPERATION DURING S-IVB COAST MODE

Figure 2-4 illustrates the functional operation of the Flight Control Computer during the S-IVB coast mode. At the completion of the S-IVB burn mode, the positioning of the missile is controlled by the spatial thrusters located on the S-IVB Stage. This is called the S-IVB coast mode. As in the S-IVB burn mode, triple redundancy circuits are used for the S-IVB coast mode to achieve a high reliability.

Altitude error signals ($\Delta\phi_Y$, $\Delta\phi_P$, and $\Delta\phi_R$) for the S-IVB coast mode are supplied by the LVDA in the same manner as for the S-IB and S-IVB burn modes. The amplified $\Delta\phi_Y$ error signals from redundant dc amplifiers J46, J47, and J32 are coupled through closed relay contacts and simultaneously applied to triple redundant Roll-Yaw I spatial amplifiers J65 through J67 and triple redundant Roll-Yaw II spatial amplifiers J71 through J73. The Roll-Yaw I and II spatial amplifiers will then develop spatial thruster control signals in proportion to the input error signals. However, only the spatial thruster control signals from Roll-Yaw I spatial amplifier J66 and Roll-Yaw II spatial amplifier J72 are normally used. The control signal from J66 is coupled through the normally closed contacts of the comparator relay to control relay package I and the control signal from J72 is coupled through the normally closed contacts of the comparator relay to control relay package II. The control relay packages then activate their associated spatial thruster to correct for errors in the roll axis.

Roll-Yaw I spatial comparator J68 compares the outputs of Roll-Yaw I spatial amplifiers J65 and J66. When a malfunction occurs in either of the two separate and identical channels, Roll-Yaw I spatial comparator J68 automatically opens the closed relay contact in the J66 output and closes the relay contact in the J67 output. The control signal for control relay package I will then be applied through Roll-Yaw I spatial amplifier J67.

Roll-Yaw II spatial comparator J74 compares the outputs of Roll-Yaw II spatial amplifiers J71 and J72. When a malfunction occurs in either of the two separate and identical channels, Roll-Yaw II spatial comparator J74 automatically opens the closed relay contact in the J72 output and closes the relay contact

in the J73 output. The control signal for control relay package II will then be applied through Roll-Yaw II spatial amplifier J73.

The amplified $\Delta\phi R$ error signals from redundant dc amplifiers J34, J52, and J53 are coupled through closed relay contacts and applied to triple redundant Roll-Yaw I spatial amplifiers J65 through J67 and triple redundant Roll-Yaw II spatial amplifiers J71 through J73. The $\Delta\phi R$ error signals are algebraically added to the $\Delta\phi Y$ error signals by the Roll-Yaw I and II spatial amplifiers to produce control signals for the control relay packages.

The amplified $\Delta\phi P$ error signals from redundant dc amplifiers J48, J49, and J33 are coupled through closed relay contacts to the pitch spatial amplifiers J60, J61, and J62. The pitch spatial amplifiers will then develop spatial thruster control signals in proportion to the input error signal. However, only the spatial thruster control signal from pitch spatial amplifier J61 is coupled through the closed contacts of the comparator relay and simultaneously applied to control relay package I and control relay package II. The control relay packages then actuate their associated spatial thruster to correct for errors in the pitch axis.

Pitch spatial comparator J63 compares the output of pitch spatial amplifiers J60 and J61. When a malfunction occurs in either of the two separate and identical channels, pitch spatial comparator J63 automatically opens the closed relay contacts in the J61 output and closes the relay contact in the J62 output. The control signal for the control relay packages will then be applied through pitch spatial amplifier J62.

The angular rate error signals ($\dot{\phi}Y$, $\dot{\phi}P$, and $\dot{\phi}R$) are supplied by the Control-EDS Rate Gyro Package through the Control Signal Processor. Three paths are provided for each of these inputs. The $\dot{\phi}Y$ error signals are coupled through closed relay contacts to dc amplifiers J81, J82, and J87. The amplified $\dot{\phi}Y$ error signals from the dc amplifiers are simultaneously applied to their respective triple redundant Roll-Yaw I spatial amplifiers and the triple redundant Roll-Yaw II spatial amplifiers where they are algebraically added to existing yaw and roll error signals.

The $\dot{\phi}R$ error signal is coupled through a closed relay contact to redundant dc amplifiers J37 through J39. The amplified $\dot{\phi}R$ error signals from the dc amplifiers are simultaneously applied to their

respective triple redundant Roll-Yaw I spatial amplifiers and the Roll-Yaw II spatial amplifiers, where they are algebraically added to existing yaw and roll error signals.

The $\dot{\phi}P$ angular rate error signals are coupled, through closed relay contacts to dc amplifiers J80, J88, and J89. The amplified $\dot{\phi}P$ error signals from the dc amplifiers are applied to their respective triple redundant pitch spatial amplifiers where they are algebraically added to the $\Delta\phi P$ altitude error signals.

2-7 SUBASSEMBLY FUNCTIONAL DESCRIPTIONS

The following paragraphs contain functional descriptions of the subassemblies contained within the Flight Control Computer.

DC Amplifier

The Flight Control Computer contains 23 identical dc amplifiers which are used throughout the Flight Control Computer to amplify yaw, pitch, and roll error signals. The yaw, pitch, and roll error signals are carried on isolated, balanced lines. To maintain this isolation and provide maximum amplification with relatively little distortion, each side of the balanced lines is amplified by the dc amplifiers. A functional block diagram of the dc amplifier is shown in Figure 2-5.

The balanced error signal input is applied to push-pull differential amplifier Q5, which amplifies the balanced error signal and provides compensation for fluctuations in current due to component, or temperature variations. The output of push-pull differential amplifier Q5 is further amplified by push-pull amplifier Q7 and push-pull amplifier Q9 and applied to bridge connected complementary symmetry amplifier Q10, Q11, Q12. Bridge connected complementary symmetry amplifier Q10, Q11, Q12 provides maximum undistorted amplification while maintaining ground isolation for the output signal. The amplified balanced error signal output is taken from the junction of Q10A and Q11 and the junction of Q10B and Q12.

Temperature changes which will effect the overall gain of the dc amplifier are sensed by temperature compensators Q6 and Q8. Temperature compensators Q6 and Q8 control the gain of the dc amplifier by varying the bias level on push-pull differential amplifier Q5 and push-pull amplifier Q7 in proportion to the temperature change.

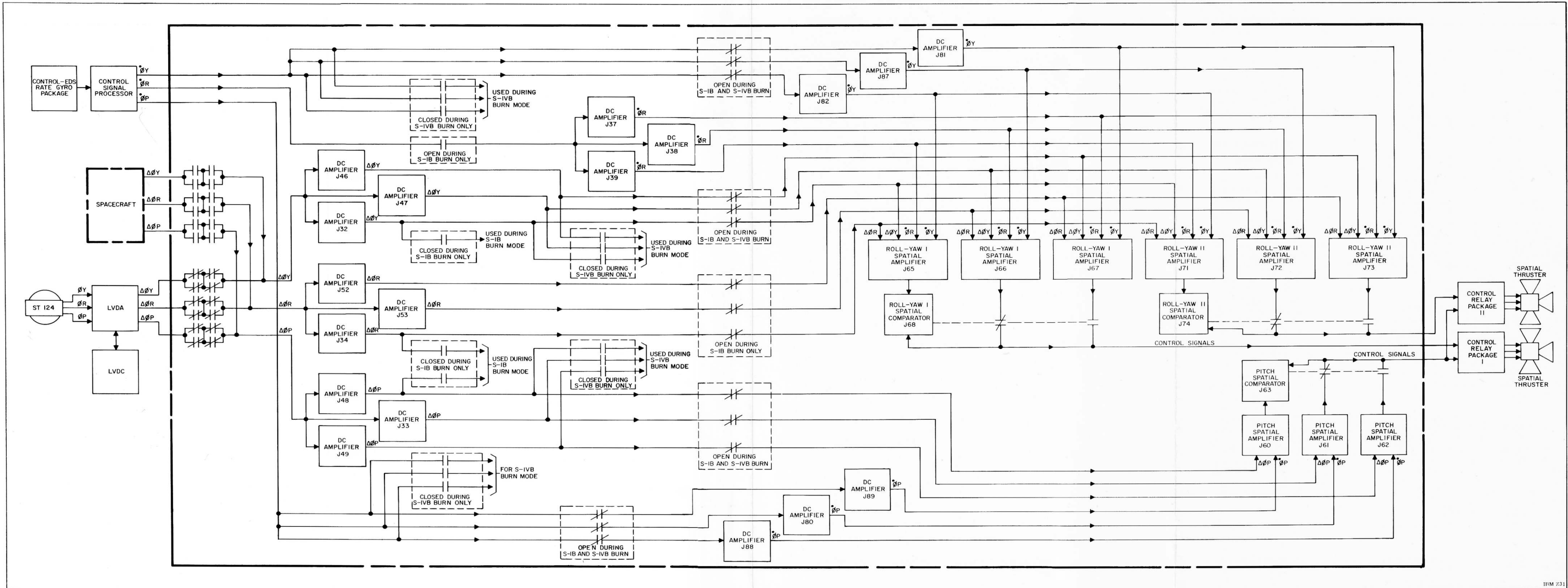
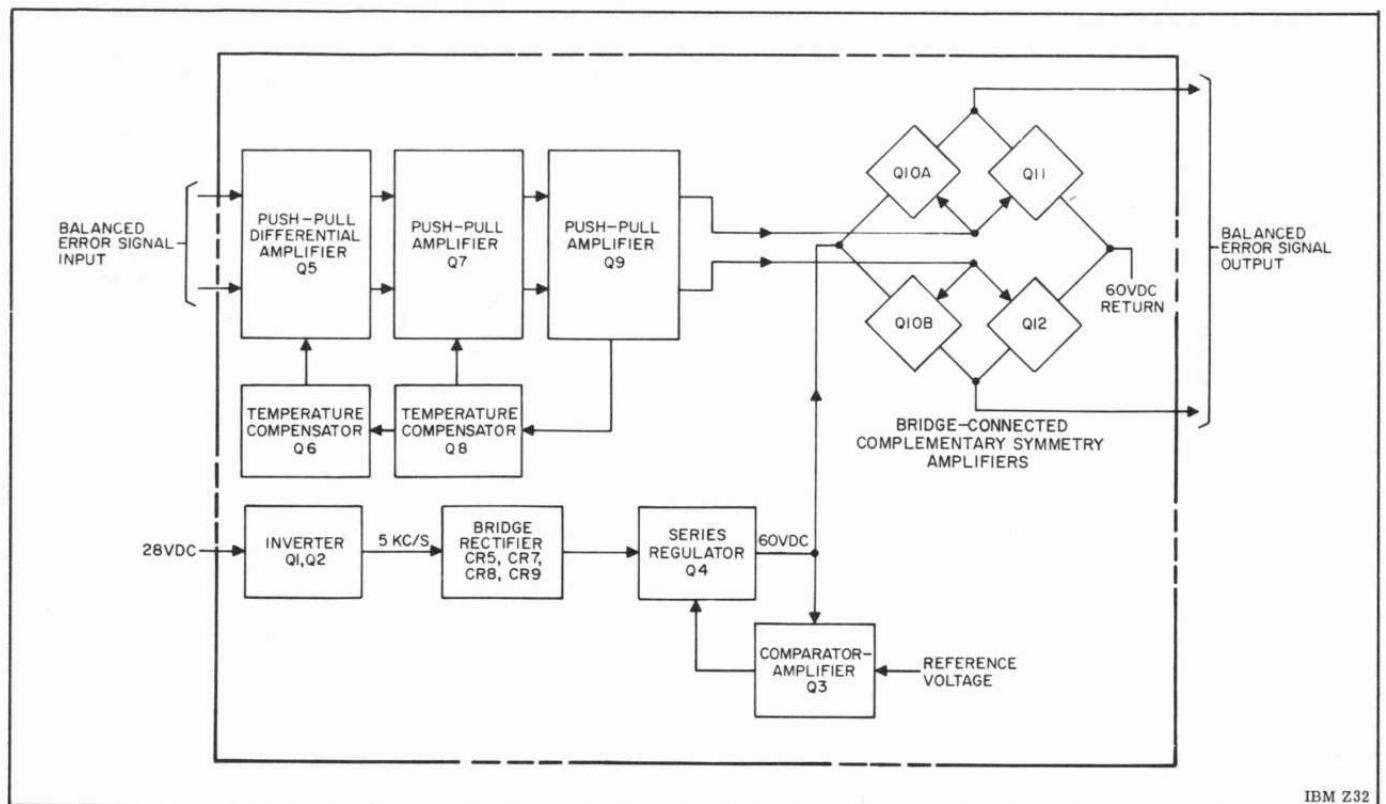


