The Japanese Yen, Recursed

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The Japanese Yen(JY) is a major currency traded world wide by corporations, institutions, banks, commodity funds and futures traders. The JY is traded 24 hours per day and most of the worlds largest banks make a two sided market in the JY and its associated derivatives. Small traders however, are constrained to trade the JY futures on the Chicago Mercantile Exchange(CME). The JY futures are traded from 7:20am to 2pm on the CME and from 2:30pm to 7:05am Monday through Thursday 5:30 P.M. to 7:05 AM Sundays and holidays on the CME Globex system. While the CME JY futures trading volume is small when compared to total world wide bank and institutional trading volume, arbitrage keeps the future prices in line with the bigger markets.

Data Discussion

The JY futures contract on the CME trades in the quarterly cycles of March, June, September and December. The current active JY futures contract is the JY Dec/98. This is the CME futures contract that expires on the second business day before the third Wednesday of December 1998. The JY Mar/99 will become the active contract one week before the Dec/98 expiration day.

The Japanese Yen is the currency of Japan. Each JY futures contract is worth the dollar value of 12,500,000 Japanese Yen. From *The Wall Street Journal* , on September 4th, 1998 the JY Dec/98 closed at 0.7584 Dollars per 100 JY making one JY contract worth $94,800 (12,500,000*0.7584/100). The JY future trades in units of $0.000001 per JY. Thus a move of one tick of $0.000001 is worth $12.50 per contract ($0.000001 $/JY x 12,500,000 = $12.50).

The JY futures started trading on 1975. However, for this article we will limit our study to the price history from 1/1/88 to today. Here we will use a JY futures continuous contract. Since JY future contracts expire each quarter, a continuous contract is constructed by switching to the active contract on rollover day and back adjusting the difference in prices between the new contract and old contract thus creating a smooth continuous contract.

The performance results from systems using continuous contracts cannot match actual results from trading real contracts because of the costs of actually having to rollover, and execution slippage. Execution slippage is the differences in prices from actually executing an order when a buy or sell signal is given and the price the computer system assumes that the order was executed at. When rolling over in real time via actual executions, the difference in prices between the new contract and the old contract on rollover day may not be the same as the closing prices the computer uses to construct the continuous contract.

Another problem with continuous contracts is that the past data is back adjusted by the difference in prices between the two contracts on rollover day. Systems developed on continuous contracts that use some form of percentage of prices will be impacted somewhat by this difference adjustment to past prices.   Despite these qualifiers, system results based upon continuous contracts are still indicative of the worth of the trading system.

The Recursive Moving Trend Line Fit.
In a previous article I used the technique of least Squares to fit a straight line through 30+ closing prices to create a curve that served as a proxy for the market trend. When the curve moved up by a certain percent from its previous local low, the trend was assumed to have changed to the upside and a buy signal was given.   When the curve moved down by a certain percent from its previous local high, the trend was assumed to have changed to the downside and a sell signal was given.

Here I will use another technique called the *Recursive Moving Polynomial Fit*. This is a mathematical technique that uses a small number of past values of the estimated price and a today's price to predict tomorrows price. The most familiar case of this recursive technique is the exponential moving average. This technique is in contrast to the computationally intensive Least Squares Polynomial fit, covered in my previous articles, which takes a large number past price points and solves for the least squares polynomial fit each day.

Consider a time series x(t) where t is an integer value like the number of days or minutes, etc from some starting time. Suppose we want to find at some given time some *n*th-degree polynomial that fits the data well at current and recent prices but ignores the fit as we move into the distant past. One way to construct this type of fit would be to weight the past data with a number that got smaller and smaller the further back in time we went. If we let the polynomial function be represented by the symbol p(t-τ) where p(t-0) is today, p(t-1) is yesterday, etc., then we can form a error function that consists of the weighted sum of the squared difference between the price series x(t-τ) and the polynomial p(t-τ) given by

$$\text{error} = \Sigma\beta^{\tau}(x(t-\tau) - p(t-\tau)\ )^2 \ \ \tau\text{=0 to } \infty \quad \textbf{(1)}$$

where $0 < \beta < 1$ **and** β^{τ} is much less than **1** for large τ**.**

It turns out that if we let the n$^{\text{th}}$ degree polynomial p(t-τ) be constructed as a linear combination of orthogonal polynomials called Meixner polynomials(please see to Mengert and Raudseps, Ref [1] for details) then minimizing the error with respect to the coefficients of the orthogonal polynomials yields the best estimate of **x(t-τ)** as $\mathbf{x_{est}}$**(t-τ)** and given by the equation

$$\mathbf{x_{est}(t-\tau)=(1-\beta)\Sigma\beta^k b_k(t)\Phi_k(\tau) \ \ k\text{=0 to n}} \quad \textbf{(2)}$$

where n is the polynomial degree, $\mathbf{\Phi_k(\tau)}$ are the Meixner polynomials of degree k, and $\mathbf{b_k(t)}$ are the coefficients that minimize the error of equation (1).

For the exact mathematical solutions that produce equation (2) and the mathematical descriptions of the Meixner polynomials please refer to Mengert and Raudseps, Ref [1]

To yield the 1 day ahead prediction the above equation becomes;

$$\mathbf{x_{est}(t+1)=(1-\beta)\Sigma\beta^k b_k(t)\Phi_k(-1) \ \ k\text{=0 to n}} \quad \textbf{(3)}$$

Two cases are of immediate interest. Case 1 where the polynomial is a constant, that is n=0, and Case2 where the polynomial is of one degree, n=1; that is a straight line or trend line.

For case 1 the solution to equation (3) is

$$X0_{est}=\beta*X0_{est}[1] +(1-\beta)*x(t) \quad (4)$$

Where $X0_{est}[1]$ is the previous estimated value, x(t) is today's price and where the 0 in $X0_{est}$ indicates that we are estimating a polynomial of degree 0 or simply a constant. If we make a change of variables and let $\alpha=(1-\beta)$ then equation (4) becomes:

$$X0_{est}=(1-\alpha)*X0_{est}[1] +\alpha*x(t) \quad (5)$$

which is the familiar formula for the exponential moving average.

Solving equation (2) for the case n=1 and substituting $\alpha=(1-\beta)$ yields the following recursive equations:

$$b_0(t)=(1-\alpha)*b_0(t-1)+x(t)$$
$$b_1(t)=(1-\alpha)*b_1(t-1) + b_0(t) - b_0(t-1) \quad (6)$$
$$X1_{est}(t+1)=\alpha*[b_0(t) + b_1(t)]$$

A little algebraic manipulation of equation (6) yields;

$$b_0(t)=(1-\alpha)*b_0(t-1)+x(t)$$
$$X1_{est}(t+1)=(1-\alpha)*X1_{est}(t) + \alpha*[x(t)+b_0(t) - b_0(t-1)] \quad (7)$$

Equation (7) represents the recursive estimation of the predicted one step ahead value of the best trend line fitted to the data. In other words this can be dubbed as the recursive moving average trend line.

The Recursive Moving Trend Line System Defined.
In constructing this system we are interested in the difference between the recursive moving trend line value and the exponential moving average value. What we are looking for are changes in the price series that are above the normal daily noise fluctuations that indicate that a up trend or down trend has started. Thus let us define a simple trend oscillator defined as

$$Tosc= X1_{est}(t+1) - X0_{est}$$

In general what we will be doing is following the plotted curve of **Tosc** . When the curve is above the level **_dup_** we will go long. When the curve is below the level **_-ddn_** we will go short.

Buy Rule:
* **IF Tosc** is greater than **_dup_** then buy the JY futures on the close.

Sell Rule:
* **IF Tosc** is less than **_-ddn_** then short the JY futures on the close.

Walk Forward Optimization
Walk forward optimization will be used here as a result of the nature of the Japanese Yen. The JY vs Dollar relationship in general represents the political and economic differences between the economies of Japan and the U.S. as they relate to the world economies. This is a constantly changing relationship. As such, conditions that prevailed 5 years ago may no longer be representative of today's relationship.

The walk forward procedure will be applied as follows. A period of 5 years from the start of the data, January 1, 1988 through December 31, 1992, is chosen and system parameter values are found through optimization on this daily data segment. The parameter values found are then applied to the out-of-sample data in the year following the test segment which in this case is year 1993. The out-of-sample results are then tabulated and saved for year 1993.

Next, the data testing window is now moved forward one year to January 1, 1989 through December 31 1993, and new optimum parameter values are found. The new optimum parameters are applied to the out-of-sample year 1994 and the out-of-sample results are tabulated for year 1994 and so forth.

The moving data test window walks forward one year at a time, creating optimum values for each 5 year window data segment. The optimum parameters derived from these windows are applied to the year outside the test data window. At the end, all tabulated one year out-of-sample results are merged to create one big out-of-sample results segment.

The theory behind this computationally intensive method is that price dynamics available for modeling and the parameters found will change slowly over time. It is assumed that enough data is available to predict a short time into the future before things change and the model falls apart. It takes time for events and technology to change things, so it is _assumed_ that using the optimum values based upon the previous five years will be adequate to use in the year forward.

Why 5 year data segments? Why not 10 years or 3 years? Well the answer is that there is no correct ratio of test data needed to produce good one year out-of-sample results. By experimenting with different window lengths, the five to one ratio seemed to work well. In walk forward testing enough data is needed to model most of the price dynamics that will be encountered in the out-of-sample segment, but not so much data that when the price dynamics start to change they are swamped by the weight of distant past data price dynamics that are no longer are valid. An important unspoken point in walk forward testing is that if you can not get

good results in the out-of-sample segments, then the price dynamics cannot be modeled with the system . This means that real time performance will be random using the model. Traders observe this type of random performance (that is it looks great on paper but falls apart in real time) when trying systems based on curve fitting or anecdotal "proof" without any out-of-sample testing .

