HIGH ENERGY TAPE FOR VIDEO RECORDING APPLICATIONS

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Over the past two decades, cable television has grown from small community antenna systems serving remote areas to large systems penetrating all types of communications. As cable television entered the "70's", new demands and opportunities represent fantastic challenges. Demands for program origination and better quality pictures must be met. Advances in technology such as two way cable, and more channels, offer new opportunities. Also, rumbles were being heard concerning improvements in television recording. This news of better things to come seemed to be all encompassing. From a hardware standpoint promises of new and improved video recorders were being backed up by introductions of sophisticated machines for both quadruplex and helical recording. The industry began using a new type of video tape that guards itself against damage. Several announcements and demonstrations have been made concerning revolutionary approaches to the duplication of recorded video material. All this is fascinating and important to our developing industry, but a common denominator that cuts across all of the topics that we have mentioned is the capability of the magnetic recording medium itself.

There have been vast improvements in the media during the last several years. Improvements that took us from what we thought were good black and white pictures, to the well defined, richly colored pictures that each of us expects to see on our monitors today. The low noise oxide introduced in the mid-sixties, coupled with advanced clean running binders, was an important breakthrough moving us toward that excellence that we now take for granted. Because of the improved signal-to-noise ratios attainable with the low noise oxide, multiple generation dubbing was not only possible, but became the accepted way to produce everything from a dog food commercial to a ninety-minute extravaganza. In the close analysis, the oxide on the tape has caused a lot of changes in the television industry, and it appears that these changes are not about to stop.

In exploring new ways to make even further improvements in the electro-mechanical properties of video recording tapes, it appeared that we had gone just about as far as was possible with our present day family of synthetic low noise oxides. If we wanted to see a meaningful improvement in the key recording characteristics of both RF output and signal-to-noise ratio, we would have to enter into some extensive research centered upon modifying the basic oxide particle.

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After many years of work, and extensive application evaluation, we were ready to announce the result of this basic research. We had succeeded in developing a new family of oxides that offered all the features indicated in the objectives of our tape design engineers. The products in which the new oxides are used are referred to as High Energy tapes because of the higher output that can be derived by proper application of this new recording media.

Since it is generally well known that a higher output can be predicted when the coercive force and remanence of a tape are increased, it was an adjustment in these parameters that made this breakthrough possible. We achieved the needed increase in coercivity and remanence by modifying the composition of the gamma ferric oxide and properly dispersing it in a binder system. A small amount of cobalt has been introduced into each particle of oxide in a manner that allows the control of the resultant coercive force to a pre-determined level. This technology of introducing cobalt into the particle to increase coercive force has been known for years by the chemists in the industry, but results in the past were disappointing in that the introduction of the cobalt detrimentally altered the particle size and shape. This altering of particle size and shape had an adverse effect on the signal retention of the tape, especially when it was heated or flexed. With the development of this new technology, it is now possible for us to produce High Energy oxide that has the same controlled particle size and shape as the gamma ferric oxide. As a result, it has the same signal retention ability as the gamma ferric oxide.

This new oxide technology enables the tape manufacturer to tailor make magnetic tapes with coercive force values from as low as 300 oersteds to as high as 1000 oersteds while maintaining retentivity values in the 1200 gauss range. Because of the ability to control the coercive force in the finished product, tapes can be specifically designed to accomplish a specific purpose.

We could now use this proprietary oxide to develop a family of tapes that would provide immediately noticeable benefits to the user. When used to manufacture video tapes, both improved signal-to-noise ratio and increased RF output are achieved. We are currently producing tapes for both quadruplex and helical recording with coercivities of 500 and 900 oersteds. The 500 oersted version is totally compatible with video recorders that are in use today, and the 900 oersted tape will find use in the field of advanced systems technology. It is interesting to note that the benefits just described were accomplished without the need for the usual technical tradeoffs that plague design engineers. These new High Energy tapes still incorporate the best features of present day tapes in the areas of physical handling, tape wearability and head life.

The classic means used to compare the capabilities of various oxides is the familiar hysteresis loop. An analysis of the loop provides us with three important parameters. These are the saturation value, referred to as B_s; the amount of retained flux, known as B_r; and the amount of energy required to reduce the retained flux to zero, called the H_c. These three properties, as well as the shape and size of the oxide particle, determine the magnetic capabilities of the finished tape.

Here in figure 1, we see three hysteresis loops. The small one represents the pattern seen for conventional video tape, such as "SCOTCH" Brand No. 361. The next largest is a trace of the loop formed by a compatible 500 oersted High Energy tape, and the largest described an experimental 900 oersted High Energy product. The three important points are labeled on each of the three curves. Saturation, or B_s, is seen in the first quadrant in the upper right hand corner. The amount of retained flux, B_r, is seen on the positive vertical axis and the H_c or energy required to reduce the flux to zero appears on the left. In this type of measurement, a great deal can be learned from the shape and size of the curve in the second quadrant between the points B_r and H_c. The amount of area that lies under the curve in this quadrant is a measure of the relative energy available from that oxide for recording.

Note the additional area gained by the two High Energy products. Inspection reveals that the 900 oersted tape yields nearly four times the area of conventional 300 oersted oxides. And the 500 oersted tape encompasses an area that is about twice as large. This extra energy that is available can, of course, be used to good advantage for television recording.