Figure 2-4. S-IVB Coast Mode, Functional Block Diagram

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Figure 2-5. DC Amplifier, Functional Block Diagram

In order to develop a balanced error signal output of sufficient amplitude, the amplifier stages in the dc amplifier require a higher voltage source than the available 28V dc power source. To accommodate this power requirement, each of the dc amplifiers contain an inverter and regulating circuit which converts the 28V dc source to 60V dc.

The 28V dc source is applied to the inverter Q1, Q2, which converts the 28V dc source to a 5 kc/s signal of sufficient amplitude. This 5 kc/s signal is then rectified by bridge rectifier CR5, CR7, CR8, and CR9. The resulting stepped-up dc voltage is then routed through series regulator Q4 to the amplifier circuits. A sample of the output voltage is compared in comparator-amplifier Q3 with a stable reference voltage. A regulator control voltage, produced by this comparison, is applied to series regulator Q4. This control voltage controls the internal impedance, and consequently the voltage drop of series regulator Q4. If the 60V dc output voltage varies, the regulator control voltage varies proportionally. The variation in control voltage produces a corresponding variation in the voltage drop across series regulator Q4 and returns the output voltage to the proper level.

12 Ma Servo Amplifier

The Flight Control Computer contains four yaw 12 ma servo amplifiers and four pitch 12 ma servo amplifiers. The 12 ma servo amplifiers control the servo cylinders in the S-IB Stage by producing drive signals in proportion to the combined attitude, angular rate, and lateral acceleration error input signals. The servo cylinders mechanically position the four gimballed engines in the S-IB Stage in proportion to the drive signals received from the 12 ma servo amplifier. A functional block diagram of the 12 ma servo amplifier is shown in Figure 2-6.

Attitude, angular rate, and lateral acceleration error signals are applied to coil windings in magnetic amplifier Q1, Q2. Magnetic amplifier Q1, Q2 algebraically combines the attitude, angular rate, and lateral acceleration error signals and produces a proportional, balanced output. The balanced output of magnetic amplifier Q1, Q2 is then amplified by push-pull amplifier Q4, push-pull amplifier Q5, and push-pull amplifier Q6, Q7. The collector current for push-pull amplifier Q6, Q7 is routed through the feedback developing resistor network and solenoid coil windings in the S-IB Stage servo cylinder actuator

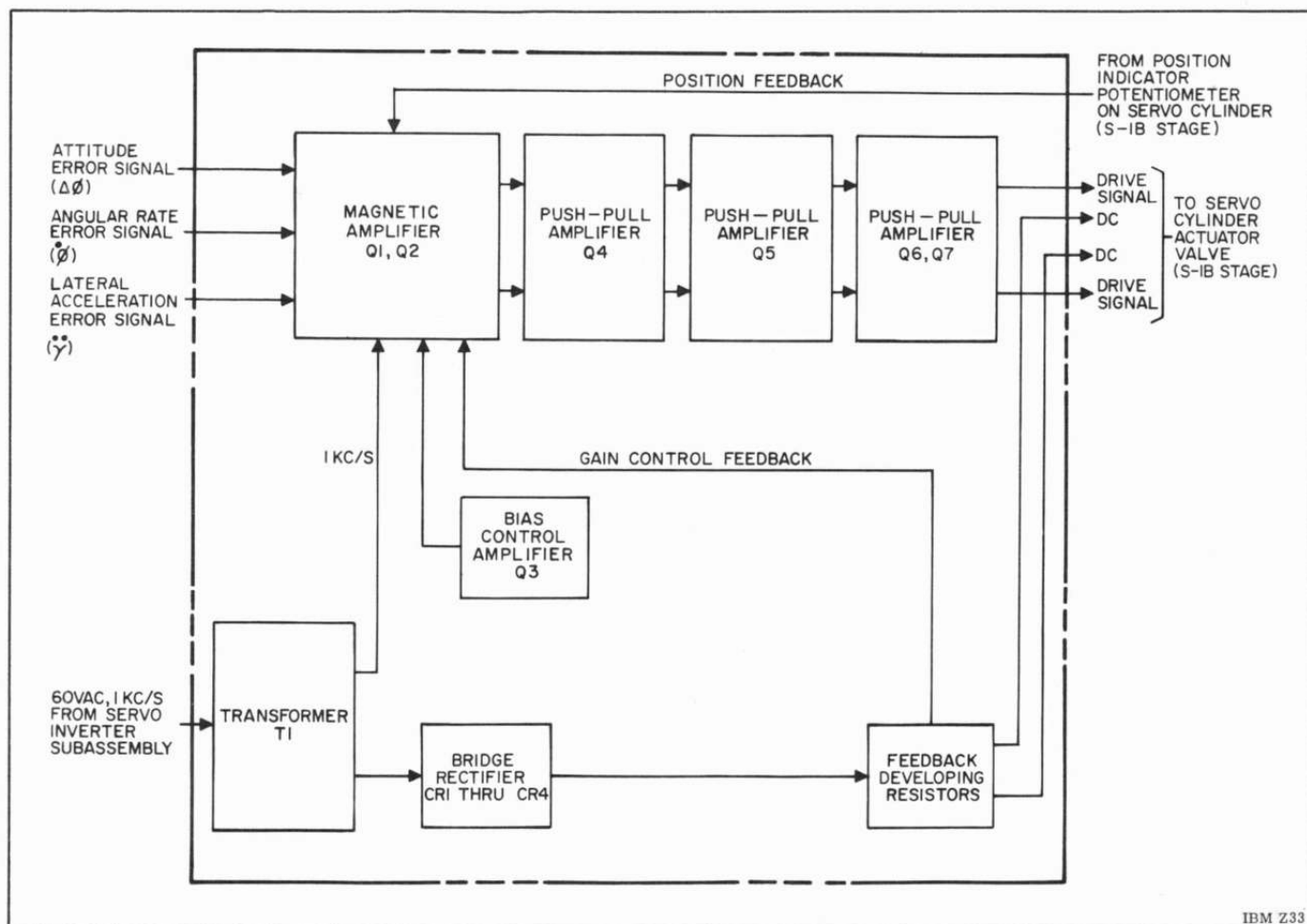


Figure 2-6. 12 Ma Servo Amplifier, Functional Block Diagram

valve. Thus, when an error signal is applied to push-pull amplifier Q6, Q7, proportional signals developed within the solenoid coil windings of the S-IB Stage servo cylinder actuator valve operate the valve. A portion of this drive signal is developed across the feedback developing resistors and applied to magnetic amplifier Q1, Q2 as a gain control feedback.

The 1 kc/s excitation signal for magnetic amplifier Q1, Q2 is received from the servo inverter and coupled through transformer T1 to magnetic amplifier Q1, Q2. The 1 kc/s output signal from transformer T1 is also rectified by bridge rectifier CR1 through CR4 to provide dc power for the 12 ma servo amplifier. Operating level bias for magnetic amplifier Q1, Q2 is provided by bias control amplifier Q3.

A dc position feedback signal from the position indicator potentiometer on the S-IB Stage servo

cylinder, is also applied to magnetic amplifier Q1, Q2. The dc position feedback signal opposes the error signal in magnetic amplifier Q1, Q2 to prevent over-correction of the gimballed engines in the S-IB Stage.

Continuous Attenuation Timer

The Continuous Attenuation Timer (C.A.T.) controls the presence and amplitude of the yaw and pitch lateral acceleration error signals ($\dot{\gamma}_Y$ and $\dot{\gamma}_P$) applied to the 12 ma servo amplifier during the S-IB Stage burn mode. A functional block diagram of the C.A.T. is shown in Figure 2-7.

