SECTION IX

CAPABILITY DATA

Introduction

This section describes the method of determining the spring loads and current flow requirements for the wire spring relays. These loads have been tabulated for the AF, AJ, and AK relays. The AG relays are treated in more detail in Part II due to their precise release-time requirements.

Pull curves are provided from which the operate, nonoperate, hold, and release ampere turns may be obtained. The ampere turns required to operate various numbers of springs on the AF and AJ relays have been tabulated.

The following tables and pull curves form a part of this section.

Tables:

Pull Curves - Figures:

PART I - AF, AJ, AND AK RELAYS

General

In considering ampere turn adjusting requirements for any spring combination, the following must be considered:

1. The magnetic capability of the relay, including the size, flatness, and quality of the magnetic parts;

2. The operated airgap, or stop-disc height;

3. The maximum airgap which, with the stop-disc height, determines the armature travel;

4. The gram loads at the critical points in the travel.

With such a large number of variables, it does not seem reasonable to assume all contributing factors at their extreme limits. The gram loads, therefore, have been taken as maximum and the airgaps as

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nominal. The nominal air gap values may be used in considering maximum critical loads because, for the small percentage of cases where the maximum loads are combined with minimum pull, maximum airgap, and unfavorable contact gauging, adjustments can be made. If the load at the backstop is too high, the armature travel cannot be changed to obtain a smaller airgap, but the back tension can be adjusted to compensate for this. Considering the critical load point, if there is a large spread between contact actuations, the critical load point will be toward the minimum anyway. If there is a small spread between contact actuations, a mass adjustment can be made to reduce the load point.

The construction of the relay is such that for any stage the break-contact loads may be picked up earlier than the make-contact loads. However, to provide a simple method of computing spring loads and operate ampere turns, no differentiation has been made between the pickup point of breaks and makes. The resulting error in the load is small and usually on the conservative side.

Contact Actuation

The wire spring relay uses a single card system with the single wires held in a fixed position. The twin wires are actuated by the moving card on the armature, either making or breaking contact with the single-wire contact.

Makes

The make twin wires are pretensioned toward the single contact, but held away from them by the tension of the balance spring against the moving card. Thus, they provide an opposing back tension tending to push the armature toward the core but counteracted by the balance spring. As the relay starts operating, the tension of the twin wires decreased in magnitude, resulting in an increasing balance spring load on the armature. This continues up to the pickup point where the twin wires just make contact with the single wire. During the next 0.8-mil travel, the make load is transferred from the card, or armature, to the single contact. At this critical load point, the make wire tension against the card becomes zero, resulting in further increased load on the armature. The make wire tension on the armature remains zero for the remainder of the armature travel as the moving card and twin wires separate. Fig. IX-1 shows how the load on the armature changes as the armature moves toward the core.

Breaks

In the unoperated position, the twin break wires rest against their mating single contact. The twin wires do not touch the card and no load is on the armature at this point; therefore, no build-up of load occurs as the gap between the card and the twin wires closes to the pickup point. During the next 0.8-mil travel, the load is transferred from the single contact to the card. From this critical load point, where the transfer is completed, to the end of the travel, the break spring load builds up at a small, but uniform, rate due to the buildup of the break spring wires, the balance spring, and the armature hinge.

The load on the armature from combined make and break loads is shown in Fig. IX-1. The armature is held against the backstop by the balance spring tension. This tension has two components, the assumed back tension, holding the armature against the backstop, and the twin make wire spring tension, tending to operate the armature. As the armature moves toward the core, the load builds up at a slow uniform rate due to the buildup of the balance spring, armature hinge, and the contact spring. When the actuating card touches the break spring, there is a rapid buildup of load until the break-contact opens, at which point the armature is carrying the full break spring contact pressure.

As the armature continues its movement, the make-contact closes. At this point there is another rapid buildup of load as the twin wire make-contact tension tending to operate the armature is transferred to the single contact. From this point on there is only the buildup due to the balance spring, armature hinge, and break-contact spring.

For multiple stage loads, the load would increase in a similar manner as later stage makes and breaks are picked up.

Critical Load Points

The critical load points are the points in the armature travel where a major load change takes place, such as picking up a break or a make twin contact spring. Fig. IX-2 shows a typical load buildup curve and pull curves indicating the way in which the critical load points control the ampere turns required to operate the relay.

The critical load airgaps have been computed for the different armature travels and stop discs and are shown on Table IX-1. The loads at the critical points for relays with 0.006-inch stop discs are shown on

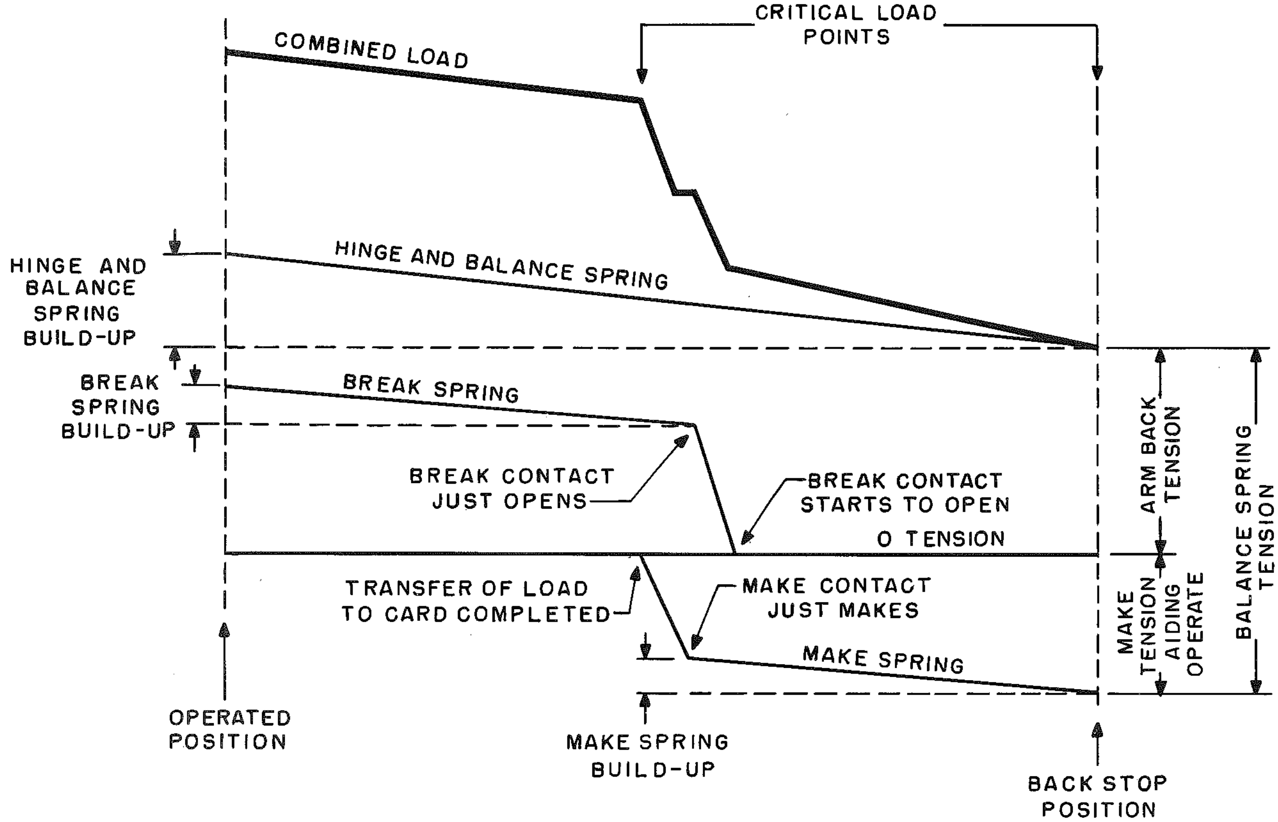

Fig. IX-1 - Single Stage Load Buildup

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Table IX-2. These loads assume that the last of all makes and breaks in each stage is picked up at this point.

When considering marginal or sensitive relays, the adjustment should be computed on a more exact basis. Fig. IX-4 shows the distribution of the contact pickup points

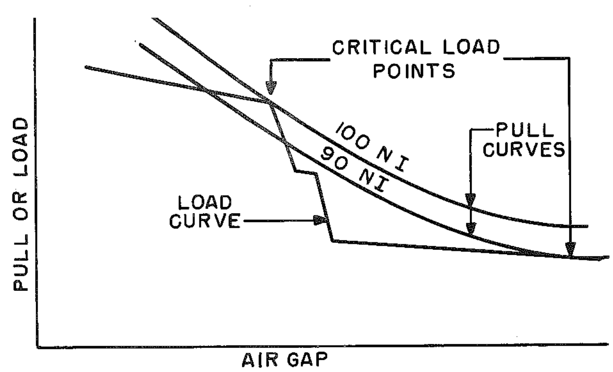

Fig. IX-2 - Typical Load and Pull Curve

for marginal or sensitive adjustments. This figure will be discussed in more detail in Appendix A.

Light Contact Forces

In relay applications requiring great sensitivity, an extremely slow release, etc, a lighter contact force has been used. The loads are figured the same as for the standard force except that the nominal contact load is reduced from 13.3 grams at the card to 8.6 grams.

Balance Spring, Armature Hinge, and Back Tension

The balance spring is pretensioned to provide an initial tension on the armature of minimum 30 grams above that required to counteract the tension of the make-contact springs. Critical or sensitive relays may be figured with a back tension of minimum 20 grams, and the lower tension is specified in the shop requirements and on the Circuit Requirements Table. The balance spring tension can be adjusted, if necessary, to meet the electrical requirements.

The thickness of the balance spring varies with the number of makes and armature travel in accordance with the following table.

Balance Springs

No. of Makes	Travel* S	I	L	P Detail	Thickness inch	Buildup in Gm/Mil Travel Min	Nom	Max
AF and AJ Relays								
0	x	x	x	15A220	0.014	0.090	0.107	0.127
1	x	x	x	15A221	0.016	0.134	0.159	0.189
2	x	x	x	15A221	0.016	0.134	0.159	0.189
3	x	x	x	15A226	0.018	0.189	0.225	0.267
4	x	x	x	15A226	0.018	0.189	0.225	0.267
5	x			15A226	0.018	0.189	0.225	0.267
5		x	x	15A222	0.020	0.258	0.307	0.364
6	x	x	x	15A222	0.020	0.258	0.307	0.364
7	x			15A222	0.020	0.258	0.307	0.364
7		x	x	15A223	0.022	0.338	0.403	0.478
8	x	x	x	15A223	0.022	0.338	0.403	0.478
9	x			15A223	0.022	0.338	0.403	0.478
9		x	x	15A224	0.025	0.494	0.588	0.697
10	x	x		15A224	0.025	0.494	0.588	0.697
10			x	15A225	0.025	0.494	0.588	0.697
11	x			15A224	0.025	0.494	0.588	0.697
11		x	x	15A225	0.025	0.494	0.588	0.697
12	x	x	x	15A225	0.025	0.494	0.588	0.697
24	x			15A334	0.032	1.030	1.230	1.460
24	x			11F880	0.036	1.452	1.696	1.977
AK Relays								
0 to 2	x	x		10B698	0.018	0.175	0.209	0.249
3 to 5	x	x		10B697	0.020	0.234	0.278	0.330

*S = Short
I = Intermediate
L = Long

A thicker balance spring may be specified to facilitate meeting a nonoperate or release requirement.

The balance spring tension, plus a buildup of 1 gram per make-contact per stage, is added to the spring load at the critical points in computing the total gram loads. The 24-make relay requires an extra heavy balance spring which if figured as 24 grams per stage.

The armature hinge is assumed to have an initial load of zero grams and builds up at a uniform rate of 7 grams per stage for AF, AJ, and AK relays.

Buffer Springs

Buffer springs are provided to aid in meeting a release requirement. The buffer spring is provided on a code basis and is used normally in adjusting the relay if the specified release cannot be met without its use. This spring is picked up with a minimum 0.004-inch, maximum 0.010-inch gauge at the center line of the card.

The buffer spring load is thus picked up after the last critical load point. Normally, it should not affect the operate ampere turns, but the operate load where the buffer spring is picked up should be checked to be sure that the operate is not affected. The buffer spring tension is effective only with less than the maximum spring load and thus will not affect the hold ampere turns.

Determination of Airgaps

The backstop position is set by the core plate and the core, while the operated position is controlled by the stop disc height. The airgap with the armature at the backstop is dimension A of the core plate minus the 0.058-inch armature thickness. The height of the stop disc has no effect on this. The tolerances affecting the unoperated airgap total ±0.005 inch and are due to variations in the core plate dimension A, the armature flatness, and the armature thickness. Dimension A for the various travels and stop discs is shown on Table IX-1. A short travel relay with 0.006-inch stop discs will have a nominal unoperated airgap of 0.092 inch - 0.058 inch = 0.034 inch ±0.005 inch. The minimum airgap for a nonoperate would be 0.034 inch - 0.005 inch = 0.029 inch.

The armature stop discs set the operated position of the armature. With 0.006-inch stop discs, the armature is parallel to the core in the operated position and the gap at the center line of the card is the same as that at the stop disc. This is because the armature hinge holds the rear of the armature 0.006 inch away from the core. With larger stop discs, there is, effectively, a triangle on top of a rectangle as shown in Fig. IX-3. The triangular part, ie, the difference between the stop disc height and 0.006 inch, is converted to the center line of the card by dividing by the a/b ratio of Fig. IX-3. For example, with 0.022-inch stop discs (average 0.0235) on an AF relay, the average effective stop-disc height at the center line of the card is:

$$0.006 \text{ inch} + \frac{0.0235 \text{ inch} - 0.006 \text{ inch}}{0.718} = 0.030 \text{ inch}$$

Operate Ampere Turns - Simplified Method

The simplified method of computing the operate ampere turns is recommended for general use. The detailed method described later should be used for marginal or sensitive requirements where a more precise method may enable more difficult circuit

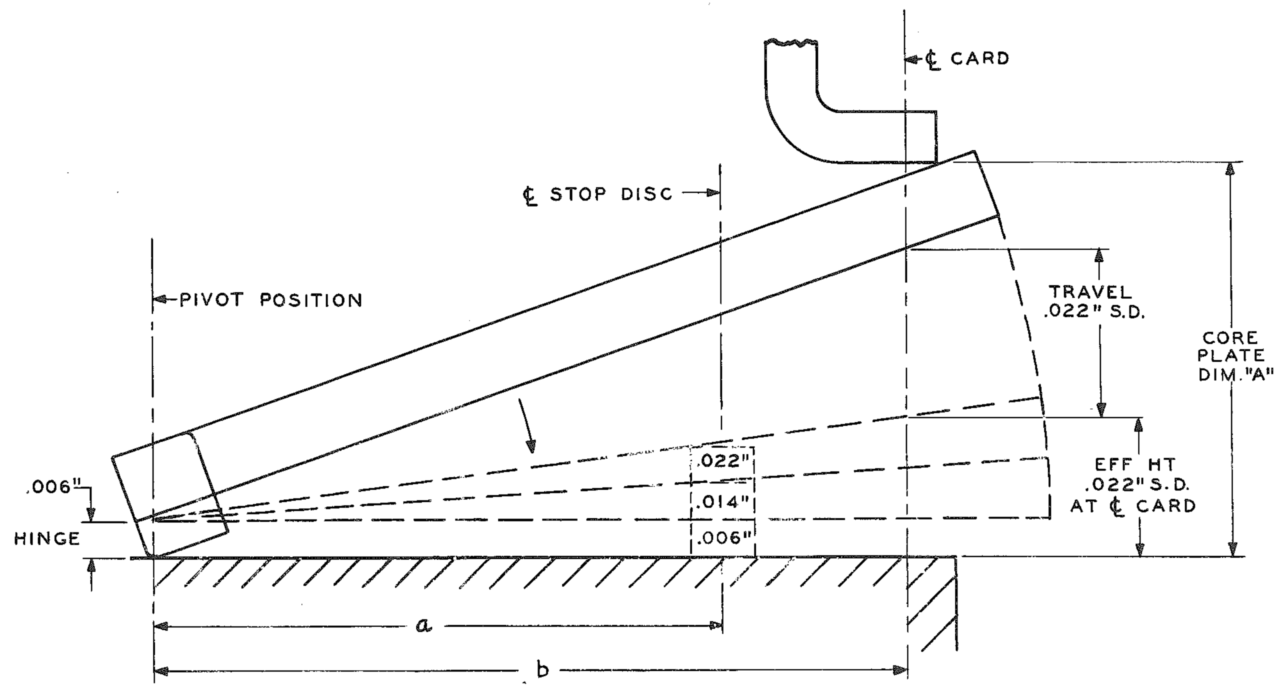

Fig. IX-3 - Airgap Relationship

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conditions to be met. The simplified method of computing the operate ampere turns for standard adjustments is shown on Table IX-1. This table also shows the airgap values for the different armature travels and stop discs. The critical load points and maximum operated loads computed in this manner are shown on Table IX-2. This table is calculated on the basis of 0.006-inch stop discs, but may be used for any stop disc by substituting the proper airgap from Table IX-1. The operate ampere turn values have been computed and are shown on Tables IX-3, IX-4, and IX-5 for the AF and AJ relays and the AJ relay with laminations.

Operate Ampere Turns - Detailed Method

This method of computing the operate ampere turns gives more accurate results than the simplified method. It is used on sensitive or marginal relays where the requirements figured in the normal manner fail to meet the circuit requirements.

Fig. IX-4 shows the maximum load curves from which the load buildup for any spring combination may be determined. This curve starts with an assumed back tension at the unoperated airgap; has a slight buildup to the point where the contacts make, or break; and then a rapid buildup occurs for a small travel interval. The make-contacts at the pickup point have a load of 13.3 grams ±25 percent. At the backstop, this tension will be 13.3 grams plus the buildup in tension from the pickup point to the backstop.

After contact actuation, there is a small buildup on break-contacts to the end of the travel. For intermediate travel, there are two stages of contact pickup; for long travel, three stages.

The buildups for the various thickness balance springs and the armature hinge are also shown.

The actual method of using the load buildup curve to determine the ampere turn operate is shown in Appendix A.

Nonoperate Ampere Turns

No load tables are needed for the nonoperate ampere turn values as the back

Travel	Stop Discs	Minimum Unoperated Airgap	Core Plate Dim. A	Core Plate P Number Ordinary Duty	Core Plate P Number Long Life
	Inch				
Short	0.006	0.029	0.092	15A212	15A215
Intermediate	0.006	0.047	0.110	15A213	15A216
Long	0.006	0.063	0.126	15A214	15A217
Short	0.014	0.040	0.103	15A280	15A279
Intermediate	0.014	0.058	0.121	15A277	15A281
Long	0.014	0.074	0.137	15A278	-
Short	0.022	0.047	0.110	15A213	15A216
Short (special)	0.006	0.020	0.083	15A282	-

tension, stop discs, and armature travel are the only significant factors. The non-operate ampere turns are obtained by reading the back tension at the minimum unoperate airgap on the nonoperate pull curves Fig. IX-11, IX-17, IX-23, or IX-33. The minimum airgaps are tabulated above.

The back tension is usually taken as 30 grams, but this may be increased to 60 grams with no change in spring thickness, or to a maximum of 85 grams by using the next thicker balance spring. A still higher nonoperate may be obtained by using a balancing spring two sizes thicker. This allows a maximum back tension of 115 grams. Any increase in tension over 60 grams must be added to the critical load points. A higher nonoperate may also be obtained by using an airgap higher than that required for the spring combination. The speed coils (4.4-, 16-, 270-, 395-, 400-, and 700-ohm coils) have a maximum armature back tension of 60 grams specified in the M specification. Nonoperate or release requirements for these coils should not be figured on a back tension greater than 60 grams. The back tension requirement in the M specification for these relays with a nonoperate or release should be maximum 80 grams.

Where no nonoperate adjustment is specified and an equivalent nonoperate is desired for time studies, or for consideration in a marginal circuit, the equivalent nonoperate is assumed to correspond to 30 grams at the minimum unoperated airgap. This nonoperate should be met without readjustment and should be used, if possible, when adding a nonoperate requirement to existing relays.

Hold Ampere Turns

The maximum load in the operated position is the critical point for the hold ampere turns. These maximum loads are shown on Table IX-2 and read on the hold pull curve to determine the hold ampere turns. The operated airgap for hold is based on the maximum stop-pin height and corrected to the equivalent gap at the center line of the card. These operated position airgaps are shown on Table IX-1.

Release Ampere Turns

The procedure for obtaining the release ampere turns, together with the critical release loads, is shown on Table IX-6. The critical release loads shown on Table IX-6 are based on a back tension of 30 grams, but the nominal 60-gram tension may be used by increasing the release loads by 30 grams. This does not change the operate requirements. The 30-gram back tension gives a release requirement that can be met with the minimum amount of adjustment and should be used where it will meet the circuit conditions.

A relay may be tensioned up to an 85-gram back tension to meet a release circuit condition by using the next thicker balancing spring. This, however, requires that the operate loads at the critical points be increased by the amount the back tension is raised above 60 grams. Where critical release conditions are involved, a more exact release requirement may be computed using the minimum load buildup curve (Fig. IX-5). The method of using this figure is the same as shown in Appendix A for figuring the operate.

Current Flow Requirements

The current flow requirements are obtained by dividing the ampere turns by the specified turns. The operate and hold requirements must be increased and the nonoperate and release decreased, if necessary, to use values that are readable on the 35F relay test set.

The 35F relay test set has four scales with the nearest readable value as shown below:

Scale	Readable Tolerance
ma	
0-3	±0.02
3-15	±0.10
15-75	±0.50
75-750	±5.00

Check Adjustments

Multiple-wound relays may be used with the windings in series or with the windings in separate operating circuits. The current flow requirements for the first condition are computed the same as for a single winding equivalent to the sum of the turns of the two windings.

Where each winding has a different operating condition, readjust requirements are computed for one winding in the normal manner. Check adjustments are computed for the other winding, or windings, assuming a +5 percent variation in turns on the windings. This is necessary in order to insure that any relay, adjusted on the winding that has the readjust requirements, will always meet the requirements on the check winding provided the check winding has the proper number of turns.

The method of computing the check readjust or test requirements is as follows, assuming that the primary winding is the adjusting winding.

$$\text{Operate} - \frac{\text{pri operate x pri turns x 105\%}}{\text{sec turns}}$$

$$\text{Hold} - \frac{\text{pri hold x pri turns x 105\%}}{\text{sec turns}}$$

$$\text{Nonoperate} - \frac{\text{pri nonoperate x pri turns}}{\text{sec turns x 105\%}}$$

$$\text{Release} - \frac{\text{pri release x pri turns}}{\text{sec turns x 105\%}}$$

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SECTION IX

CAPABILITY DATA

PART II - AG RELAYS AND SLOW RELEASE AK RELAYS

AG Relays

The AG relay is a slow release wire spring relay having a maximum capacity of 12 transfers. An AG relay with the lightest contact load is capable of providing a minimum release time of 0.380 second. The maximum release time is generally 2 to 2-1/2 times the minimum release time.

Instead of stop discs, which are provided on the AF and AJ relays, the AG relay has a dome embossing on the armature pole face. In the operated position of the armature, the dome touches the center leg of the core. This provides a relatively uniform point of contact between the armature and the core and thereby minimizes the effects of varying alignment of the armature and the core on the release times. The core of the AG relay is hydrogen annealed to obtain the permeability and coercive force required, so that the AG relay minimum to maximum release time spread is within the required limits.

Generally, the AG relay is provided with a short-circuited winding in the form of a sleeve over the center leg of the core. An aluminum sleeve of 0.046-inch wall thickness or a copper sleeve of 0.046-inch, 0.091-inch, or 0.147-inch wall thickness is furnished as required to obtain the desired release times. Most AG relays are equipped with a buffer spring which is adjustable to provide additional load in the operated position for reducing or controlling the maximum release time.

Relays having a copper or aluminum sleeve over the core are slower in operating than relays having only a single inductive winding. For this reason, where a fast operate, slow release relay is required, an AG relay may be used with a noninductive resistance in parallel with the inductive winding. The same arrangement may also be used where the required relay release times are less than those provided by the minimum size of sleeve. Instead of a sleeve, a short-circuited secondary winding may be provided. This is used only where the circuit conditions require that the variation in relay release times shall be less than those obtainable with a sleeve. Where fast operate time is required, the secondary winding is short-circuited by a make-contact of the relay.

Test and readjust hold and release current flow requirements are specified to control the releasing times of AG relays. The hold requirement determines the minimum release time and the release requirement determines the maximum release time. Current flow requirements are more convenient to apply than direct timing requirements and are unaffected by variations in copper resistance due to changes in ambient and relay winding temperatures. These hold and release requirements shall not be used to meet any circuit marginal hold or release current conditions. A circuit current release condition is not desirable for an AG relay and would require special consideration.

In the manufacturing specification for an AG relay, minimum and maximum release times, based on the readjust hold and release current requirements, are specified. In the shop, the relays are adjusted to the readjust hold and release current requirements, and the release time requirements provide a check of the dimensional and magnetic characteristics of the parts and their proper assembly in the relay. This assures that the relays as manufactured are capable of providing the required release times.

Slow Release AK Relay

The AK relay can be made slow release by using an embossing on the armature, similar to that of the AG relay, and a copper or aluminum sleeve over the core. It is not necessary that both units on the AK relay be made slow release, since one unit can have the embossed armature and the other unit the standard stop discs. Requirements similar to those of the AG relay are usually specified for the slow release AK relay, except the release requirements are not as effective in controlling the maximum release time since buffer springs are not provided on the AK relays.

Selection of Coded Relay

List of Codes

Section II of this specification provides a list of coded AG and AK relays according to the number of contacts. When the selection of a relay code is made, spare contacts may be tolerated, depending on the demand, as outlined in Section II, page 1.

Release Times

The minimum and maximum test release times are given in Section II for each relay code, except where the relay does not have a sleeve. These are the release time limits that the relay will not exceed with the relay adjusted within the test hold and release current requirements. These release times, although they are not specified in the circuit requirements table, are listed here for information purposes when selecting a suitable coded relay. The effect of heating or magnetic interference on the release times will be considered later in this section.

Requirements for Circuit Requirements Table

The current flow requirements given in Section II are the test and readjust operate, hold, and release requirements that shall be specified in the Circuit Requirements Table. With AG relays, as well as with AF and AJ relays, it is impractical from a manufacturing consideration to have more than one adjustment for a relay code. This is because all wire spring relays are adjusted in the relay assembly shop in accordance with the M specification requirements. Accordingly, current flow requirements other than those shown in Table II-3 cannot be specified without changing the M specification requirements.