One of the things to investigate in evaluating a new video tape formulation is the amplitude of RF output seen when this tape is played back. There are three sets of curves in figure 2 that illustrate this. The curves next to the 300 oersted label will be used as a reference because they are typical of conventional tapes currently in use for quadruplex recording, such as "SCOTCH" Brand No. 400. Here, represented as a solid line, we see the traditional optimization curve showing the peak being reached at a point slightly above the level that represents 25% of the available RF drive used in recording the tape. The relative output on playback is seen on the scale as reaching 40 units. While this peak level of 40 on the vertical axis is important for making comparisons with tapes with greater coercive forces, noting the shape of the curve is important, too. We see here that the optimization curve rises rather steeply to the peak and then descends with equal steepness.

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When we compare the optimization curve for the 500 oersted High Energy tape, we immediately notice a 4 db increase in RF output. We notice also that the entire curve is positioned farther to the right, indicating that additional RF drive was used when the tape was recorded. We mentioned that the 500 oersted High Energy tape was compatible with today's recorders. This curve substantiates this, as the entire curve falls well within the available RF drive. The peak, or actual optimization point, falls at about 45% of the maximum drive utilizing a 1.5 mil gap depth. While a new head that has full gap depth requires more drive, the record drivers have more than enough range to easily obtain optimization.

The shape of the 500 oersted curve is quite different than that representing the 300 oersted conventional video tape. It is not as steep and this is a convenient advantage. The operator performing the optimization will notice a broader optimization range making it easire to adjust for the desired maximum. This broadened range also means that RF drive optimization need not be performed as often throughout the life of the video head assembly.

The broken lines in the figure indicate the chroma slope for each of the tapes, this represents the equalization change that is needed to compensate for wear of the video head pole tips. As the tape coercivity is increased, the slope of this line decreases, meaning that less correction is needed to maintain proper equalization. Just as was true when speaking about RF drive, the equalizers, too, would not require adjustment as often and such adjustment would be less critical.

The uppermost solid curve is representative of the 900 oersted experimental product. This tape is not designed to be compatible with recorders in normal use. As can be seen, the RF drive was set at maximum to obtain optimization. The head that was used was specially selected for this test to provide the efficiency needed to attain the optimization point. While we agree that this does not represent normal operating conditions for present equipment, it does clearly demonstrate the rather dramatic 7.5 db increase in RF output that this 900 oersted tape will yield, when compared with the 300 oersted tape that is the standard of the industry today.

The optimization curve is even more broad than it was with the 500 oersted tape and the chroma slope is approaching the horizontal. It is evident that when machines are readily available that will make use of tape in the coercivity range, the need for repeated RF drive and equalization adjustment will be minimal.

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Signal-to-noise ratio is a key parameter and a much discussed topic when speaking in terms of picture quality. This is especially true where video tape is concerned. Great strides in this direction have been made by camera designers, switching and processing equipment manufacturers and by the builders of the recorders themselves. With the advent of the high band color standard, companies such as ours introduced video tape manufactured with low noise oxide. Master tapes were clean and quiet. So quiet, in fact, that it was now possible to produce a second or third generation dub that looked as good as the master would have looked using the former tape. It wasn't long and multiple generation editing and dubbing was the standard way of doing business.

A meaningful improvement in the signal-to-noise ratio of the recording tape for today's as well as tomorrow's applications is the second very important benefit that is gained with the use of the High Energy oxide. In figure 3, we see a set of curves that, at first glance, look a great deal like the ones in the previous drawing. Once again, on the X axis, we see RF drive indicated in per cent of maximum. On the Y axis, however, we have shown signal-to-noise referenced to optimum conditions for the 300 oersted tape. The peak on the bottom curve, then, is zero db. The improvement in signal-to-noise ratio, when using the 500 oersted tape, amounts to an impressive 4 db. Once again, we should restate that this will be achieved on today's recorders without any modification. All that is necessary is a normal optimization adjustment.

On the same drawing, we have also shown a plot for the 900 oersted tape. With the specially selected head and maximum RF drive, we realize a 7 1/2 db improvement over the reference tape. This, of course, is not a compatible product, but does stimulate the imagination as we look to the future; to a time when machines are designed that can supply the additional RF drive needed to properly record it and sufficient erase fields so that it can be erased and used again.

The additional 4 db gained in signal-to-noise ratio, when using the 500 oersted tape, is particularly advantageous when one considers that many tapes used today are really fourth generation copies of a master. With the aid of the chart in figure 4, we can easily compare several combinations of multiple generation dubbing.

The data shown is for quadruplex recorders, however, helical recorders follow the same pattern. The same relative advantage is realized when High Energy tape is used for multiple generation copies on helical recorders.

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The first example, labeled Number 1, charts the progression of the four generations using 300 oersted tape in each step. This is the way things are being done now, using conventional video tape. Moving to the right through the first example, we note that the established signal-to-noise ratio of the master on the 300 oersted tape is 50 db. We have placed a circle around that number because it will be used for comparisons with the other examples. As we move into the second generagion that will also be on 300 oersted tape we encounter a loss in duplication of 1.5 db in signal-to-noise. The second generation copy will have a signal-to-noise ratio of 48.5 db. The duplication loss into the thrid generation is again 1.5 db, and the same is true for the fourth generation. This final copy has a signal-to-noise ratio of 45.5 db which is down 4.5 db from the original master.