The C.A.T. consists of switches S1 through S3 and potentiometers R1 through R4 (R1 and R2 are not used) which are mechanically positioned by motor B1. At liftoff, a first motion signal is coupled through the closed contacts of switch S2 to the power distribution assembly. At the same time, 115V ac,

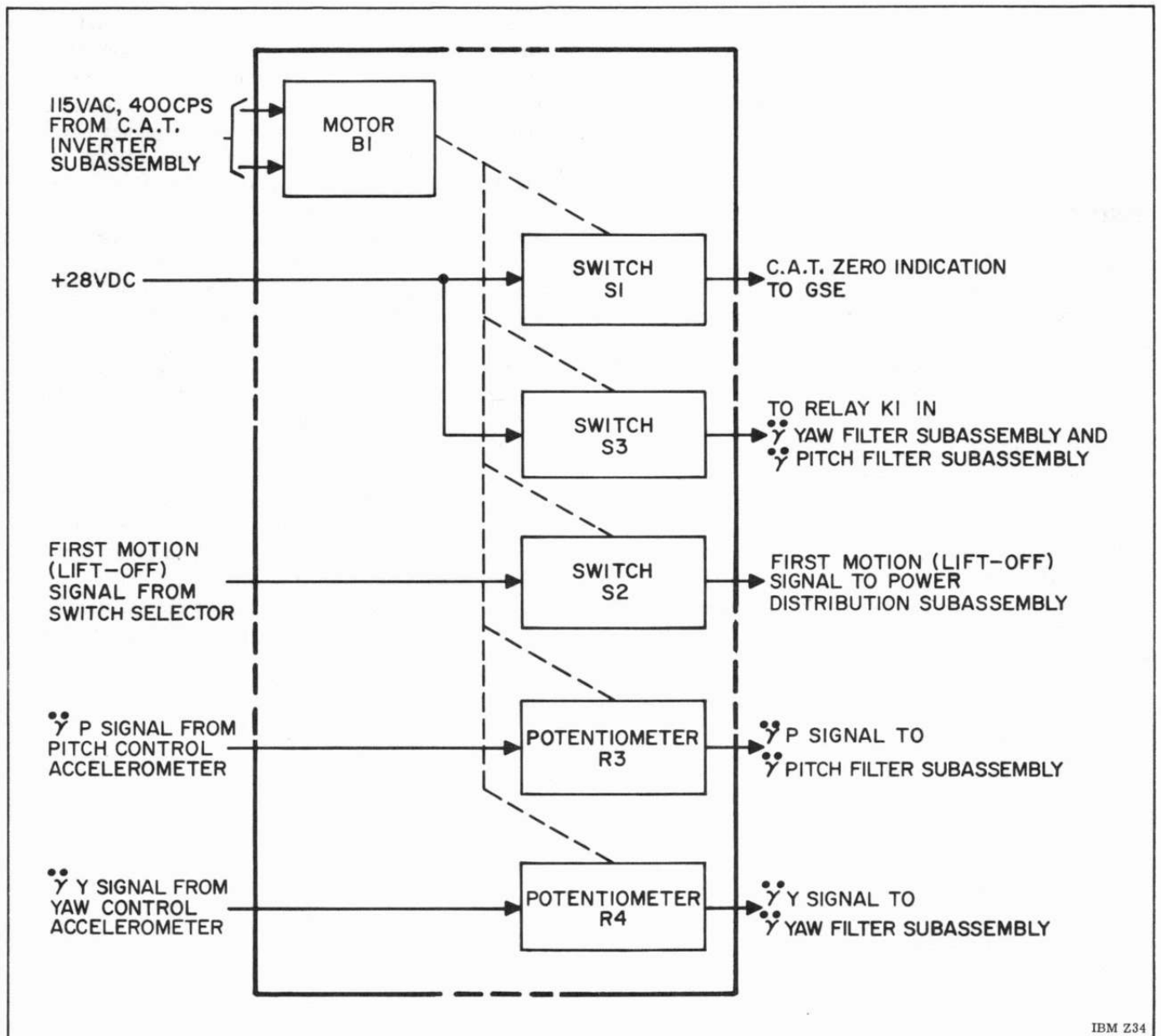


Figure 2-7. Continuous Attenuation Timer (C.A.T.), Functional Block Diagram

400 cps from the C.A.T. inverter is applied to motor B1, causing motor B1 to begin rotation and close switch S1. The closing of switch S1 applies a C.A.T. zero indication signal (28V dc) to the Ground Support Equipment (GSE) via telemetry.

Thirty seconds into the flight (T plus 30 seconds), the rotation of motor B1 causes switch S3 to close, which applies +28V dc to relays K1 in the \ddot{Y} and \ddot{P} filters. Energizing relays K1 in the \ddot{P} and \ddot{Y} filters allows the \ddot{P} and \ddot{Y} error signals to be applied to the 12 ma servo amplifiers through C.A.T.

potentiometers R3 and R4, respectively. The amplitude of the \ddot{P} and \ddot{Y} error signals during burn of the S-IB Stage are controlled by the position of the wiper arms of potentiometers R3 and R4. These wipers are positioned by motor B1. At T plus 30 seconds, potentiometers R3 and R4 provide maximum signal attenuation; between T plus 30 seconds and T plus 60 seconds the attenuation decreases to a minimum; from T plus 60 seconds to T plus 80 seconds the least amount of attenuation is provided; and between T plus 80 seconds and T plus 110 seconds the attenuation again increases to maximum.

At T plus 120 seconds, the rotation of motor B1 causes switch S3 to open, deenergizing relays K1 in the γ Y and γ P filters. Between T plus 120 seconds and T plus 125 seconds, the rotation of motor B1 opens switch S2 and applies C.A.T. zero command signal to the GSE via telemetry.

Inverter

The Flight Control Computer contains a C.A.T. inverter and a servo inverter, which differ only in output voltage and frequency. The C.A.T. inverter converts the 28V dc primary power to the 115V ac, 400 cps required for operation of the C.A.T. The servo inverter converts the 28V dc primary power to the 60V ac, 1 kc/s required for operation of the eight 12 ma servo amplifiers. A functional block diagram of the inverter is shown in Figure 2-8.

The plus side of the 28V dc primary power is routed through series regulator Q5 to inverter Q1, Q2. Inverter Q1, Q2 converts the 28V dc to an ac signal which is amplified by driver-amplifier Q6, Q7 and coupled through transformer T2 to the associated subassemblies.

The operating frequency of inverter Q1, Q2 is directly proportional to the dc input voltage level to inverter Q1, Q2 and is determined by the voltage drop across series regulator Q5. A sample of the dc input voltage level is compared in frequency adjust comparator Q3 with a stable reference voltage. A regulator control voltage, produced by this comparison, is amplified by driver Q4 and applied to series regulator Q5. This control voltage controls the internal impedance and consequently the voltage drop across series regulator Q5. If the dc input voltage to inverter Q1, Q2 varies, the regulator control voltage varies proportionally. The variation in control voltage produces a corresponding variation in the voltage drop across series regulator Q5 and returns the inverter dc input voltage to the proper level.

Frequency adjust comparator Q3 contains an adjustment which varies the operating frequency of inverter Q1, Q2 by varying the regulator control voltage applied to series regulator Q5. For the C.A.T. inverter, frequency adjust comparator Q3 is adjusted so that the output frequency of inverter Q1, Q2 is 400 cps. For the servo inverter,

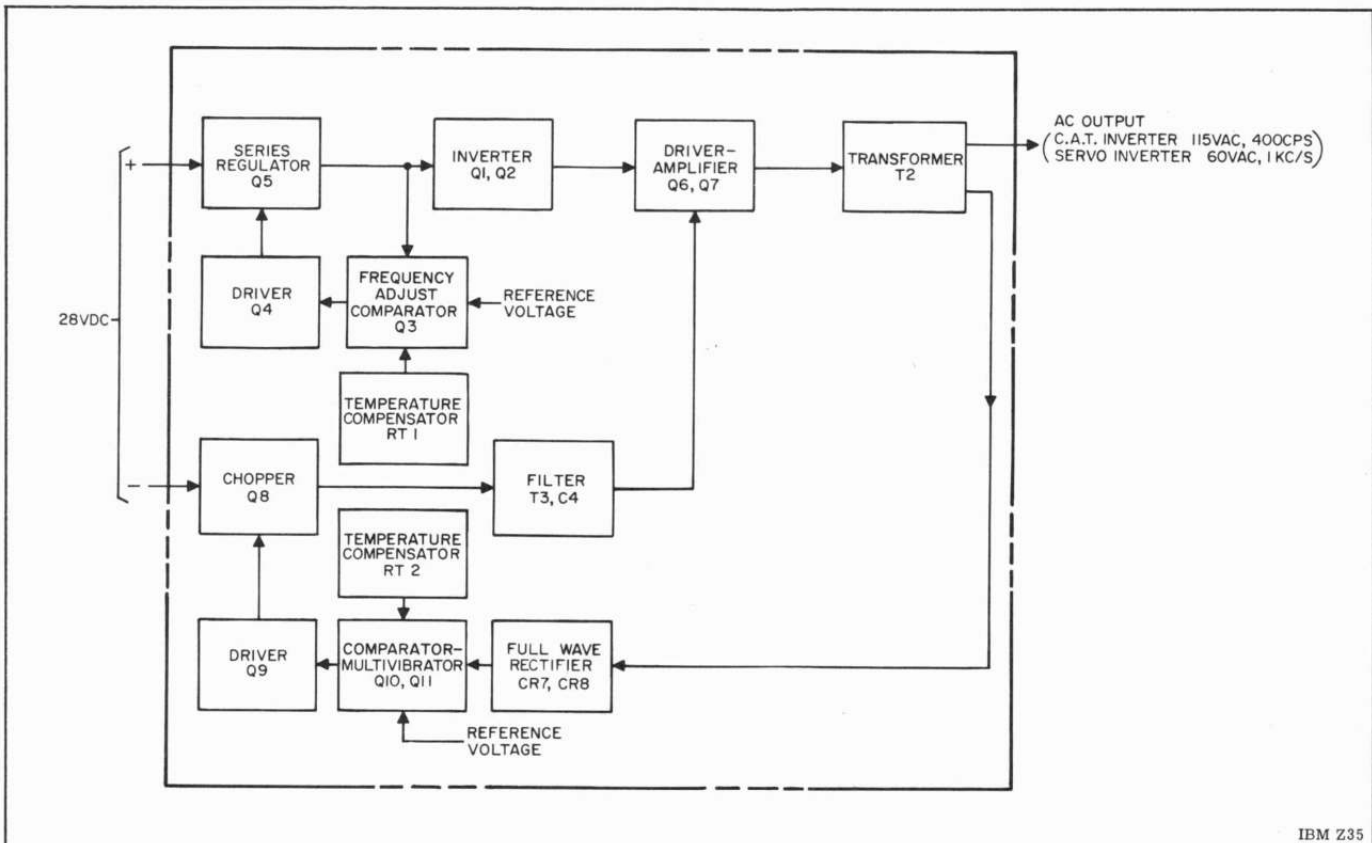


Figure 2-8. C.A.T. and Servo Inverter, Functional Block Diagram

frequency adjust comparator Q3 is adjusted so that output frequency of inverter Q1, Q2 is 1 kc/s.