A full soak (FS) requirement shall be specified in the soak column of the Circuit Requirements Table before all current flow requirements. The current flow soak shown in Section II corresponds to 300-ampere turns saturation and is specified in the manufacturing specification as we have no control of the voltage used in the shop adjustment. The difference between the effect of FS and 300-ampere turns soak on the release time is negligible.

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Soak Effect

The release times for AG relays are based on releasing after a 300-ampere turn soak. If the soak is less than 300-ampere turns, the releasing time will decrease by the following amounts.

250 NI soak - 1.0%
200 NI soak - 2.0%
150 NI soak - 4.0%

The circuit current should be applied to an AG relay for a period of time somewhat longer than the actual operate time of the relay to insure that the full releasing time will be obtained. The minimum circuit closure should be 0.3 second for the 0.147-inch sleeve, and 0.2 second for the 0.091- and 0.046-inch sleeves.

Effect of Heating on Release Times

Where a slow release relay has a long circuit holding time, an appreciable increase in winding resistance results, due to the temperature rise of the relay coil. A corresponding increase in the resistances of the sleeve and the core, or equivalent decrease in the sleeve and the core conductance results. The effect is to reduce the minimum release times shown in Table II-3, which were determined on the basis of the relay at an ambient temperature of 80° F.

The final winding temperature is obtainable from the information provided in Section IV. For the relay winding at final temperature T, the minimum release time is equal to the minimum release time at room temperature multiplied by

$$\frac{1}{1 + \frac{(0.9T - 80)}{458}}.$$

The 0.9 factor allows for the sleeve and the core being at a lower temperature than the average winding temperature T.

Effect of Magnetic Interference

The effect of magnetic interference on the requirements and performance of AG and AK relays is covered in Section V.

Operate Times

Operate times may be determined from the data contained in Section VII, Part I. In general, operate times of AG relays are considered to be load-controlled. This is due to the time constant of the AG relay coil, including a sleeve where provided, being of such length as to result in an average operate time greater than 0.010 second.

General Design Information

In determining the adjusting requirements for slow releasing relays, the same factors are involved that are described in Part I of this section for the AF and AJ relays under the headings "General" and "Contact Actuation." There are, however, some differences because of the dome embossing on the armature of the AG relay and some AK relays, as compared with stop discs on the armature of the AF and AJ relays. These differences are:

1. The operated airgap is zero, since the dome embossing on the armature touches the core. For this reason, the airgap is the same as the armature travel at all critical load points.

2. The critical load airgaps for determining operate and nonoperate requirements for AG relays and AK relays with the domed armature have been computed and are shown in Tables IX-7 and IX-8.

3. For light contact force, the loads are figured the same as for the heavy contact force, except that the nominal contact load is reduced by 5 grams for each contact pair.

The general procedure for designing an AG relay is as follows:

1. Determine the maximum operated load.

2. Determine the corresponding readjust and test hold ampere turn and current flow requirements.

3. Select a sleeve so that the minimum release time required of the relay is met with the test hold requirement.

4. Determine the minimum operated load, and add the buffer spring load that is to be used (generally 160 grams).

5. Determine the corresponding readjust and test release ampere turn and current flow requirements.

6. Determine the maximum test and readjust release times.

7. Determine the operate readjust and test requirements.

Details of this procedure are covered in subsequent pages of this section and in Appendixes B and C. The design of an AG relay with a sleeve is covered in Appendix B, and the design of an AG relay with the winding in parallel with a noninductive resistance is shown in Appendix C.

Balance Spring, Armature Hinge, and Back Tension

Balance springs are pretensioned and are used to provide back tension to position the armature against the backstop. With make-contacts in the spring combination, the balance spring must also overcome the forward tension of the twin wire make-contact springs in keeping the contacts open in the unoperated position. For AG relays, the net back tension of 85 grams is used in determining the operate and release loads and 20 grams in determining the nonoperate and hold loads. The balance spring tension and the buildup of the balance spring at the critical load points are included in the spring load data in Tables IX-9 to IX-11, inclusive.

Balance Spring for AG Relays

No. of Makes	Travel* S	I	L	P Detail	Thickness inch	Buildup in Gm/Mil Travel Min	Nom	Max
0	√			15A220	0.014	0.090	0.107	0.127
0		√	√	15A221	0.016	0.134	0.159	0.189
1	√	√		15A221	0.016	0.134	0.159	0.189
1			√	15A226	0.018	0.189	0.225	0.267
2	√	√		15A226	0.018	0.189	0.225	0.267
2			√	15A222	0.020	0.258	0.307	0.364
3	√	√		15A226	0.018	0.189	0.225	0.267
3			√	15A222	0.020	0.258	0.307	0.364
4	√	√	√	15A222	0.020	0.258	0.307	0.364
5	√			15A222	0.020	0.258	0.307	0.364
5		√	√	15A223	0.022	0.338	0.403	0.478
6	√	√	√	15A223	0.022	0.338	0.403	0.478
7	√	√		15A223	0.022	0.338	0.403	0.478
7			√	15A224	0.025	0.494	0.588	0.697
8	√			15A223	0.022	0.338	0.403	0.478
8		√	√	15A224	0.025	0.494	0.588	0.697
9	√	√		15A224	0.025	0.494	0.588	0.697
9			√	15A225	0.025	0.494	0.588	0.697
10	√			15A224	0.025	0.494	0.588	0.697
10		√	√	15A225	0.025	0.494	0.588	0.697
11	√	√	√	15A225	0.025	0.494	0.588	0.697
12	√	√	√	15A225	0.025	0.494	0.588	0.697

*S = Short
I = Intermediate
L = Long

The required thickness of the balance spring depends on the number of make-contacts used and the armature travel, as shown in the foregoing table. For the same spring combinations, balance springs for AG relays are generally thicker than those for AF and AJ relays because the back tension for AF and AJ relays is considered to be 60 grams instead of 85 grams in computing the operate and release requirements. The greater back tension for AG relays allows for a wider range of operated load adjustment.

The armature hinge is assumed to have zero load in the unoperated position. As the armature moves to the operated position, there is an additional load because of the stress in the armature hinge. At each critical load point, the increase in hinge tension is added to the contact load. This buildup of armature hinge tension is approximately 1 gram per stage for operate and hold, and 0.5 gram per stage for release.

Buffer Spring

AG relays are generally provided with a buffer spring which is effective after most or all contacts have been actuated.

The buffer spring is adjustable and provides for increasing the release load without materially affecting the operate ampere turns. The buffer spring load is adjusted as required, to take care of variations in release characteristics of AG relays as manufactured. Where a particular relay has a coercive force greater than average (poor anneal), the buffer spring is adjusted so that the release requirement is met. On the other hand, where a relay has a coercive force less than average (good anneal), the hold requirement is controlling and the release requirement can be met without any buffer spring load. By this means, a smaller difference between the hold and release adjusting ampere turn requirements is obtainable, and this reduces the spread between minimum and maximum release times.

AG relays require the buffer spring where the balancing spring and contact springs do not provide the release load that is necessary for a 6-ampere turn readjust release requirement. This is the lowest readjust release recommended for AG relays in order to provide adequate margin for adjustment deterioration.

Originally, only a 0.012-inch buffer spring was provided. Later a 0.016-inch buffer spring was made available. The use of either the 0.012-inch or the 0.016-inch thick buffer spring is optional with the shop depending on which spring they find most desirable in meeting the release requirement of the relay being adjusted. The 0.012-inch buffer spring is capable of being adjusted to a maximum of 160-gram load at the center line of the card, and 0.016-inch buffer spring to 280 grams.

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Before the 0.016-inch buffer spring was made available, it was the general practice to use the full 160-gram buffer spring load in calculating the readjust release requirement. This gives the least spread in release times and often makes the relay suitable for many circuit applications, thereby reducing the number of codes. • For future AG relay designs, the use of 160-gram buffer spring load will be continued as the standard; however, with the availability of the thicker buffer spring, the buffer spring load may be increased to a maximum of 280 grams, if required.

<u>Minimum Release Time</u>

A particular AG or AK relay design meets the minimum release time required for circuit application by means of the specified hold requirement and the size of the sleeve. These are determined as outlined briefly in the following paragraphs and as covered in greater detail in Appendixes B and C.

The readjust hold ampere turn requirement is determined by the maximum operated load with the minimum armature back tension of 20 grams for the AG relay and 30 grams for the AK relay. The maximum operated loads are shown for the various spring combinations in Table IX-10. The maximum operated load read on the hold pull curve of Fig. IX-6 or IX-35 gives the readjust hold ampere turn requirement. All AG relays have a readjust hold of not less than 9-ampere turns and generally a minimum of 3-ampere turns difference between the hold and release readjust requirement. The 3-ampere turns provide a suitable adjustment range so that the relays are adjustable with normal adjusting effort. The test hold shall be 5 percent, but not less than 1-ampere turn greater than the readjust hold.

The minimum release time is obtained from Fig. IX-6 or IX-35. The test and readjust hold ampere turns are referred to the minimum time curve for the specified size of sleeve, and the minimum test and readjust release times are read on the ordinate scale.

<u>Maximum Release Time</u>

The specified release requirement and the size of sleeve selected for the relay determine the maximum release time. These are determined as outlined briefly in the following paragraphs and as covered in greater detail in Appendixes B and C.

The minimum operated load, with an armature back tension of 85 grams for the AG or 60 grams for the AK relay, is used to obtain the readjust release ampere turn requirement. This load can be determined, for any particular spring combination, from the data in Table IX-11. The minimum operated load is applied to the release pull curve of Fig. IX-6 or IX-35 to obtain the readjust release ampere turn requirement. When a buffer spring is provided on the AG relay, an additional load of 160 grams is generally added to the minimum operated load and the readjust release ampere turn requirement is determined for this total operated load. With the introduction of the thicker 0.016-inch buffer spring, a maximum of 280-gram buffer spring load may be added. In most cases, however, the 160-gram added buffer spring load is sufficient to provide the required readjust release requirement and maximum release time.

The minimum readjust release requirement permissible for the AG relay is 6-ampere turns. The minimum difference between the readjust hold and release ampere turns shall be 3-ampere turns. Where the relay has a light contact load, the buffer spring must be provided in order to obtain at least 6 ampere turns readjust release. The test release is 2 ampere turns less than the readjust release. A test release below 4 ampere turns is undesirable because an adjustment range is approached where release performance becomes unreliable due to small differences in operated load causing large differences in release ampere turns and release times.

The margin provided between test and readjust requirements is greater for release than for the hold because (1) the maximum release time is generally not as critical as the minimum release time and so greater release requirement margin is permissible and (2) the tendency is for the release time to increase due to wear. It is desirable to make allowance for this effect so that maintenance is not excessive and therefore, a 2-ampere turn spread between test and readjust release is generally provided.

The maximum release time is obtained from Fig. IX-6 or IX-35. The test and readjust release ampere turns are referred to the maximum release time curve for the proper sleeve from which the maximum test and readjust release times are obtained.

<u>Operate Ampere Turns</u>

AG Relay

The operate ampere turn requirement is based upon maximum loads, maximum armature travel, and average contact gauging. The loads and the airgaps are at the center line of the card. The load at the backstop and at each critical load point is determined from the data shown in Table IX-9. These loads include the balance spring load. The operate ampere turns are read for the various loads at their respective airgap on curves of Fig. IX-7. Since a buffer spring is generally provided, a critical operate load occurs at the buffer spring pickup point, which is at the 0.007-inch airgap. This load is obtainable from the data shown in Table IX-9, and the operate ampere turns for this load are determined from Fig. IX-7. The greatest of the operate ampere turns for the various critical load points is specified as the readjust operate requirement. For many of the AG relay designs the critical load in determining the operate ampere turns is the 85-gram back tension load at the unoperated airgap (armature against the backstop).

AK Relay

The operate ampere turn requirement for the AK relay with the embossed armature is figured as shown in Part I for the relay with the standard stop disc.

<u>Nonoperate Ampere Turns</u>

A nonoperate requirement is specified only where there is a nonoperate circuit condition or a minimum operate time requirement. A margin of 15 percent shall be provided between the readjust nonoperate and the maximum circuit nonoperate current. Nonoperate requirements are not recommended on the slow releasing AK relays due to the difficulty of adjusting the balancing spring.

The nonoperate readjust ampere turn requirement for the AG relay is determined by the minimum back tension of 20 grams at the minimum unoperated airgap which is shown in Table IX-8. The readjust nonoperate ampere turn requirement is read on curves shown in Fig. IX-8.

If the 20-gram back tension is insufficient to provide a suitable readjust nonoperate requirement, greater back tension may be used. The added back tension must also be considered when determining the hold requirement. A thicker balance spring may be required and shall be in accordance with the recommendation of the switching apparatus group responsible for the AG relay. Another method for increasing the nonoperate requirement is to use a core plate that is associated with a larger armature travel, which provides a greater unoperated airgap.

<u>Check Adjustments</u>

Check adjustments required for plural winding AG relays shall be determined in the same manner as outlined for AF and AJ relays.

SECTION IX

CAPABILITY DATA

PART III - AL AND AM RELAYS

For AL and AM relays the adjustments of the relay that are implied by the current flow requirements are verified in the same way as the requirements of other wire spring relays. However, the technique for making current flow tests is different since the core of the relay can retain a magnetic bias and in some cases this significantly affects the outcome of current flow tests. The added steps in making current flow tests on magnetic latching relays are necessary to insure that the proper magnetic state has been obtained before each relay characteristic is tested.

The operate and nonoperate (if specified) current flow values are applied when the magnetic structure of the relay is in its zero flux state (demagnetized state). To obtain the zero flux state, the specified soak current is applied followed by the specified NF release (no flux release) current. These currents are applied in a manner that causes the NF release flux to be in the opposite direction from the soak flux. Single-wound coils require current reversal. The soak current, specified with a negative (-) sign, will be in the same direction as the operate current, which also has a negative sign. All release currents will be specified with a positive sign indicating that these currents must flow in an opposite direction to the operate, nonoperate, and soak currents. Double-wound coils are basically the same as single-wound coils except that the operate and soak currents will generally be specified for the secondary winding. Some exceptions to these general rules will occur, usually because the secondary resistance may be so high that nonoperate and/or NF release currents cannot flow from the standard central office battery. The same sign convention will be used on both single- and double-wound coils.

The release, nonrelease, and NF release current flow values are applied when the magnetic structure of the relay is in its saturated flux state (latched state). To obtain the saturated state, the specified soak current is applied. The specified release, nonrelease, and NF release currents are applied in such a manner that the release flux is in the opposite direction from the soak (saturate) flux. Single-wound coils require current reversal. The release, nonrelease, and NF release current will be specified as a positive current. Double-wound coils are basically the same as single-wound coils and it is intended that the flux resulting from release currents be opposite to the soak and operate flux. The release, nonrelease, and NF release current generally will be specified on the secondary winding except as noted previously.

The AL and AM magnetic latching relays are not polar relays, ie, there is no preferred operate direction. However, the magnetic structure does exhibit a hysteresis effect such that the previous coil current affects relay performance when the next current is applied. Therefore, current flow testing results depend on the technique that is used to perform the test. The following sequence is recommended:

	Step	Omit these steps when:
1.	Soak current	
2.	NF release current	
3.	Operate current flow test	
4.	Soak current	Nonoperate is not specified
5.	NF release current	
6.	Nonoperate current flow test	
7.	Soak current	Nonrelease is not specified
8.	Nonrelease current flow test	
9.	Soak current	
10.	Release current flow test	
11.	Soak current	
12.	NF release current	Relay is to be left operated

Note: If there is no circuit specification that the relay be left operated after it is tested, it should be returned to its released state.

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Appendix A

Gram Load Determination Using the Maximum Load Curve - Fig. IX-4

A brief description of the curves in Fig. IX-4 will be helpful in describing its use. The gram load curves have several diagonal lines starting at the right side of the sheet. The meaning of the different lines is marked and needs no further explanation. These lines represent the negative buildup of the springs resting against the armature. They continue in a uniform manner until the make-contacts close, at which time there is a rapid change of tension to zero, where it remains until the end of the travel. Just before the make load is picked up, there is a rapid buildup of the break-contact load for a few mils travel. The break buildup then continues at a low, uniform rate until the end of the travel.

The numbers under TRAVEL at the right top of the sheet (Fig. IX-4) have the following significance.

P	Preliminary contacts
E	Early contacts
L	Late contacts
LONG L	Starting point for late contact on long travel relay
LONG E	Starting point for early contact on long travel relay
INT L	Starting point for late contact on intermediate travel relay
LONG P	Starting point for preliminary contact on long travel relay
INT E	Starting point for early contact on intermediate travel relay
SHORT L	Starting point for late contact on short travel relay

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The four horizontal scales are for the following purposes.

The top scale (P) is for preliminary contacts, the next (E) is for early contacts, the third (L) is for late contacts, and the lower scale (L SPL) is for contacts on a relay with a special travel. Thus, an early contact on a long travel relay would start on the E scale under LONG E, and on an intermediate travel relay on the E scale under INT E. A special travel relay is one that has a core plate that does not provide for the full contact gauging, such as a core plate for a 0.006-inch stop disc on a relay equipped with 0.014-inch stop discs.

Assume that it is desired to determine the maximum gram load for a relay having a spring combination consisting of 2EBM, 2EMB, 4M, and 2B.

Step 1: Examine the spring combination to determine:

Types of contacts. There are EB, EM, M, and B contacts.

Number of each type of contact. This is 2EB, 2EM, 6M, and 4B.

Whether makes or breaks are predominant. Makes are predominant. Use curve 2.

Balance spring required. 8 makes requires 0.022-inch spring.

Armature travel: Intermediate.

Step 2: From curve find travel points for backstop, pickup, and critical load points (CLP). These are:

Backstop travel point for intermediate travel: (INT E) - 50 mils.

Early pickup: first EB (break curve A, E scale) - 30.8 mils.

Critical load point: second EM (make curve B, E scale) - 28.2 mils.

Late pickup: first B (break curve A, L scale) - 17.8 mils.

Late critical load point: sixth M (make curve D, L scale) - 13.2 mils.

Step 3: Find loads for each type of contact plus balance spring and armature at backstop, pickup, and critical load points for late and early contacts and zero airgap. Multiply the loads for each type of contact by the number of contacts of that type. These are shown on the following table for the combination assumed.

Travel	Back-stop (CLP) 50	Early Contact Pickup 30.8	Early Contact (CLP) 28.2	Late Contact Pickup 17.8	Late Contact (CLP) 13.2	Oper Pos 0
2EB	0	0	29.6	30.6	31.2	32.4
2EM	- 35	- 33.2	0	0	0	0
4B	0	0	0	0	60	62.4
6M	-108	-104.6	-102	-99.6	0	0
Bal Spg	0	9.5	11	16	18	23.5
Armtr	0	7	8	11	12.6	16
Step 4						
Bal Spg Tension	203	203	203	203	203	203
Step 5						
Total Load	60	81.7	149.6	161	324.8	337.3
Airgap	57	37.8	35.2	24.8	20.2	7
NI Reqd	140	118	158	130	185	118

The balance spring tension selected in step 4 is a plus load that will exceed the make contact load at the backstop by an amount equal to the chosen armature back tension. In the example above, the armature back tension is 60 grams. The same value is added to all gaps. The make-contact load at the backstop is an aiding load since it is a tension tending to operate the relay and must be counteracted by the balancing spring tension. When the make-contacts close, the negative make-contact load against the armature becomes zero, and, in effect, a positive make-contact load is picked up by the armature.

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These loads are read on the operate pull curves for the particular type of relay under consideration and at the airgaps corresponding to the travel points plus the effective stop-disc height. The effective stop-disc heights are:

Stop Disc	Average Effective Stop Disc at Card AF	AJ
	inch	
0.006	0.007	0.007
0.014	0.019	0.017
0.022	0.030	0.027

The loads, computed as shown above, may be used in conjunction with the marginal capability data for the AJ relay, with 0.014-inch or 0.022-inch stop disc (Fig. 28 to 31). A typical use of these figures is in the design of the line supervisory relays.

Appendix B

AG or AK Relay With Sleeve

The hold and release requirements and the minimum and maximum release times are determined in the following manner. Since the circuit minimum release time is generally of greater importance than the maximum release, the hold requirements and minimum release times are determined first.

1. Determine the maximum operated load in grams, for the particular contact arrangement, from Table IX-10.

2. Read the readjust hold ampere turns, corresponding to the maximum operated load, on the hold pull curve of Fig. IX-6 or IX-35.

3. Obtain readjust hold current in milliamperes by dividing readjust hold ampere turns by the winding (U) turns.

4. The test hold current = 1.05 x readjust hold current. The test hold current multiplied by the winding (U) turns gives the test hold ampere turns, which shall be at least 1 ampere turn greater than the readjust hold ampere turns. If necessary, increase the test hold current to provide the 1-ampere turn difference.

5. The test hold ampere turns are referred to the minimum release time curves in Fig. IX-6 or IX-35. A sleeve is selected that will provide an adequate minimum release time as read on the ordinate scale. The release time obtained is the minimum test release time.

6. The readjust hold ampere turns are referred to the minimum time curve of the sleeve selected in Fig. IX-6 or IX-35. The release time as read on the ordinate scale is the minimum readjust release time.

7. Determine the minimum operated load in grams for the particular contact combination, from Table IX-11. To this load is added the buffer spring load (AG relays only), which is generally considered 160 grams. This is the maximum for a 0.012-inch buffer spring, but values up to 280 grams may be used for the 0.016-inch buffer spring.

8. On the release pull curve of Fig. IX-6 or IX-35, read the readjust release ampere turns corresponding to the gram load (Item 7). The readjust release ampere turns shall be at least 6 ampere turns. A minimum difference of 3 ampere turns between the readjust release and hold ampere turns is a design objective; however, in special cases where the required release times make a smaller difference necessary, a smaller difference is allowable, but the difficulty and cost of adjustment will be increased.

9. Obtain the readjust release current in milliamperes by dividing the readjust release ampere turns by the winding (U) turns.

10. The test release current = 0.95 x readjust release current. The test release current multiplied by the winding (U) turns gives the test release ampere turns. A minimum difference of 2 ampere turns between the readjust and test release ampere turns is preferred. A smaller difference is allowable where required by the release time limits.

11. The readjust release ampere turns are referred to the maximum time curve of the sleeve selected in Fig. IX-6 or IX-35. The release time as read on the ordinate scale is the maximum readjust release time.

12. The test release ampere turns are referred to the maximum time curve of the sleeve selected in Fig. IX-6 or IX-35. The release time as read on the ordinate scale is the maximum test release time.

Appendix C

AG Relay - Release in Parallel with An External Resistor

The hold and release requirements, the value of the shunt resistor, and the minimum and maximum release times are determined in the following manner. Since the circuit minimum release time is generally of greater importance than the maximum release, the hold requirements and minimum release times are determined first.

1. Determine the maximum operated load in grams for the particular contact arrangement, from Table IX-10.

2. Read the readjust hold ampere turns, corresponding to the maximum operated load, on the hold pull curve of Fig. IX-9.

3. Obtain readjust hold current in milliamperes by dividing readjust hold ampere turns by the winding (U) turns.

4. The test hold current = 1.05 x readjust hold current. The test hold current multiplied by the winding (U) turns gives the test hold ampere turns which shall be at least 1 ampere turn greater than the readjust hold ampere turns. If necessary, increase the test hold current to provide the 1-ampere turn difference.

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5. The test hold ampere turns referred to the minimum release time curve in Fig. IX-9 gives the minimum test release time in milliseconds for a core conductance plus relay coil conductance of 100 kilomhos.

6. The minimum total conductance required with the resistor shunt is

$$G_c = \left(\frac{\text{required min rel time}}{\text{test rel time (Item 5)}}\right) 100 \text{ Kmhos}$$

7. The minimum core conductance G_e at the test hold ampere turns is read on the minimum G_e curve of Fig. IX-9.

8. The minimum conductance of the shorted winding G_c is equal to the conductance (Item 6 minus Item 7).

9. The maximum total resistance of the relay winding and the external shunt resistor in ohms is

$$R_t = \frac{[\text{winding (U) turns}]^2}{[\text{conductance (Item 8)}]10^3}$$

10. The external resistor maximum value is the difference between maximum resistance (Item 9) and the maximum winding resistance. A suitable coded resistor shall be selected with resistance variation limits as required by the time conditions.

11. The minimum conductance in kilomhos of the coil with the selected resistor in parallel =

$$\frac{[\text{winding (U) turns}]^2}{(\text{coil max res + resistor max res})10^3}$$

12. The minimum test release time in milliseconds = test release time (Item 5) x

$$\frac{\text{conductance (Item 11 + Item 7)}}{100 \text{ kilomhos}}$$

13. The readjust hold ampere turns referred to the minimum release time curve of Fig. IX-9 gives the minimum readjust release time in milliseconds for core conductance plus a relay coil conductance of 100 kilomhos.

14. The minimum core conductance at the readjust hold ampere turns is read on the minimum G_e curve of Fig. IX-9. This value is usually close to that for Item 7.

15. The minimum readjust release time in milliseconds = readjust release time (Item 13) x

$$\frac{\text{Conductance (Item 11 + Item 14)}}{100 \text{ kilomhos}}$$

16. Determine the minimum operated load in grams for the particular contact combination, from Table IX-11. To this load is added the buffer spring load, which is generally considered 160 grams. This is the maximum for a 0.012-inch buffer spring, but values up to 280 grams may be used for the 0.016-inch buffer spring.

17. Read the readjust release ampere turns, corresponding to the gram load (Item 16), on the release pull curve of Fig. IX-9. A minimum difference of 3 ampere turns between the readjust hold and release ampere

turns is preferred; however, where the required release times make a smaller difference necessary, a smaller difference is allowable but the difficulty and cost of adjustment will be increased.

18. Obtain readjust release current in milliamperes by dividing readjust release ampere turns by winding (U) turns.

19. The test release current = 0.95 x readjust release current. The test release current multiplied by the winding (U) turns gives the test release ampere turns. A minimum difference of 2 ampere turns between the readjust and test release ampere turns is preferred. A smaller difference is allowable where required by the release time limits.

20. The readjust release ampere turns referred to the maximum release time curve in Fig. IX-9 gives the maximum readjust release time in milliseconds for a core conductance plus relay coil conductance of 100 kilomhos total.

21. The maximum conductance in kilomhos of the relay coil with the resistor shunt =

$$\frac{[\text{winding (U) turns}] + 50)^2}{(\text{coil min res} + \text{resistor min res})10^3}$$

22. The maximum core conductance at the readjust release ampere turns is read on the maximum G_e curve of Fig. IX-9.

23. The maximum readjust release time in milliseconds = readjust release time (Item 20) x

$$\frac{\text{conductance (Item 21 + Item 22)}}{\text{100 kilomhos}}$$

24. The test release ampere turns referred to the maximum release time curve in Fig. IX-9 gives the maximum test release time in milliseconds for a relay coil conductance of 100 kilomhos.