Finding The System Parameters Using Walk Forward Optimization

There are three system parameters to find *ndays***, *dup and ddn*. We will convert *ndays* to α using the standard formula $\alpha=2/(1+\textbf{ndays})$. The best parameters will be defined as those values that give the best Net Profits with the highest percentage of wins, the minimum drawdown and minimum largest losing trades. In addition, the results should be stable, e.g. the profits, wins, and drawdowns should not change by much as the parameters move by a small amount away from their optimum values. Also in choosing the "best" parameters, I considered only those parameters sets whose maximum consecutive losses were 4 or less. Optimization is defined as the search for the parameter values that give the best results as defined above. It should be noted that in this stage of system development, the only thing indicated by the optimum values that are found is that the data has been *curve fitted* as best it can with this system. Without further testing on out-of-sample data there is no way to tell if the system will work in the future.

As explained above, the walk forward testing will be done on six moving 5 year data windows. Those data windows are:

Test Data Window 1. 1/1/88 to 12/31/92
Test Data Window 1. 1/1/89 to 12/31/93
Test Data Window 2. 1/1/90 to 12/31/94
Test Data Window 3. 1/1/91 to 12/31/95
Test Data Window 4. 1/1/92 to 12/31/96
Test Data Window 5. 1/1/93 to 12/31/97

Results

Figure 1 presents a table of the six window data segments and the corresponding optimum parameter values found. Most of the parameter values do not change much from segment to segment verifying that five years is enough data to produce parameter values that are stable over the next out of sample year and that capture most of the price dynamics.

Figures 2 through 7 present the performance summary using the derived optimum values for the six data window segments shown in Figure 1.

Figure 8 presents the performance summary of the merged out-of-sample one year data segments from 1/1/93 to 9/11/98. This performance represents what would have happened in *real time* if one followed the walk forward out-of-sample buy and sell signals. Slippage, commissions and rollover costs have not been included in this performance summary.

Figure 9 presents a comparison performance summary table for each of the 6 time segments. This table also presents the best optimized one year performance and the out-of-sample

performance for that same year produced from the optimized parameters of the previous 5year time segment.

Figure 10 presents a specialized percentage trade by trade summary from 1/1/88 to 9/11/98. Note that the trades from 1/1/88 to 12/31/92 are generated from the optimized parameters from that period but the trades from 1/1/93 to 9/11/98 are from the merged out-of-sample one year data segments.

Figure 11 presents the trade by trade Risk/Reward summary for 1/1/88 to 9/11/98.

Figure 12 presents the trade by trade Risk/Reward summary for the out-of-sample segment only from 1/1/93 to 9/11/98.

Figures 13A through 13K present the charts of the daily continuous Japanese Yen future with all the Recursive Moving Trend Line System and buy and sell signals from the trade by trade summary of Figure 10 indicated on the charts. Also plotted in the chart window are the recursive moving trend line and the exponential moving average. Each buy trade and sell trade *percent* drawdown and *percent* gain is plotted along the bottom of the charts in a separate window.

Discussion of System Performance
As can be observed from the test sample Performance summaries in Figures 2 through 7, the percent profitable trades and dollar drawdowns are pretty stable as the test windows move toward the current date. The largest drawdowns and the largest losing trades were all generated from the bad buy trade on 8/02/89 which lost -$4087. The Japanese Yen had an unusual 2 day jump in price from 92.15 on Friday 7/28/89 to 93.81 on Tuesday 8/1/89. This jump was unusual and was probably caused by some news event. However, whatever the cause, the event generated the worst trade for the total time period analyzed by the system. As soon as 1989 was dropped out of the 5 year time window, the drawdowns dropped to the -$4000 level and the worst trades were in the -$2900 range. Another interesting observation from figures 2 through 7 was that the net profit increased from a low of $39750 to a high of $86212 as the test windows moved forward. This means that trends in the Japanese Yen's price were larger in magnitude in later years then they were in the past. However it should be noted, from observing Figure 9, that the larger recent 5 year net profits are mainly due to the inclusion of 1995 which had an unusually large one year net profit. Excluding 1995 the one year walk forward net profits for the other time segments were much smaller.

Figure 8 presents the out-of-sample performance of the walk forward JY Recursive Moving Trend Line System from 1/1/93 to 9/11/98. The out of sample performance is excellent. On a one contract basis, the average winning trade is $12457 and the average losing trade is -$2616...a more that 4.75 to one ratio. The largest losing trade is -$3500 and the largest winning trade is $48262 a 13 to 1 ratio. Slippage and commissions have not been taken into account. With commissions and slippage of $100 round trip, 11 round trip trades decrease the total net profits by $1100 or only 1.2%.

Examining the trade by trade summary in Figure 10 we can see that the out-of-sample trades from 1/1/93 to 9/11/98 performed similar to the curve fitted test segment trades from 1/1/88 to 12/31/92, with approximately the same percentage gains and losses in magnitude. The test segment had maximum % drawdown losses in the 0% to 3% range , while the OOS had maximum % drawdown losses also in the 0 to 3% range. The profits of the curve fitted test segment were in the 0 to 12% range and the profits in the OOS segments were in the 0 to 10% range (excluding the 29.55% profit on 7/10/95 short trade).

Examining the trade by trade Risk/Reward summary for the out of sample trades in Figure 12, we can see that the compounded return of the buy and sell signals beat the compounded return of buy & hold by 16% per annum. Examining the buy only compounded return we can see that most of the return came from the sell signals. The best closed trade %win was a short initiated on 7/10/95 that was closed out on 5/14/97 for a 29.55% profit. The trade had been as high as 34.61% on 4/30/97. Amazingly this system held this short position for 2 years during one of the biggest downtrends in the yen. this was excellent. The compounded buy and sell returns were larger for the out-of-sample segment indicating bigger trends when compared to the numbers in Figure 11. All these percentage figures are based on 100% margin.

From the charts in Figures 13A through 13L we can observe that Yen had a number of large trends and few whipsaw type markets. However 1994 and the latter half of 1992 consisted mainly of a whipsaw markets creating low profits for those years. As mentioned above 1995 consisted of, at first, a large bull market from February 1995 to April 1995 and then a large long two year bear market from April 1995 to May 1997. The out-of-sample trades for this system for these two big moves was picture perfect...a traders dream. Of course when we jump in we will probably get stuck with a whipsaw market like in 1994! As we can see from Figure 1, the walk forward Recursive Moving Trend Line System adapted fairly fast to these sudden changes in price dynamics of the Japanese Yen. From the charts we can observe that the Japanese Yen has many sudden reversals and gaps. This type of jerking movement caused the majority of losses in the system. However, the system did quite well in staying with the trend when it was established and minimizing the losses due to the sudden reversals. Almost all the drawdowns in the out-of-sample segment from 1993 forward were contained within 3% with the majority between the 0 and 2% level. On the profit side, trade run-ups of 2 to 12% were quite common.

The drawdown and gain percentages discussed above are based on 100% margin. If the margin on the futures contract was 10% a 3% of equity drawdown loss would become a 30% of equity drawdown loss.

References:
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Info on Dennis Meyers

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Figure 1 Optimum Parameter Values For Each Walk Forward Data Segment

Start Date	End Date	Ndays	dup	ddn
1/1/88	12/31/92	25	0..225	0.275
1/1/89	12/31/93	25	0.225	0.525
1/1/90	12/31/94	20	0.100	0.450
1/1/91	12/31/95	25	0.325	0.525
1/1/92	12/31/96	25	0.325	0.525
1/1/93	12/31/97	25	0..325	0.525

Figure 2 Performance Summary for JY RecursiveMovTL System 01/04/88-12/30/92

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RecursiveMovTL(T+1)  Japanese Yen - CME-Daily   01/04/88 - 12/31/92

         Performance Summary:  All Trades

Total net profit      $ 39750.000    Open position P/L    $     0.000
Gross profit          $ 48475.000    Gross loss           $ -8725.000

Total # of trades          14        Percent profitable         64%
Number winning trades       9        Number losing trades        5

Largest winning trade $ 12725.000    Largest losing trade $ -4087.500
Average winning trade $  5386.111    Average losing trade $ -1745.000
Ratio avg win/avg loss     3.087     Avg trade(win & loss) $  2839.286

Max consec. winners         4        Max consec. losers          3
Avg # bars in winners     110        Avg # bars in losers       44

Max intraday drawdown $ -6300.000
Profit factor              5.556     Max # contracts held        1

         Performance Summary:  Long Trades

Total net profit      $ 17562.500    Open position P/L    $     0.000
Gross profit          $ 25712.500    Gross loss           $ -8150.000

Total # of trades           7        Percent profitable         57%
Number winning trades       4        Number losing trades        3

Largest winning trade $ 12725.000    Largest losing trade $ -4087.500
Average winning trade $  6428.125    Average losing trade $ -2716.667
Ratio avg win/avg loss     2.366     Avg trade(win & loss) $  2508.929

Max consec. winners         2        Max consec. losers          1
Avg # bars in winners     119        Avg # bars in losers       31

Max intraday drawdown $ -5550.000
Profit factor              3.155     Max # contracts held        1

         Performance Summary:  Short Trades

Total net profit      $ 22187.500    Open position P/L    $     0.000
Gross profit          $ 22762.500    Gross loss           $  -575.000

Total # of trades           7        Percent profitable         71%
Number winning trades       5        Number losing trades        2

Largest winning trade $ 11375.000    Largest losing trade $  -450.000
Average winning trade $  4552.500    Average losing trade $  -287.500
Ratio avg win/avg loss    15.835     Avg trade(win & loss) $  3169.643

Max consec. winners         3        Max consec. losers          2
Avg # bars in winners     102        Avg # bars in losers       64

Max intraday drawdown $ -2212.500
Profit factor             39.587     Max # contracts held        1
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Figure 3 Performance Summary for JY RecursiveMovTL System 01/03/89-12/30/93

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!RecursiveMovTL  Japanese Yen - CME-Daily   01/03/89 - 12/31/93

        Performance Summary:  All Trades

Total net profit      $ 47950.000    Open position P/L    $      0.000
Gross profit          $ 56787.500    Gross loss           $  -8837.500

Total # of trades           11       Percent profitable         73%
Number winning trades        8       Number losing trades         3

Largest winning trade $ 20612.500    Largest losing trade $ -4325.000
Average winning trade $  7098.438    Average losing trade $ -2945.833
Ratio avg win/avg loss    2.410       Avg trade(win & loss) $  4359.091