The amplitude of the ac output is determined by the coupling ratio of transformer T1. For the C.A.T. inverter, the ac output level is 115 volts. For the servo inverter, the ac output level is 60 volts. The correct coupling ratio is provided during manufacture of the transformers.

Regulation of the ac output level is provided by chopper Q8, which regulates the negative side of the 28V dc primary power applied to driver-amplifier Q6, Q7. Chopper Q8 intermittently applies the negative dc primary power to filter T3, C4 where it is filtered to produce the negative source for driver-amplifier Q6, Q7. The rate at which chopper Q8 switches ON and OFF is controlled by the output frequency of comparator-multivibrator Q10, Q11 which is coupled through driver Q9 to chopper Q8. The frequency of comparator-multivibrator Q10, Q11 is determined by the comparison of a reference voltage and the output of full wave rectifier CR7, CR8. When the ac output voltage of transformer T2 increases, the output of full wave rectifier CR7, CR8 will also increase, causing the frequency of comparator-multivibrator Q10, Q11 to decrease. The decreased frequency of comparator-multivibrator Q10, Q11 increases the off time of chopper Q8 and decreases the dc voltage applied to driver-amplifier Q6, Q7. Decreasing the dc voltage decreases the gain of

driver-amplifier Q6, Q7. When the ac output decreases, the resulting frequency increase of comparator-multivibrator Q10, Q11 decreases the off time of chopper Q8, and increases the dc voltage applied to driver-amplifier Q6, Q7. Increasing the dc voltage increases the gain of driver-amplifier Q6, Q7.

Beta Command Power Supply

The Flight Control Computer contains eight beta command power supplies. Four are used in conjunction with the position indicator potentiometers on the four yaw servo cylinders in the S-IB Stage to develop position feedback signals for the yaw 12 ma servo amplifiers; and four are used in conjunction with position indicator potentiometers on the four pitch servo cylinders in the S-IB Stage to develop position feedback signals for the pitch 12 ma servo amplifiers. A functional block diagram of a beta command power supply is shown in Figure 2-9.

The purpose of the beta command power supply is to change the 28V dc source to 60V dc. To accomplish this purpose, the dc source voltage is first converted by inverter Q1, Q2 to a 1 kc/s signal. The 1 kc/s signal is then rectified by bridge rectifier CR1 through CR4 and applied to chopper Q3. Chopper Q3 intermittently applies the rectified voltage to filter L2, C5 where it is filtered to produce the 60V dc output. The rate at which chopper Q3

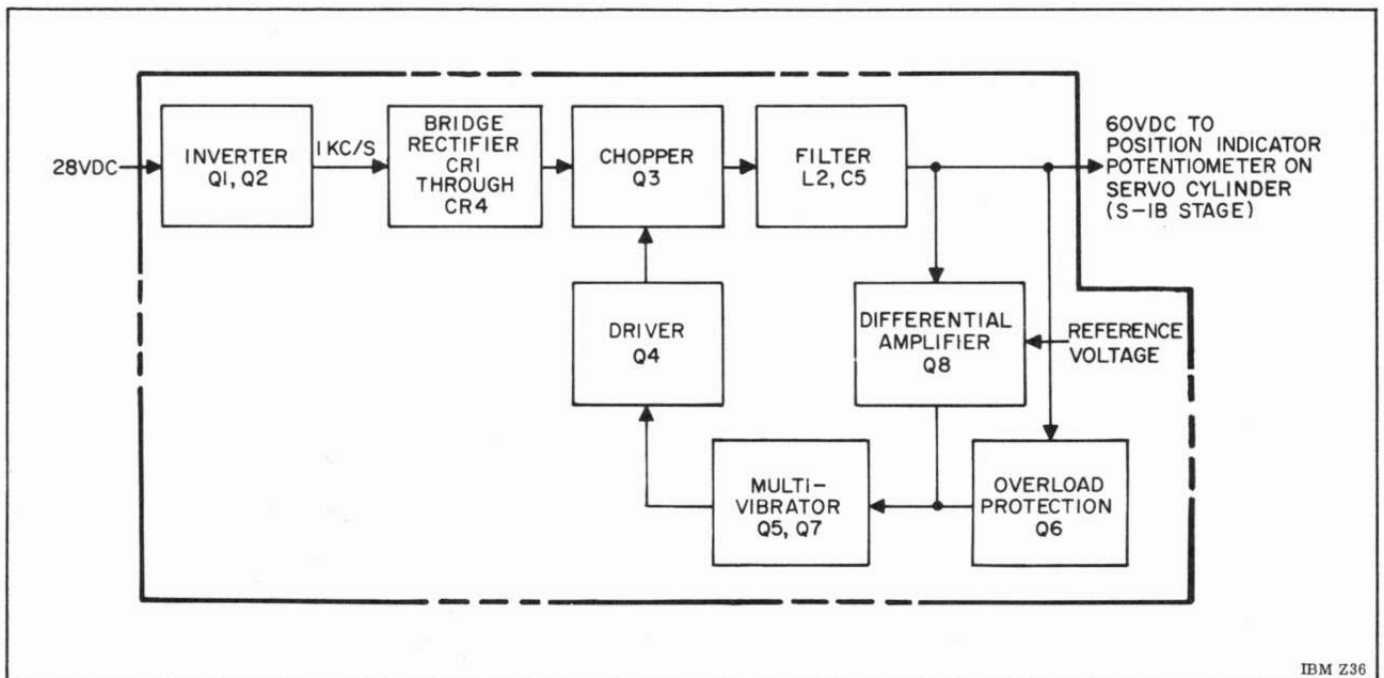


Figure 2-9. Beta Command Power Supply, Functional Block Diagram

switches ON and OFF is controlled by multivibrator Q5, Q7 which is coupled through driver Q4 to chopper Q3.

Differential amplifier Q8 compares the 60V dc output with a reference voltage and produces an output in proportion to the difference. The output of the differential amplifier Q8 is then used to regulate the frequency of multivibrator Q5, Q7. When the output voltage increases, the output of differential amplifier Q8 causes the frequency of multivibrator Q5, Q7 to decrease, which increases the ON and OFF time of chopper Q3, resulting in the output voltage being decreased. When the output voltage decreases, the frequency of multivibrator Q5, Q7 is increased, which decreases the off time of chopper Q3, resulting in the output voltage being increased.

Overload protection of the beta command power supply is provided by Q6, which senses an overload condition and applies a control signal to the multivibrator Q5, Q7, causing it to cutoff chopper Q3. Periodically, chopper Q3 is turned ON and the output load condition is sampled. If the overload is still

present, the control signal again causes multivibrator Q5, Q7 to cutoff chopper Q3.

50 Ma Servo Amplifier

The Flight Control Computer contains triple redundant yaw 50 ma servo amplifiers and triple redundant pitch 50 ma servo amplifiers. The purpose of the 50 ma servo amplifiers is to develop drive signals for the pitch and yaw servo cylinder solenoids in the S-IVB Stage in proportion to the yaw and pitch error signals. Triple redundancy is used to ensure a high reliability factor within the Flight Control Computer. A functional block diagram of a 50 ma servo amplifier is shown in Figure 2-10.

Attitude ($\Delta\phi$) and angular rate ($\dot{\phi}$) error signals are applied to coil windings in magnetic amplifier CR12 through CR15. The error signals are algebraically combined by magnetic amplifier CR12 through CR15 to produce a proportional balanced output signal. The balanced output signal of magnetic amplifier CR12 through CR15 is amplified by push-pull amplifier Q6 and applied to differential amplifier Q10, Q11