25. The maximum core conductance at the test release ampere turns is read on the maximum G_e curve of Fig. IX-9.

26. The maximum test release time in milliseconds = test release time (Item 24) x

$$\frac{\text{conductance (Item 21 + Item 25)}}{\text{100 kilomhos}}$$

TABLE IX-1

Airgap Values					Airgap (Center Line of Card)				
							Critical Load Point		
Relay Type	Stop Discs	Core Plate Dim. A	Nom Travel	Gauging	Backstop	Opr Pos	Late	Early	Prel
AF,AJ	0.006	0.092	0.026	Std	0.034	0.010	0.019	-	-
AF,AJ	0.006	0.110	0.044	Std	0.052	0.010	0.019	0.032	-
AF,AJ	0.006	0.126	0.060	Std	0.068	0.010	0.019	0.032	0.045
AJ	0.014	0.103	0.028	Std	0.045	0.019	0.028	-	-
AJ	0.014	0.092	0.017	Spl	0.034	0.019	0.0245	-	-
AF	0.014	0.103	0.026	Std	0.045	0.021	0.030	-	-
AF	0.014	0.121	0.044	Std	0.063	0.021	0.030	0.043	-
AF	0.014	0.137	0.060	Std	0.079	0.021	0.030	0.043	0.056
AJ	0.022	0.110	0.025	Std	0.052	0.0285	0.038	-	-
AJ	0.014	0.121	0.046	Std	0.063	0.019	0.028	0.045	-
AJ	0.006	0.083	0.017	Spl	0.025	0.010	0.015	-	-
AK	0.005	0.105	0.026	Std	0.032	0.007	0.015	-	-
AK	0.005	0.087	0.044	Std	0.050	0.007	0.015	0.027	-

Note: The above airgap values (all given in inches) are to be used for general purpose relays only. For marginal relays, use Fig. IX-4.

Procedure for Obtaining Operate and Hold Ampere Turns for AF, AJ, and AK Relays

Load Buildup

The critical loads shall be determined using the following assumptions.

1. The back tension, including friction, shall be 60 grams, except that this may be adjusted in extreme cases to 30 grams to permit 18 contact pairs on the AF relay.

2. Buildup of the armature spring shall be 7 grams per stage starting at the backstop.

3. Buildup of the balance spring shall be 1 gram per contact per stage, starting at the backstop, with a maximum of 12 grams per stage. The one exception to the 12 gram maximum is the 24 make relay with 24 grams per stage buildup.

4. Contact force at the center line of the card due to contact pickup shall be 11 grams for light, 16 grams for standard, and 21 grams for heavy contact force relays.

5. Contact spring tension buildup shall be 1/2 gram per contact per stage, starting at the contact pickup point.

Airgap Values

1. For airgap at the backstop, nominal travel and stop-disc heights are assumed.

2. For critical load points, nominal gauging values and stop-disc heights are assumed.

The airgap values at the backstop and at the critical load points for the coded AF, AJ, and AK relays are as shown above.

Operate Ampere Turns

Using the load and airgap values described above and shown in Table IX-2, the operate ampere turns are obtained from the operate capability curves which are as follows:

AF Relay	Figure IX-10
AJ Relay	Figure IX-16
AJ Relay with laminations	Figure IX-22
AK Relay	Figure IX-32

Procedure for Obtaining Hold Ampere Turns for AF, AJ, and AK Relays

For hold, maximum loads in the operated position are critical. Thus loads are built up as for the operate, then continued one further stage, following the same rules, to operate the operated loads. These maximum operated loads are shown in Table IX-2.

To determine the ampere turns required to hold, use the maximum load with Fig. IX-12, IX-18, IX-24, or IX-34 selecting the appropriate number of contacts, armature travel, relay type, stop discs, and soak ampere turns.

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TABLE IX-2

AF, AJ, AND AK RELAYS

CRITICAL LOAD POINTS AND MAXIMUM OPERATED LOADS

	For Use in Figuring Operate — Critical Load - Grams — Travel and Airgap									For Use in Figuring Hold — Max Operated Load - Grams		
	Short		Intermediate			Long						
No. Cont	Late 19	BS 34	Late 19	Early 32	BS 52	Late 19	Early 32	Prel 45	BS 68	Short Travel	Inter-mediate Travel	Long Travel
1	84	60	-	84	60	-	-	84	60	93	-	-
2	101	60	110	101	60	-	110	101	60	111	120	-
3	118	60	128	118	60	138	128	118	60	130	140	150
4	135	60	147	135	60	158	147	135	60	148	160	171
5	152	60	165	152	60	178	165	152	60	166	180	192
6	169	60	184	169	60	197	183	169	60	185	200	213
7	186	60	202	186	60	216	202	186	60	204	219	234
8	203	60	220	203	60	236	220	203	60	222	239	255
9	220	60	238	220	60	255	238		60	240	258	276
10	237	60	256	237	60	274	256		60	259	278	297
11	254	60	274	254	60	294	274		60	278	298	318
12	271	60	293	271	60	314	293		60	296	318	339
13	287	60	309		60	330	309		60	312	334	356
14	303	60	326		60	346	326		60	329	352	372
15	319	60	342		60	362	342		60	346	368	388
16	335	60	358		60	377	358		60	362	385	404
17	351	60	374		60	396			60	378	402	424
18	367	60	390		60	411			60	395	418	439
19	383	60	406		60	428			60	412	435	456
20	399	60	423		60	444			60	428	452	473
21	415	60	439		60	460			60	444	468	490
22	431	60	456		60	477			60	461	486	507
23	447	60	472		60	493			60	478	502	524
24	463	60	488		60	510			60	494	519	541
24 makes	475	60								506		

The airgap values apply only for the relays with 0.006-inch stop discs (0.005 for the AK relay). The critical loads apply with any stop discs, but for light contact force, subtract 5 grams per contact. Standard gauging values apply in all cases.

The maximum load values assume 60 grams back tension. If this is changed, the operated load is changed by the same amount.

For AJ relays with 20 or more springs, the load may be assumed to be somewhat dispersed and the critical load gap may be reduced by 0.003 inch if necessary.

TABLE IX-3

AF RELAY

OPERATE AMPERE TURNS

No. Contacts	Short Travel	Intermediate Travel		Long Travel		
		L+E	E	L+E+P	E+P	P
1	98	-	130	-	-	157
2	98	130	130	-	157	157
3	98	130	132	157	157	167
4	101	130	141	157	157	178
5	107	130	151	157	157	192
6	114	130	160	157	169	207
7	120	130	169	157	180	222
8	127	132	181	157	191	241
9	133	139	192	157	204	
10	139	146	203	157	218	
11	145	152	218	160	237	
12	151	159	233	169	258	
13	157	167		179	279	
14	164	177		190	315	
15	172	187		205		
16	183	199		206§		
17	195	206†				
18	206	206‡				
19	206*					

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* Assumes back tension adjustment 40 grams
† Assumes back tension adjustment 50 grams
‡ Assumes back tension adjustment 35 grams
§ Assumes back tension adjustment 45 grams

Note: This table is for use only for relays with 0.006-inch stop discs. When other stop discs are used, use Table IX-1 and Table IX-2 with operate capability curve, Fig. IX-10. For marginal relays, use Fig. IX-4 with operate capability curve.

Example:

Assume the operate is desired for a relay with a spring combination consisting of 2EBM, 2EMB, 3M, and 2B. Armature travel - intermediate.

The spring combination has a total of 13 contacts, 4 early and 9 late. Under intermediate travel, 4 contacts in column E requires 141 ampere turns and in column L+E, 13 contacts requires 167 ampere turns. Thus 167 ampere turns is required for the spring combination assumed.

TABLE IX-4

AJ RELAY

OPERATE AMPERE TURNS

No. Contacts	Short Travel	Intermediate Travel		Long Travel		
		L+E	E	L+E+P	E+P	P
1	91	-	126	-	-	157
2	91	126	126	-	157	157
3	91	126	126	157	157	160
4	91	126	133	157	157	173
5	96	126	142	157	157	186
6	101	126	151	157	159	199
7	107	126	160	157	168	212
8	113	126	169	157	178	229
9	118	126	179	157	189	
10	123	129	188	157	200	
11	128	135	199	157	213	
12	134	141	211	157	227	
13	139	147		157	240	
14	145	153		160	256	
15	150	159		167	275	
16	156	164		173	298	
17	162	172		181		
18	168	180		191		
19	176	188		200		
20	184	198		211		
21	193	207		222		
22	202	220		236		
23	213	233		251		
24	227	245		267		
24 makes	235					

Note: This table is to be used only for relays with 0.006-inch stop discs. When other stop discs are used, use Table IX-1 and Table IX-2 with operate capability curve, Fig. IX-22. For marginal relays, use Fig. IX-4 with capability curve.

TABLE IX-5

AJ RELAY WITH LAMINATIONS

OPERATE AMPERE TURNS

No. Contacts	Short Travel	Intermediate Travel L+E	Intermediate Travel E	Long Travel L+E+P	Long Travel E+P	Long Travel P
1	91	-	126	-	-	157
2	91	126	126	-	157	157
3	91	126	126	157	157	159
4	91	126	131	157	157	171
5	96	126	139	157	157	182
6	101	126	147	157	157	193
7	106	126	154	157	162	203
8	112	126	162	157	171	217
9	117	126	171	157	180	
10	122	127	180	157	189	
11	127	133	189	157	199	
12	132	138	197	157	209	
13	137	143		157	218	
14	142	148		157	227	
15	146	153		159	237	
16	151	158		164	247	
17	156	163		169		
18	161	168		175		
19	166	174		180		
20	171	179		187		
21	176	184		193		
22	182	190		199		
23	187	196		206		
24	193	202		212		
24 makes	200					

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Note: This table is to be used only for relays with 0.006-inch stop discs. When other stop discs are used, use Table IX-1 and Table IX-2, with operate capability curve, Fig. IX-16. For marginal relays, use Fig. IX-4 with operate capability curve.

TABLE IX-6

AF, AJ, AND AK RELAYS

PROCEDURE FOR OBTAINING RELEASE AMPERE TURNS CRITICAL RELEASE LOADS

Short			Intermediate				Long Travel			
Total No. Contacts	Opr Load	Load at Pickup	Total No. Contacts	Opr Load	No. Early Contacts	Load at Late PU	Total No. Contacts	Opr Load	No. E+P Contacts	Load at Late PU
1	47	33	1	-	1	69*	1	-	1	-
2	59	34	2	64	2	80*	2	-	2	94*
3	73	35	3	78	3	91*	3	83	3	105*
4	86	36	4	92	4	102*	4	98	4	116*
5	99	37	5	106	5	113*	5	113	5	127*
6	112	38	6	120	6	124	6	128	6	138*
7	125	39	7	134	7	135	7	143	7	149*
8	138	40	8	148	8	146	8	158	8	160
9	151	41	9	162	9	157	9	173	9	171
10	164	42	10	176	10	168	10	188	10	182
11	177	43	11	190	11	179	11	203	11	193
12	190	44	12	204	12	190	12	218	12	204
13	201	44	13	215			13	229		
14	212	44	14	226			14	240		
15	223	44	15	237			15	251		
16	234	44	16	248			16	262		
17	245	44	17	259			17	273		
18	256	44	18	270			18	284		
19	267	44	19	281			19	295		
20	278	44	20	292			20	306		
21	289	44	21	303			21	317		
22	300	44	22	314			22	328		
23	311	44	23	325			23	339		
24	322	44	24	336			24	350		
24 makes	334	56	24 makes	360			24 makes	386		

* These values assume a total of 12 contacts. If total number of contacts is less than 12, subtract 2 grams for each contact less than 12.

Release

For release, minimum loads in the operated or late pickup positions are critical. The following rules apply:

1. The back tension shall be 30 grams.
2. Buildup of the combined balance spring and contact spring shall be 1 gram per contact per stage, starting at the backstop (maximum 12 grams per stage).
3. Buildup of the armature spring shall be 2 grams per stage.
4. Tension at the center line of the card due to contact pickup shall be 6 grams per contact for light, 11 grams for standard, and 16 grams for heavy contact force relays.
5. These load values assume 30 grams back tension. If the back tension is changed, the load is changed by the same amount.
6. To determine release ampere turns, use critical release loads with the release curves, selecting the applicable number of contacts, armature travel, relay type, stop discs, and soak ampere turns. Check the release for the operated position, Fig. IX-13, IX-19, IX-25, or IX-34 and for the AF and AJ relays at the late pickup position also (0.012-inch gauging), Fig. IX-14, IX-20, or IX-26.

Note: This procedure applies for general purpose relays only. For marginal relays use Fig. IX-4 for hold, Fig. IX-5 for release. Fig. IX-15, IX-21, and IX-27 show the release pull for use with special gauging values.

TABLE IX-7

AG RELAYS

PROCEDURE FOR OBTAINING OPERATE AND HOLD AMPERE TURNS

Loads - Maximum Loads Used (maximum pickup and buildup)

Operate: Compute loads at backstop and all contact points. These are called critical operate loads. Assume back tension is adjusted to 85 grams as for the release case (see Table IX-8), since both cases are essentially the same magnet (poor anneal), and the release is more important than the operate on most AG relays.

Hold: Compute loads at operated position only. Assume the back tension is adjusted as low as permitted by rebound (20-grams back tension). These are called maximum operated loads. (See Table IX-10.)

Assumptions for Computing Loads:

1. Back tension is adjusted to 85 grams for operate, 20 grams for hold.

2. Buildup of the armature spring is 1 gram per stage.

3. Contact force at the center line of the card due to contact pickup shall be 11 grams for light, 16 grams for standard, and 21 grams for heavy contact force relays.

4. Balance springs used and their buildups are as follows:

Spring Thickness mils	No. of Makes on Relay Short Travel	Inter Travel	Long Travel	Stiffness Max gm/mil Travel
14	0	-	-	0.133
16	1	0-1	0	0.196
18	2-3	2-3	1	0.280
20	4-5	4	2-4	0.380
22	6-8	5-7	5-6	0.508
25	9-12	8-12	7-12	0.735

5. Contact spring build-up is 0.043-gram/mil travel/contact starting at the contact pickup point.

6. A contact consists of the pair of twin contacts that mate with one face of a single fixed contact.

7. Total buildup for all springs from buffer pickup to operated position is 30 grams (approx).

Airgap Values for Computing Loads and Comparing Pull

1. Unoperated airgaps (at card center line), assuming maximum travel and minimum dome height:

Short travel relay	32 mils
Intermediate travel relay	50 mils
Long travel relay	66 mils

2. Nominal gauging values are used as critical gaps, assuming that critical load points can be adjusted into these gaps, if necessary. These are:

BUFF = Buffer pickup	7.0 mils
L = late contacts	11.5 mils
E = early contacts	24.5 mils
P = preliminary contacts	37.5 mils

Ampere Turns

Operate: Using critical loads on Table IX-9 computed from above rules, obtain operate ampere turns (for above gaps) from operate capability pull in Fig. IX-7.

Hold: Using maximum operated loads on Table IX-10 computed from above rules, obtain hold ampere turns from hold capability pull in Fig. IX-6. Tolerance on load adjustment requires that the specified hold ampere turns shall be at least 3 ampere turns above the specified release ampere turns.

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TABLE IX-8

AG RELAYS

PROCEDURE FOR OBTAINING
NONOPERATE AND RELEASE AMPERE TURNS

Loads - Minimum Loads Used (minimum pickup and buildup)

Nonoperate: Load at backstop must be controlling. Assume back tension is adjusted to 20 grams as for the hold case (see Table IX-7) since both cases are essentially the same magnet (excellent anneal) and hold is more important than the nonoperate on most AG relays. Back tension up to 85 grams may be used to increase the nonoperate ampere turns, if required. This also increases the maximum operated loads on Table IX-10, increases the hold ampere turns, and reduces the minimum release time.

Release: Compute load at operated position only. Assume back tension adjusted to maximum permitted by stress in balance spring (85 grams). These are called minimum operated loads (see Table IX-11). Buffer spring loads must be added to these values per Note E on Table IX-11.

Assumptions for Computing Loads:

1. Back tension is adjusted to 20 grams for nonoperate and 85 grams for release.

2. Buildup of the armature spring is 0.5 gram per stage.

3. Contact force at the center line of the card due to contact pickup shall be 6 grams for light, 11 grams for standard, and 16 grams for heavy contact force relays.

4. Balance springs used, and their buildups are as follows:

Spring Thickness mils	No. of Makes on Relay Short Travel	Inter Travel	Long Travel	Stiffness Min gm/mil Travel
14	0	-	-	0.094
16	1	0-1	0	0.142
18	2-3	2-3	1	0.201
20	4-5	4	2-4	0.279
22	6-8	5-7	5-6	0.369
25	9-12	8-12	7-12	0.552

5. Contact spring buildup is 0.036-gram/mil travel/contact, starting at the contact pickup point.

6. A contact consists of the pair of twin contacts that mate with one face of a single fixed contact.

Airgap Values

1. Unoperated airgaps (at card center line), assuming minimum travel and maximum dome height:

Short travel relay	20 mils
Intermediate travel relay	38 mils
Long travel relay	54 mils

2. Nominal gauging values and nominal buffer spring pickup are used as the critical gaps, assuming that the critical load points and buffer pickup can be adjusted out to these gaps, if necessary. These gaps are:

BUFF = Buffer pickup	7.0 mils
L = late contacts	11.5 mils
E = early contacts	24.5 mils
P = preliminary contacts	37.5 mils

Ampere Turns

Nonoperate: Using load above (for nonoperate) obtain nonoperate ampere turns (for above unoperated gaps) from nonoperate capability pull in Fig. IX-8.

Release: Using minimum operated loads on Table IX-11 (including buffer springs if on relay) which were computed from the above rules, obtain release ampere turns from release capability pull in Fig. IX-6. Tolerance on load adjustment requires that the specified release ampere turns shall be at least 3 ampere turns below the specified hold ampere turns. To insure release however, it shall not be less than 6 ampere turns readjust.

TABLE IX-9

AG RELAYS

CRITICAL OPERATE LOADS
(To Be Used In Establishing Operate
Ampere Turn Requirements)

At Stage	Gap	No. of Actuated Contacts	Using Table IX-	Load gm
Backstop	66	-	-	85
Preliminary	37.5	N = 2PM = 2	9A	124
		M = 2PM + 7M = 9	9B	26
			9A & 9B (total)	150
Early	24.5	N = 2PM + 3EB = 5	9A	175
		M = 2PM + 7M = 9	9B	39
			9A & 9B (total)	214
Late	11.5	N = 2PM + 3EB + 7M = 12	9A	291
		M = 2PM + 7M = 9	9B	50
			9A & 9B (total)	341
BUFF	7.0		Load required for release (see Table IX-11)	392
			minus buildup (Note 4)	-30
			total	362

Notes

1. N = number of contacts actuated at given stage or an earlier stage. Table IX-9A inculdes loads per Table IX-7, Items 1, 2, 3, and item 4 for 0 make contacts.

2. M = total M, EM, and PM contacts on relay. Table IX-9B approximates loads per Table IX-7, Item 5, and the additional buildup per Item 4 above that for 0 makes.

3. The above loads are for back tension of 85 grams (see Table IX-7 for reason).

4. For relays with buffer spring, critical operate load at buffer pickup is total operated load (including buffer) required for release (see Table IX-11) minus 30 grams. (per Table IX-7, Item 7).

5. For light contact force relays, reduce values in Table IX-9A by 5 grams per contact, ie, 5 x N (grams). For heavy contact force relays, increase values in Table IX-9A by 5 grams.

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USE OF TABLES

Example (Same relay as on Table IX-11):

Long travel relay 2PM, 3EB, 7M, with 16-mil buffer spring.

TABLE IX-9 (Cont)

AG RELAYS

CRITICAL OPERATE LOADS
(To Be Used In Establishing Operate Ampere Turns Requirements)

TABLE IX-9A (see Note 1)

Loads - For 85-Gram Back Tension

Relay Travel Stage	Short		Inter.			Long			
Airgap (mils)	L	BS	L	E	BS	L	E	P	BS
N = No. Cont.	11.5	32	11.5	24.5	50	11.5	24.5	37.5	66
1	105	85	111	107	85	115	111	108	85
2	121	85	127	123	85	131	127	124	85
3	137	85	143	139	85	147	143	140	85
4	153	85	159	155	85	163	159	156	85
5	169	85	175	171	85	179	175	172	85
6	185	85	191	187	85	195	191	188	85
7	201	85	207	203	85	211	207	204	85
8	217	85	223	219	85	227	223	220	85
9	233	85	239	235	85	243	239	236	85
10	249	85	255	251	85	259	255	252	85
11	265	85	271	267	85	275	271	268	85
12	281	85	287	283	85	291	287	284	85
13	297	85	303	299	85	307	303		85
14	313	85	319	315	85	323	319		85
15	329	85	335	331	85	339	335		85
16	345	85	351	347	85	355	351		85
17	361	85	367	363	85	371			85
18	377	85	383	379	85	387			85
19	393	85	399	395	85	403			85
20	409	85	415	411	85	419			85
21	425	85	431		85	435			85
22	441	85	447		85	451			85
23	457	85	463		85	467			85
24	473	85	479		85	483			85

TABLE IX-9B (see Note 2)

M = No. Makes	Short L 11.5	Inter. L 11.5	Inter. E 24.5	Long L 11.5	Long E 24.5	Long P 37.5
1	2	1	1	7	5	3
2	5	6	4	14	11	7
3	5	8	5	17	13	9
4	8	13	9	19	15	10
5	9	20	14	28	22	15
6	13	21	15	31	24	16
7	14	23	16	45	35	23
8	14	34	23	48	37	25
9	20	35	24	50	39	26
10	21	37	25	52	40	27
11	22	39	26	55	42	28
12	23	40	27	57	44	30

TABLE IX-10

AG OR SLOW RELEASE AK RELAYS

MAXIMUM OPERATED LOADS
(To Be Used In Establishing Hold Ampere Turn Requirements)

TABLE IX-10A (See Notes 1 and 5)
Loads - For 20-Gram Back Tension

N = No. Cont	Short Travel	Inter. Travel	Long Travel
1	43	-	-
2	59	67	-
3	76	84	88
4	92	101	105
5	109	118	122
6	125	135	139
7	142	152	156
8	158	169	173
9	175	186	190
10	191	203	207
11	208	220	224
12	224	237	241
13	241	254	258
14	257	271	275
15	274	288	292
16	290	305	309
17	307	322	326
18	323	339	343
19	340	356	360
20	356	373	377
21	373	390	394
22	389	407	411
23	406	424	428
24	422	441	445

TABLE IX-10B (See Note 2)

M = No. Makes	Short Travel	Inter. Travel	Long Travel
1	3	0	7
2	6	4	14
3	7	4	15
4	10	9	16
5	11	15	26
6	15	15	27
7	16	15	43
8	16	15	44
9	25	27	45
10	25	27	46
11	26	27	47
12	26	27	48

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NOTES

1. N = total number of contacts on relay. Table IX-10A includes loads per Table IX-7, Items 1, 2, 3, Item 4 for 0 makes, and Item 5 (approx).
2. M = total M, EM, and PM contacts on relay. Table IX-10B approximated additional build-up per Table IX-7, Items 4 and 5, above that for 0 makes.
3. The above are maximum loads adjusted as low as permitted by rebound requirements (20-gram back tension). For higher back tension, increase values in Table IX-10A by the increase in the back tension. This will also increase the nonoperate ampere turn value (see Table IX-8).
4. For light contact force relays, reduce values in Table IX-10A by 5 grams per contact, ie, 5xN (grams). For heavy contact force relays, increase values in Table IX-10A by 5 grams per contact.
5. For AK relays, add 10 grams to each of the loads in Table IX-10A as the AK relay is adjusted on minimum 30-gram back tension and the load data is based on 20-gram back tension.

USE OF TABLES

Example: Long travel relay 2PM, 3EB, 7M

N = 2PM + 3EB + 7M = 12; from Table IX-10A, load = 241
M = 2PM + 7M = 9; from Table IX-10B, load = 45
Total 286 grams

TABLE IX-11

AG OR SLOW RELEASE AK RELAYS

MINIMUM OPERATED LOADS
(To Be Used In Establishing Release Ampere Turns)

TABLE IX-11A (See Notes 1 and 6)

Loads - For 85-Gram Back Tension

N = No. Cont	Short Travel	Inter. Travel	Long Travel
1	99	104	-
2	111	115	118
3	122	127	130
4	134	138	141
5	145	150	153
6	156	161	165
7	168	173	176
8	179	184	188
9	191	196	199
10	202	207	211
11	213	219	223
12	225	230	234
13	236	242	246
14	248	253	257
15	259	265	269
16	270	276	281
17	282	288	292
18	293	299	304
19	305	311	315
20	316	322	327
21	327	334	339
22	339	345	350
23	350	357	362
24	362	368	373

TABLE IX-11B (See Note 2)

M = No. Makes	Short Travel	Inter. Travel	Long Travel
1	1	1	4
2	2	3	9
3	2	4	10
4	4	7	10
5	4	11	16
6	6	12	17
7	6	12	27
8	6	20	28
9	9	20	28
10	9	21	29
11	9	21	30
12	9	22	31

NOTES

1. N = total number of contacts on relay. Table IX-11A includes loads per Table IX-8, Items 1, 2, 3, and approximately Items 4 and 5 for 0 makes.

2. M = total M, EM, and PM contacts on relay. Table IX-11B approximates additional buildup per Table IX-8, Items 4 and 5, above that for 0 makes.

3. The above are minimum loads adjusted as high as permitted by stress in balance spring (85 grams). For lower back tension, reduce values in Table IX-11A by the reduction in back tension.

4. For light contact force relays, reduce values on Table IX-11A by 5 grams per contact, ie, 5 x N (grams). For heavy contact force relays, increase values in Table IX-11A by 5 grams per contact.

5. For relays equipped with buffer springs, the highest load permitted by stress in the springs is 160 grams for the 12-mil buffer used on the early relays and 280 grams for the standard 16-mil buffer. The load added with the buffer, however, should be kept as low as possible.

6. For AK relays, reduce the loads in Table IX-11A by 25 grams as the AK relay is adjusted on 60-gram back tension instead of 85 grams on which the loads in the table are figured.

USE OF TABLES

Example: Long travel relay 2PM, 3EB, 7M with 16-mil buffer

N = 2PM + 3EB + 7M = 12; from Table IX-11A, load = 234
M = 2PM + 7M = 9; from Table IX-11B, load = 28
Add with buffer* = 130
Total 392 grams

* Assuming desired release ampere turns requires 392 grams total.