Look now at the second example. Here, the master and each of the succeeding generations were made on 500 oersted, High Energy tape. With this product, the master reflects the 4 db improvement in signal-to-noise ratio so we begin with 54 db. Each generation of copying will again reduce the ratio by 1.5 db. This results in a fourth generation copy with a signal-to-noise of 49.5 db. When we compare this to the original master recorded on 300 oersted tape, we see only one-half db difference. We have now succeeded in producing a fourth generation copy that is as good, visually, as the traditional master made on conventional tape.

The third example indicates the use of the High Energy tape throughout the mastering and editing steps, but here conventional tape was used for the final fourth generation copies. The first three generations are the same as example Number 2, with 1.5 db duplication loss per step. As we move into the fourth generation, that will be recorded on standard 300 oersted tape, we will encounter a 2 db duplication loss. The net result is a final copy with a signal-to-noise ratio of 49 db. This is an insignificant one-half db down from a final copy made on the new High Energy tape and barely perceptible one db below a conventional 300 oersted master.

The numbers on the chart clearly suggest that for almost all fourth generation copies, it would be wise to master and edit on High Energy tape and economically sound to produce those final copies on traditional video tape. In those instances when the absolute ultimate in signal-to-noise is required, an extra one-half db can be gained by using High Energy tape throughout the entire process for either quadruplex or helical recorders.

Our discussion to this point has centered about the 500 oersted product. We have seen from the previous curves, however, that both RF output and signal-to-noise ratio are greatly improved as the coercivity is increased. Since the High Energy oxide lends itself so well to being tailored to yield a wide range of coercive force, it is our hope that future machine designs will tape advantage of this aspect. For a given application it may be that a system making use of 650 oersted tape would be ideal. For another use, 825 or 435 might render optimum performance. Tape is no longer the limiting factor in the recording process. High Energy tape is a reality. All that is needed now is the hardware to take advantage of this breakthrough.

We say this as a preface to our discussion on the application of High Energy tape to the field of helical video recording. Here, just as with the quadruplex systems previously discussed, increased coercivity of the recording tape has the capability of yielding an increase in both RF output and signal-to-noise ratio.

Figure 5 contains the optimization curves for the standard 300 oersted helical tape now in use as well as two High Energy constructions. Once again, RF drive is plotted along the bottom in terms of the drive that is available and relative RF output appears along the vertical axis. Note that with traditional tape optimum drive is about 50% of what is available. The 500 oersted High Energy tape will require about 70% of the total available drive and would deliver 6 db more RF output. This, of course, is compatible with present day equipment.

We have also shown a curve representing a 700 oersted experimental product. Even with the use of a specially selected video head, we were just able to reach the optimization point. You will notice, however, that the increase in RF output amounts to 8 db. Just as we noticed with the quadruplex examples, as we increase the coercivity the curve becomes more rounded and loses its steepness. This would again mean that optimization adjustments would be less critical and that they would be required less often.

Signal-to-noise ratio is also increased with the higher coercivity tapes. Figure 6 plots RF drive against signal-to-noise for the three tapes being discussed. Using the standard 300 oersted tape as the reference, we see that the 500 oersted compatible product offers an increase of 4 db, and the 700 oersted experimental tape yields a 6 db increase.

These curves, used in the last two figures, were generated on a one inch helical recorder. While this type of machine would not handle 700 oersted High Energy tape without modification, it does an excellent job with the 500 oersted tape. This, however, does not hold true across the complete line of helical recorders. In some cases the signal-to-noise ratio established by the machine electronics is very close to what is possible with traditional tapes. With most half inch recorders, even though we see a significant increase in RF output, the signal-to-noise ratio cannot be improved more than 2 db because of the electronics improvement in signal-to-noise, it is distrubing to note that the signal-to-noise of the tape playback is only 5 db below the EE (electronics-to-electronics) capabilities of the recorder. With the tapes used up until now these shortcomings were not really noticeable, but with the introduction of the High Energy family of tapes we can see that picture quality is seriously hampered by the limitation of the recorder electronics. Now that an improved tape is available we sincerely urge the hardware designers of our industry to develop the equipment to utilize the potential of this new oxide to complete what can amount to a great leap forward in video technology.

A summary of 500 oersted compatible High Energy tape performance on existing helical video recorders is as follows. All helical VTR's will give a noticeable improvement in signal-to-noise ratio (about 2 db) and RF output (about 50%) increase without making any recorder adjustments. Half inch recorders generally show no further signal-to-noise improvement when record drive is optimized for High Energy tape even though the RF output increases because of recorder electronic limitations. One inch recorders generally show another 2 db improvement in signal-to-noise ratio, or a total of 4 db, when record drive is optimized for High Energy tape. The RF output is then double that of conventional tape.

Recorded High Energy tapes can be played back on any recorder without adjustments with full signal improvement. In other words, to realize best performance, only the VTR used for record need be adjusted.

As we look to the future we can see constant attempts at miniaturization and a desire to place more information on a reel of tape. The High Energy tapes that we have been discussing have a greatly improved short wavelength response. This offers the possibility of operating at slower speeds. To many, this ability to operate at a reduced speed signals the gateway to practical video cassette recording. Up until now the drawback has been the need for an overly large cassette, an unduly short program or a serious sacrifice in picture resolution.