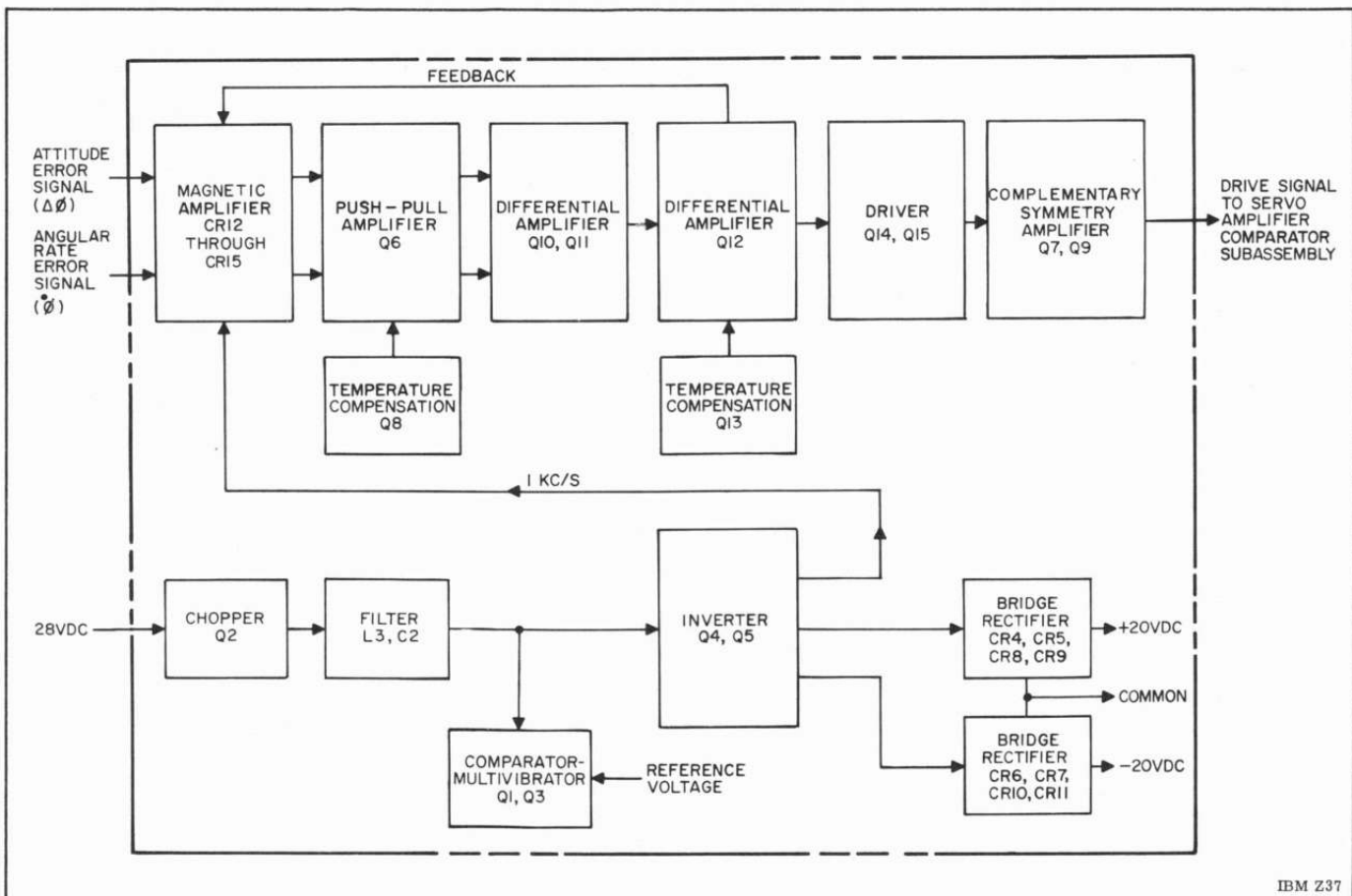


Figure 2-10. 50 Ma Servo Amplifier, Functional Block Diagram

Q10, Q11. Differential amplifier Q10, Q11 amplifies the balanced signal and produces a single ended output signal. The single ended output signal of differential amplifier Q10, Q11 is amplified by differential Q12 and applied to driver Q14, Q15. Driver Q14, Q15 further amplifies the signal and applies it to complementary symmetry amplifier Q7, Q9. The resulting output of complementary amplifier Q7, Q9 is the drive signal for the servo cylinder solenoid in the S-IVB Stage.

Differential amplifier Q12 also develops a feedback signal which is applied to a coil winding in magnetic amplifier CR12 through CR15. The feedback signal opposes the input error signals of magnetic amplifier CR12 through CR15 so as to provide a damping action which will prevent the servo cylinder in the S-IVB Stage from overcorrecting.

The excitation signal for magnetic amplifier CR12 through CR15 is provided by inverter Q4, Q5 which converts the dc source to a 1 kc/s signal. Regulation of inverter Q4, Q5 is provided by chopper Q2. Changes in the output voltage of filter L3, C2 are sensed by comparator-multivibrator Q1, Q3, which increases or decreases the output frequency of comparator-multivibrator Q1, Q3 in proportion to the difference between the output voltage of filter L3, C2 and a reference voltage. The output of comparator-multivibrator Q1, Q3 controls the ON and OFF time of chopper Q2.

Inverter Q4, Q5 also applies a 1 kc/s signal to bridge rectifiers CR4, CR5, CR8, CR9, and CR6, CR7, CR10, CR11. The 1 kc/s signal is rectified by bridge rectifiers CR4, CR5, CR8, CR9, and CR6, CR7, CR10, CR11 to produce the + and - 20V dc necessary for the operation of the amplifier stages in the 50 ma servo amplifier.

Temperature changes which will affect the overall performance of the 50 ma servo amplifier are sensed by temperature compensators Q8 and Q13. Temperature compensators Q8 and Q13 control the gain of the 50 ma servo amplifier by varying the bias level on push-pull amplifier Q6 and differential amplifier Q12 in proportion to the temperature change.

Servo Amplifier Comparator

The Flight Control Computer contains a yaw servo amplifier comparator, which is used in conjunction with the triple redundant yaw 50 ma servo amplifiers, and a pitch servo amplifier comparator,

which is used in conjunction with the triple redundant pitch 50 ma servo amplifiers. The purpose of the servo amplifier comparator is to compare the identical drive signal outputs of the two of its associated triple redundant 50 ma servo amplifiers, one of which is applied to a servo cylinder actuator in the S-IVB Stage. When a malfunction occurs in either of the two 50 ma servo amplifiers being compared, the servo amplifier comparator automatically terminates the signal being applied to the servo cylinder actuator and applies the drive signal from the third (standby) 50 ma servo amplifier to the servo cylinder actuator. A functional block diagram of the servo amplifier comparator is shown in Figure 2-11.

Identical drive signals from the triple redundant 50 ma servo amplifiers (A, B, and C) are applied to the servo amplifier comparator. The drive signal from 50 ma servo amplifier B is normally routed through closed relay contacts in switchover relays K1, K3, K4 to a servo cylinder actuator in the S-IVB Stage. The drive signal from 50 ma servo amplifier A is applied to dummy load R1, which represents the load presented by the servo cylinder actuator: The drive signal from 50 ma servo C is normally routed through closed relay contacts in switchover relays K1, K3, K4 to dummy load R25, which also represents the load presented by the servo cylinder actuator.

The drive signals from 50 ma servo amplifiers A and B are also coupled through a summing network to a dc amplifier. The drive signals are amplified by the dc amplifier and applied to comparator CR1 through CR4.

Under a normal balanced condition (both inputs to comparator CR1 through CR4 are equal), there will be no signal applied to level detector Q1. When a malfunction occurs in either of the 50 ma servo amplifiers (A or B), an unbalanced condition will occur within comparator CR1 through CR4 causing level detector Q1 to change states. The resulting output of level detector Q1 is amplified by dc amplifier Q2 and applied to relay driver Q3, causing relay driver Q3 to conduct. The conduction of relay driver Q3 energizes switchover relays K1, K3, K4, and causes a lock-in feedback to be applied to dc amplifier Q1. The lock-in feedback forward biases dc amplifier Q1, which will in turn keep the relay driver Q3 locked in a conducting state.

With switchover relays K1, K3, and K4 energized, the drive signal from 50 ma servo amplifier B will be terminated at open relay contacts and the drive signal from 50 ma servo amplifier C will be

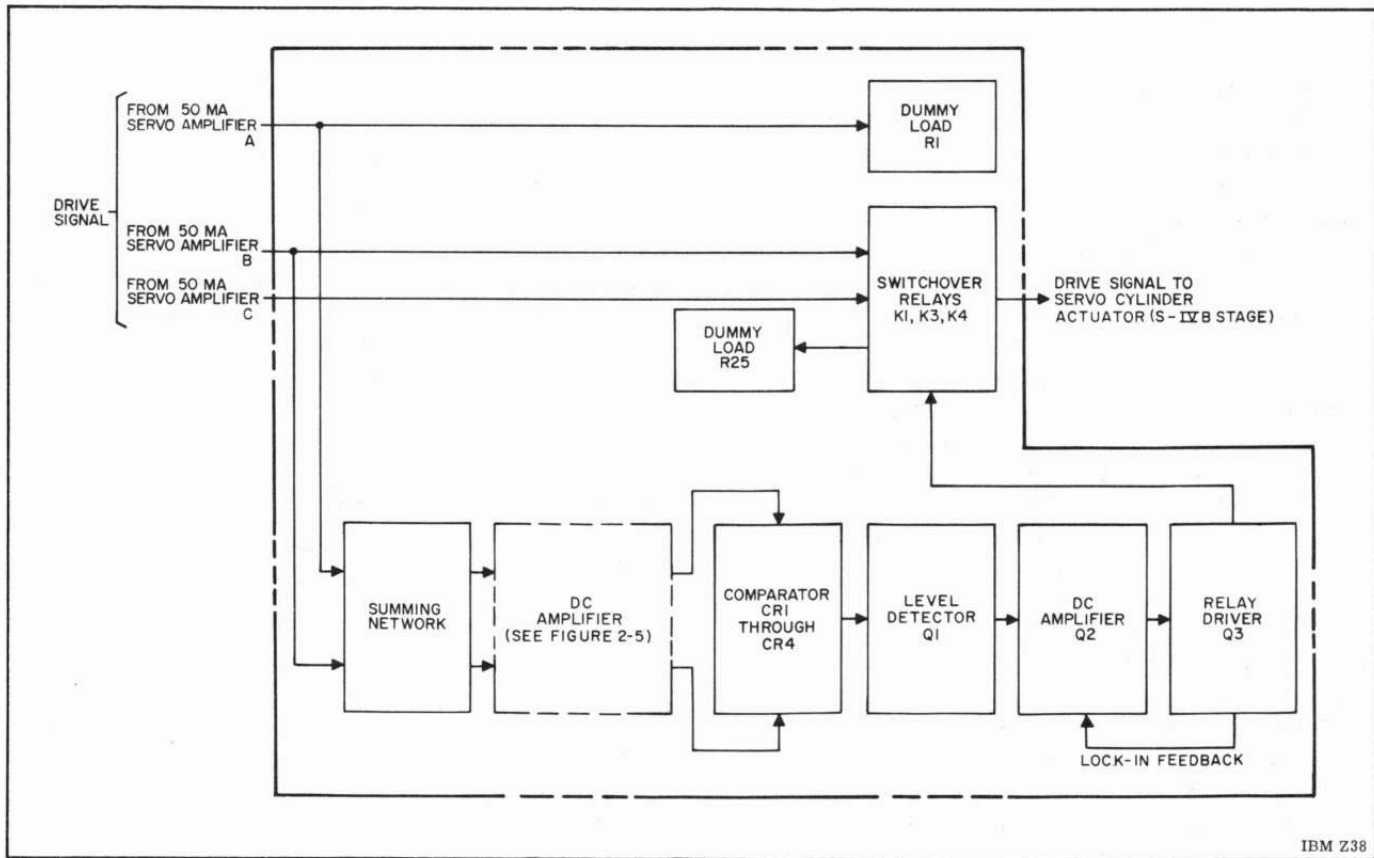


Figure 2-11. Servo Amplifier Comparator, Functional Block Diagram

removed from dummy load R25 and routed through closed relay contacts to a servo cylinder actuator in the S-IVB Stage.

Spatial Amplifier

The Flight Control Computer contains triple redundant Roll-Yaw I spatial amplifiers, triple redundant Roll-Yaw II spatial amplifiers and triple redundant pitch spatial amplifiers. The purpose of the spatial amplifiers is to develop spatial thruster control signals for the control relay packages in the S-IVB Stage in proportion to the yaw, pitch, and roll error signals. Triple redundancy is used to ensure a high reliability factor within the Flight Control Computer. A functional block diagram of the spatial amplifier is shown in Figure 2-12.