Max consec. winners         5        Max consec. losers           2
Avg # bars in winners     143        Avg # bars in losers        23

Max intraday drawdown $ -6775.000
Profit factor             6.426      Max # contracts held         1

        Performance Summary:  Long Trades

Total net profit      $ 31212.500    Open position P/L    $      0.000
Gross profit          $ 38325.000    Gross loss           $ -7112.500

Total # of trades            5       Percent profitable         60%
Number winning trades        3       Number losing trades         2

Largest winning trade $ 20612.500    Largest losing trade $ -4325.000
Average winning trade $ 12775.000    Average losing trade $ -3556.250
Ratio avg win/avg loss    3.592       Avg trade(win & loss) $  6242.500

Max consec. winners         2        Max consec. losers           1
Avg # bars in winners     223        Avg # bars in losers        20

Max intraday drawdown $ -5787.500
Profit factor             5.388      Max # contracts held         1

        Performance Summary:  Short Trades

Total net profit      $ 16737.500    Open position P/L    $      0.000
Gross profit          $ 18462.500    Gross loss           $ -1725.000

Total # of trades            6       Percent profitable         83%
Number winning trades        5       Number losing trades         1

Largest winning trade $  7050.000    Largest losing trade $ -1725.000
Average winning trade $  3692.500    Average losing trade $ -1725.000
Ratio avg win/avg loss    2.141       Avg trade(win & loss) $  2789.583

Max consec. winners         3        Max consec. losers           1
Avg # bars in winners      95        Avg # bars in losers        30

Max intraday drawdown $ -2950.000
Profit factor            10.703      Max # contracts held         1
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Figure 4 Performance Summary for JY RecursiveMovTL System 01/03/90-12/30/94

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!RecursiveMovTL  Japanese Yen - CME-Daily   01/02/90 - 12/30/94

        Performance Summary:  All Trades

Total net profit      $ 42637.500    Open position P/L    $      0.000
Gross profit          $ 49750.000    Gross loss           $  -7112.500

Total # of trades           15       Percent profitable         73%
Number winning trades       11       Number losing trades        4

Largest winning trade $ 13350.000    Largest losing trade $  -2612.500
Average winning trade $  4522.727    Average losing trade $  -1778.125
Ratio avg win/avg loss      2.544    Avg trade(win & loss) $  2842.500

Max consec. winners          4       Max consec. losers          2
Avg # bars in winners       98       Avg # bars in losers       34

Max intraday drawdown $ -4675.000
Profit factor               6.995    Max # contracts held        1

        Performance Summary:  Long Trades

Total net profit      $ 42250.000    Open position P/L    $      0.000
Gross profit          $ 44575.000    Gross loss           $  -2325.000

Total # of trades            7       Percent profitable         86%
Number winning trades        6       Number losing trades        1

Largest winning trade $ 13350.000    Largest losing trade $  -2325.000
Average winning trade $  7429.167    Average losing trade $  -2325.000
Ratio avg win/avg loss      3.195    Avg trade(win & loss) $  6035.714

Max consec. winners          5       Max consec. losers          1
Avg # bars in winners      134       Avg # bars in losers       26

Max intraday drawdown $ -3062.500
Profit factor              19.172    Max # contracts held        1

        Performance Summary:  Short Trades

Total net profit      $   387.500    Open position P/L    $      0.000
Gross profit          $  5175.000    Gross loss           $  -4787.500

Total # of trades            8       Percent profitable         63%
Number winning trades        5       Number losing trades        3

Largest winning trade $  1925.000    Largest losing trade $  -2612.500
Average winning trade $  1035.000    Average losing trade $  -1595.833
Ratio avg win/avg loss      0.649    Avg trade(win & loss) $     48.438

Max consec. winners          2       Max consec. losers          1
Avg # bars in winners       55       Avg # bars in losers       36

Max intraday drawdown $ -4362.500
Profit factor               1.081    Max # contracts held        1
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Figure 5 Performance Summary for JY RecursiveMovTL System 01/03/91-12/30/95

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!RecursiveMovTL  Japanese Yen - CME-Daily   01/02/91 - 12/29/95

        Performance Summary:  All Trades

Total net profit      $ 72250.000    Open position P/L    $     0.000
Gross profit          $ 76562.500    Gross loss           $ -4312.500

Total # of trades            9        Percent profitable          67%
Number winning trades        6        Number losing trades         3

Largest winning trade $ 26300.000    Largest losing trade $ -2937.500
Average winning trade $ 12760.417    Average losing trade $ -1437.500
Ratio avg win/avg loss    8.877       Avg trade(win & loss) $  8027.778

Max consec. winners          3        Max consec. losers           1
Avg # bars in winners      170        Avg # bars in losers        66

Max intraday drawdown $ -3337.500
Profit factor            17.754       Max # contracts held         1

        Performance Summary:  Long Trades

Total net profit      $ 47625.000    Open position P/L    $     0.000
Gross profit          $ 47625.000    Gross loss           $     0.000

Total # of trades            4        Percent profitable         100%
Number winning trades        4        Number losing trades         0

Largest winning trade $ 19862.500    Largest losing trade $     0.000
Average winning trade $ 11906.250    Average losing trade $     0.000
Ratio avg win/avg loss  100.000       Avg trade(win & loss) $ 11906.250

Max consec. winners          4        Max consec. losers           0
Avg # bars in winners      206        Avg # bars in losers         0

Max intraday drawdown $ -1200.000
Profit factor           100.000       Max # contracts held         1

        Performance Summary:  Short Trades

Total net profit      $ 24625.000    Open position P/L    $     0.000
Gross profit          $ 28937.500    Gross loss           $ -4312.500

Total # of trades            5        Percent profitable          40%
Number winning trades        2        Number losing trades         3

Largest winning trade $ 26300.000    Largest losing trade $ -2937.500
Average winning trade $ 14468.750    Average losing trade $ -1437.500
Ratio avg win/avg loss   10.065       Avg trade(win & loss) $  4925.000

Max consec. winners          1        Max consec. losers           2
Avg # bars in winners       99        Avg # bars in losers        66

Max intraday drawdown $ -3337.500
Profit factor             6.710       Max # contracts held         1
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Figure 6 Performance Summary for JY RecursiveMovTL System 01/03/92-12/30/96

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!RecursiveMovTL  Japanese Yen - CME-Daily   01/02/92 - 12/31/96

          Performance Summary:  All Trades

Total net profit      $ 84112.500    Open position P/L    $     0.000
Gross profit          $ 89637.500    Gross loss           $ -5525.000

Total # of trades            7        Percent profitable          71%
Number winning trades        5        Number losing trades          2

Largest winning trade $ 45362.500    Largest losing trade $ -2937.500
Average winning trade $ 17927.500    Average losing trade $ -2762.500
Ratio avg win/avg loss      6.490    Avg trade(win & loss) $ 12016.071

Max consec. winners          3        Max consec. losers            1
Avg # bars in winners      224        Avg # bars in losers         49

Max intraday drawdown $ -3337.500
Profit factor            16.224      Max # contracts held          1

          Performance Summary:  Long Trades

Total net profit      $ 41637.500    Open position P/L    $     0.000
Gross profit          $ 41637.500    Gross loss           $     0.000

Total # of trades            3        Percent profitable         100%
Number winning trades        3        Number losing trades          0

Largest winning trade $ 20612.500    Largest losing trade $     0.000
Average winning trade $ 13879.167    Average losing trade $     0.000
Ratio avg win/avg loss    100.000    Avg trade(win & loss) $ 13879.167

Max consec. winners          3        Max consec. losers            0
Avg # bars in winners      223        Avg # bars in losers          0

Max intraday drawdown $  -450.000
Profit factor           100.000      Max # contracts held          1

          Performance Summary:  Short Trades

Total net profit      $ 42475.000    Open position P/L    $     0.000
Gross profit          $ 48000.000    Gross loss           $ -5525.000

Total # of trades            4        Percent profitable          50%
Number winning trades        2        Number losing trades          2

Largest winning trade $ 45362.500    Largest losing trade $ -2937.500
Average winning trade $ 24000.000    Average losing trade $ -2762.500
Ratio avg win/avg loss      8.688    Avg trade(win & loss) $ 10618.750

Max consec. winners          1        Max consec. losers            1
Avg # bars in winners      226        Avg # bars in losers         49

Max intraday drawdown $ -4300.000
Profit factor             8.688      Max # contracts held          1
```

Figure 7 Performance Summary for JY RecursiveMovTL System 01/04/93-12/30/97

```
!RecursiveMovTL  Japanese Yen - CME-Daily   01/04/93 - 12/31/97

          Performance Summary:  All Trades

Total net profit       $ 86212.500    Open position P/L    $     0.000
Gross profit           $ 91800.000    Gross loss           $ -5587.500

Total # of trades              8       Percent profitable           75%
Number winning trades          6       Number losing trades          2

Largest winning trade $ 48262.500    Largest losing trade $ -2937.500
Average winning trade $ 15300.000    Average losing trade $ -2793.750
Ratio avg win/avg loss      5.477    Avg trade(win & loss) $ 10776.563

Max consec. winners            3       Max consec. losers            1
Avg # bars in winners        183       Avg # bars in losers         53

Max intraday drawdown $ -6612.500
Profit factor              16.430    Max # contracts held          1

          Performance Summary:  Long Trades

Total net profit       $ 26150.000    Open position P/L    $     0.000
Gross profit           $ 28800.000    Gross loss           $ -2650.000

Total # of trades              4       Percent profitable           75%
Number winning trades          3       Number losing trades          1

Largest winning trade $ 13025.000    Largest losing trade $ -2650.000
Average winning trade $  9600.000    Average losing trade $ -2650.000
Ratio avg win/avg loss      3.623    Avg trade(win & loss) $  6537.500

Max consec. winners            3       Max consec. losers            1
Avg # bars in winners        149       Avg # bars in losers         53

Max intraday drawdown $ -3050.000
Profit factor              10.868    Max # contracts held          1

          Performance Summary:  Short Trades

Total net profit       $ 60062.500    Open position P/L    $     0.000
Gross profit           $ 63000.000    Gross loss           $ -2937.500

Total # of trades              4       Percent profitable           75%
Number winning trades          3       Number losing trades          1

Largest winning trade $ 48262.500    Largest losing trade $ -2937.500
Average winning trade $ 21000.000    Average losing trade $ -2937.500
Ratio avg win/avg loss      7.149    Avg trade(win & loss) $ 15015.625

Max consec. winners            2       Max consec. losers            1
Avg # bars in winners        216       Avg # bars in losers         52

Max intraday drawdown $ -3962.500
Profit factor              21.447    Max # contracts held          1
```

Figure 8 Walk Forward Performance Summary for JY RecursiveMovTL System

Out Of Sample Performance RecursiveMovTL   Japanese Yen Daily 10/12/92 - 09/11/98
```
Note: the system needs 40 days of past data to begin calculations thus the first buy signal using
the 10/12/92 start date was given on 02/10/93.