To demonstrate the slow speed capability of the three tapes we have been discussing, we modified a recorder with a 13 microinch head gap to run at half the normal speed. Figure 7 compares the results of this test with the same recorder operating normally. Here we see RF output plotted as a function of the recorded wavelength. Our zero db reference point is established at the one-eighth mil, normal operating point for the standard 300 oersted product. This is the vertical line on the left. By reducing the speed to one-half, we are then recording at one-sixteenth mil, and the standard product is seen to be nearly 5 db down in RF output as it crosses the vertical line on the right.

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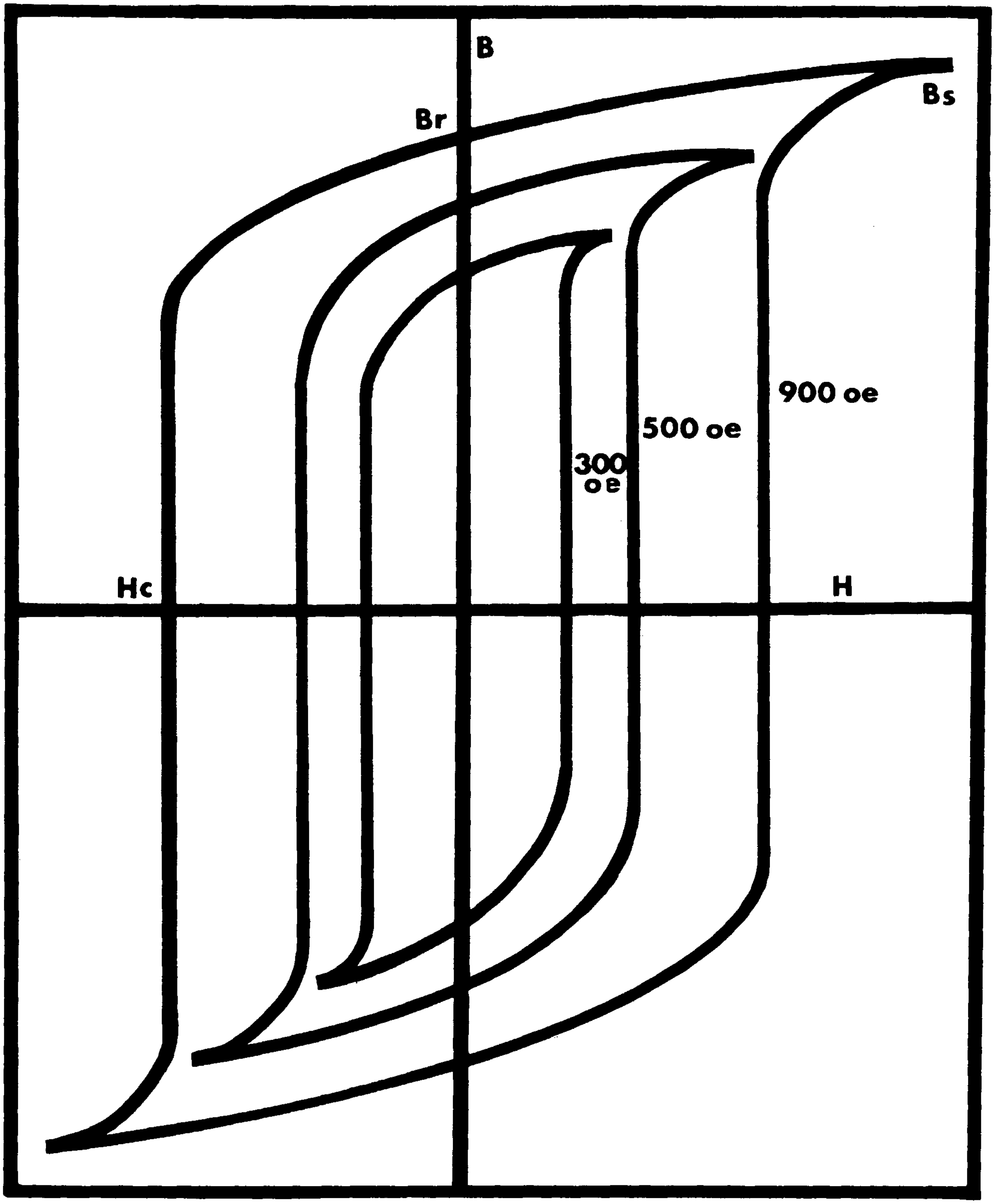
The 500 oersted High Energy tape operates at a plus 4 db from the reference at the normal speed, maintains this output at the one-twelvth mil wavelength, and has an output at one-sixteenth mil -- the half speed point -- that is about 2 db better than the 300 oersted tape at the normal speed. Standard tape at normal speed produces a picture of excellent quality. It is now possible for equipment designers to obtain better picture quality on half the length of tape by reducing the head-to-tape speed by one-half. The era of half speed recording is here now with a readily available compatible tape product.

If we follow a similar plot for 700 oersted tape, we observe an interesting result. In this case the experimental High Energy product has an output at half speed that is actually 5 db better than conventional tape at the normal speed. It is apparent from this that not only can one achieve a comparable picture at half speed, but it is now possible to obtain a better picture at half speed than has been possible at the normal speed.