Attitude ($\Delta\phi$), and angular rate ($\dot{\phi}$) error signals are applied to coil windings in magnetic amplifier Q6, Q7. Magnetic amplifier Q6, Q7 algebraically combines the attitude and angular rate error signals and produces a proportional balanced output signal. The balanced output signal of magnetic amplifier

Q6, Q7 is then amplified by differential amplifier Q8 and differential amplifier Q10, Q11. The resulting balanced signal output of differential amplifier Q10, Q11 causes schmitt trigger Q12 or schmitt trigger Q13 to change state. The polarity of the input error signals determine which schmitt trigger will change state.

When the output signal of differential amplifier Q10, Q11 causes schmitt trigger Q12 to change state, the resulting output signal is amplified by dc amplifier Q14 and relay driver Q16. When the output signal of differential amplifier Q10, Q11 causes schmitt trigger Q13 to change state, the resulting output signal is amplified by dc amplifier Q13 and relay driver Q17. The output signal from relay driver Q16 or Q17 is the control signal for the control relay package in the S-IVB Stage.

The level of input signal required to cause the schmitt trigger to change state is controlled by the threshold feedback from differential amplifier Q10, Q11. A preset level of threshold feedback is developed by differential amplifier Q10, Q11 and applied to a

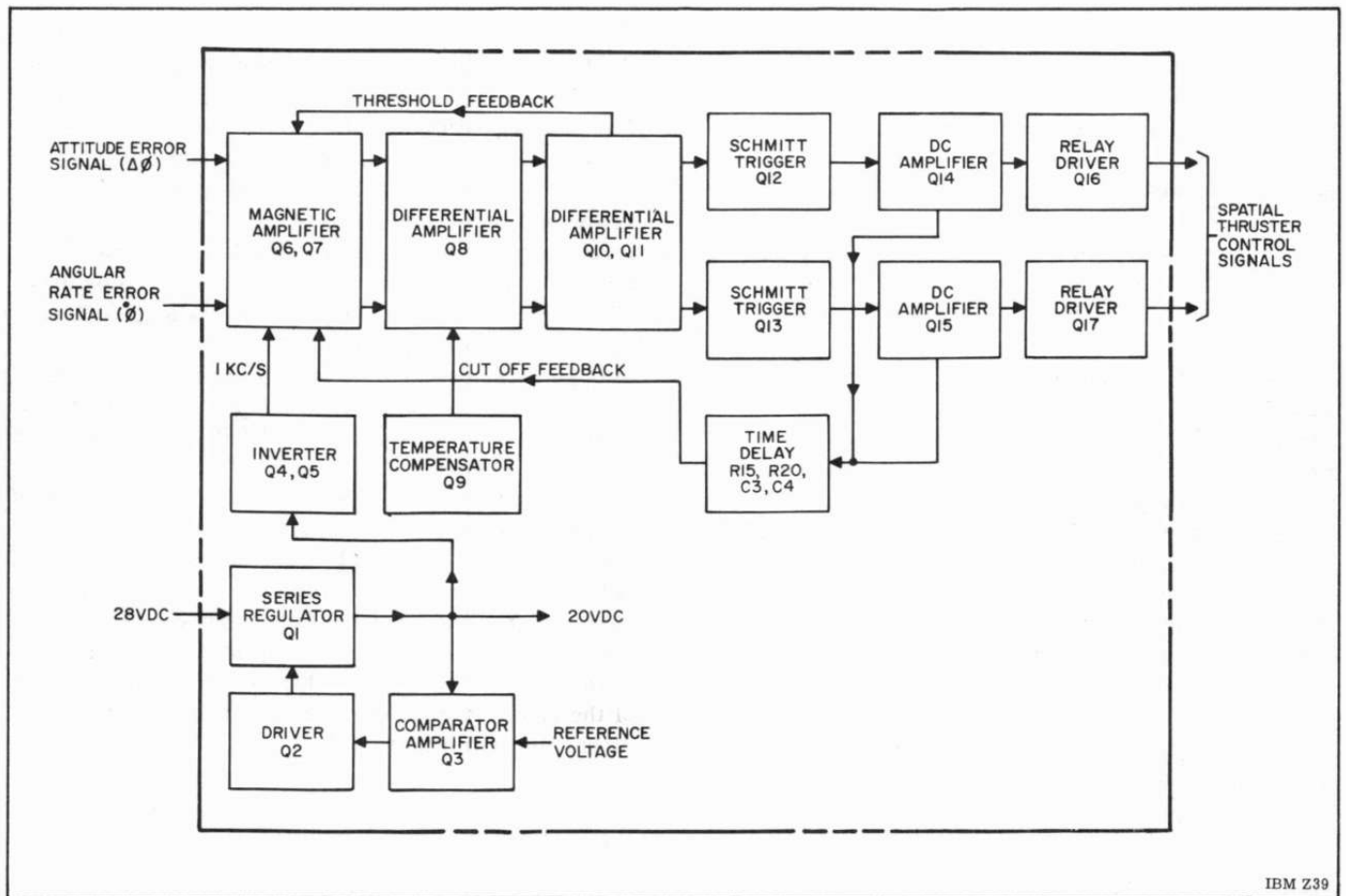


Figure 2-12. Spatial Amplifier, Functional Block Diagram

coil winding in magnetic amplifier Q6, Q7 when error signals are applied to magnetic amplifier Q6, Q7. The polarity of the threshold feedback opposes the input error signals. So, the threshold feedback signal opposes the input error signals. Therefore, for one of the schmitt triggers to change state, the level of the input error signals must be of sufficient amplitude to overcome the threshold feedback.

The duration of the spatial thruster control signal developed by the spatial amplifier assembly is determined by the comparison of the input error signals and the time delayed cutoff feedback. A preset level of cutoff feedback is developed by relay driver Q16 or Q17 and applied through a time delay R15, R20, C3, C4 to a coil winding in magnetic amplifier Q6, Q7 when the input error signals cause schmitt trigger Q12 or Q13 to change state. The cutoff feedback signal opposes the input error signals; however, due to the time delay of the cutoff feedback, the input error signals hold schmitt trigger Q12 or Q13 in a changed state until the cutoff feedback has reached

sufficient amplitude to overcome the input error signals. When this happens, schmitt trigger Q12 or Q13 returns to its normal state. The greater the amplitude of the input error signals, the longer time it will take the cutoff feedback signal to overcome the input error signals, resulting in proportionally longer duration output signals.

The 28V dc source for the spatial amplifier is regulated by series regulator Q1. A sample of the output voltage is compared in comparator-amplifier Q3 with a stable reference voltage. A regulator control voltage, produced by this comparison, is amplified by driver Q2 and applied to series regulator Q1. This control voltage controls the internal impedance, and consequently the voltage drop, of series regulator Q1. If the 20V dc output voltage varies, the regulator control voltage varies proportionally. The variation in control voltage produces a corresponding variation in the voltage drop across series regulator Q1 and returns the output voltage to the proper level.

The excitation signal required for the operation of magnetic amplifier Q6, Q7 is provided by inverter Q4, Q5, which converts the +20V dc output of series regulator Q1 to a 1 kc/s signal.

Spatial Comparator

The Flight Control Computer contains a Roll-Yaw I spatial comparator, which is used in conjunction with the triple redundant Roll-Yaw I spatial amplifiers, a Roll-Yaw II spatial comparator, which is used in conjunction with the triple redundant Roll-Yaw II spatial amplifiers, and a pitch spatial comparator, which is used in conjunction with the triple redundant pitch spatial amplifiers. The purpose of the spatial comparator is to compare the spatial thruster control signal outputs of two of its associated triple redundant spatial amplifiers, one of which is applied to the control relay control package in the S-IVB Stage. When a malfunction occurs in either of the two spatial amplifiers being compared, the spatial comparator automatically terminates the control signal being applied to the control relay package and applies the control signal from the third (standby) spatial amplifier to the control relay package. A functional block diagram of the spatial comparator is shown in Figure 2-13.

Identical spatial thruster control signals from the triple redundant spatial amplifiers (A, B, and C) are applied to the spatial comparator. The signal lines from spatial amplifier B are normally coupled through closed relay contacts in switchover relays K1, K3 to the spatial TM amplifier and the control relay package in the S-IVB Stage. The signal lines from spatial amplifier A are applied to dummy load R7, R8 which represents the load presented by the TM amplifier and the control relay package. The signal lines from spatial amplifier C are terminated at open relay contacts in switchover relays K1, K3. The signal lines from spatial amplifiers A and B are also applied to isolation network CR2, CR3, CR5, CR6.

Each of the spatial amplifiers have two output signal lines; however, a spatial control signal will appear on only one signal line at a time. The signal line that a signal will appear on is determined by the polarity of the input error signals applied to the spatial amplifiers. To simplify the description of the spatial comparator, the signal lines from each of the spatial amplifiers are called signal line 1 and signal line 2 in Figure 2-13.