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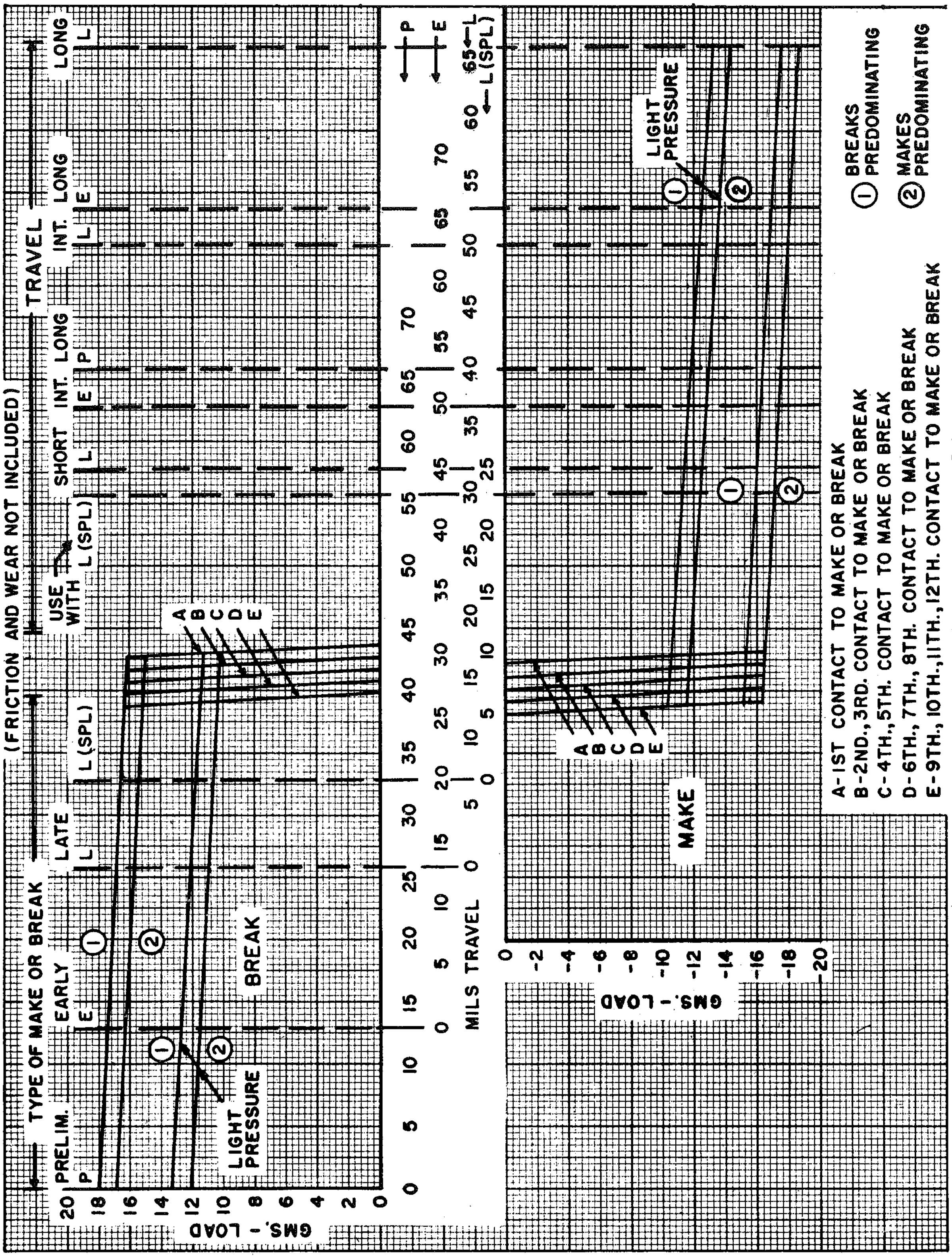

Part of Fig. IX-4

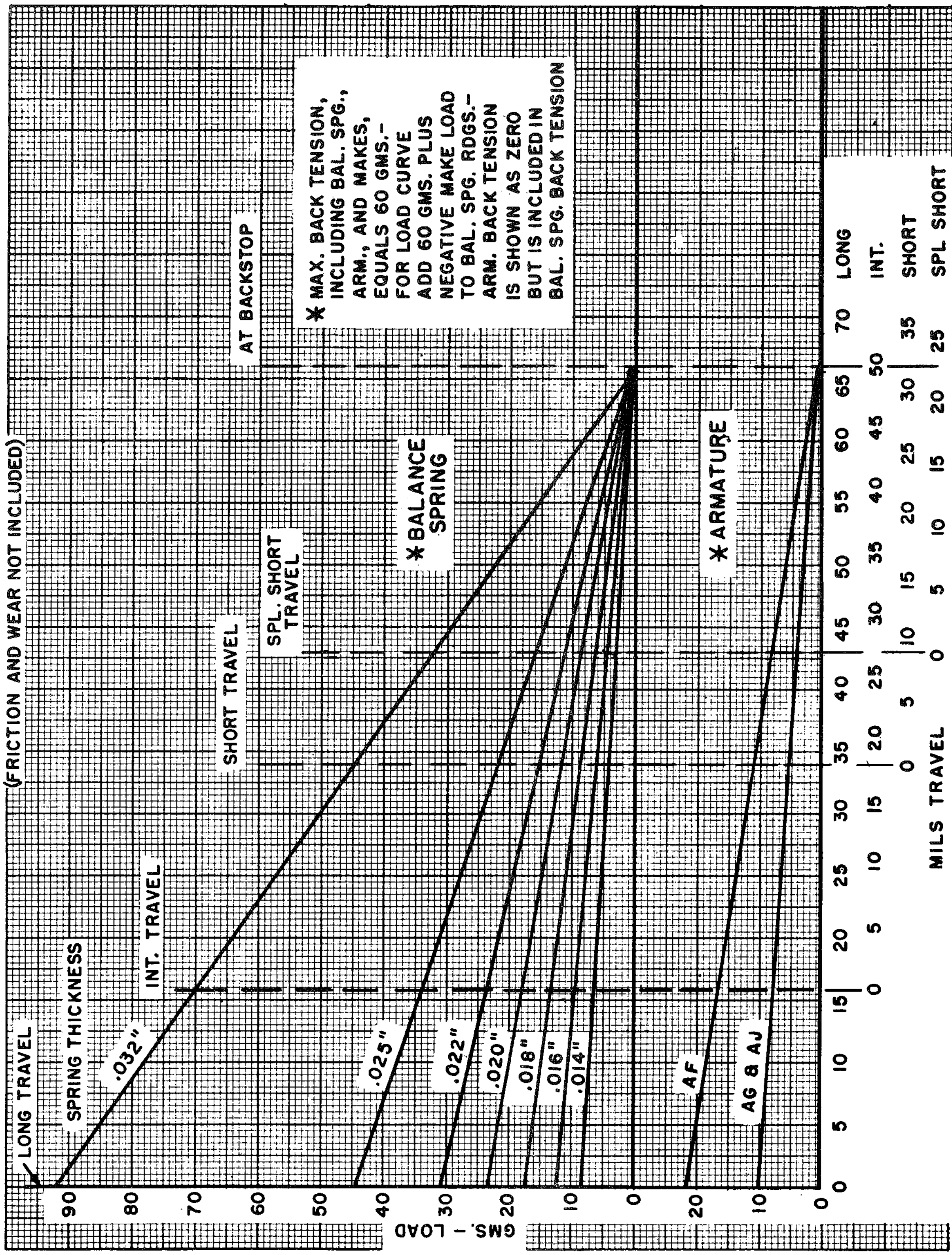

Fig. IX-4 - Maximum Load Buildup

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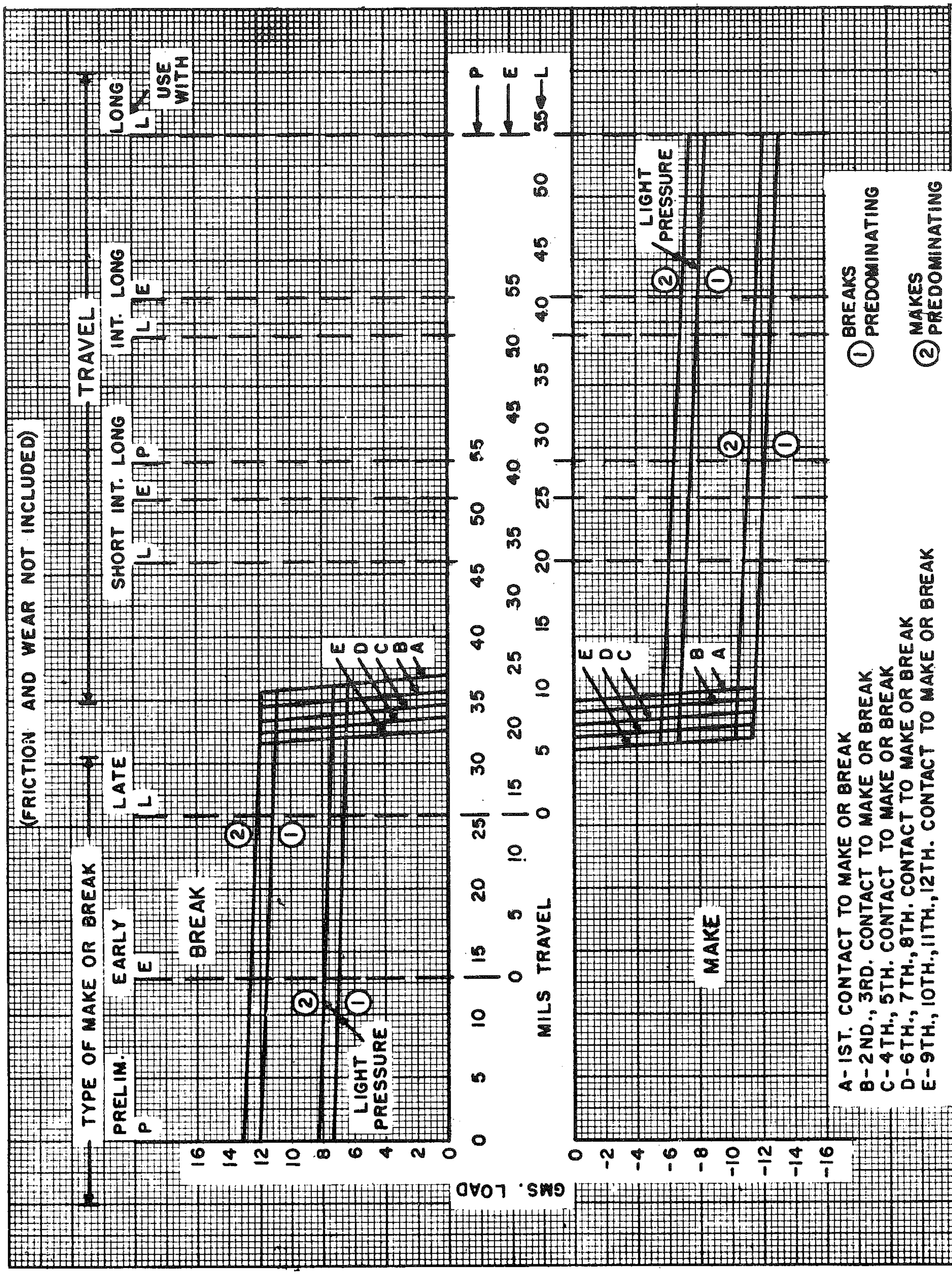

Part of Fig. IX-5

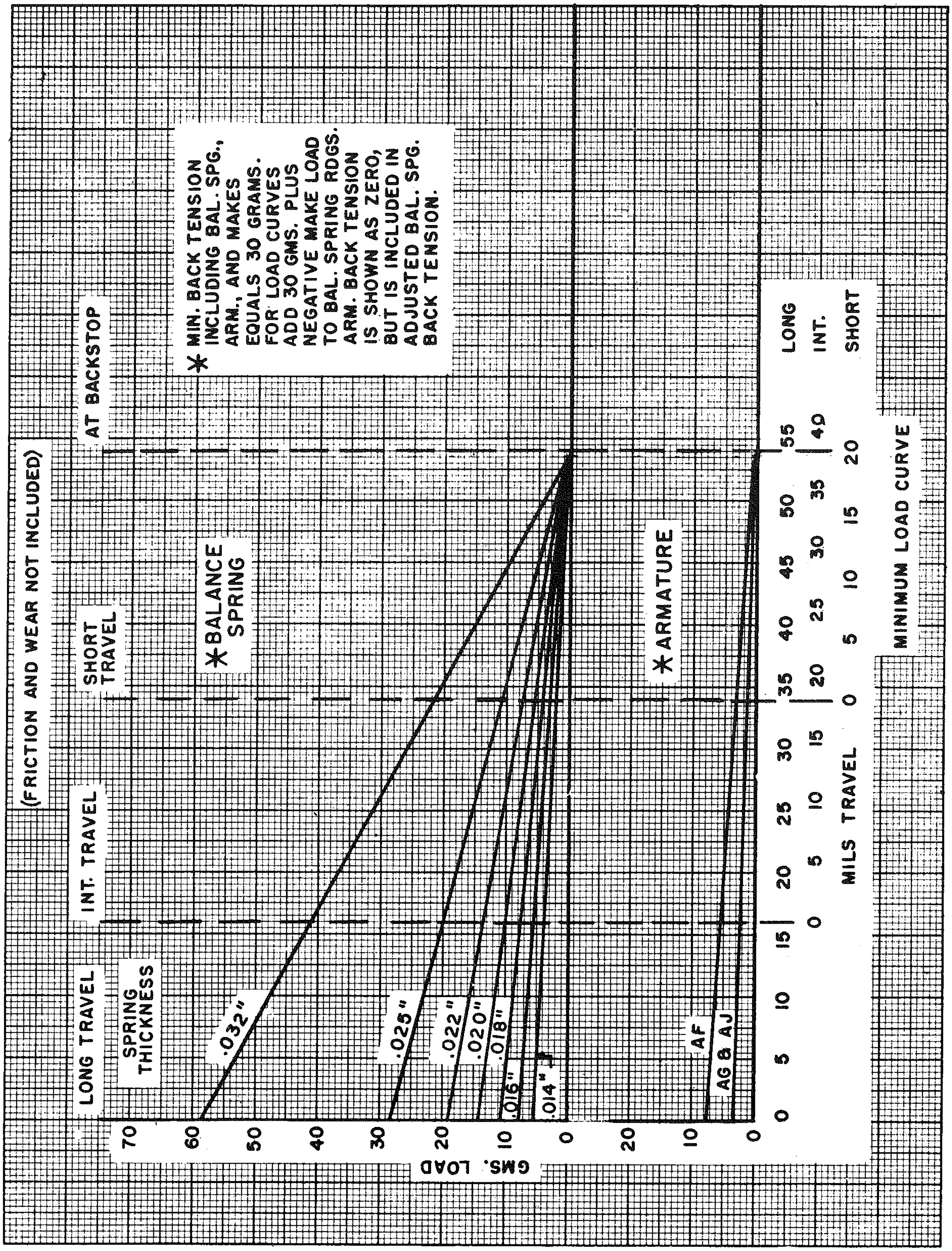

Fig. IX-5 - Minimum Load Buildup

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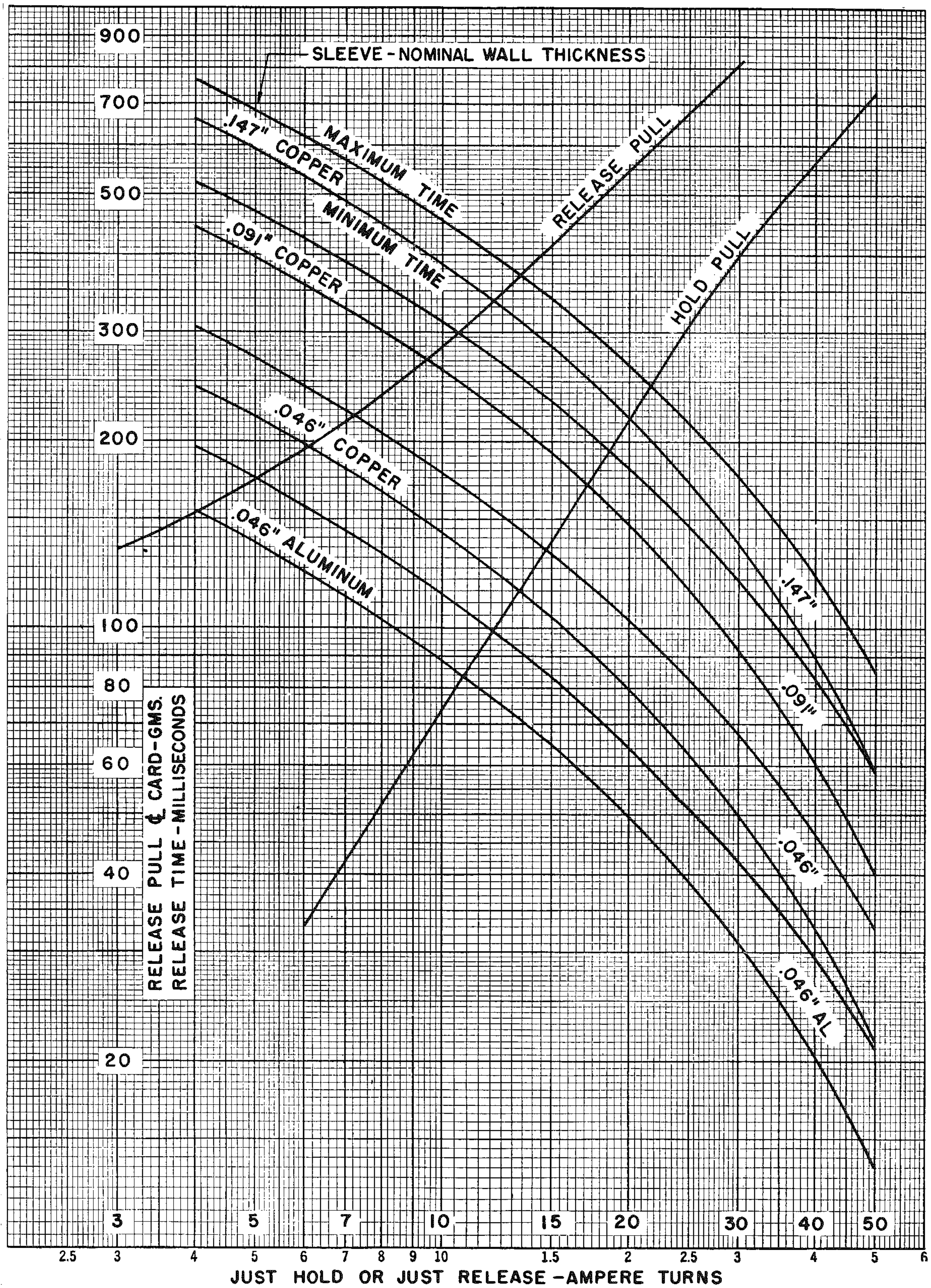

Fig. IX-6 - AG Relay - Hold and Release Ampere Turns and Time

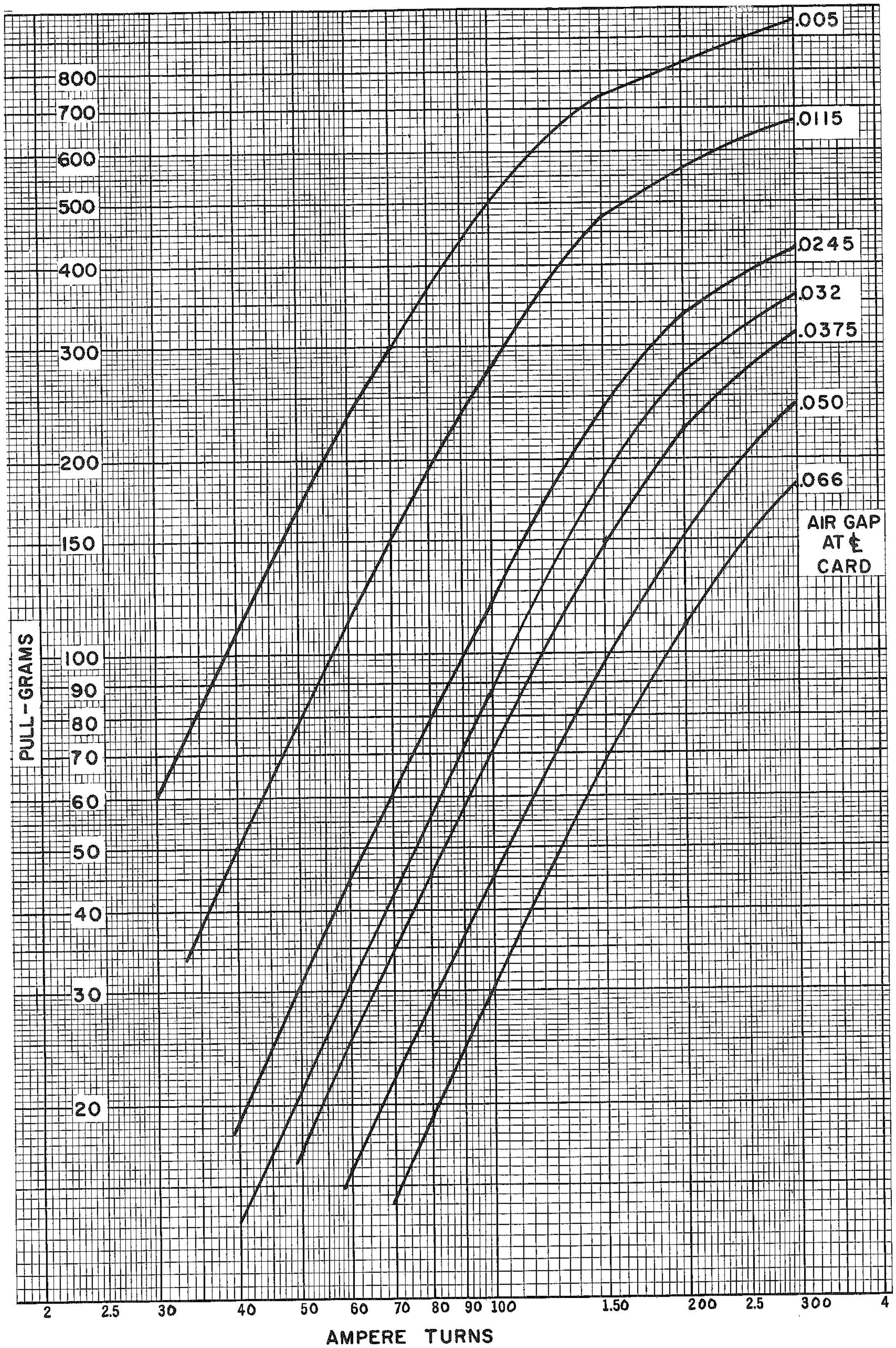

Fig. IX-7 - AG Relay - Operate

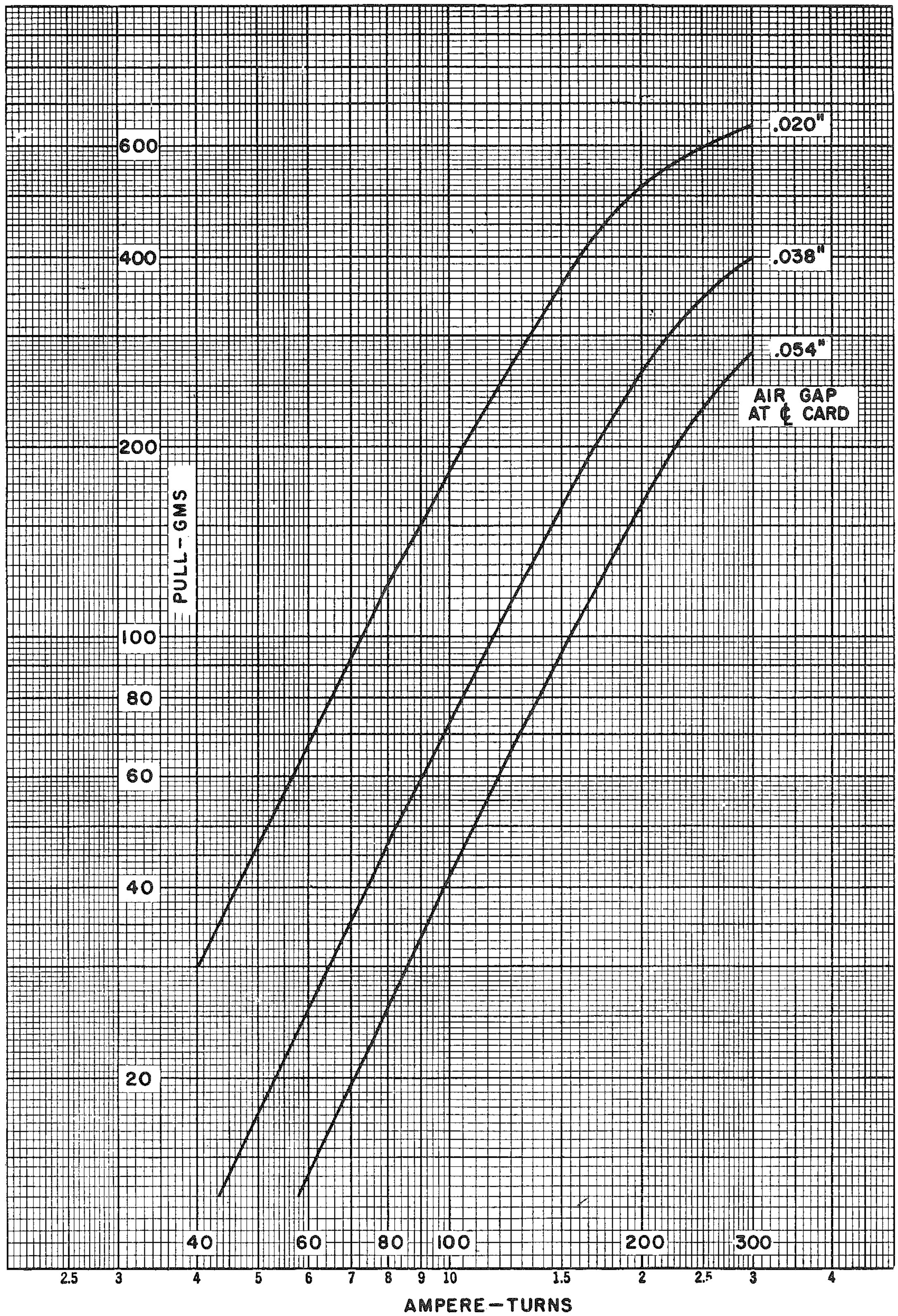

Fig. IX-8 - AG Relay - Nonoperate

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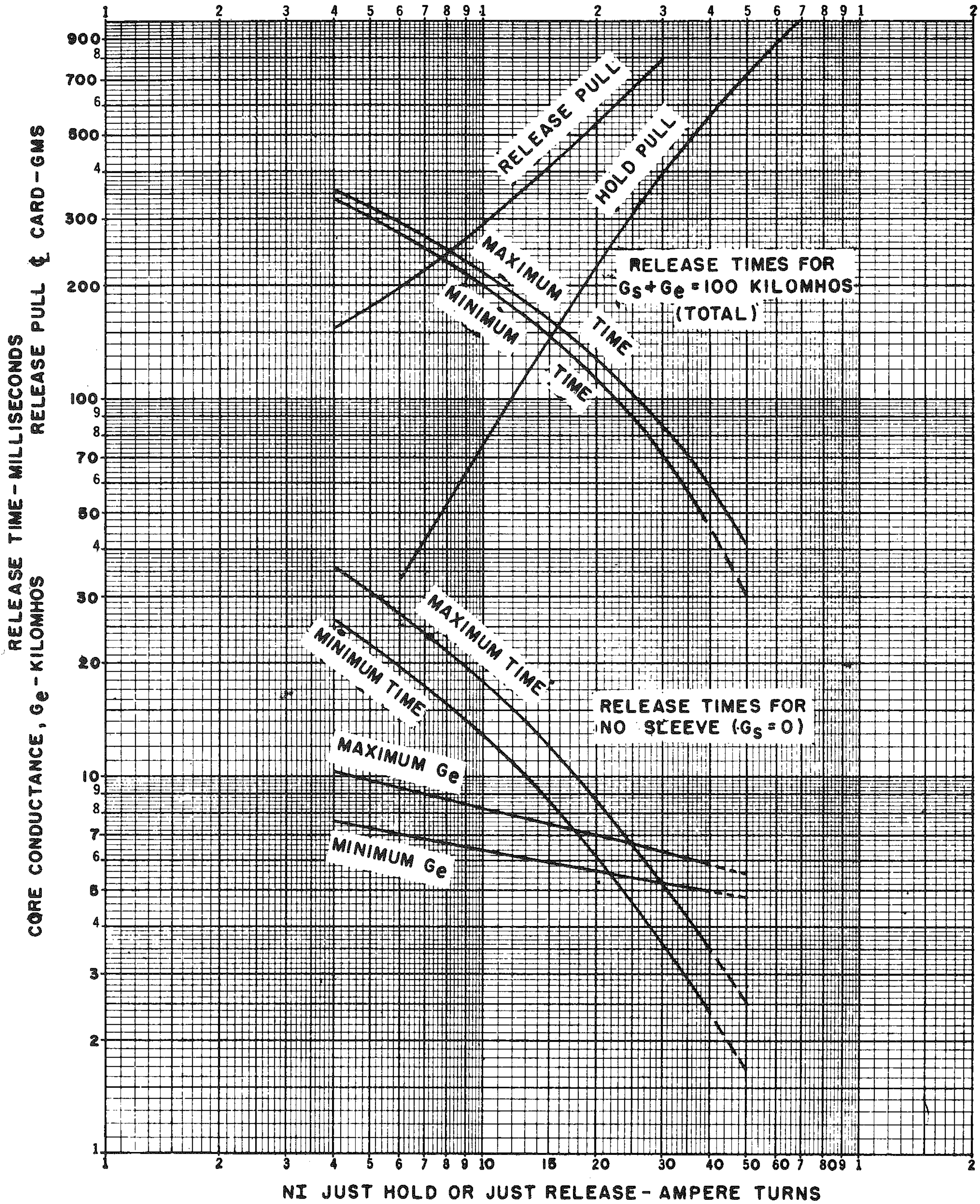