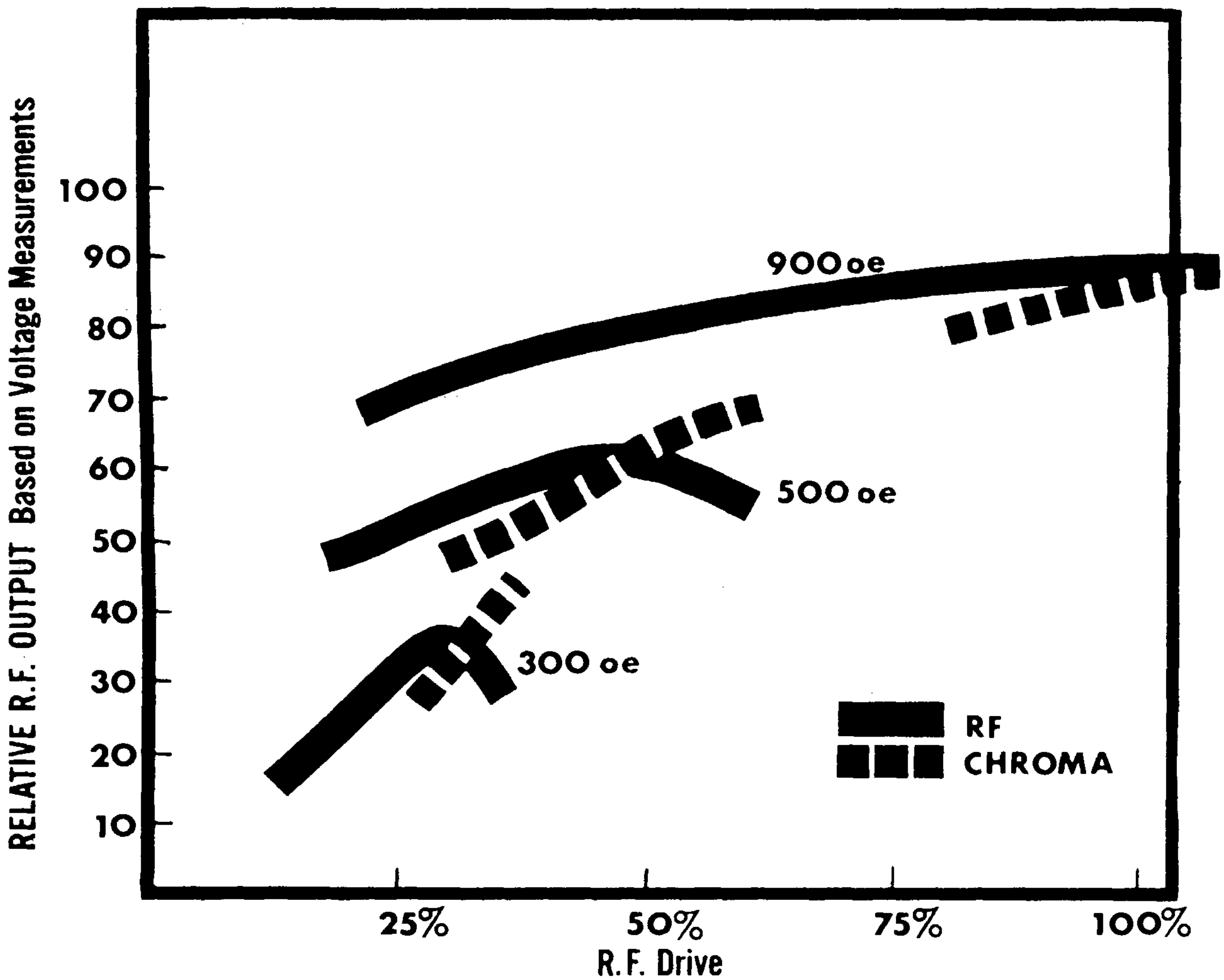
The latest breakthrough in oxide research has equipped us to accomplish many things in the immediate future. Increased RF output and improved signal-to-noise ratios are immediately achievable with the compatible 500 oersted tape and higher coercivity versions promise even further degrees of excellence. We can tailor coercive force of the finished tape product to provide the industry with whatever is needed to improve the quality of video recording. And the best thing about it is that this is not a laboratory dream; the tape is here today.