When the Spatial Amplifiers produce a spatial thruster control signal or signal line 1, the signals

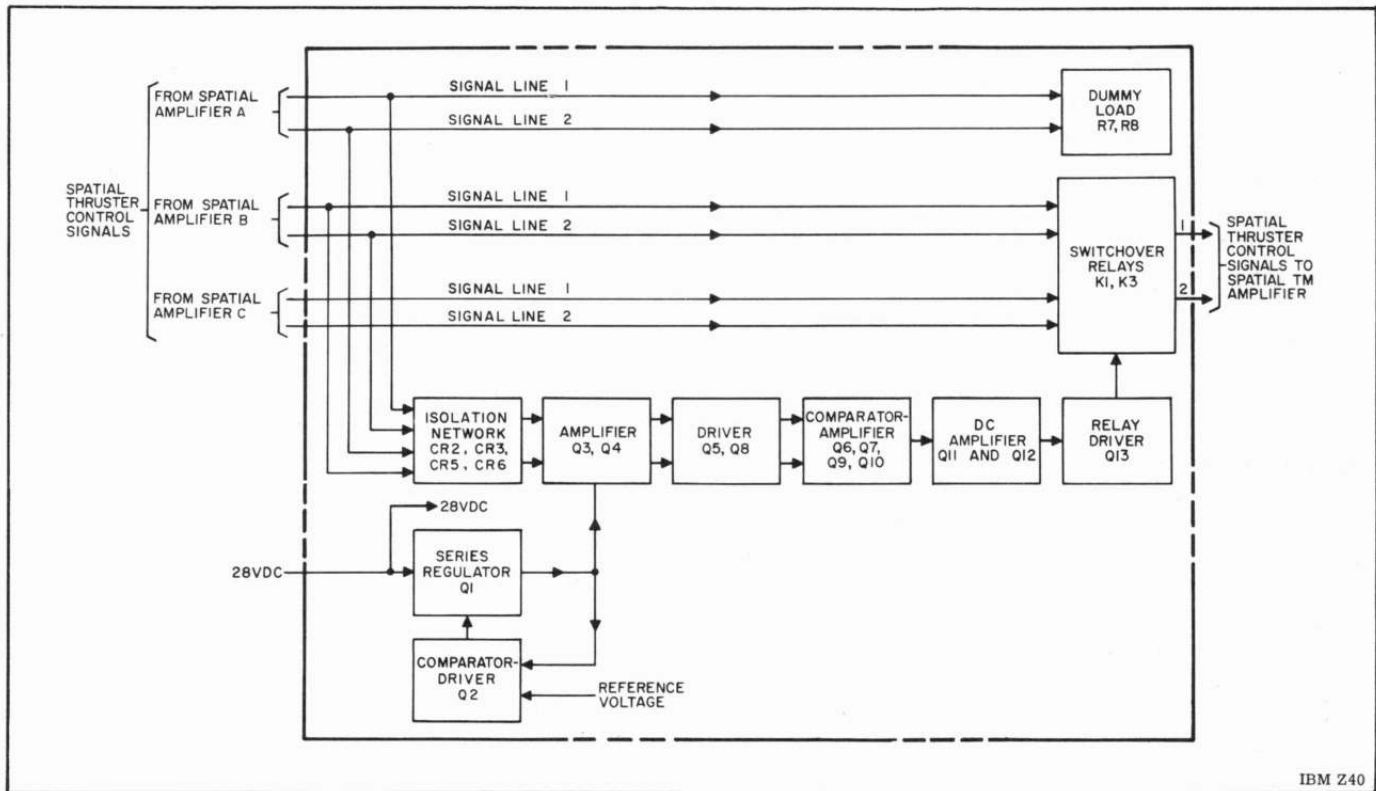


Figure 2-13. Spatial Comparator, Functional Block Diagram

on signal line 1 of spatial amplifiers A and B are coupled through isolation network CR2, CR3, CR5, CR6 to amplifier Q3, Q4. The signals are then amplified by amplifier Q3, Q4 and driver Q5, Q8, and applied to comparator-amplifier Q6, Q7, Q9, Q10. Under a normal balanced condition (both inputs to comparator-amplifier Q6, Q7, Q9, Q10 are equal), no signal appears at the output of comparator-amplifier Q6, Q7, Q9, Q10. When a malfunction occurs in either of the spatial amplifiers (A or B), an unbalanced condition will exist within comparator-amplifier Q6, Q7, Q9, Q10 which results in a signal being applied to dc amplifiers Q11 and Q12. The signal from comparator-amplifier Q6, Q7 is then amplified by dc amplifiers Q11 and Q12 and applied to relay driver Q13, causing relay driver Q13 to conduct. The conduction of relay driver Q13 energizes switchover relays K1, K3. With switchover relays K1, K3 energized, the two signal lines from spatial amplifier B are terminated at open relay contacts and the two signal lines from spatial amplifier C are coupled through closed relay contacts to the TM amplifier and the control relay package in the S-IVB Stage.

When the spatial amplifiers produce a spatial thruster control signal on signal line 2, the signals on signal line 2 from spatial amplifiers A and B are coupled through isolation network CR2, CR3, CR5, CR6 to amplifier Q3, Q4. The signals on signal line 2 are then processed in the same manner as the signals on signal line 1.

The dc source voltage for amplifier Q3, Q4 is coupled through series regulator Q1. Control of series regulator Q1 is provided by comparator-driver Q2, which applies control signals to series regulator Q1 in proportion to the difference between the output voltage and a reference voltage.

Spatial Synchronizer

The Flight Control Computer contains one spatial synchronizer which is used in conjunction with the Roll-Yaw I spatial amplifiers and the Roll-Yaw II spatial amplifiers. The purpose of the Spatial Synchronizer is to provide spatial thruster (S-IVB Stage) synchronization during the S-IVB burn mode. A functional block diagram of the Spatial Synchronizer is shown in Figure 2-14.

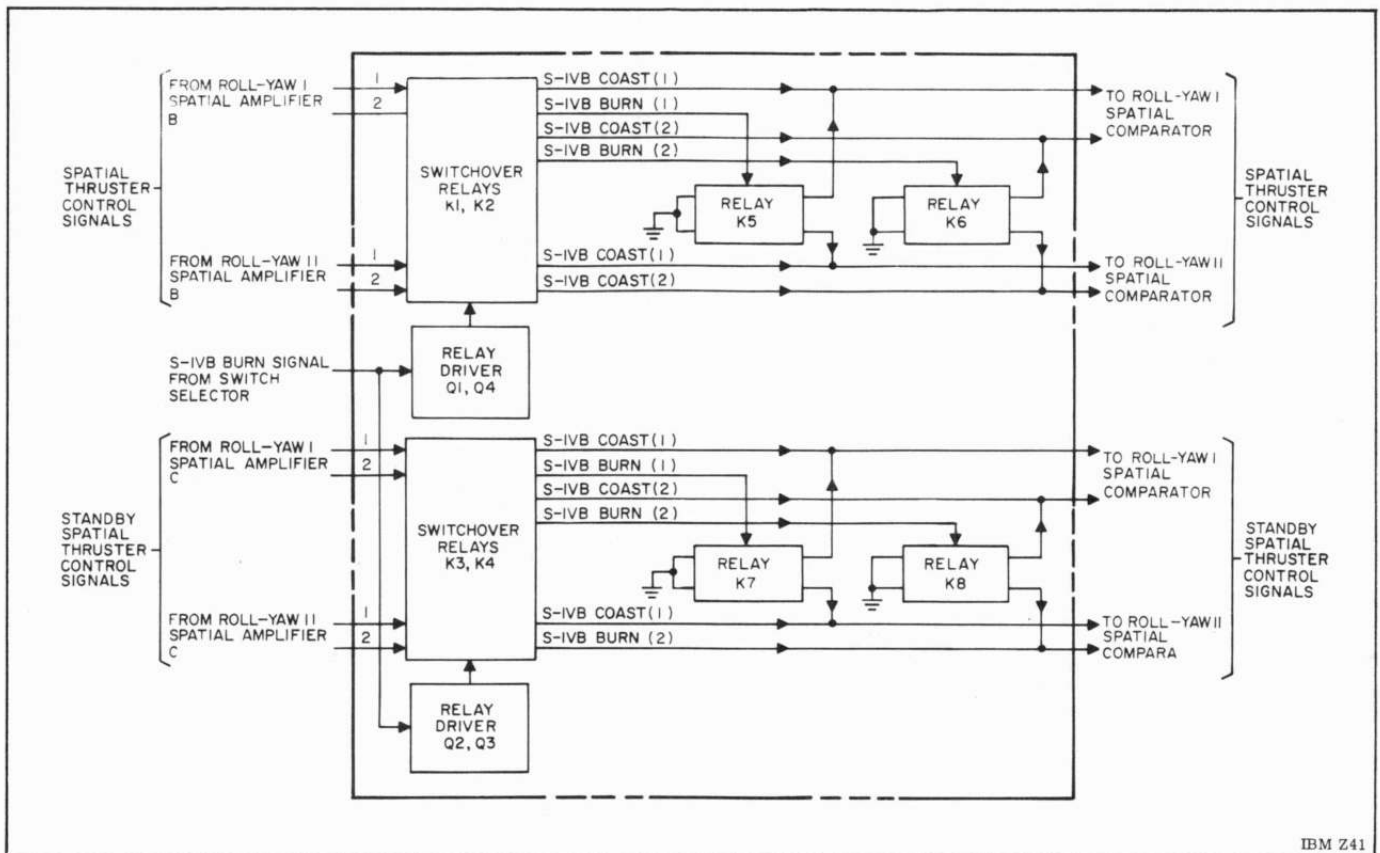


Figure 2-14. Spatial Synchronizer, Functional Block Diagram

An S-IVB burn signal from the Switch Selector is applied to relay driver Q1, Q4 and relay driver Q2, Q3 during the S-IVB burn mode, causing relay drivers Q1, Q4 and Q2, Q3 to conduct. Conduction of relay driver Q1, Q4 energizes switchover relays K1, K2 and conduction of relay driver Q2, Q3 energizes switchover relays K3, K4.

With switchover relays K1, K2 and K3, K4 energized, the signal lines from Roll-Yaw II spatial amplifiers B and C are terminated at open relay contacts. The two signal lines from Roll-Yaw I spatial amplifier B are coupled through closed relay contacts to relays K5 and K6 and the two signal lines from Roll-Yaw I spatial amplifier C are coupled through closed relay contacts to relays K7 and K8.

Relays K5 and K7 are energized when a spatial thruster control signal (ground) is present on signal line 1 of Roll-Yaw I spatial amplifiers B and C. The resulting closed contacts of relay K5 apply a ground signal to the Roll-Yaw I spatial comparator and the Roll-Yaw II spatial comparator. Likewise, the resulting closed contacts of relay K7 apply a ground signal to the Roll-Yaw I spatial comparator and the Roll-Yaw II spatial comparator.

Relays K6 and K8 are energized when a spatial thruster control signal (ground) is present on signal line 2 of Roll-Yaw I spatial amplifiers B and C. The resulting closed contacts of relay K6 apply a ground signal to the Roll-Yaw I spatial comparator and the Roll-Yaw II spatial comparator. Likewise, the resulting closed contacts of relay K8 apply a ground signal to the Roll-Yaw I spatial comparator and the Roll-Yaw II spatial comparator.

The S-IVB burn signal from the Switch Selector is removed from relay drivers Q1, Q4 and Q2, Q3 at the completion of the S-IVB burn mode, (beginning of S-IVB coast mode) causing relay drivers Q1, Q4 and Q2, Q3 to become cutoff. Switchover relays K1, K2 and K3, K4 are deenergized when relay drivers Q1, Q4 and Q2, Q3 are cutoff. The signal lines from Roll-Yaw I spatial amplifiers B and C are then coupled through closed relay contacts

in switchover relays K1, K2 and K3, K4 to the Roll-Yaw I spatial comparator. The signal lines from Roll-Yaw II spatial amplifiers B and C are also coupled through closed relay contacts in switchover relays K1, K2 and K3, K4 to the Roll-Yaw II spatial comparator.