          Performance Summary:  All Trades

Total net profit      $ 91812.500    Open position P/L     $     0.000
Gross profit          $ 99662.500    Gross loss            $ -7850.000

Total # of trades           11       Percent profitable          73%
Number winning trades        8       Number losing trades         3

Largest winning trade $ 48262.500    Largest losing trade  $ -3500.000
Average winning trade $ 12457.813    Average losing trade  $ -2616.667
Ratio avg win/avg loss     4.761     Avg trade(win & loss) $  8346.591

Max consec. winners          3       Max consec. losers           1
Avg # bars in winners      160       Avg # bars in losers        44

Max intraday drawdown $ -6612.500
Profit factor             12.696     Max # contracts held         1

          Performance Summary:  Long Trades

Total net profit      $ 29937.500    Open position P/L     $     0.000
Gross profit          $ 36087.500    Gross loss            $ -6150.000

Total # of trades            6       Percent profitable          67%
Number winning trades        4       Number losing trades         2

Largest winning trade $ 14262.500    Largest losing trade  $ -3500.000
Average winning trade $  9021.875    Average losing trade  $ -3075.000
Ratio avg win/avg loss     2.934     Avg trade(win & loss) $  4989.583

Max consec. winners          3       Max consec. losers           2
Avg # bars in winners      121       Avg # bars in losers        41

Max intraday drawdown $ -9300.000
Profit factor              5.868     Max # contracts held         1

          Performance Summary:  Short Trades

Total net profit      $ 61875.000    Open position P/L     $     0.000
Gross profit          $ 63575.000    Gross loss            $ -1700.000

Total # of trades            5       Percent profitable          80%
Number winning trades        4       Number losing trades         1

Largest winning trade $ 48262.500    Largest losing trade  $ -1700.000
Average winning trade $ 15893.750    Average losing trade  $ -1700.000
Ratio avg win/avg loss     9.349     Avg trade(win & loss) $ 12375.000

Max consec. winners          3       Max consec. losers           1
Avg # bars in winners      199       Avg # bars in losers        50

Max intraday drawdown $ -3962.500
Profit factor             37.397     Max # contracts held         1
```

Figure 9 Walk Forward Performance Summary for JY RecursiveMovTL System 01/04/88-12/31/97

		Ndays	dup	ddn	TNPft	%P	MaxDD	LBgLTd	SBgLTd	1YrOpt	1YrOOS
1/1/88	12/31/92	25	0.225	0.275	$39750	64%	-$6300	-$4087	-$450	$2612	
1/1/89	12/31/93	25	0.225	0.525	$47950	73%	-$6775	-$4325	-$1725	$21675	$14750
1/1/90	12/31/94	20	0.100	0.450	$42637	73%	-$4675	-$2325	-$2612	$4900	$2500
1/1/91	12/31/95	25	0.325	0.525	$72250	67%	-$3337	0	-$2937	$36950	$31850
1/1/92	12/31/96	25	0.325	0.525	$84112	71%	-$3337	0	-$2937	$19063	$19063
1/1/93	12/31/97	25	0.325	0..525	$86212	75%	-$6612	-$2650	-$2937	$12350	$12350

Where:
- *TNPft* = Total Net Profit for the 4 year optimized test segment.
- *%P* = Percent Profitable for the optimized test segment.
- *MaxDD* = Max Intraday Drawdown in the optimized test segment.
- *LBgLTd* = Long Largest Losing Trade in the optimized test segment.
- *SBgLTd* = Short Largest Losing Trade in the optimized test segment.
- *1YrOpt* = The one year dollar profit for the curve fitted time segment generated from the optimum parameters derived for that time segment. This is the best curve fitted profit of the last year of that 5 year time segment.
- *1YrOOS* = The walk forward *one year* dollar profit or loss generated from the optimum parameters derived from the *previous* time segment. This is the out-of-sample on year profit for the year ending on 12/31/xx.

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Figure 10 Trade by Trade Summary For JY RecursiveMovTL System 01/01/88 - 09/11/98

Entry Date		Entry Price	Exit Date	Exit Price	DysIn Trade	Trade $P&L	Trade %P&L	Max%Pft	Trade Date	Max%DD	Trade Date
880614:2	Sell	102.94	881012	100.93	120	$2,513	1.95%	6.06%	880901	-0.57%	880616
881012:3	Buy	100.93	890104	102.57	84	$2,050	1.62%	4.44%	881125	0.00%	881012
890104:3	Sell	102.57	890802	93.47	210	$11,375	8.87%	14.59%	890614	0.00%	890104
890802:3	Buy	93.47	890818	90.20	16	$(4,088)	-3.50%	0.00%	890802	-3.95%	890817
890818:5	Sell	90.20	900518	84.37	273	$7,287	6.46%	9.40%	900417	-1.85%	890929
900518:5	Buy	84.37	901210	94.55	206	$12,725	12.07%	17.58%	901018	-1.29%	900625
901210:1	Sell	94.55	910201	94.91	53	$(450)	-0.38%	2.76%	910109	-0.63%	910131
910201:5	Buy	94.91	910305	92.37	32	$(3,175)	-2.68%	2.43%	910211	-2.68%	910305
910305:2	Sell	92.37	910715	92.47	132	$(125)	-0.11%	2.75%	910328	-1.34%	910415
910715:1	Buy	92.47	920221	97.53	221	$6,325	5.47%	9.19%	920120	-1.12%	910725
920221:5	Sell	97.53	920515	97.13	84	$500	0.41%	3.35%	920423	0.00%	920221
920515:5	Buy	97.13	921110	100.82	179	$4,613	3.80%	7.13%	920929	-0.27%	920521
921110:2	Sell	100.82	930210	102.99	92	$(2,713)	-2.15%	1.18%	930115	-2.15%	930210

WALK-FORWARD OUT-OF-SAMPLE TRADES BELOW

930210:3	Buy	102.99	931014	113.42	246	$13,038	10.13%	15.78%	930817	0.00%	930210
931014:4	Sell	113.42	940203	112.47	112	$1,188	0.84%	4.19%	940105	-1.34%	931112
940203:4	Buy	112.47	941205	117.91	305	$6,800	4.84%	8.61%	940712	-0.85%	940204
941205:1	Sell	117.91	950215	119.27	72	$(1,700)	-1.15%	1.11%	950106	-1.23%	950113
950215:3	Buy	119.27	950710	130.68	145	$14,263	9.57%	18.21%	950418	0.00%	950215
950710:1	Sell	130.68	970514	92.07	674	$48,263	29.55%	34.61%	970430	0.00%	950710
970514:3	Buy	92.07	970730	89.95	77	$(2,650)	-2.30%	4.61%	970611	-2.30%	970730
970730:3	Sell	89.95	980203	82.79	188	$8,950	7.96%	12.84%	980106	-3.04%	970808
980203:2	Buy	82.79	980316	79.99	41	$(3,500)	-3.38%	2.04%	980210	-3.38%	980316
980316:1	Sell	79.99	980904	75.85	172	$5,175	5.18%	13.51%	980811	-0.90%	980326
980904:5	Buy	75.85	980911	77.44	7	$1,988	2.10%	2.10%	980911	-2.37%	980909

Table courtesy of Meyers Analytics 4x4 Super Perfomance Summaries

Figure 11 JY RecursiveMovTL System Walk Forward Risk/Reward Summary 01/01/88 - 09/11/98

```
--------COMPOUNDED RATES OF RETURN-------
Buy & Hold w/0.0%Div CompndROR= -2.74%/Yr
Buy & Sell Signals   CompndROR=  9.00%/Yr
Buy w/0.0%Div & Sells w/0.0%Int       CompndROR=  9.00%/Yr
Buy w/0.0%Div & CashOnSells w/0.0%Int CompndROR=  3.54%/Yr
----------------ALL TRADES---------------
TotNetPrft=$128650.00  #Trades= 24  #Wins= 16(66.7%)  PrftFac= 7.99
TotalDays=3741(10.24yrs) LongPosDays=1559(41.7%) SellPosDays=2182(58.3%)
Ave P&L= 3.96% AvWin= 6.93%  AvLoss= -1.96%
        M   T   W   TH   F
Buys    4   2   2   1    3
Sells   1   1   5   1    4
---------------LONG TRADES--------------
#Trades= 12  #Wins=  8(66.7%)  AvDysLng=130
Ave P&L= 3.14% AvWin= 6.20%  AvLoss= -2.96%
BestWin=    12.07% 901210 WorstLoss= -3.50% 890818
BestMax%Pft= 18.21% 950418 WorstDD=   -3.95% 890817
---------------SHORT TRADES-------------
#Trades= 12  #Wins=  8(66.7%)  AvDysSht=182
Ave P&L= 4.79% AvWin= 7.65%  AvLoss= -0.95%
BestWin=    29.55% 970514 WorstLoss= -2.15% 930210
BestMax%Pft= 34.61% 970430 WorstDD=   -3.04% 970808
```

Table courtesy of Meyers Analytics 4x4 Super Perfomance Summaries

Figure 12 JY RecursiveMovTL System Walk Forward Risk/Reward Summary 10/16/93 - 09/11/98

- Note: the system needs 40 days of past data to begin calculations thus the first buy signal using the 10/16/92 start date was given on 02/10/93.