FIG. 1



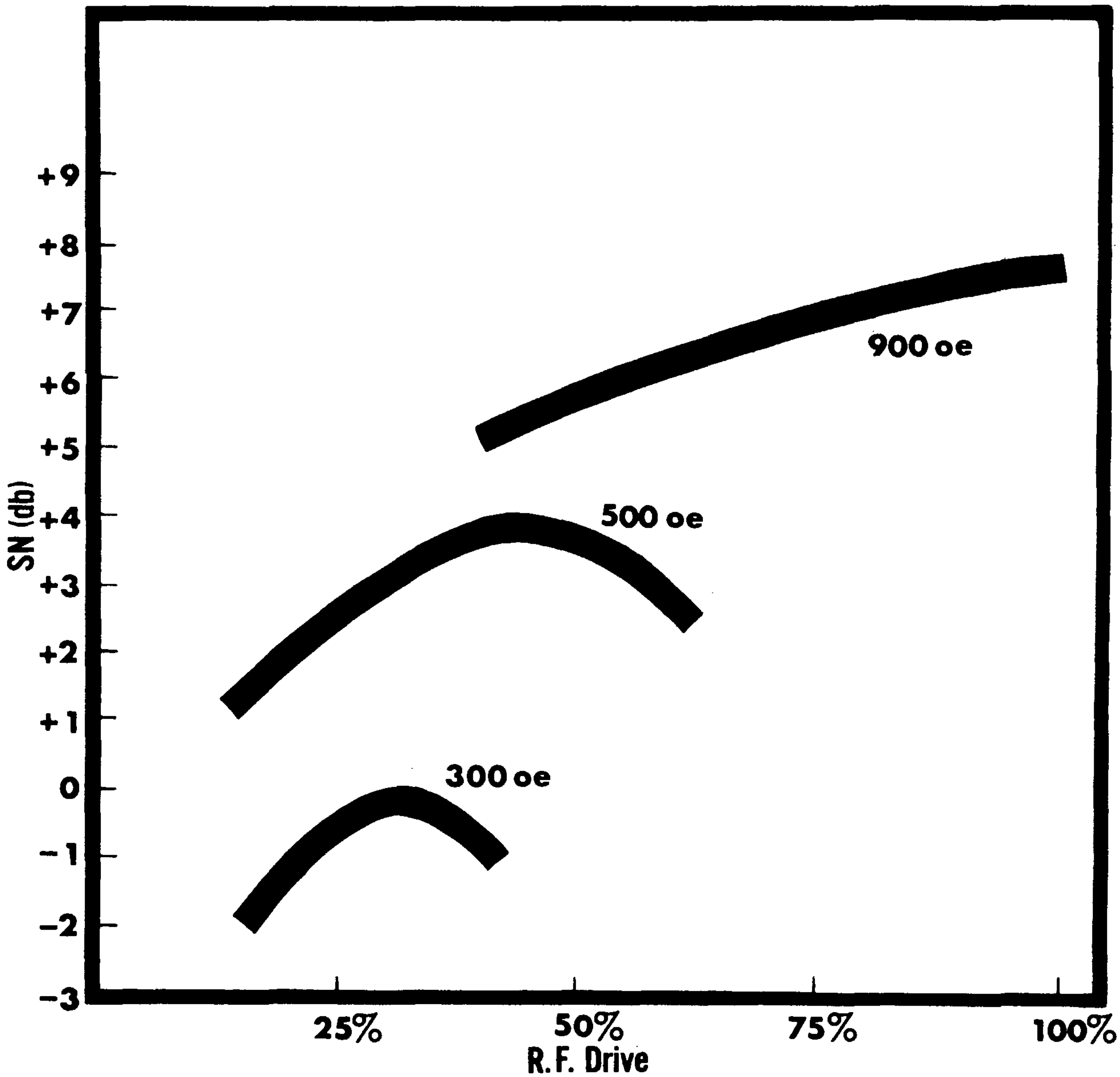
B-H HYSTERESIS LOOPS

FIG. 2



R.F. OUTPUT AND CHROMA RESPONSE VERSUS R.F. DRIVE QUADRUPLEX

FIG. 3



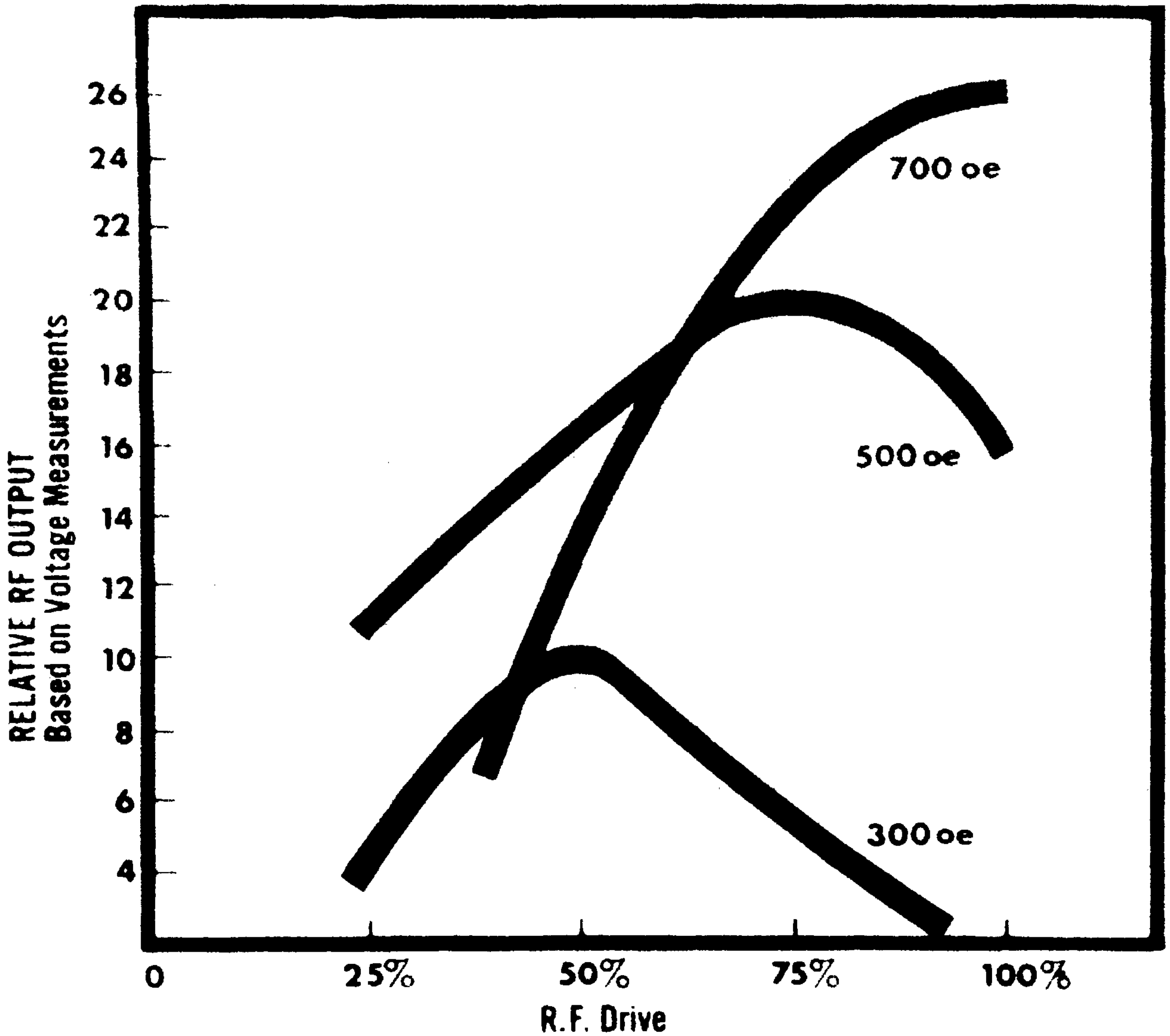
S/N VERSUS R.F. DRIVE QUADRUPLEX

FIG. 4

	1ST GENERATION		2ND GENERATION			3RD GENERATION			4TH GENERATION			
	Master Tape Type	Established S/N	Dupl. Loss	Work Master Tape Type	Resultant S/N	Dupl. Loss	Edited Master Tape Type	Resultant S/N	Dupl. Loss	End Copy Tape Type	Final S/N	Change From 300oe Master
1.	300oe	50	1.5	300oe	48.5	1.5	300oe	47	1.5	300oe	45.5	−4.5
2.	500oe	54	1.5	500oe	52.5	1.5	500oe	51	1.5	500oe	49.5	−0.5
3.	500oe	54	1.5	500oe	52.5	1.5	500oe	51	2.0	300oe	49.0	−1.0