Fig. IX-9 - AG Relay - Release Times With Shunt

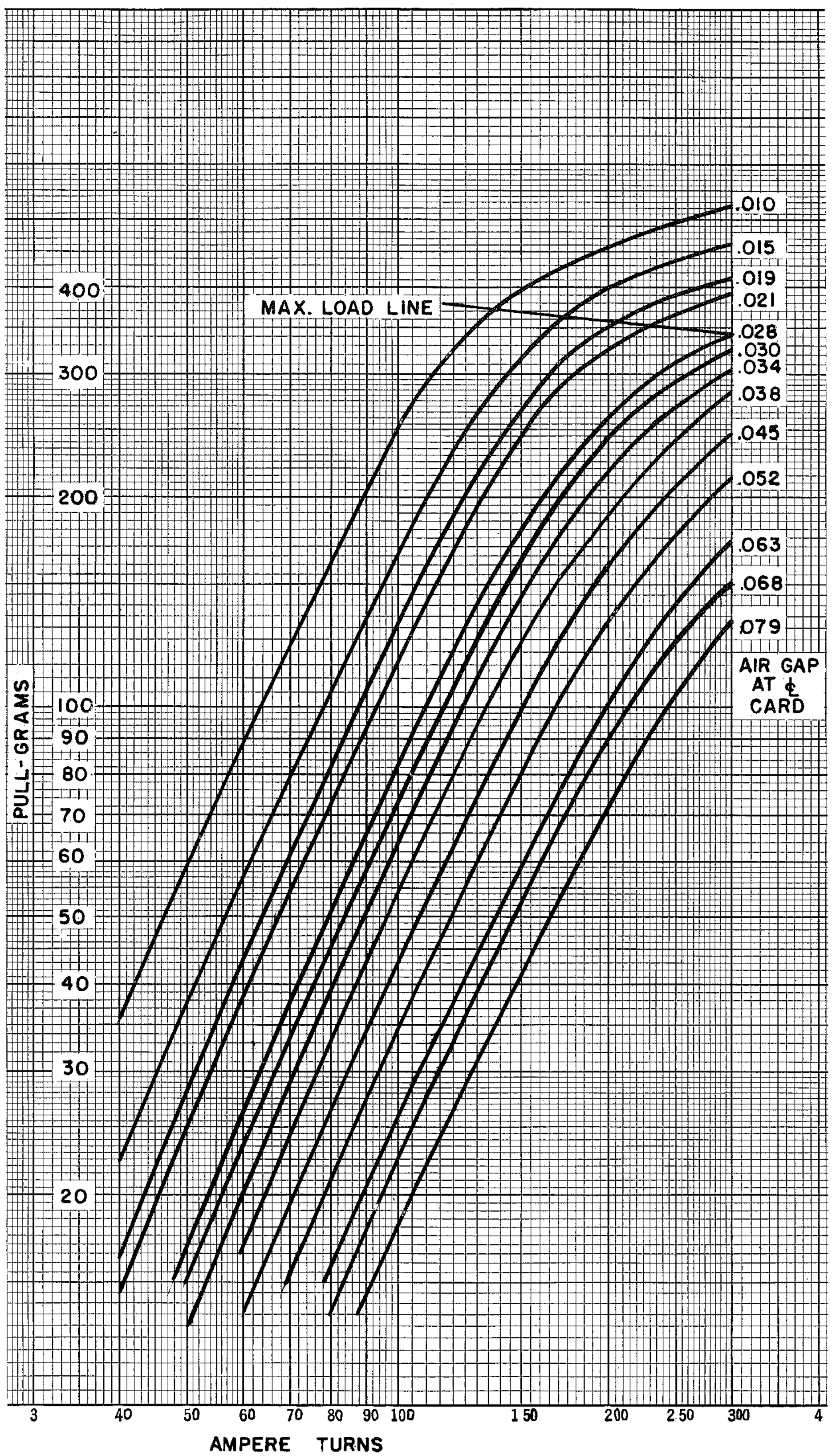

Fig. IX-10 - AF Relay - Operate

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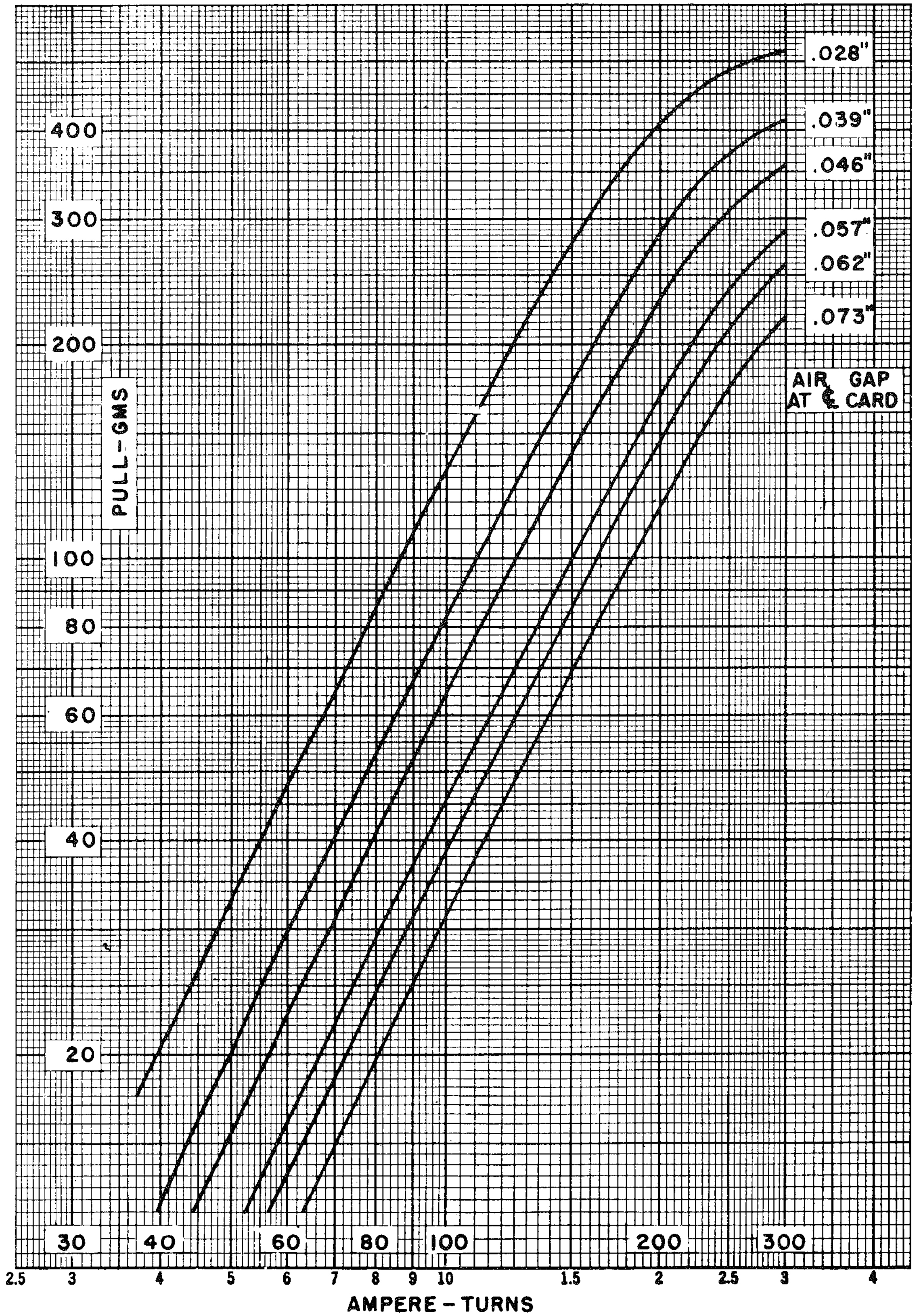

Fig. IX-11 - AF Relay - Nonoperate

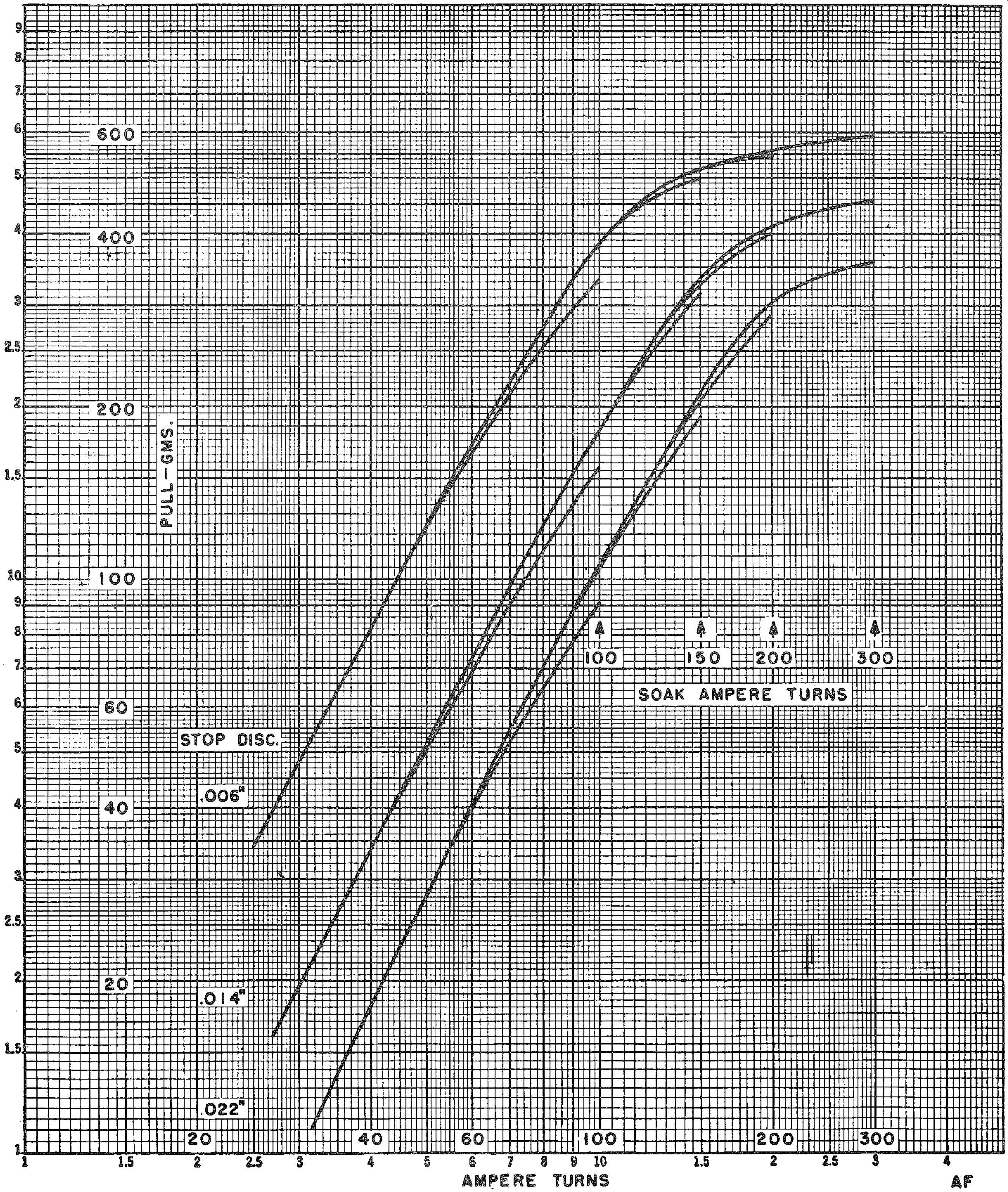

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Fig. IX-12 - AF Relay - Hold

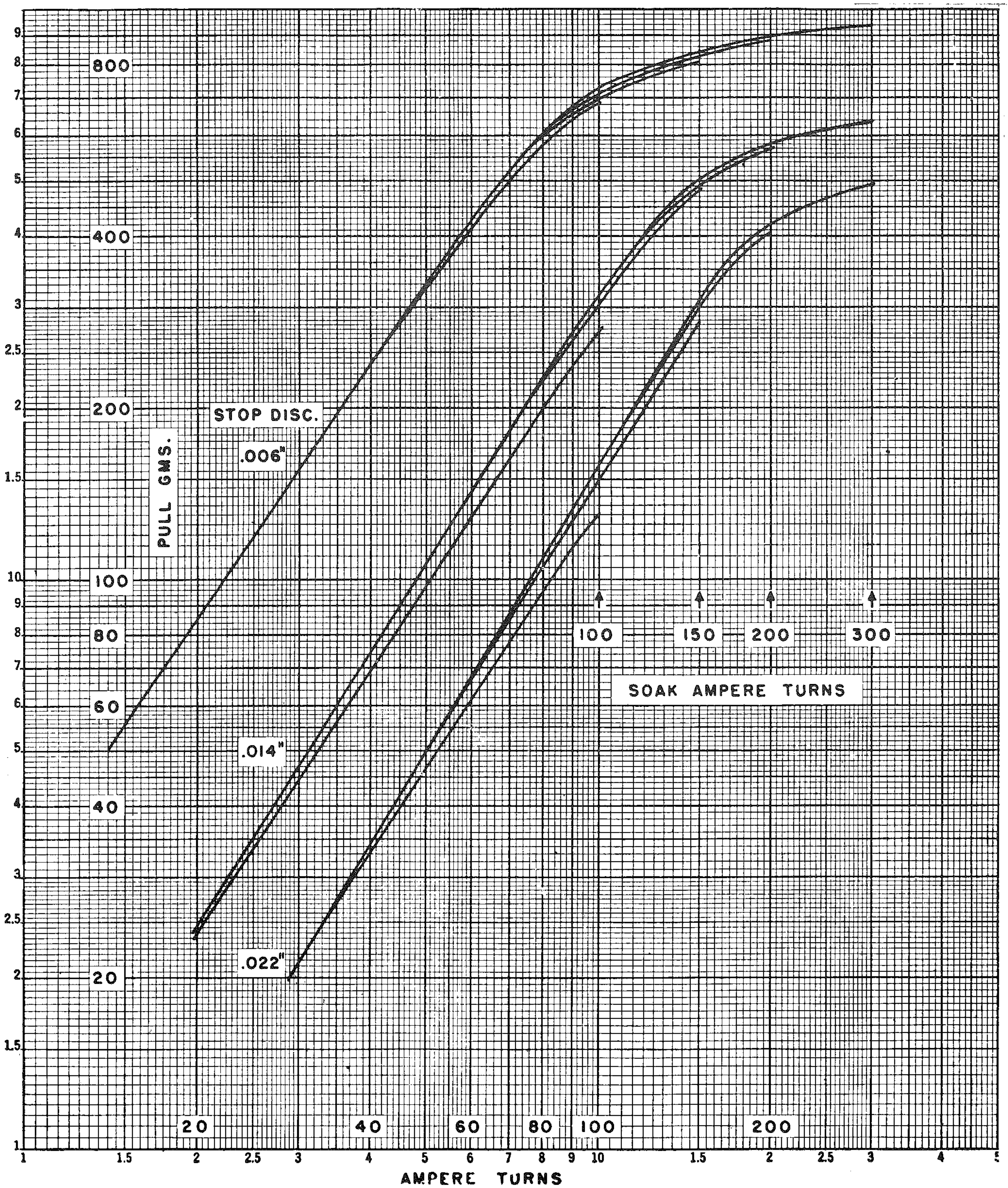

Fig. IX-13 - AF Relay - Release From Operated Position

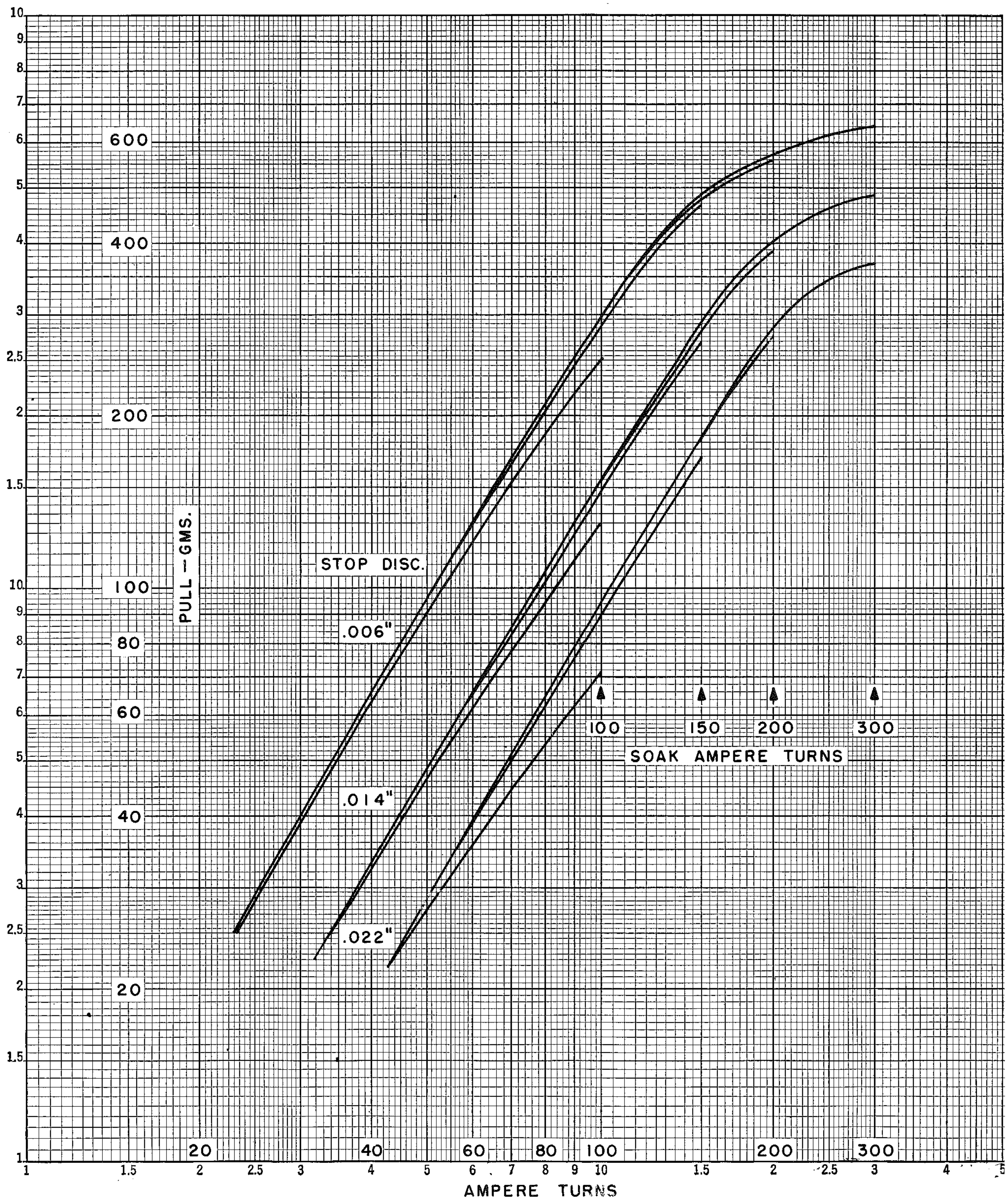

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Fig. IX-14 - AF Relay - Release From Pickup Position