```
--------COMPOUNDED RATES OF RETURN-------
Buy & Hold w/0.0%Div CompndROR= -4.98%/Yr
Buy & Sell Signals   CompndROR= 10.96%/Yr
Buy w/0.0%Div & Sells w/0.0%Int        CompndROR= 10.96%/Yr
Buy w/0.0%Div & CashOnSells w/0.0%Int CompndROR=  3.61%/Yr
---------------ALL TRADES--------------
TotNetPrft=$91812.50  #Trades= 11  #Wins=  8(72.7%)  PrftFac=12.70
TotalDays=2039( 5.58yrs) LongPosDays= 821(40.3%) SellPosDays=1218(59.7%)
Ave P&L= 5.76% AvWin= 8.77%  AvLoss= -2.28%
        M    T    W   TH    F
Buys    3    0    1    1    1
Sells   0    1    2    1    1
----------------LONG TRADES-------------
#Trades=  6  #Wins=  4(66.7%)  AvDysLng=137
Ave P&L= 3.49% AvWin= 6.66%  AvLoss= -2.84%
BestWin=    10.13% 931014 WorstLoss= -3.38% 980316
BestMax%Pft= 18.21% 950418 WorstDD=   -3.38% 980316
---------------SHORT TRADES------------
#Trades= 5  #Wins=  4(80.0%)  AvDysSht=203
Ave P&L= 8.47% AvWin=10.88%  AvLoss= -1.15%
BestWin=    29.55% 970514 WorstLoss= -1.15% 950215
BestMax%Pft= 34.61% 970430 WorstDD=   -3.04% 970808
```

Table courtesy of Meyers Analytics 4x4 Super Perfomance Summaries

Figure 13A Chart for JY RecursiveMovTL System 01/04/88-12/30/92
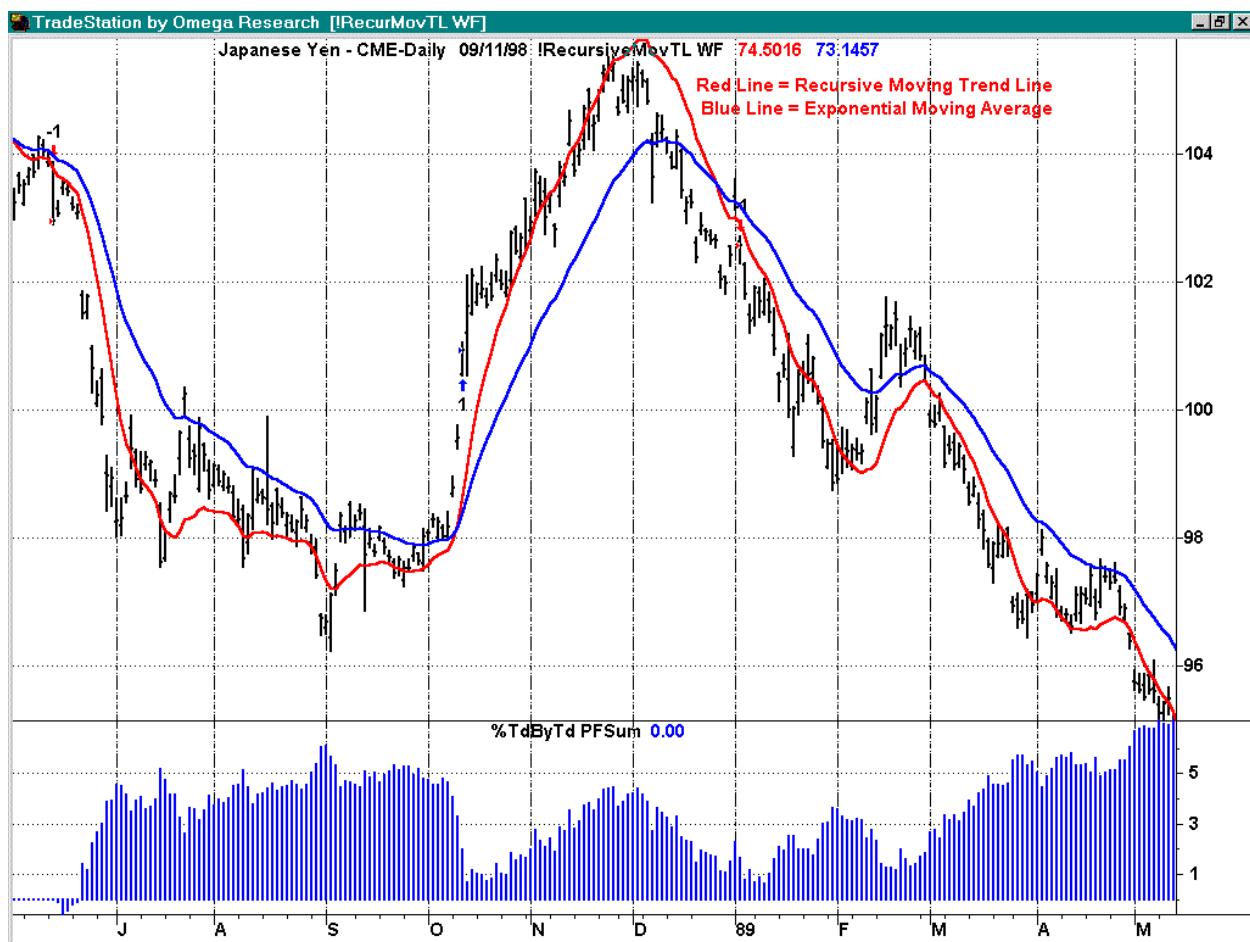