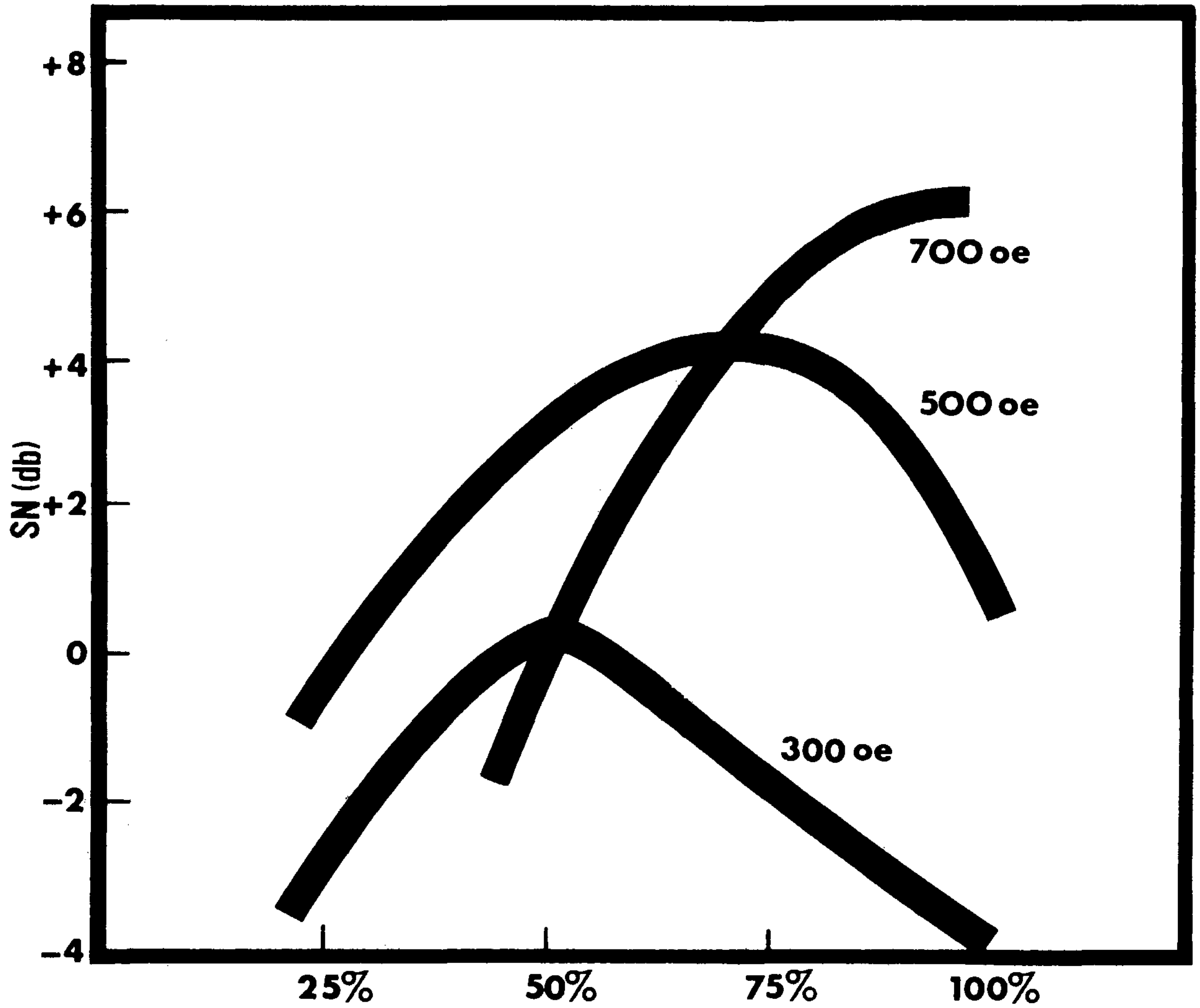
MULTIPLE GENERATION S/N COMPARISON

FIG 5



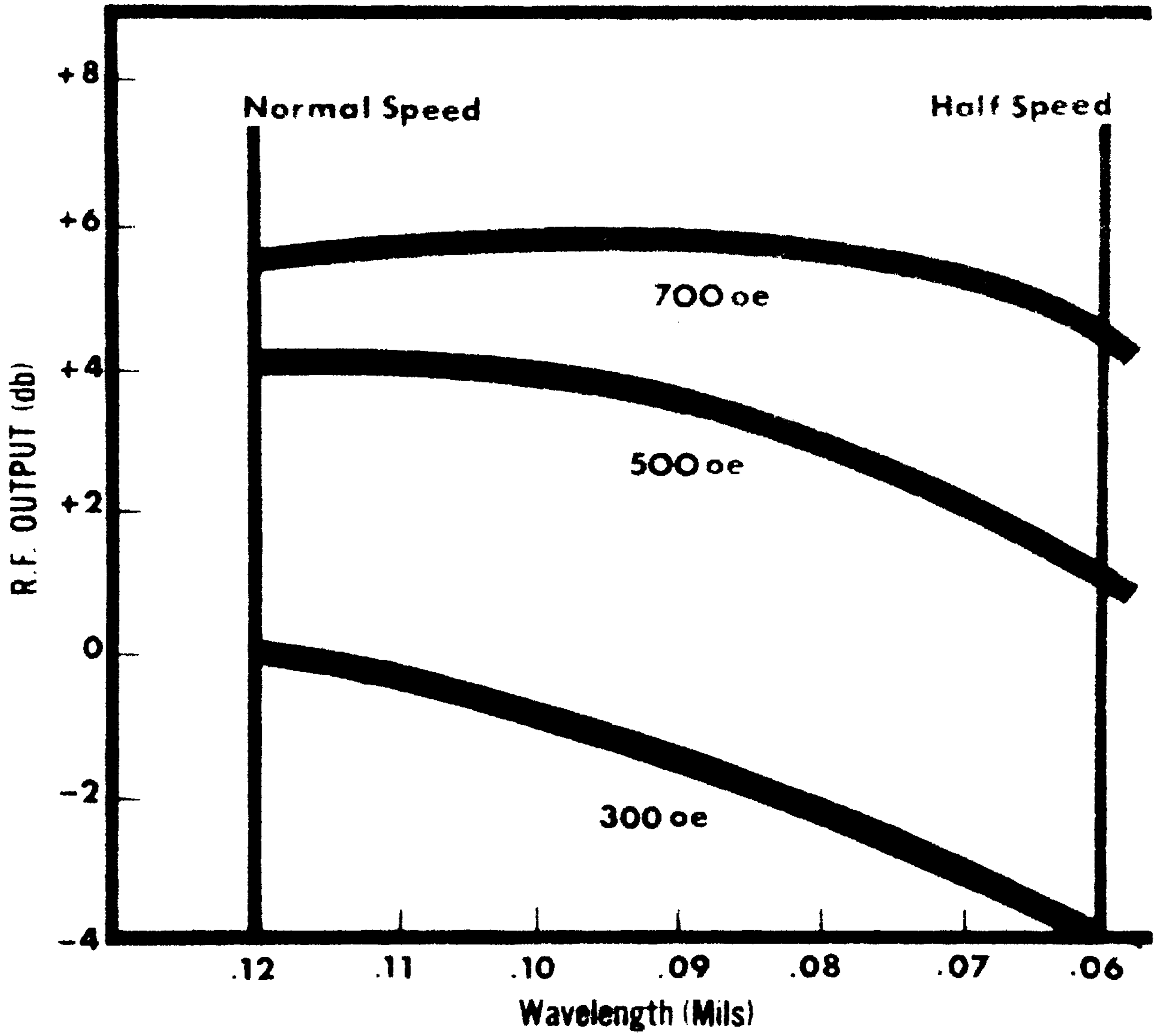
R.F. OUTPUT VERSUS R.F. DRIVE
1" HELICAL

FIG. 6



S/N VERSUS R.F. OUTPUT
1" HELICAL

FIG. 7



R.F. OUTPUT VERSUS WAVELENGTH
OPERATING AT 2 SPEEDS