X-75509

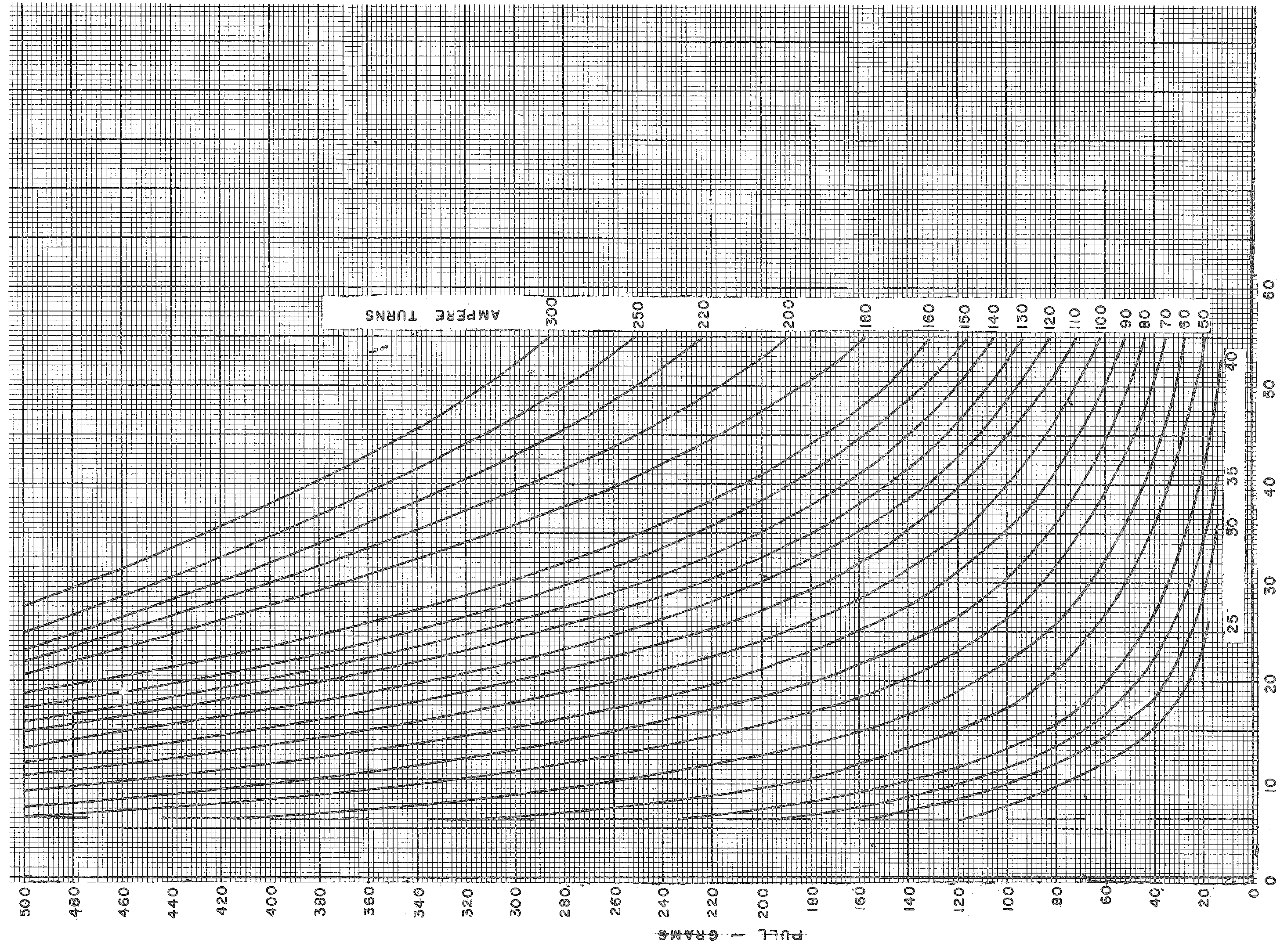

Fig. IX-15 - AF Relay - Release With Special Gauging

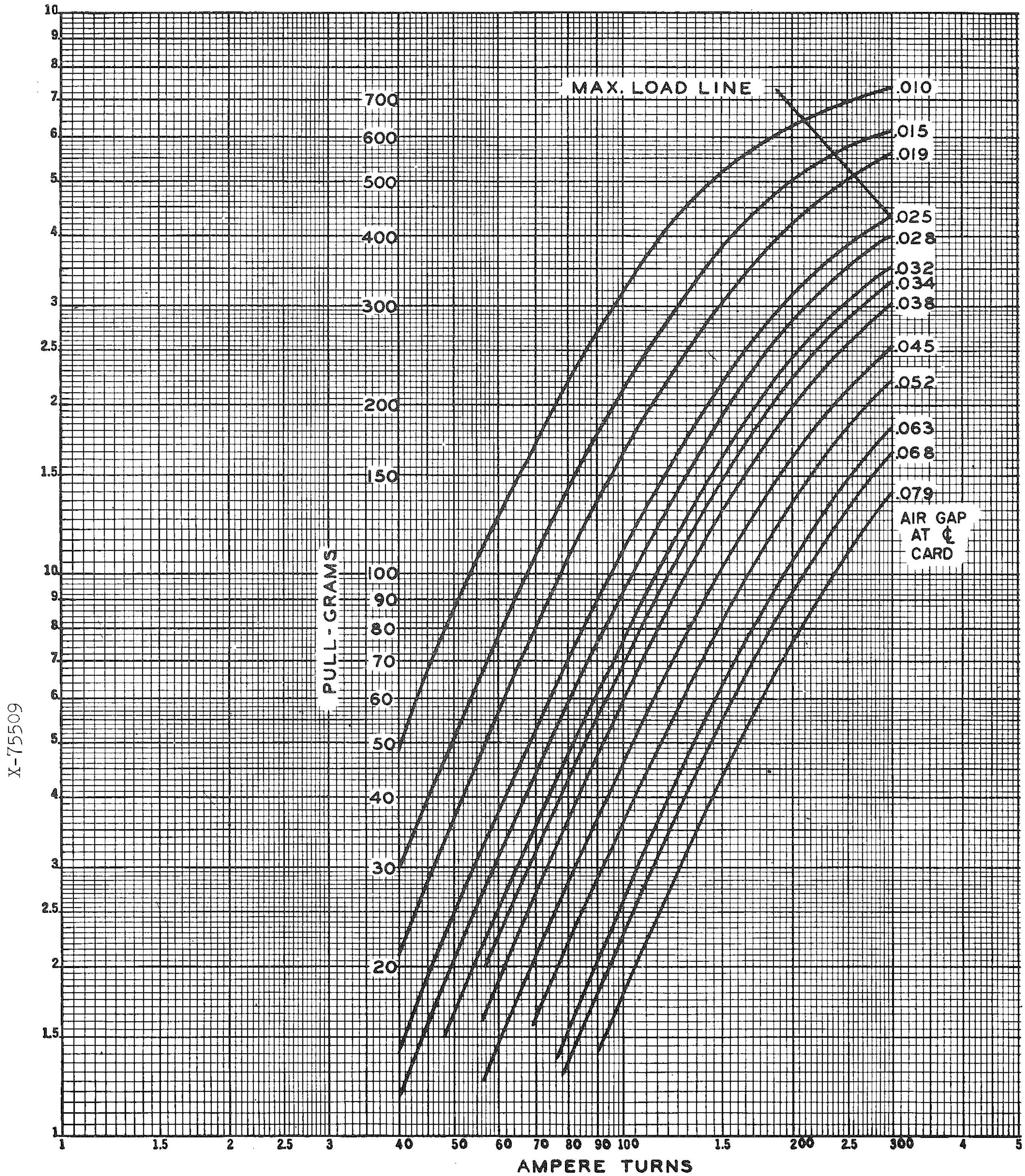

Fig. IX-16 - AJ Relay - Operate

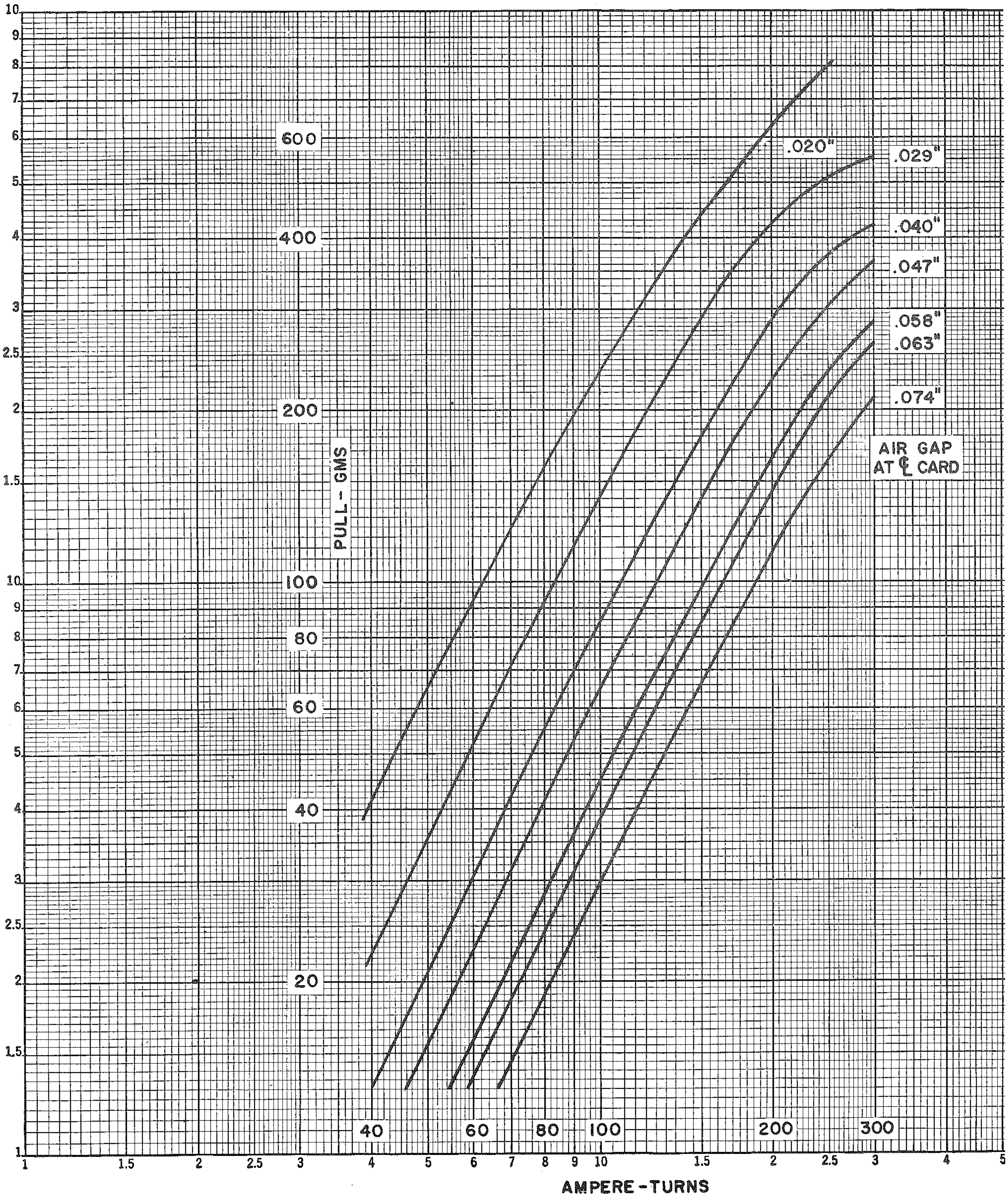

Fig. IX-17 - AJ Relay - Nonoperate

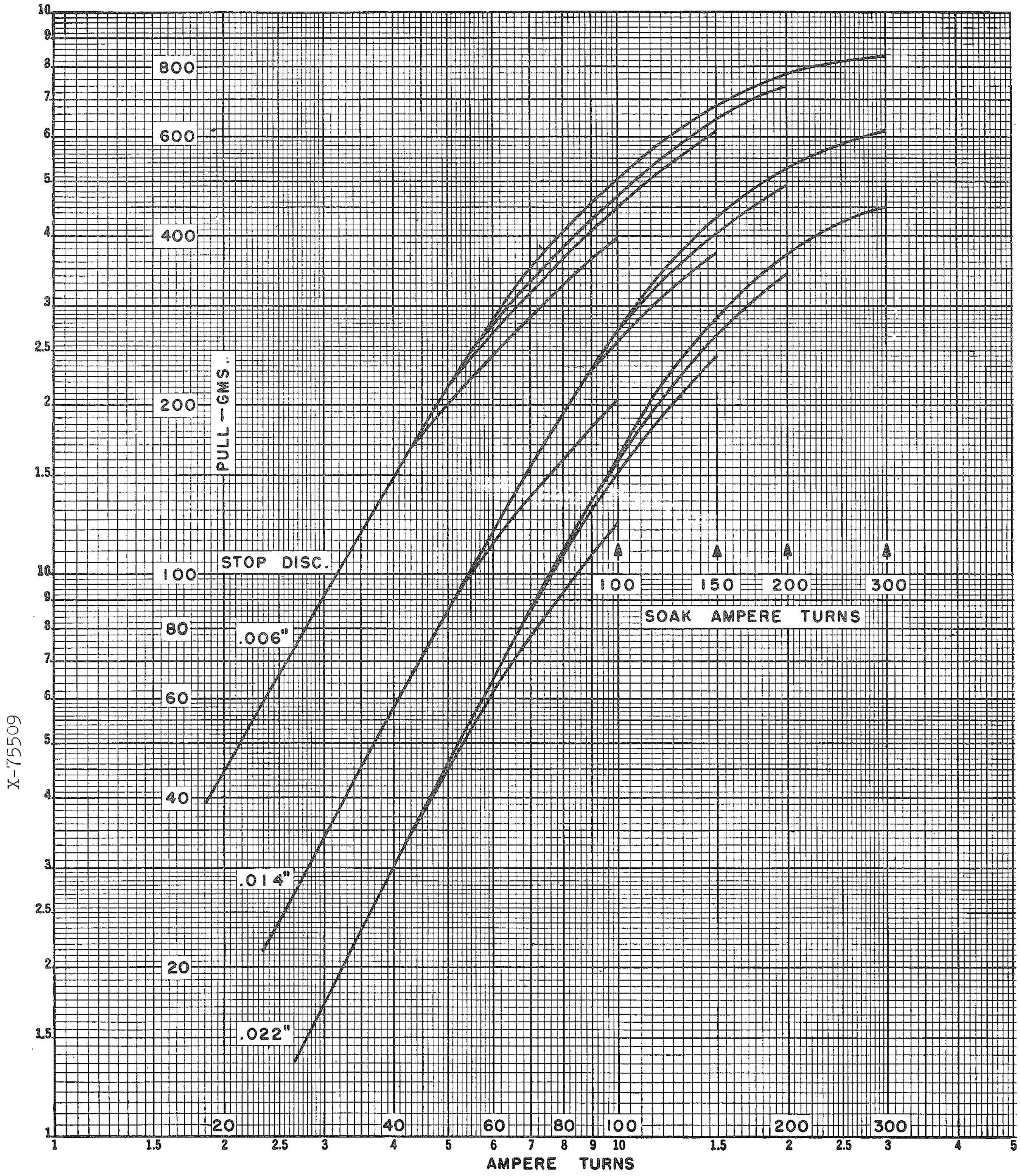

Fig. IX-18 - AJ Relay - Hold

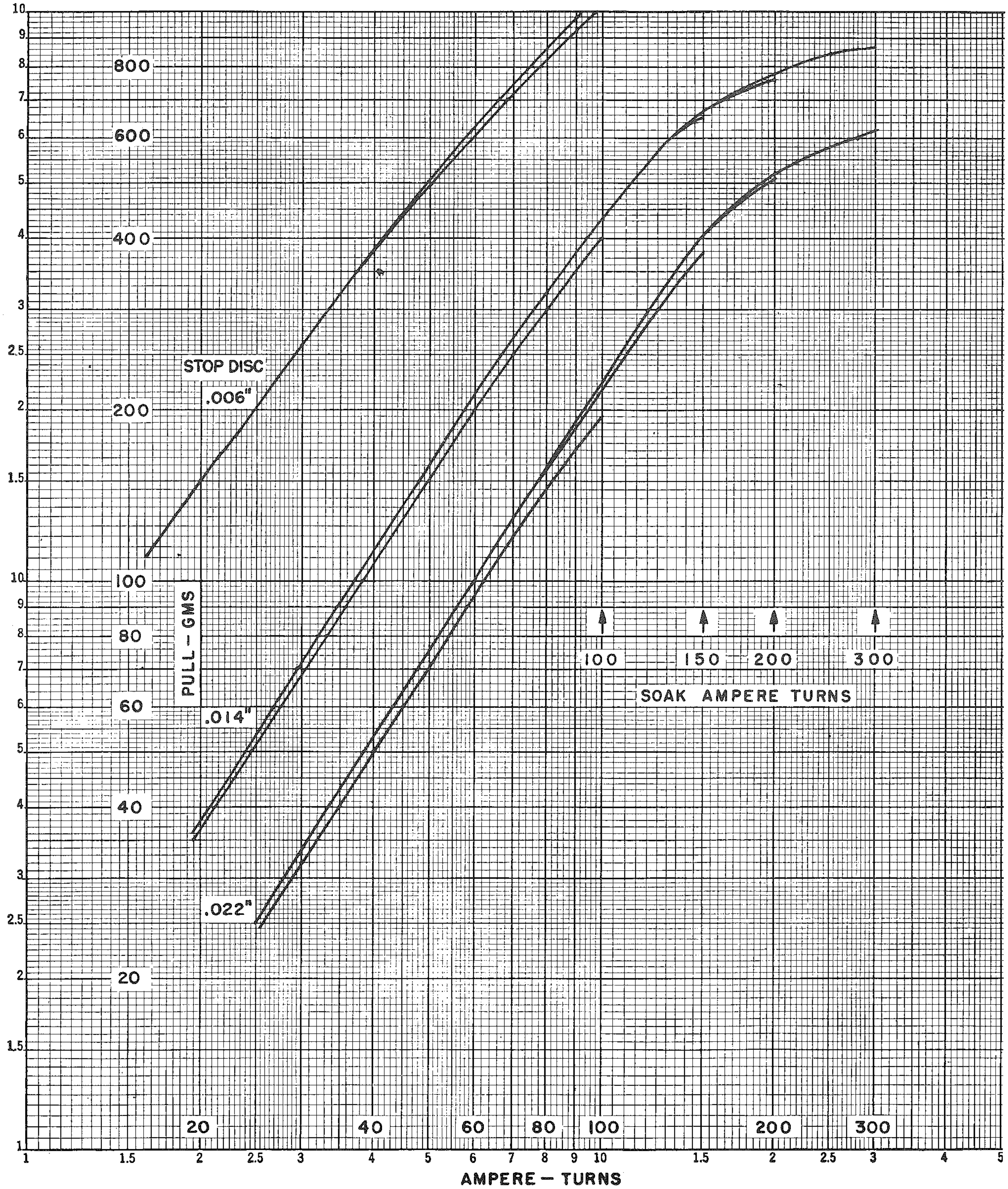

Fig. IX-19 - AJ Relay - Release From Operated Position

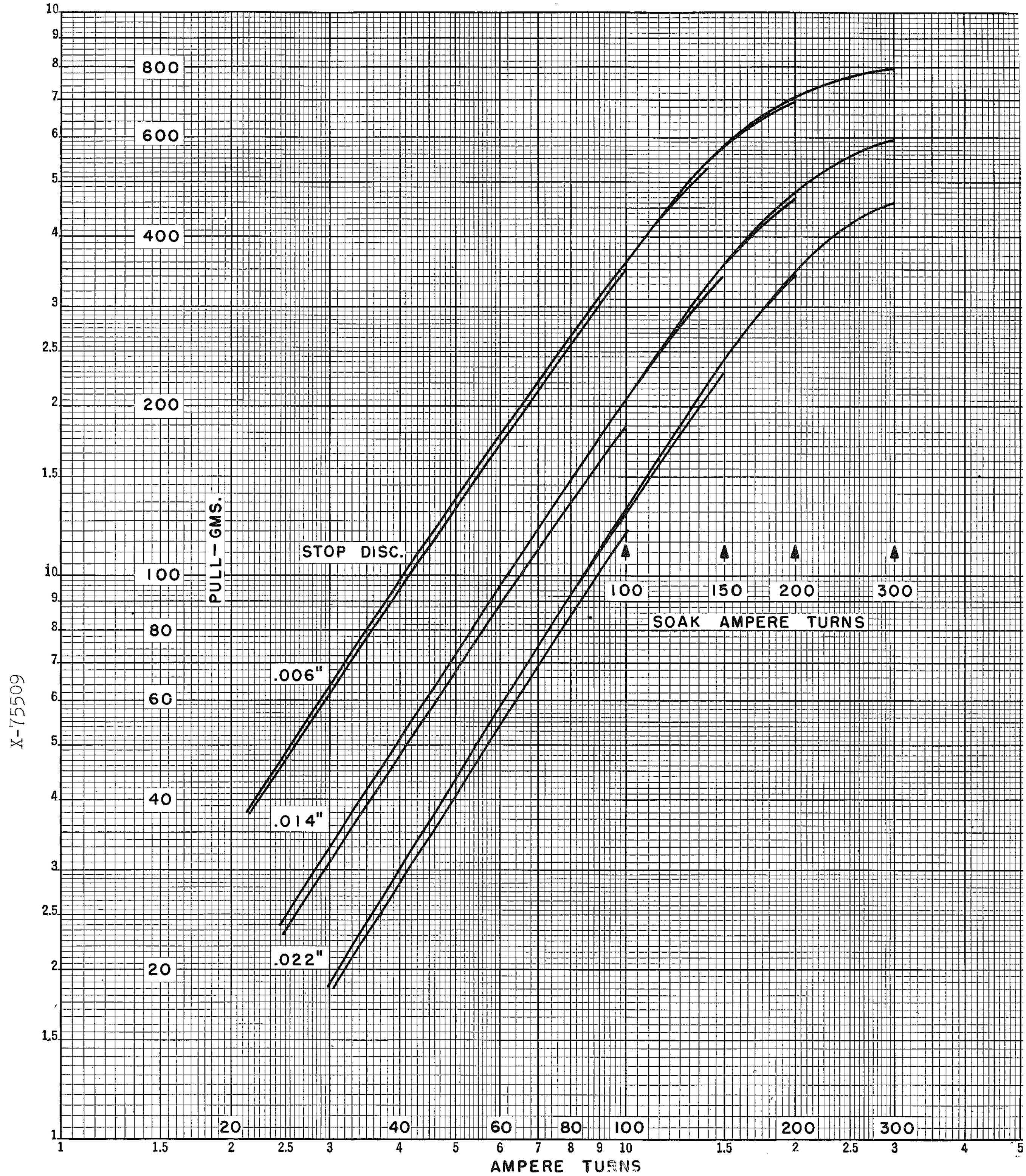

Fig. IX-20 - AJ Relay - Release From Pickup Position

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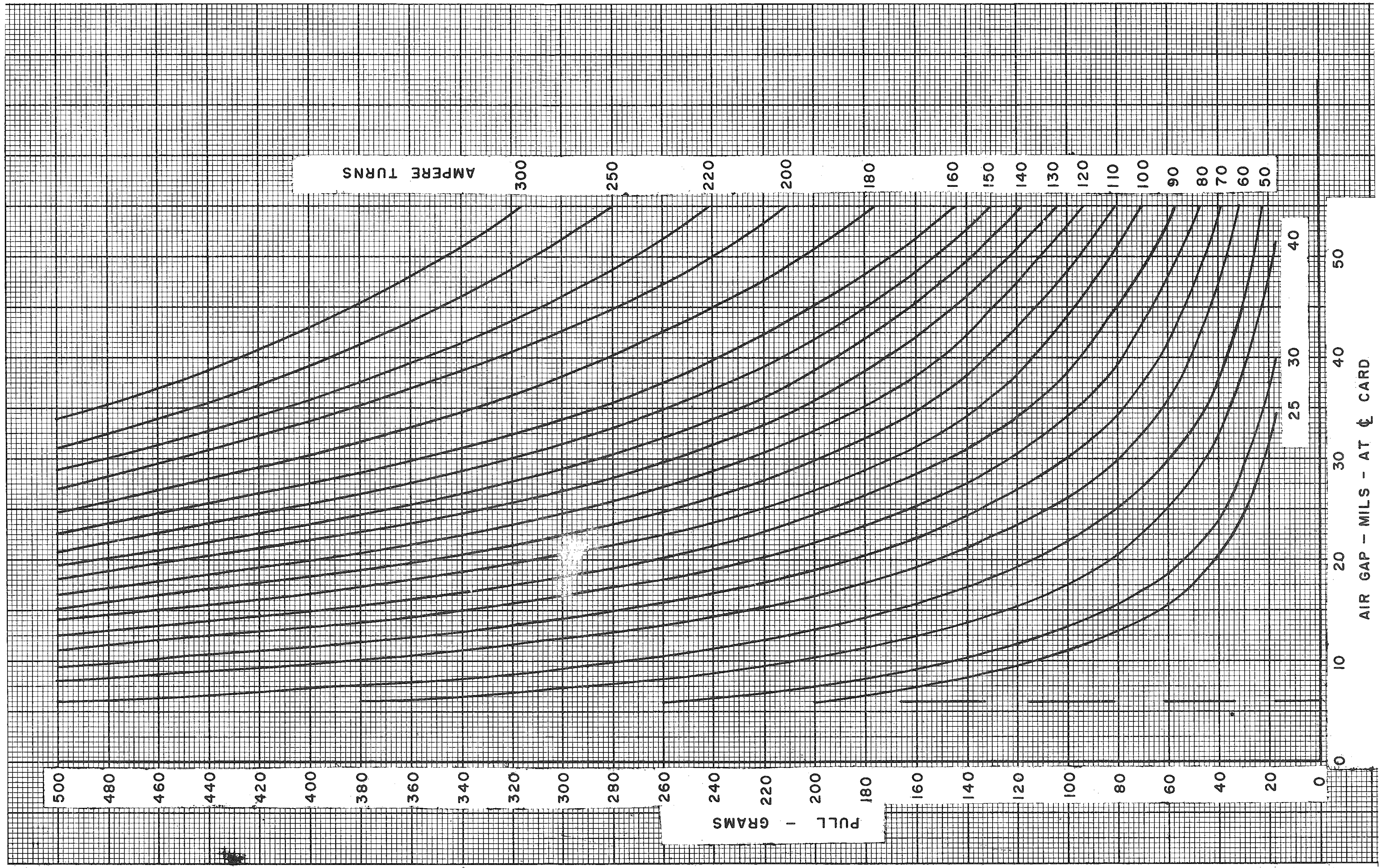