Figure 13B Chart for JY RecursiveMovTL System 01/04/88-12/30/92
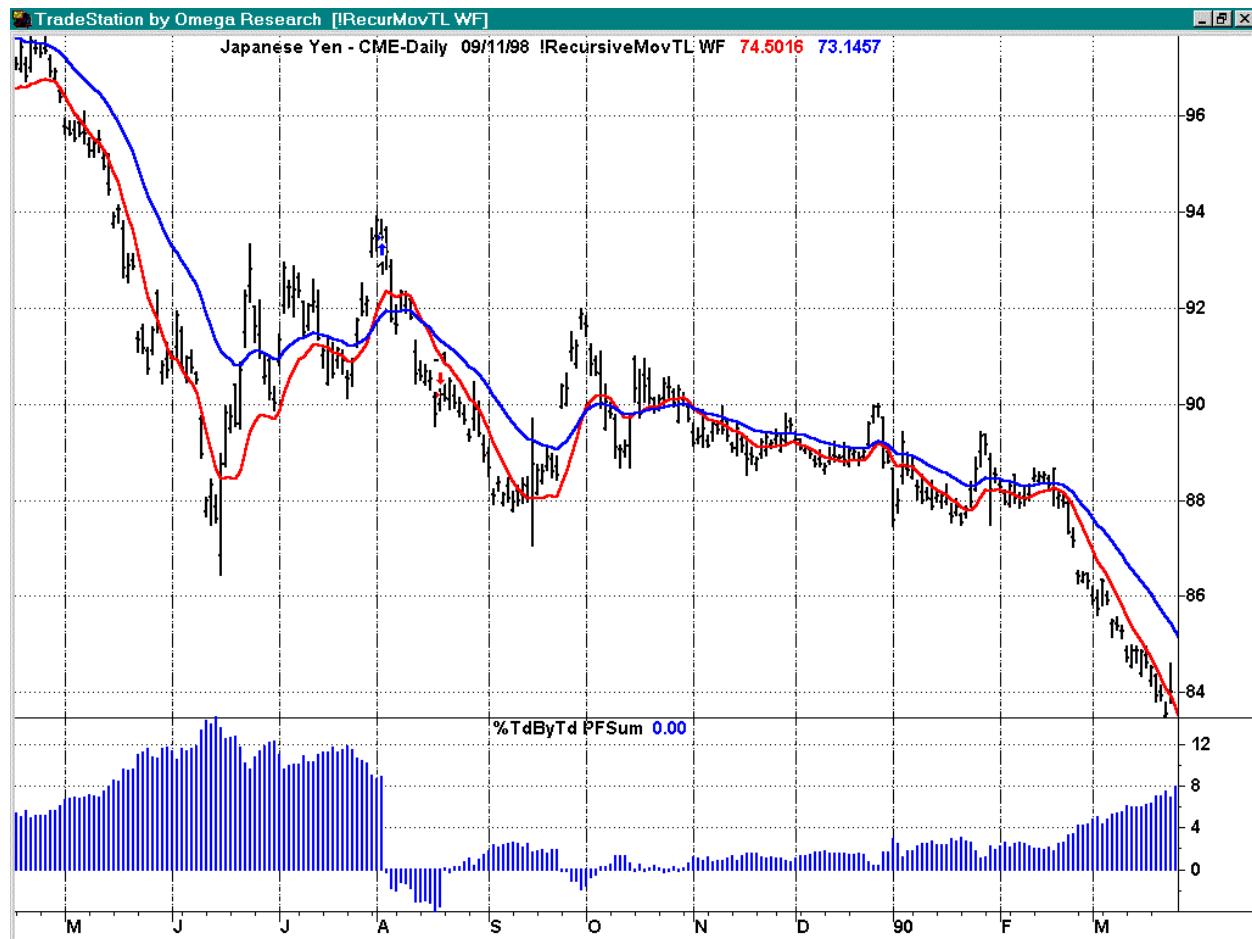
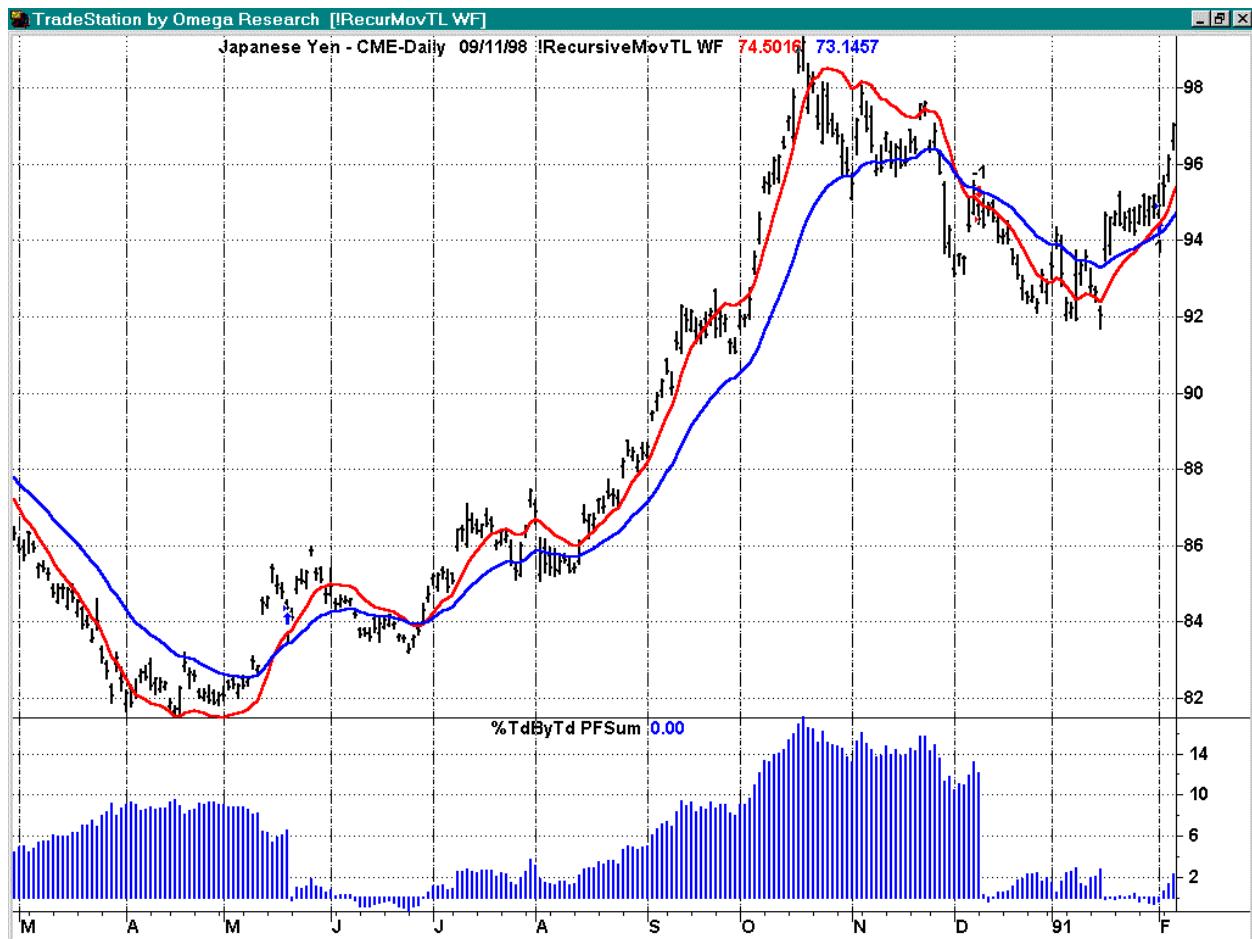**Figure 13C Chart for JY RecursiveMovTL System 01/04/88-12/30/92**

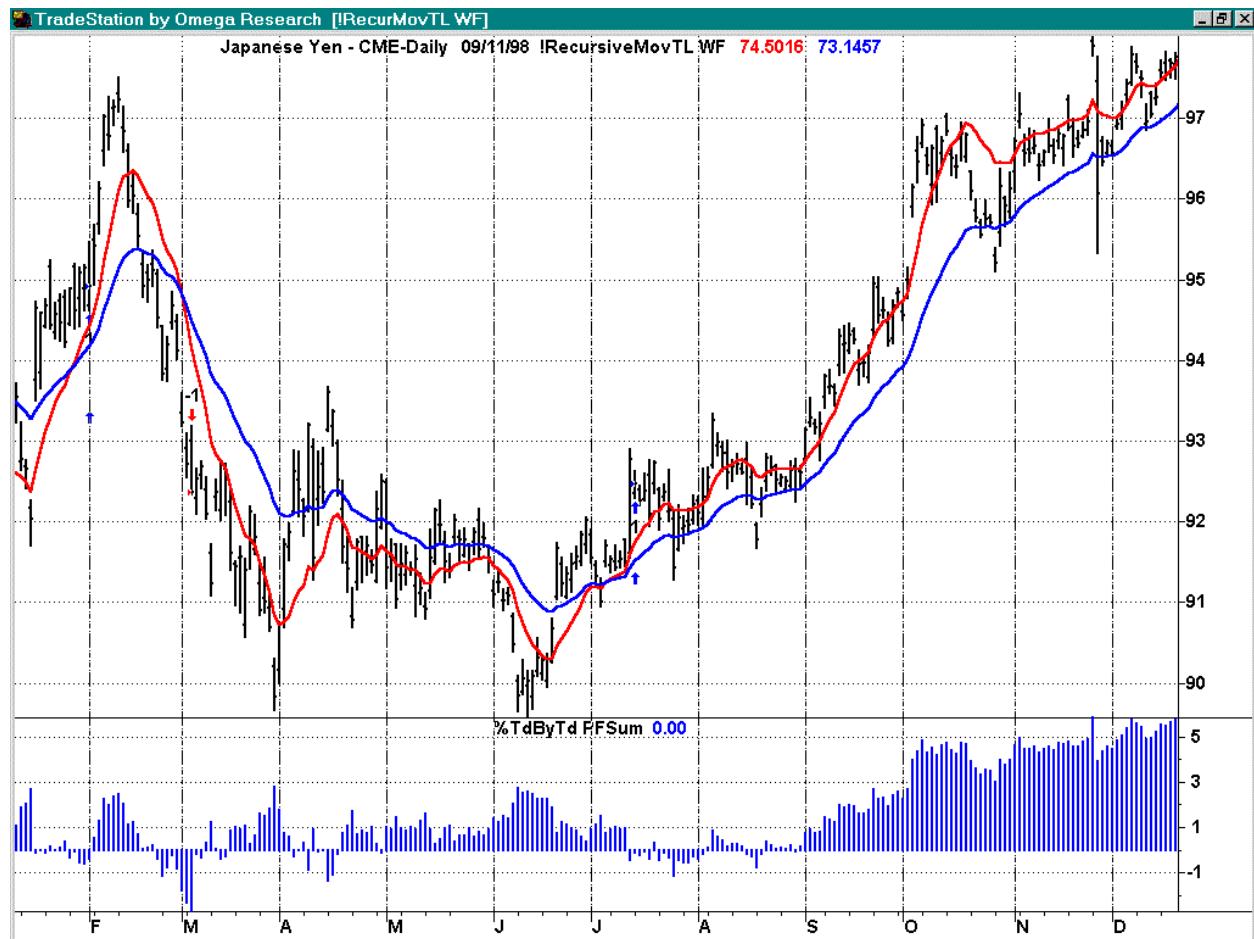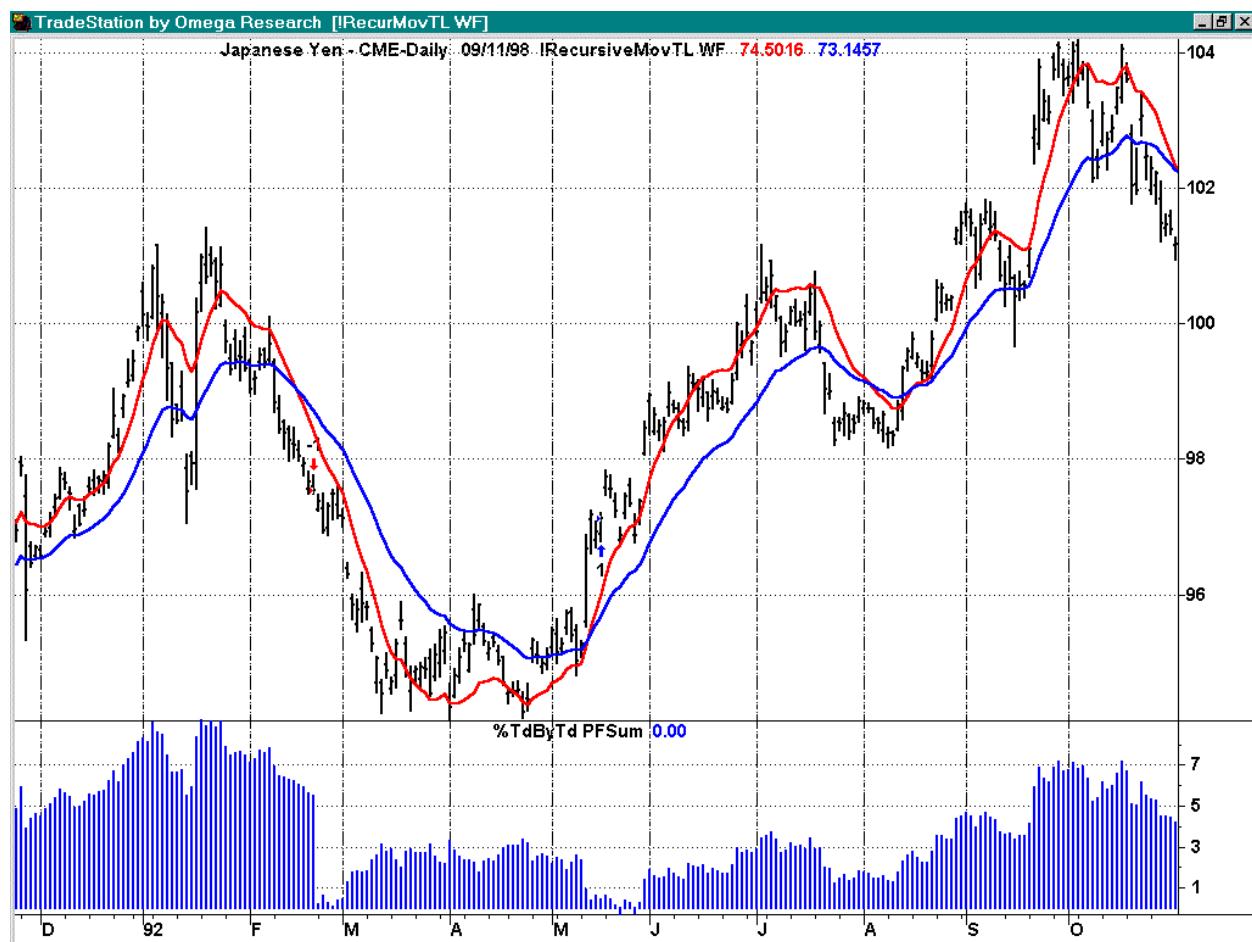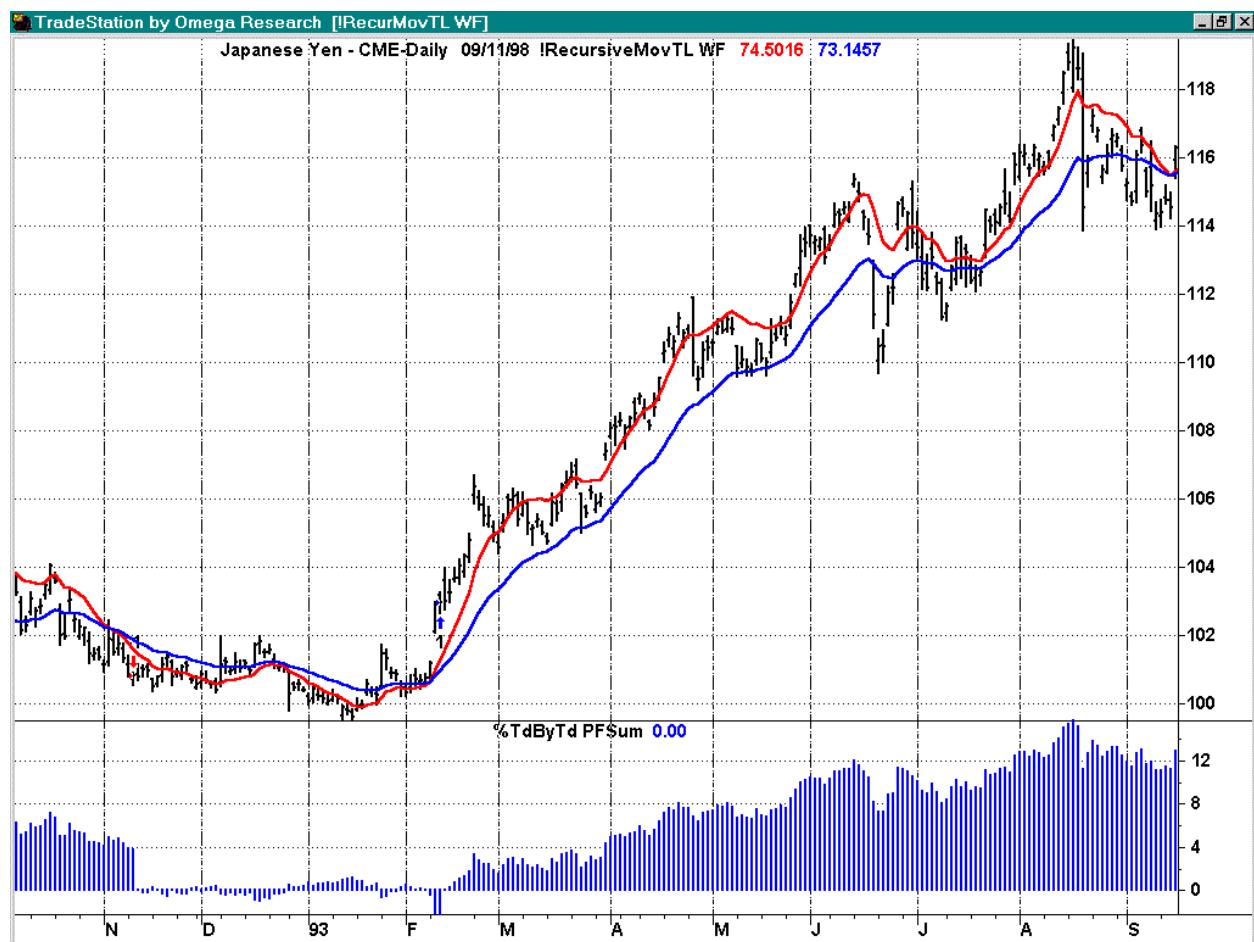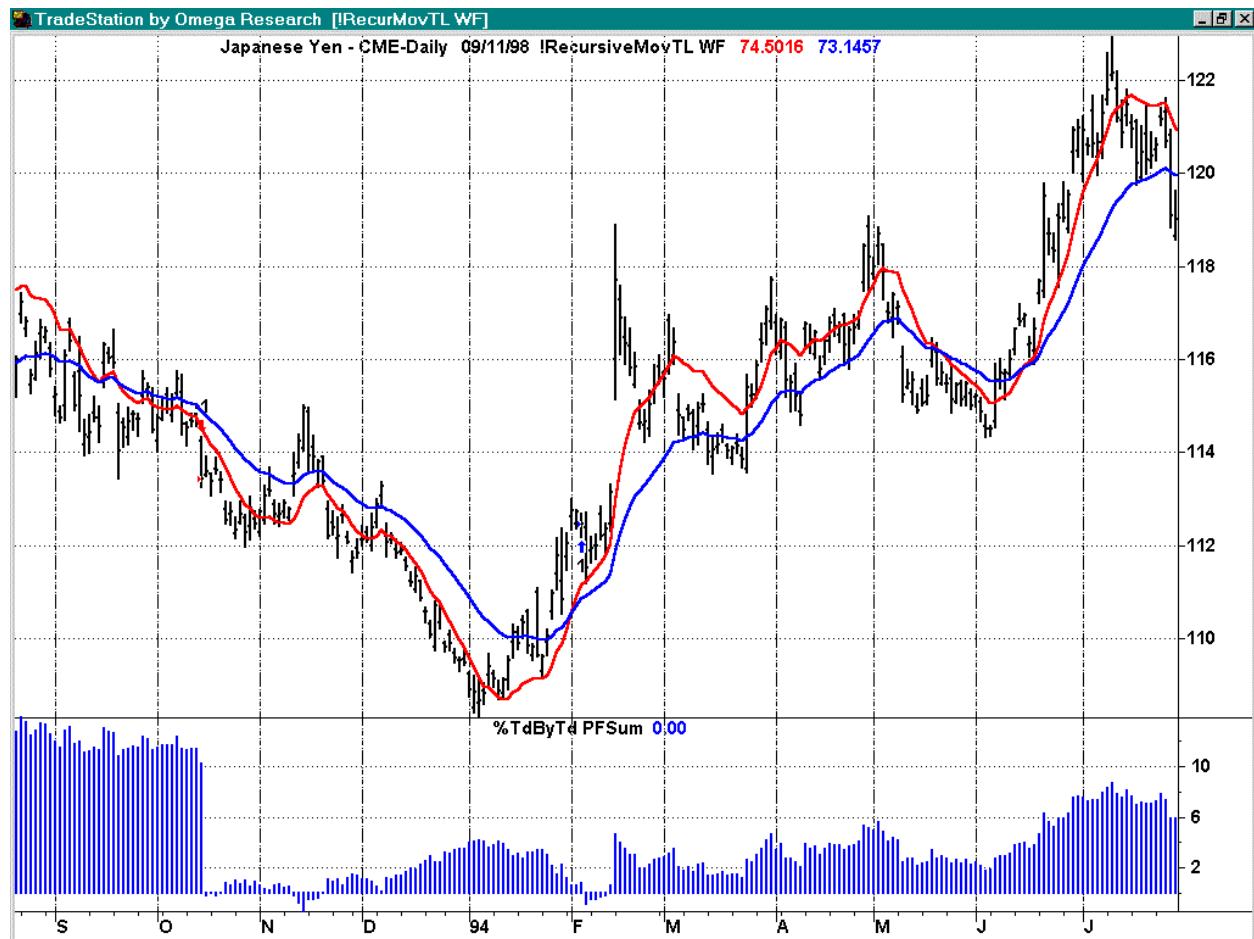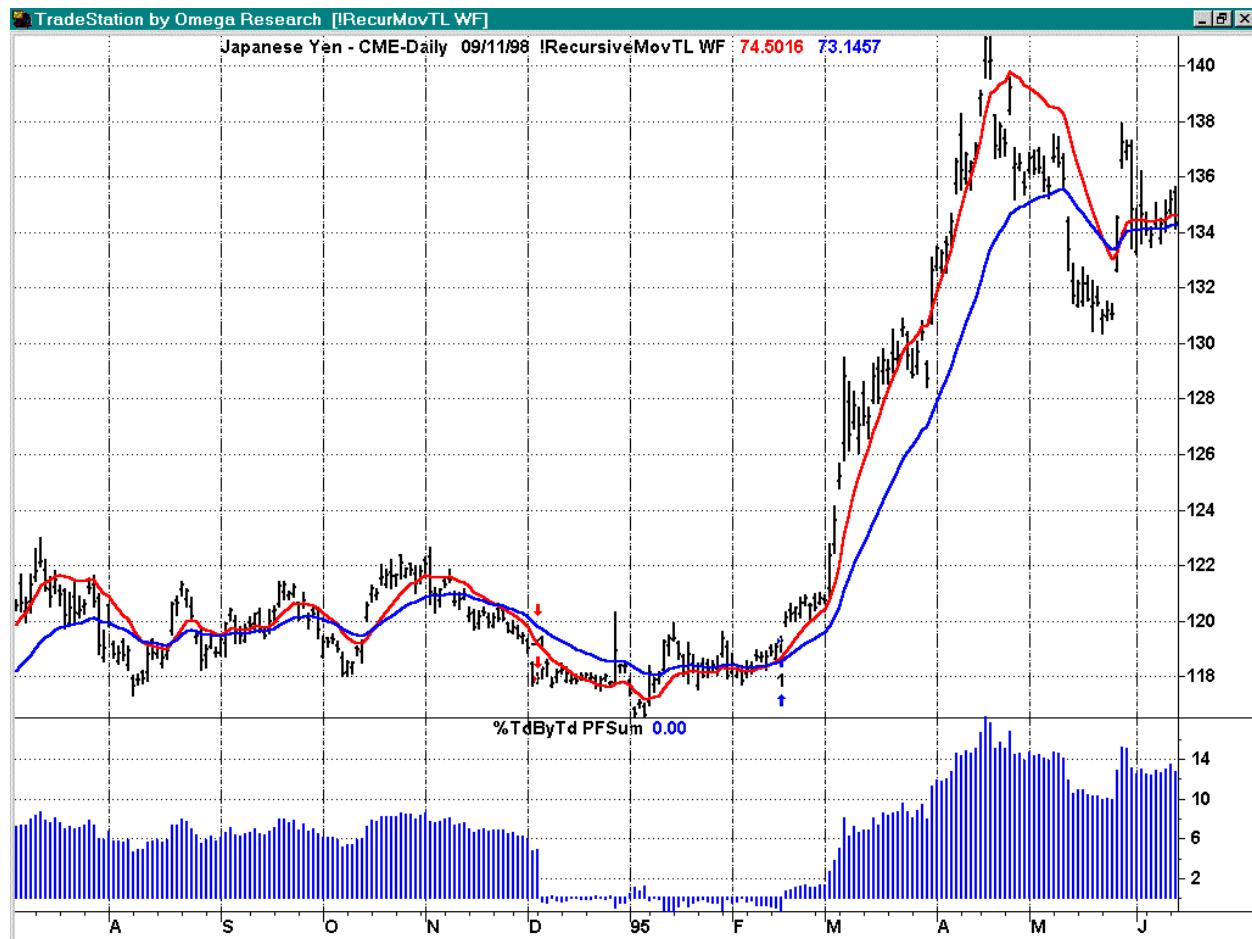**Figure 13D Chart for JY RecursiveMovTL System 01/04/88-12/30/92**

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Figure 13E Chart for JY RecursiveMovTL System 01/04/88-12/30/92