TM Amplifier

The Flight Control Computer contains three TM amplifiers. The TM amplifiers are used to monitor the output signal lines of the spatial comparators and develop a telemetry signal when spatial thruster control signals are present. A functional block diagram of the TM amplifier is shown in Figure 2-15.

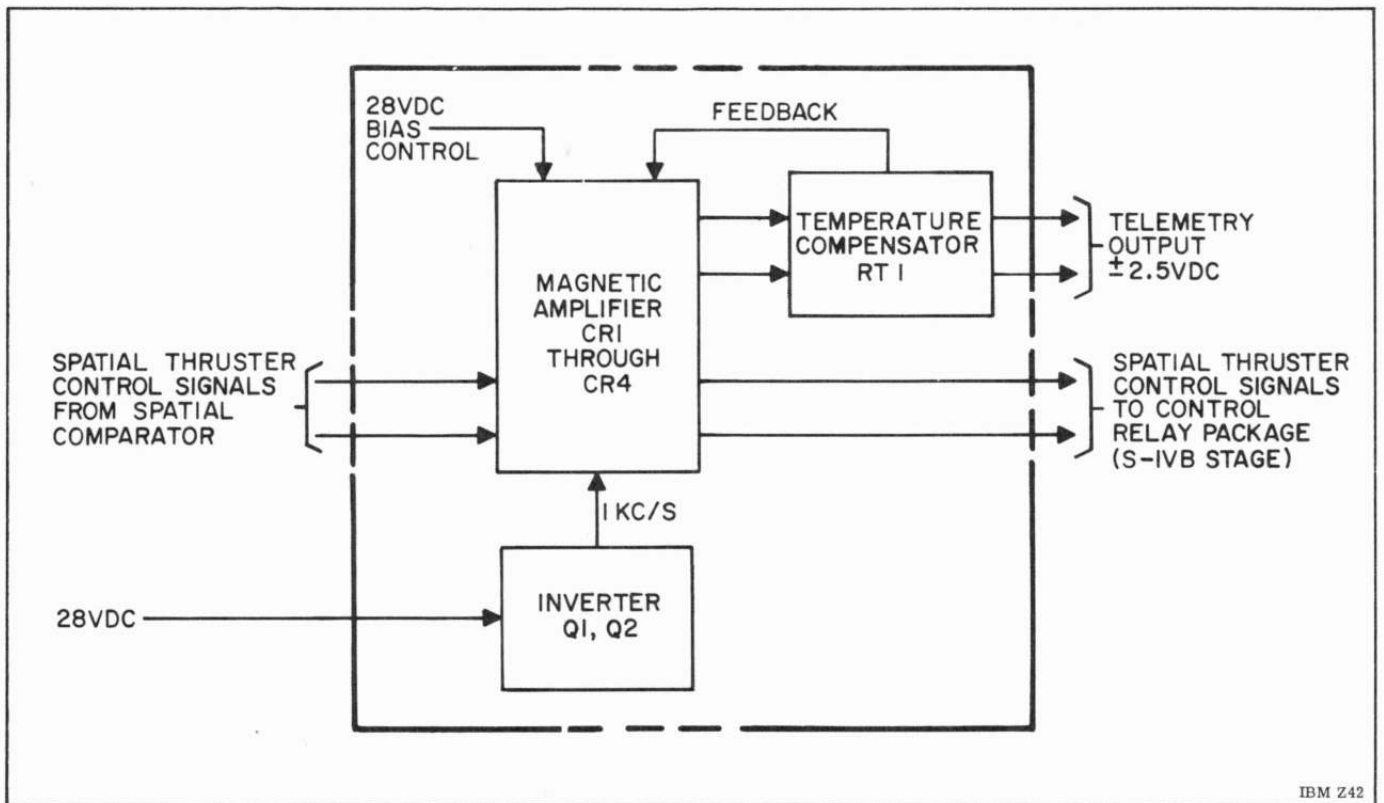
Signal lines from the spatial comparator are coupled through coil windings in magnetic amplifier CR1 through CR4 to the control relay package in the S-IVB Stage. Magnetic amplifier CR1 through CR4 produces an output signal when a spatial thruster control signal is present on one of the signal lines from the spatial comparator. The polarity of the magnetic amplifier output is determined by which signal line the spatial thruster control signal is carried on. The output of magnetic amplifier CR1 through CR4 is coupled through temperature compensator RT1 to produce the telemetry output signal.

The excitation signal for magnetic amplifier CR1 through CR4 is developed by inverter Q1, Q2 which converts the 28V dc source to a 1 kc/s signal. The amplitude of the magnetic amplifier output is preset by the 28V dc bias control.

Temperature changes which affect the overall performance of the TM amplifier are sensed by temperature compensator RT1. Temperature compensator RT1 then controls the gain of magnetic amplifier CR1 through CR4 by applying a feedback in proportion to the temperature change.

2-8 DETAILED DESCRIPTION

(To be Supplied)



IBM Z42

Figure 2-15. TM Amplifier, Functional Block Diagram

SECTION III

PREPARATION FOR USE AND SHIPMENT

3-1 PREPARATION FOR USE

To remove the Flight Control Computer from its shipping container proceed as follows:

CAUTION

The Flight Control Computer shipping container is reusable. Therefore, exercise care when unpacking the component to ensure that the container and foam cushioning are not damaged.

- a. Remove locking ring from shipping container.
- b. Remove top cover from shipping container.
- c. Check humidity indicator (see following paragraph).
- d. Remove top cushioning pad.
- e. Manually remove the Flight Control Computer from the shipping container.
- f. Visually inspect the component for physical damage and corrosion.
- i. Install the Flight Control Computer Fixture Assembly (IBM Part No. 7904046) on the component.

Refer to Component Handling Equipment manual, IBM No. 66-966-0005, Figure 8-4.

The humidity indicator has three blue indicators graduated to indicate thirty, forty, and fifty percent humidity. These indicators will turn pink when their respective percent of humidity has been reached. If the fifty percent indicator is pink, it is recommended the Flight Control Computer be returned to the laboratory for inspection and testing.

3-2 PREPARATION FOR SHIPMENT

The Flight Control Computer shall be packaged in accordance with Method II of Military Specification MIL-P-116 and marked in accordance with Military Standard MIL-STD-129.

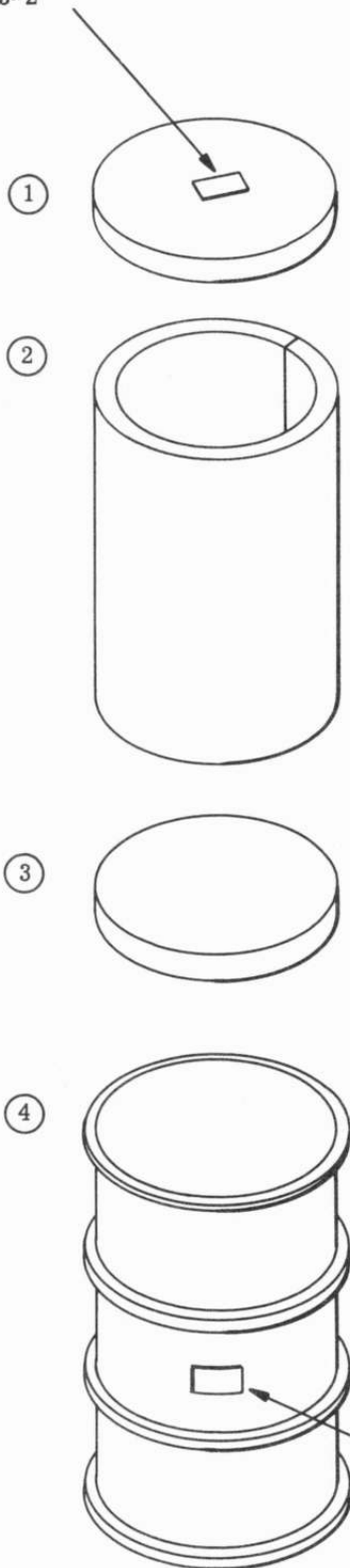
3-3 PACKAGING

The packaging instructions for the Flight Control Computer are given in Figure 3-1.

3-4 MARKING

A Method II Process Label (IBM No. 7904879) shall be applied to the outside of the shipping container assembly. Make certain the packaging date is recorded on this label.

Humidity Indicator
MS Part No.
MS 20003-2



① Polyurethane Pad

Material: Polyurethane foam cushioning,
4 lbs/cu ft density, IBM No. 7904811
Specification: MIL-P-26514, type 1, class 1
IBM Drawing No. 7904833

Dimensions:

Diameter: 22.50 inches
Thickness: 3.00 inches

Secure one eight unit bag of desiccant behind unit mounting bracket. Place a sheet of grade A paper (MIL-B-121, type 1, class 2) between unit and desiccant.

② Polyurethane Pad

Material: Polyurethane foam cushioning,
4 lbs/cu ft density, IBM No. 7904811
Specification: MIL-P-26514, type 1, class 1
IBM Drawing No. 7904833

Dimensions:

Length: 70.50 inches
Height: 24.00 inches
Thickness: 2.00 inches

③ Polyurethane Pad

Material: Polyurethane foam cushioning,
4 lbs/cu ft density, IBM No. 7904811
Specification: MIL-P-26514, type 1, class 1
IBM Drawing No. 7904833

Dimensions:

Diameter: 22.50 inches
Thickness: 6.00 inches

④ Shipping Container Assembly

Type: MS 63054-5, Metal, reusable
container Assembly Part Numbers

Body: MS 63054-15
Cover: MS 63054-21
Locking Ring: MS 63054-31
Gasket: MS 63054-41

Method II Process Label
IBM No. 7904879

IBM Z43

Figure 3-1. Packaging Instructions for Flight Control Computer

SECTION IV

PREVENTIVE MAINTENANCE AND REPAIR

4-1 PREVENTIVE MAINTENANCE (Not Applicable)

4-2 REPAIR

All repairs to the Flight Control Computer will be accomplished by component replacement. If failure analysis determines repair is possible, the component should be returned to the proper agency for repair.

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Space Systems Center
Huntsville, Alabama

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