Fig. IX-21 - AJ Relay - Release With Special Gauging

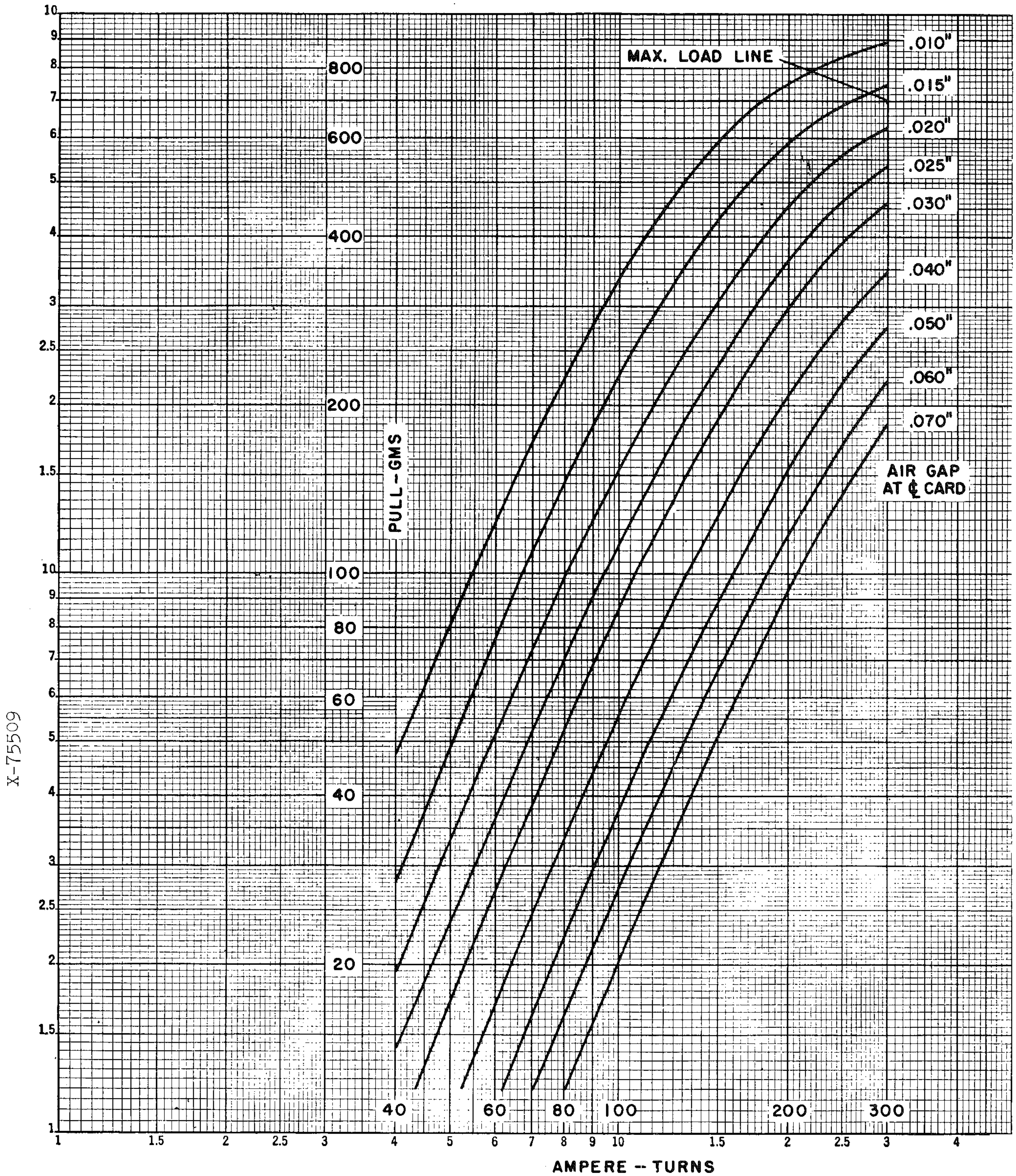

Fig. IX-22 - AJ Relay With Laminations - Operate

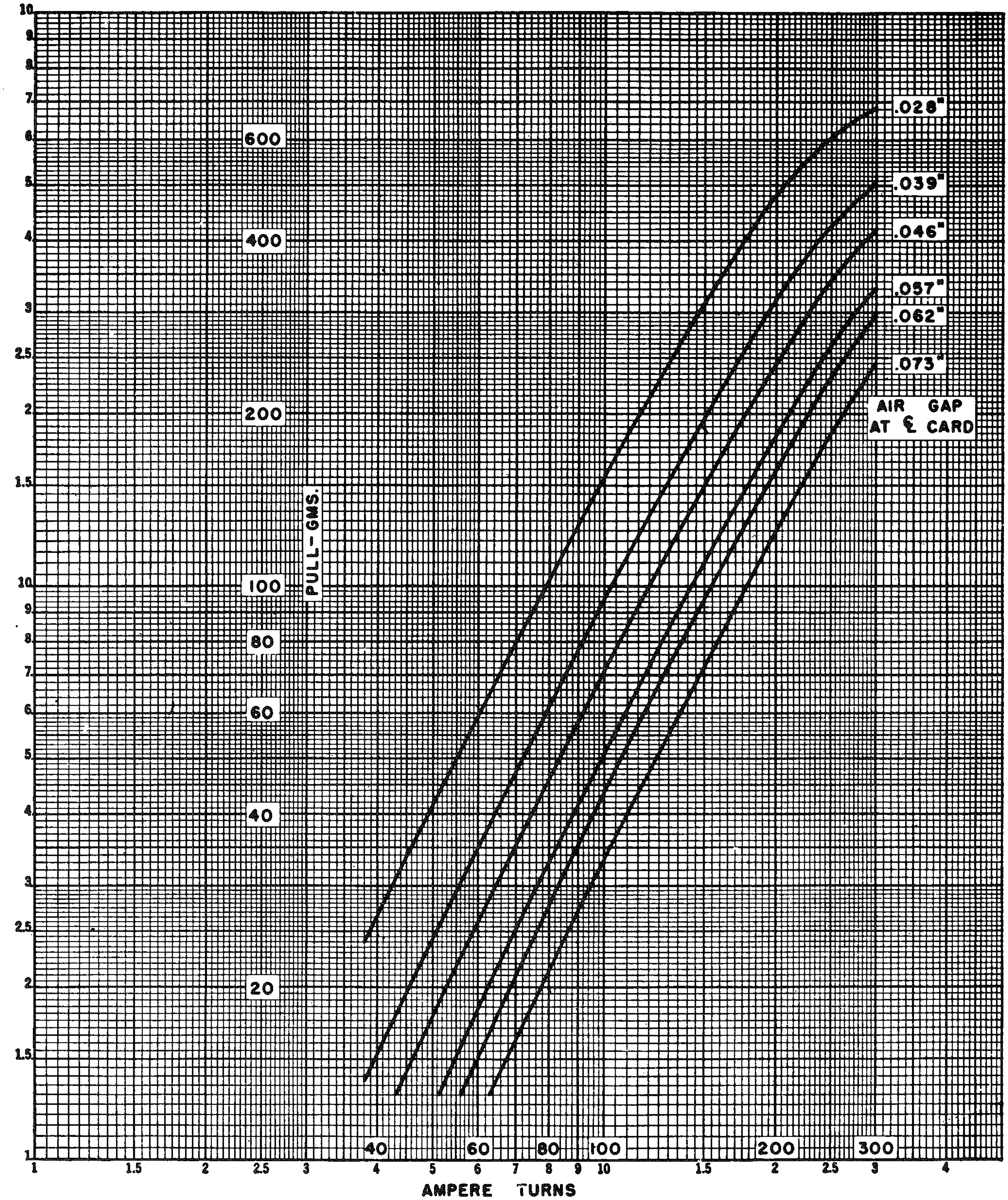

Fig. IX-23 - AJ Relay With Laminations - Nonoperate

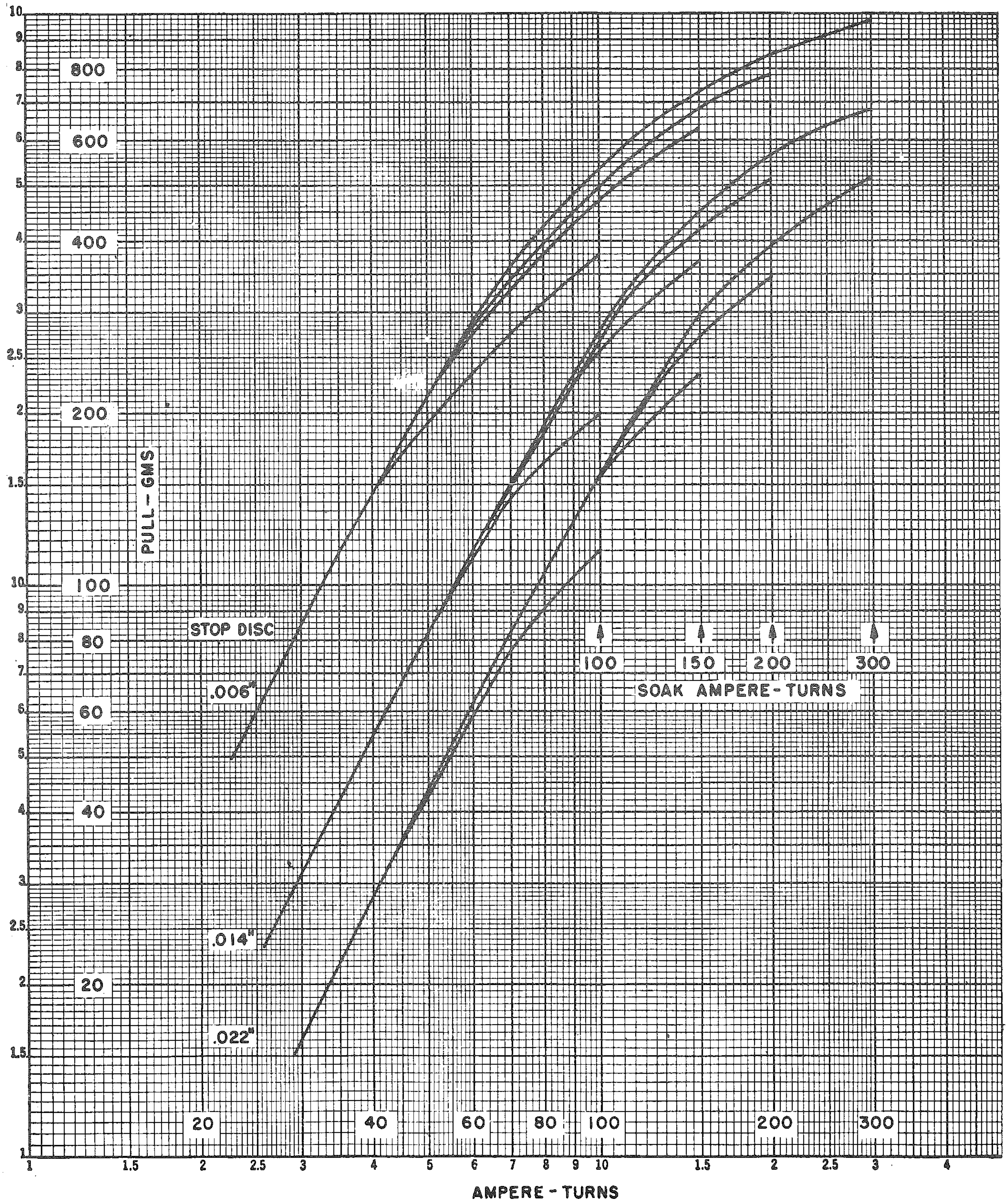

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Fig. IX-24 - AJ Relay With Laminations - Hold

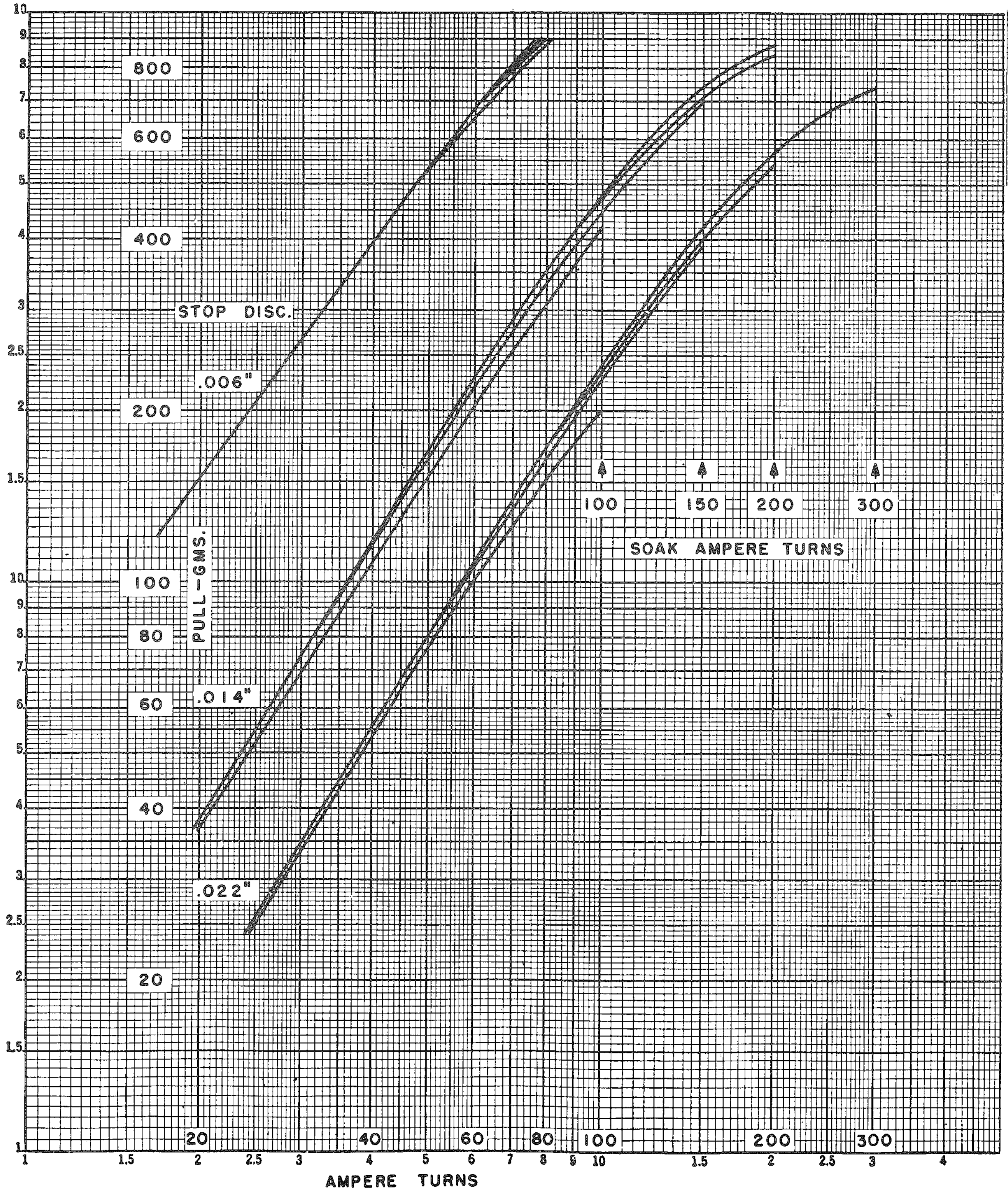

Fig. IX-25 - AJ Relay With Laminations - Release From Operated Position

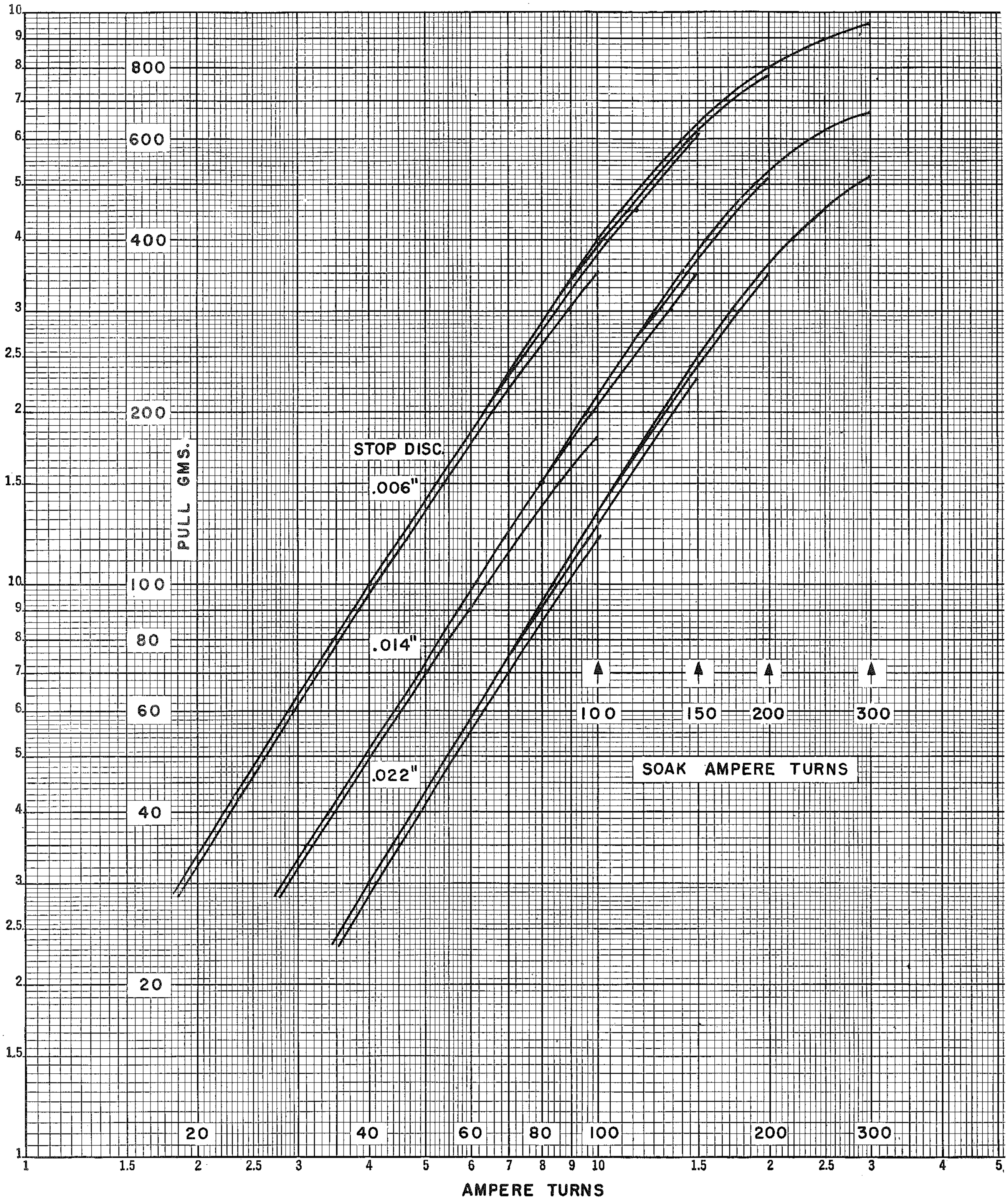

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Fig. IX-26 - AJ Relay With Laminations - Release
From Pickup Position

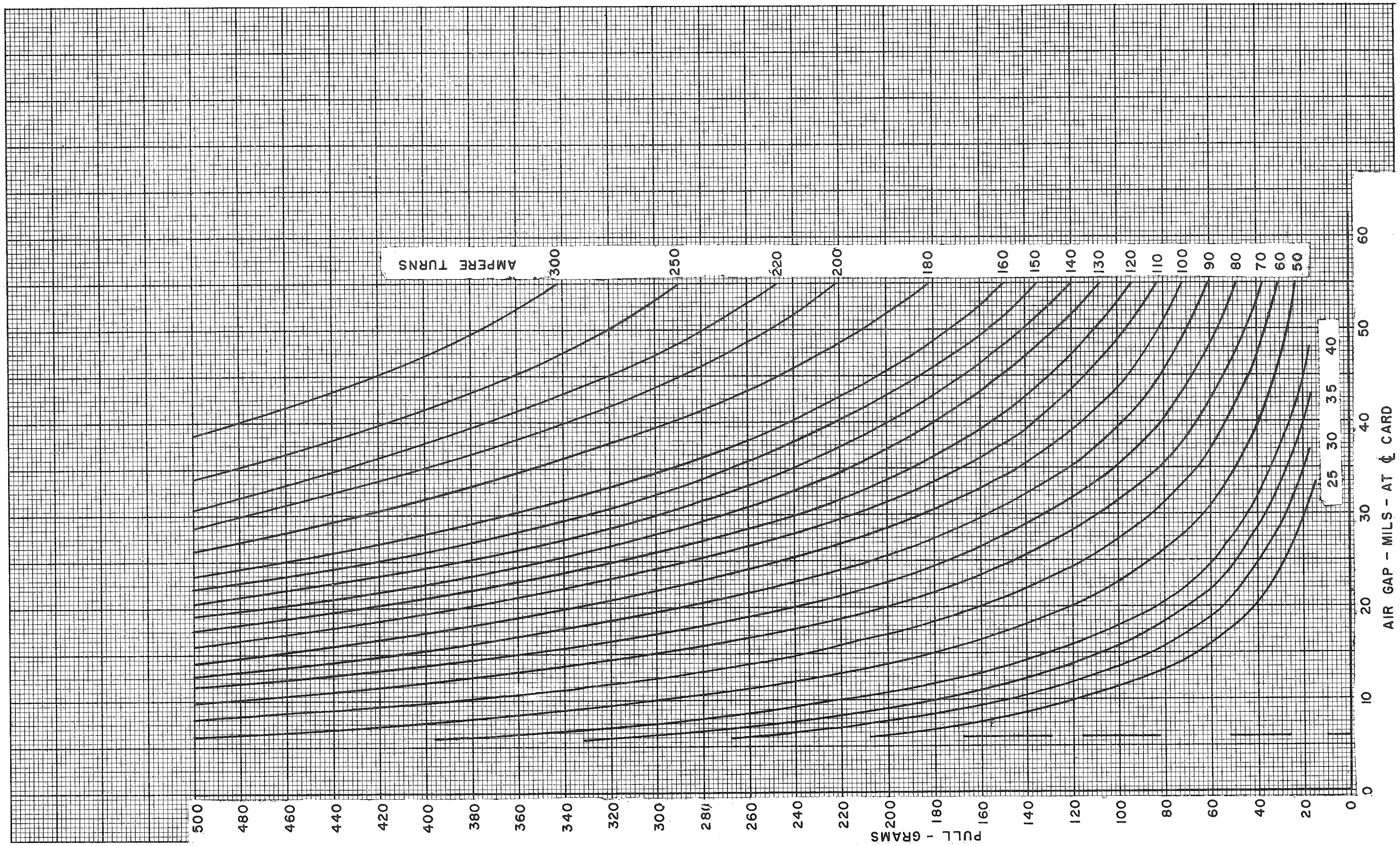

Fig. IX-27 - AJ Relay With Laminations - Release With Special Gauging

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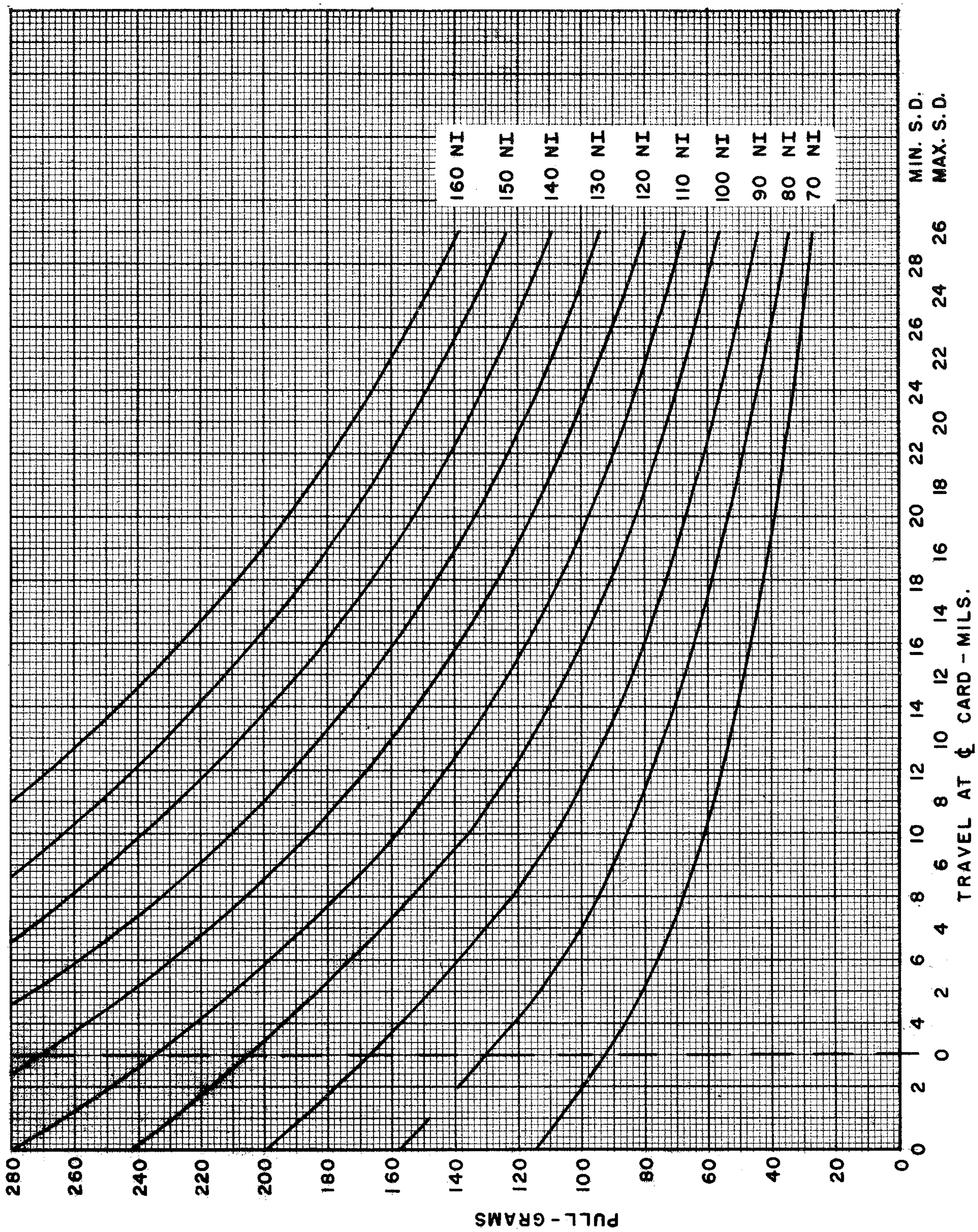

Fig. IX-28 - AJ Relay - With or Without Laminations 0.014-Inch Stop Discs - Marginal Operate Data

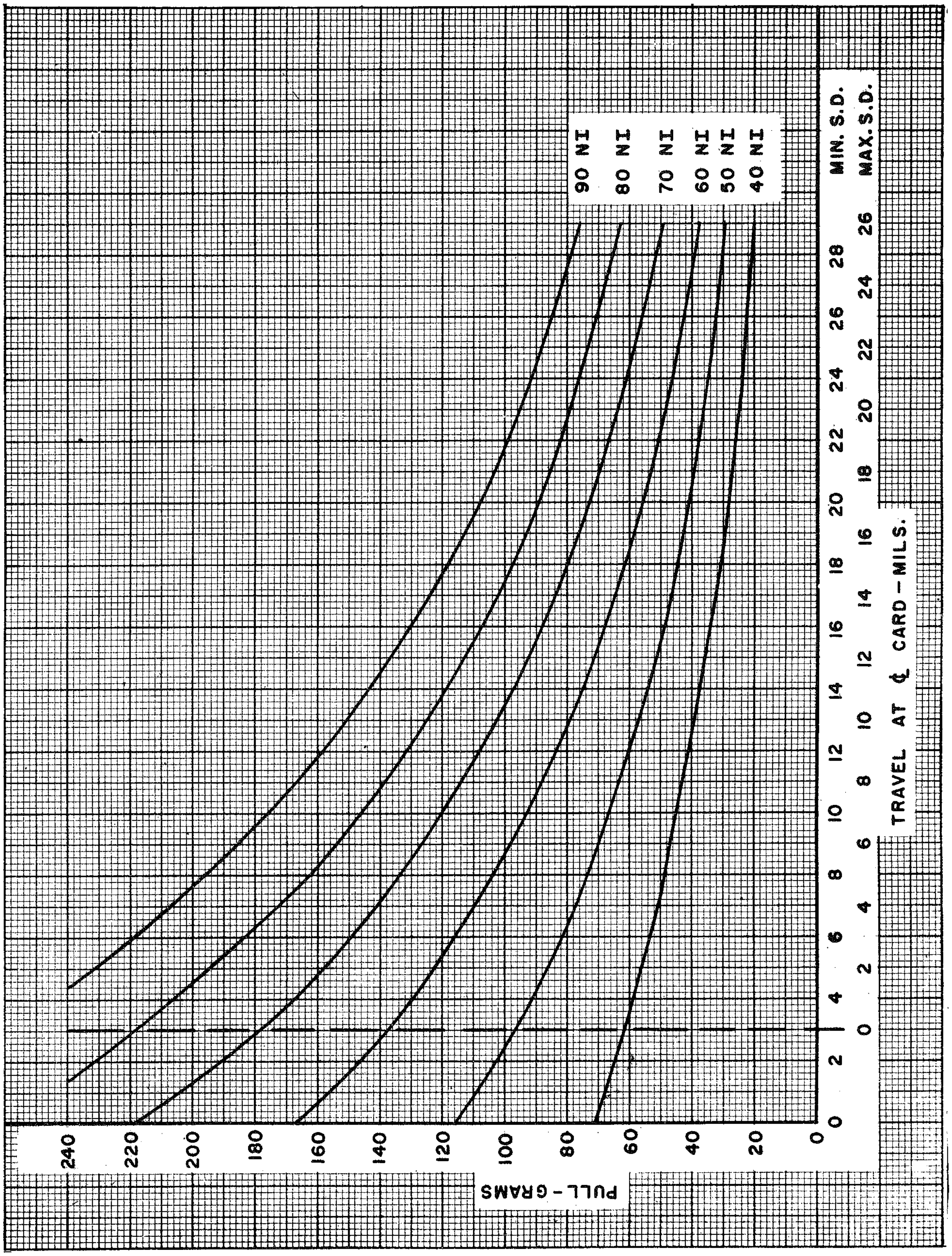

Fig. IX-29 - AJ Relay - With or Without Laminations 0.014-Inch Stop Discs - Marginal Release Data