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Figure 13F Chart for JY RecursiveMovTL System 01/04/88-12/30/92

Figure 13G Chart for JY RecursiveMovTL System 01/04/88-12/30/92

Figure 13H Chart for JY RecursiveMovTL System 01/04/88-12/30/92

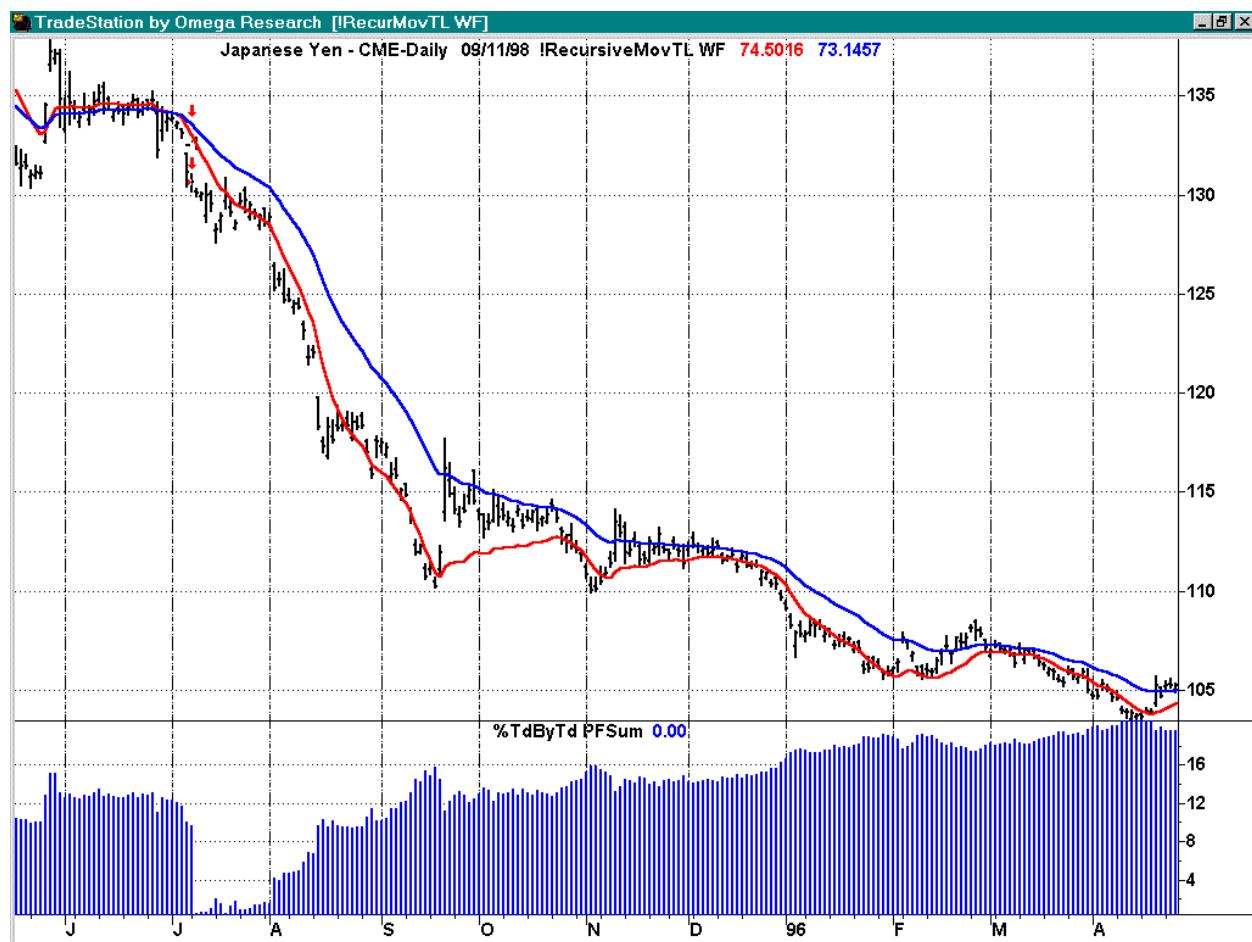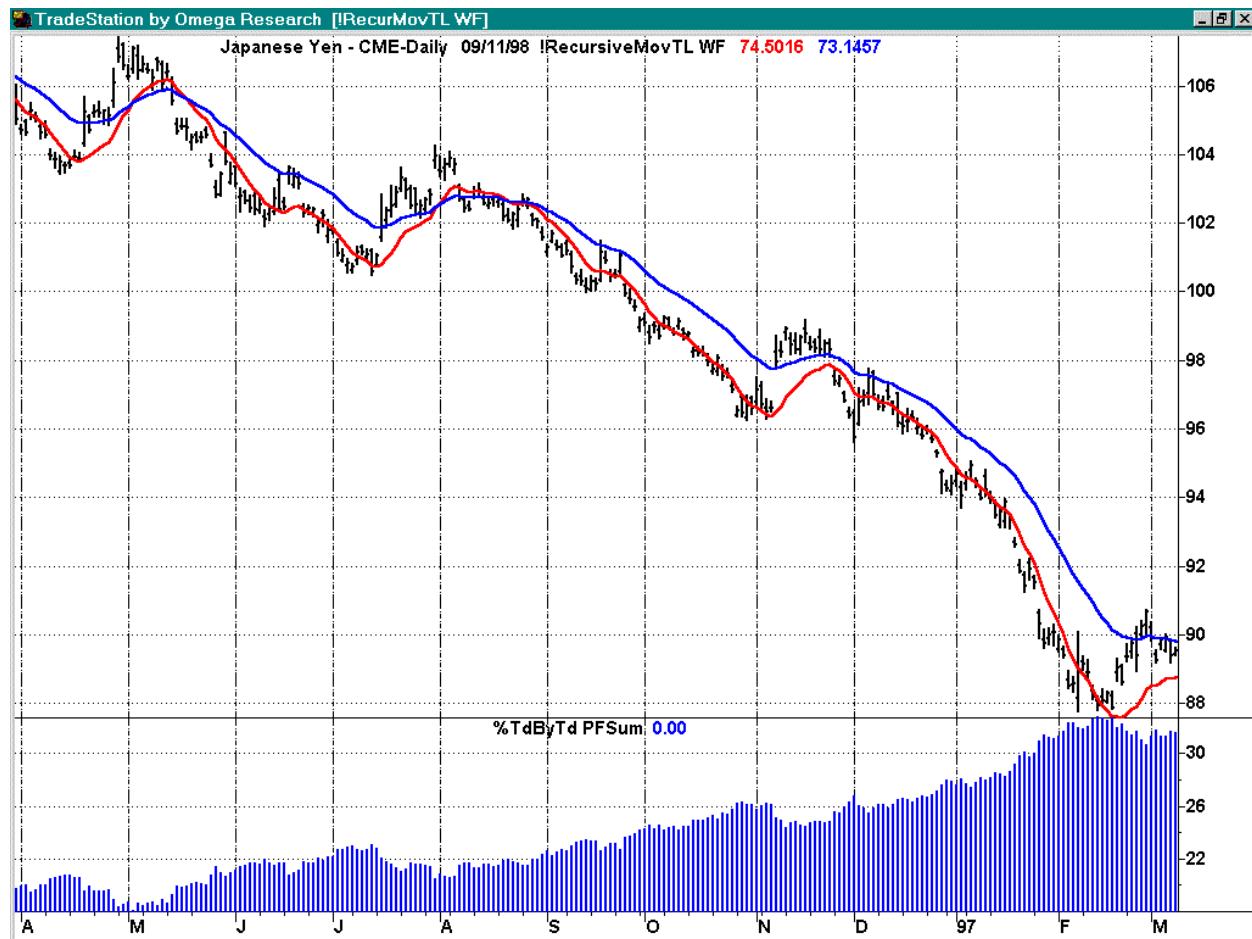**Figure 13I Chart for JY RecursiveMovTL System 01/04/88-12/30/92**

Figure 13J Chart for JY RecursiveMovTL System 01/04/88-12/30/92

Figure 13K Chart for JY RecursiveMovTL System 01/04/88-12/30/92

The Japanese Yen, Recursed

Figure 13L Chart for JY RecursiveMovTL System 01/04/88-12/30/92

The Japanese Yen, Recursed