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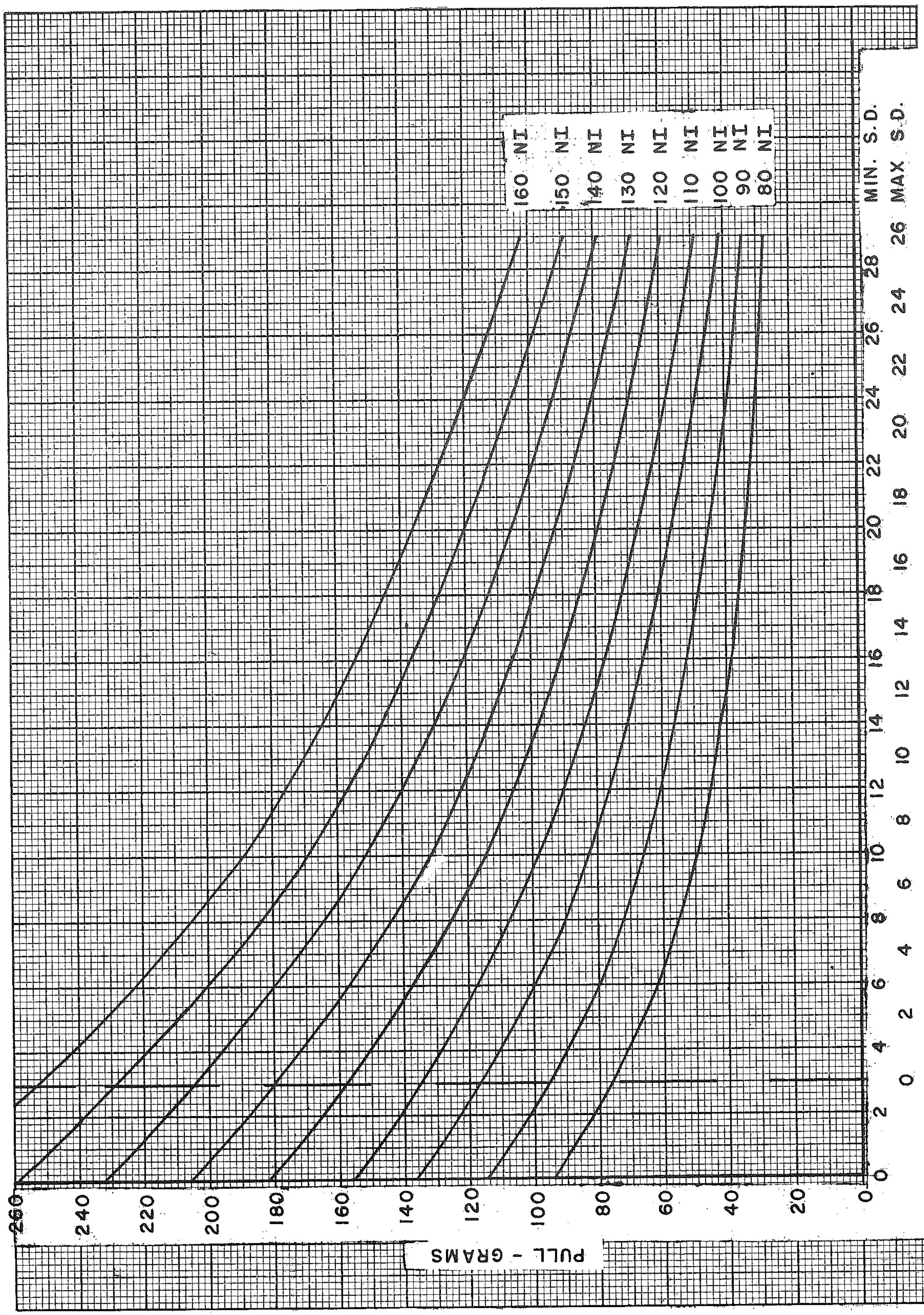

Fig. IX-30 - AJ Relay - With or Without Laminations
0.022-Inch Stop Discs - Marginal Operate Data

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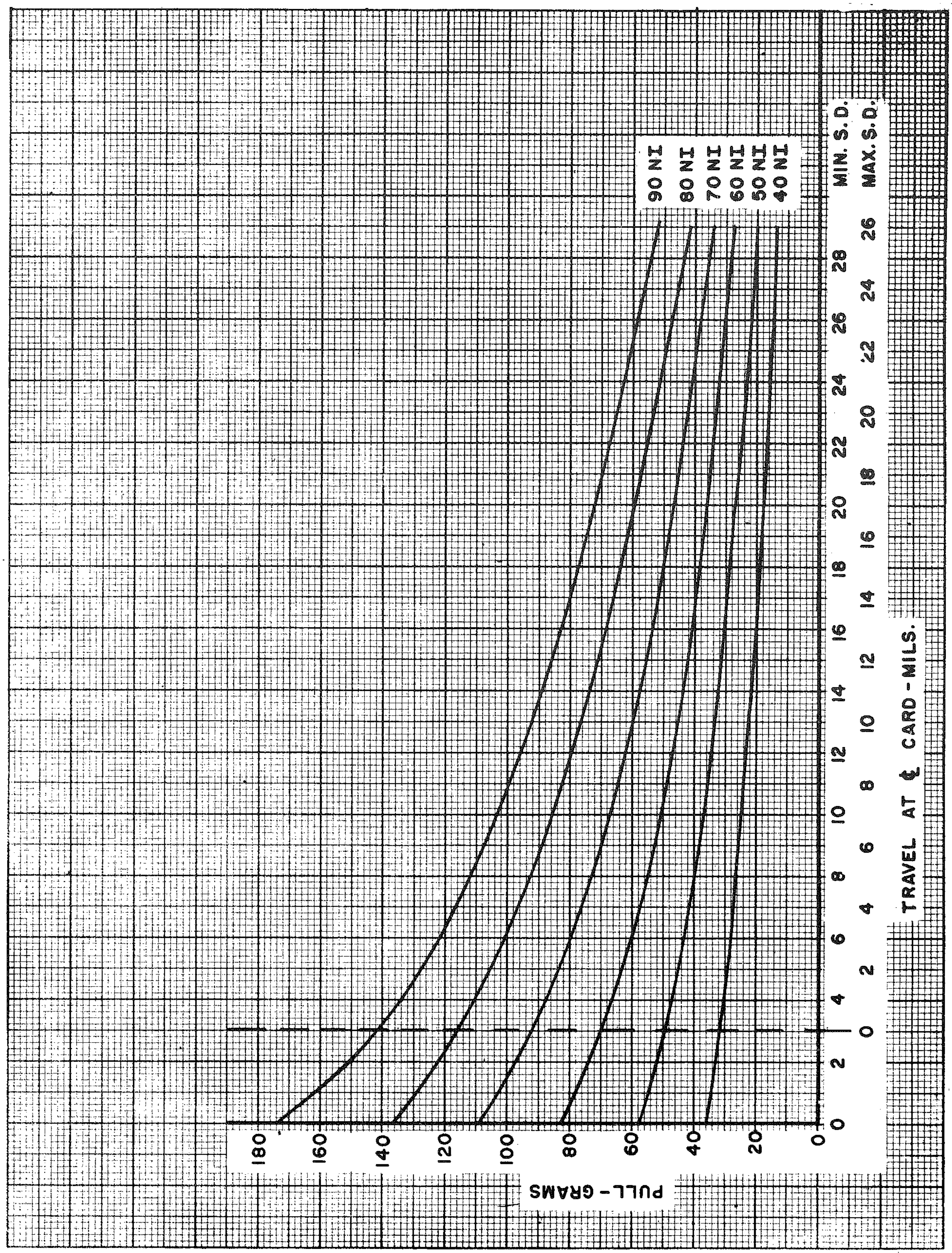

Fig. IX-31 - AJ Relay - With or Without Laminations 0.022-Inch Stop Discs - Marginal Release Data

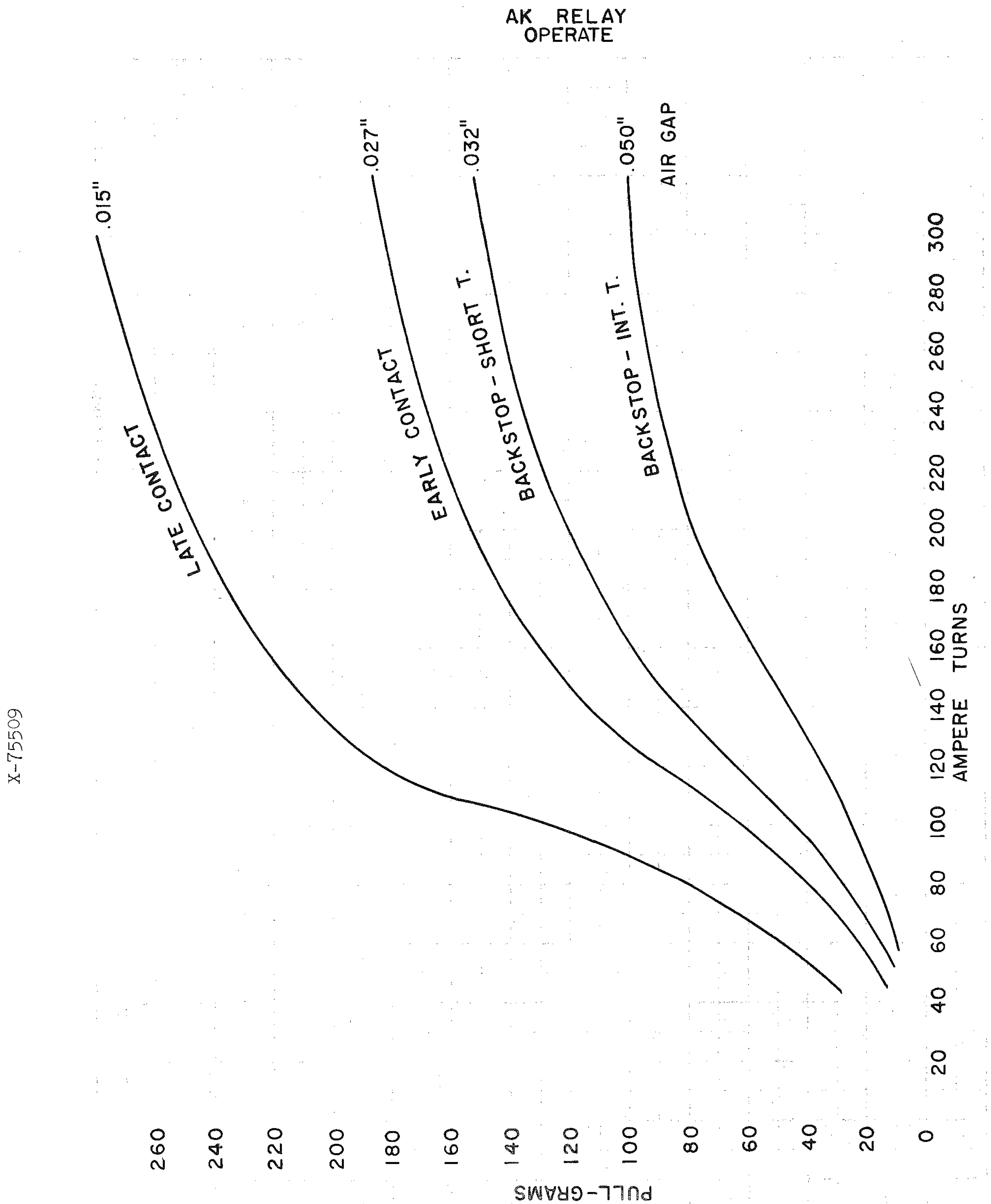

Fig. IX-32 - AK Relay - Operate

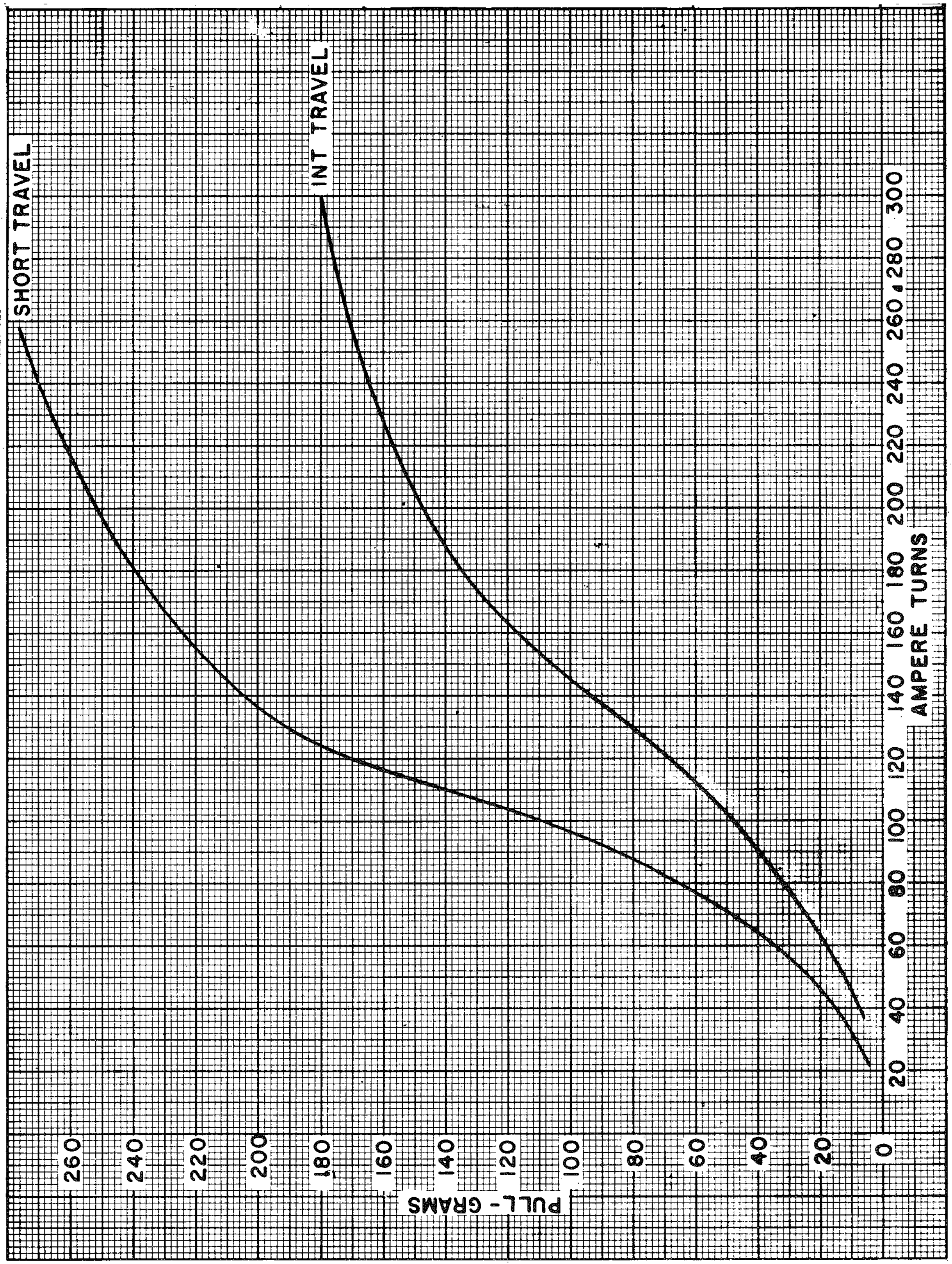

Fig. IX-33 - AK Relay - Nonoperate

X-75509

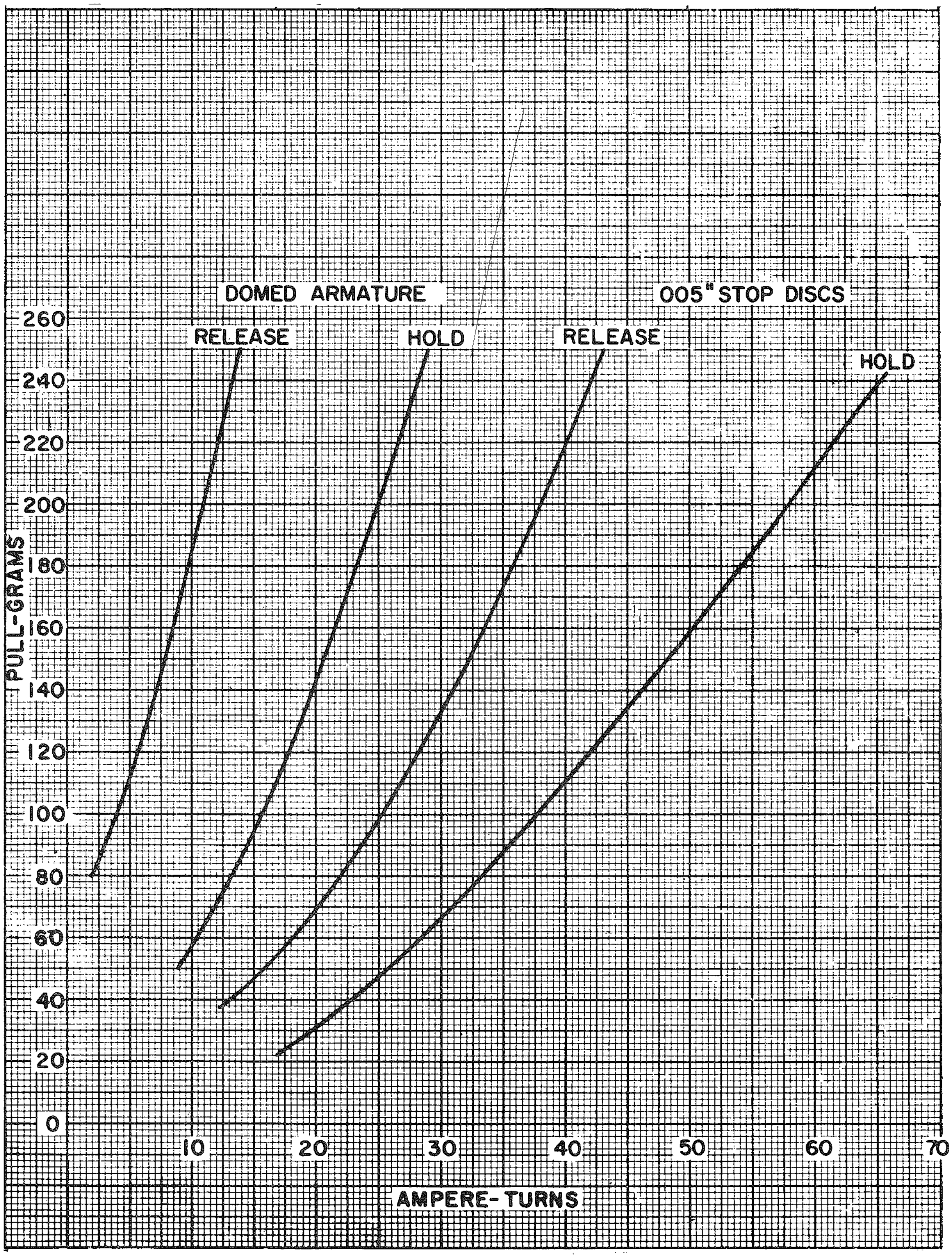

Fig. IX-34 - AK Relay - Hold and Release

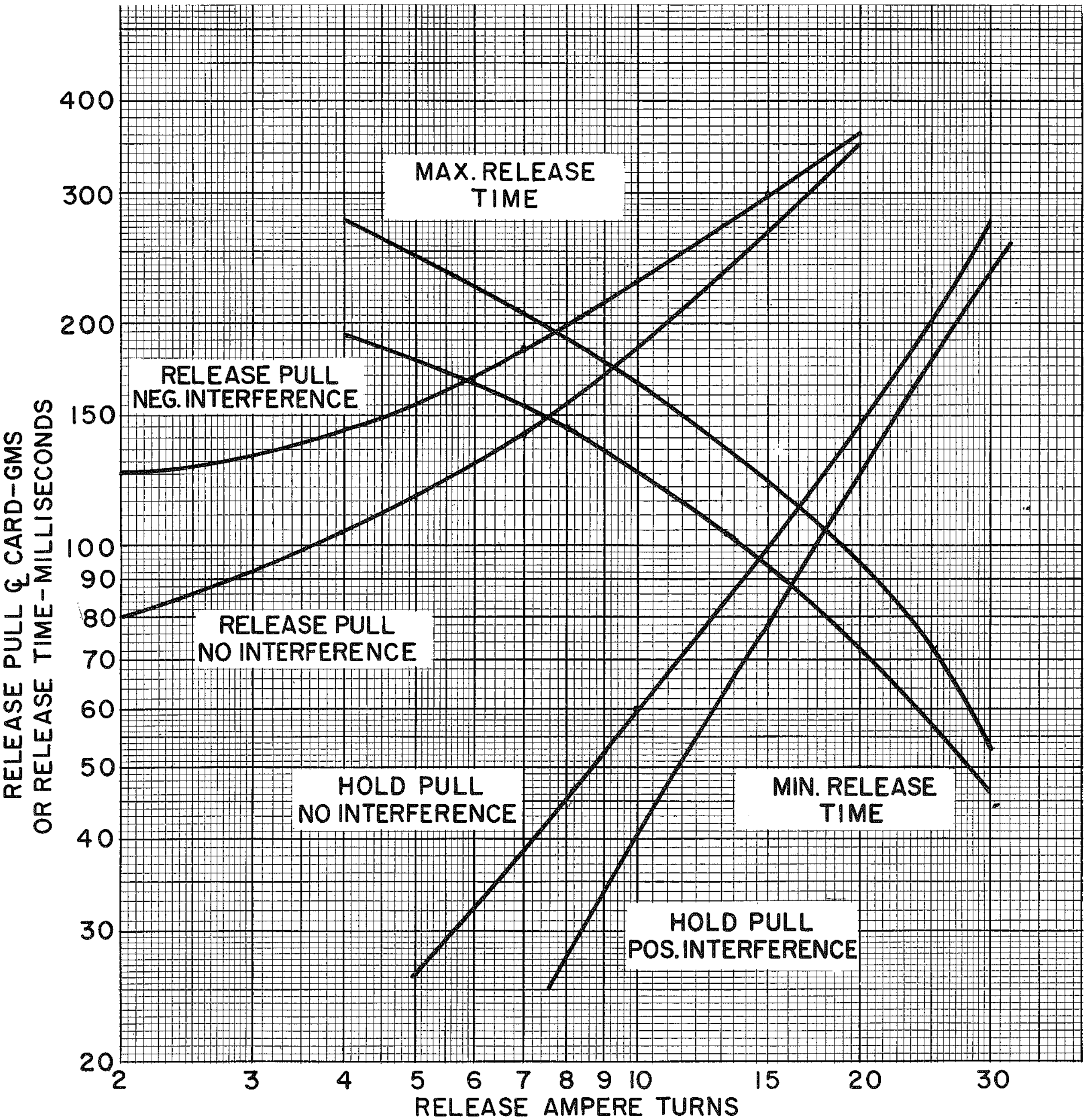

Fig. IX-35 - AK Relay - Slow Release - 0.069-Inch Copper Sleeve
(Data for Domed Armature)

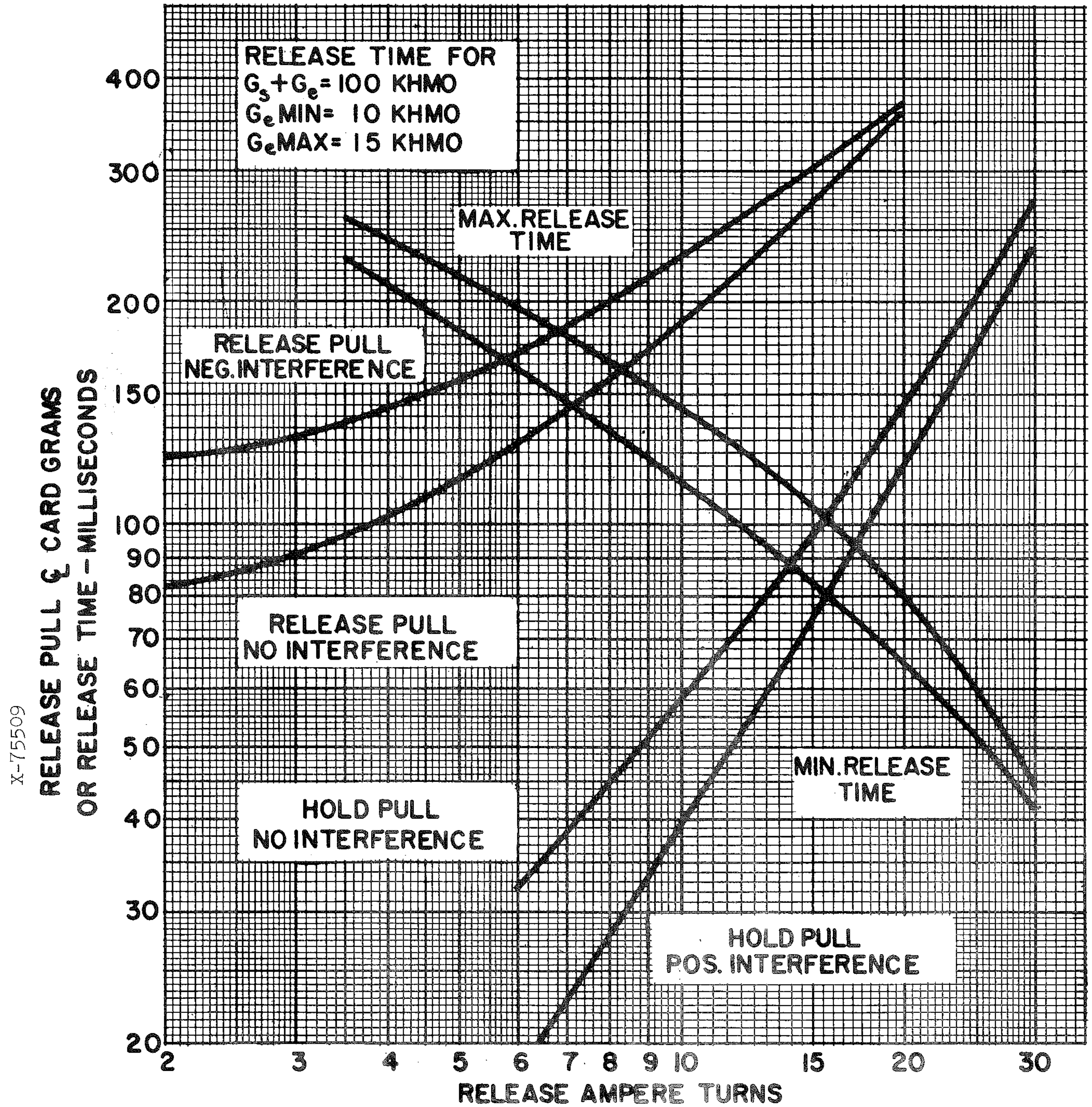

Fig. IX-36 - AK Relays - Release Time Domed Armature With Shunt